CHAPTER 2
LITERATURE REVIEW AND THEORITICAL BACKGROUND

2.1. Literature Review

(Miller, Childers, and Taaffe 2009) conduct a research project to determine the appropriate order quantity and forecasting methods for a local company maintenances, repairs and overhaul inventory. According to their simulation results, basing reorder quantities on the distribution of demand and accurate lead time data showed significant improvement to the fill rate. They believe by preventing stockouts will save a significant amount of money accross the inventory system.

The research that is conducted by (Suryani 2012) is about analysis of the product inventory control using genetic algorithm to minimize inventory cost. This research at PT.XYZ who order the raw material A to the third parties by estimate when the number of item in the warehouse is almost eshausted. When the demand for item A againts PT.XYZ soaring frequently PT.XYZ can not meet the demand. In other times PT.XYZ also have excess number of ordering goods, this create an enormous amount of inventory that must be stored in warehouse, it can affect the over runs of inventory cost.

Research conducted by (Chandra and Kumar 2006) is about the development of the rules of new heuristic ordering multi item , single vendor inventory system with random request. The position of the inventory for each item is a continuous review and each message is when all stockout cost that projected to all aitem is exceed certain multiple of the average fees.

Research that conducted by (Kao and Hsu 2002) is talk about lot size – reorder point inventory model with fuzzy demand. The objective is to find the best inventory policy. The main problem in this research is in the inventory problem that has fuzzy demands. Methods that used are Yager's Rangking method and five pair of simultaneous nonlinear equations. The results of this research by using Yager's ranking method can utilized to find the minimal total cost.

The other research was conducted by Pattnaik in 2012. This research is about the constant demand model with the easy damage product whitin a certain timeframe. This model use EOQ model to the easy damage product and expired time. The objective of this research is to obtained the total cost of the damage product such as fruits, vegetables and other kind of foods.

In 2010, Routroy and Bhausaheb conduct a research which is used simulation with arena and the objective is to evaluate the inventory system for the damage productd. The main problems on controlling the inventory of damage product are the production cycle, order cost, holding cost, lost cost, overload cost, uncertainty demand and the price of the products.

In actual inventory system, however multi-item storage is an issue typically encountered. One research that formulated a novel approach for multi-product, multi-period (Q,r) inventory models, with the objective of maximizing the profit under constraints such as storage area, budget, shelf life, and various promotions (Saracoglu, Topaloglu, and Keskinturk 2014). As the number of products and periods increase, it can be found that an optimal solution cannot be reached with ILP in a reasonable computational time. For this reason, we proposed a GA solution approach since the problem of the pharmaceutical distributor case studied is a larger sized problem.

Perbawa and Wigati (2014) analyzed the multi item inventory with demand and probabilistic leadtime and limited warehouse capacity. The aim of this research is to know when time to order the item and how much the quantity to obtain the minimum total cost and there are no stockout in the warehouse while the capacity is limited.

2.2. Theoretical Background

This section explains the theories that will be used in this research.

2.2.1. Definition of Inventory

Some inventories are in the form of raw materials and purchased item to be used in making products, some are supplies to be used up in the manufacturing process, some are partially manufactured items (work in process) in prodution departments, some are finished parts ready to be put into assembled products, some are finished products in shipping rooms and warehouses (Moore and Hendrick, 1980: 334). In other hand, inventory is defined as goods that are stored for use or sale in the future (Kusuma, 2004:131). Inventory is the important thing for the company to make company run properly.

Inventories make possible a rational production system. Without inventory company could not achieve smooth production flow. An inventory is a list of the items held in stock (Waters, 2003:3). Operation manager in the entire world reliazed that the good inventory management is so important. In the other side, a company can decrease the cost by decreasing the inventory. The production also can be stop and the costumer feel disappointed if the order is not available (Heizer & Render,2014:553).

2.2.2. Stoks Cycles

Stocks are the materials which an organizations does not use immediately. The materials are deliver from supplier and this is kept in stock until needed. Stocks are replenished by deliveries from supplier and reduced to meet demands from customers. Figure 2.1 shows the typical use of stock and Figure 2.2 shows the stock levels in a typical cycle (Waters,2003:5).

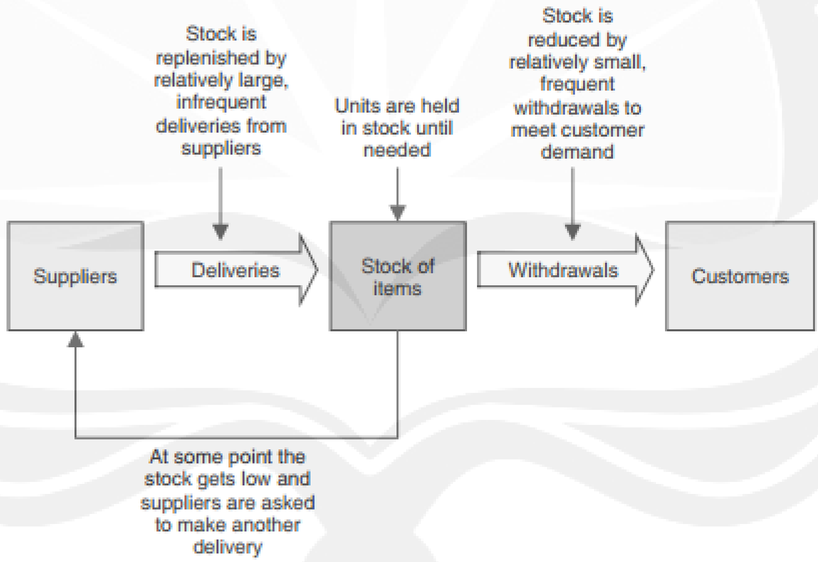

Figure 2.1 The Typical Use of Stock.

Source: (Waters,2003)

Typically, each cycle has the following elements such as:

a. An organizations buys a number of units of an item from a supplier
b. At an arranged time, these units are delivered
c. Unless they are needed immediately, the units are put into storage, replenishing the stocks
d. Customers, either internal or external, create demands for the item

e. Unit are removed from stock to meet these demand
f. At some point, the stock obtains low and it is time for the organization to place another order.

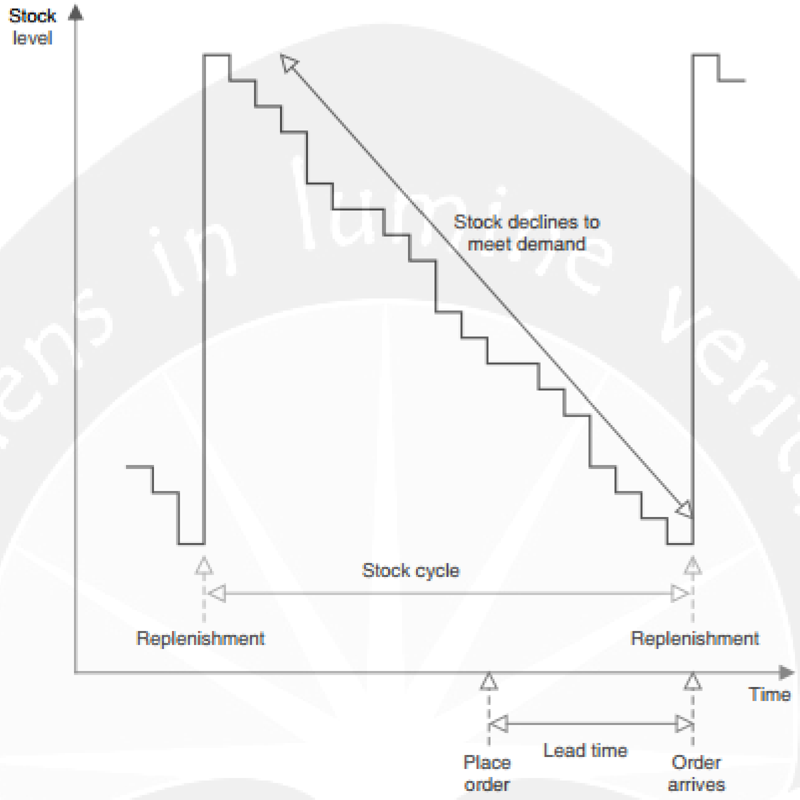

Figure 2.2 Stock Levels in a Typical Cycle

Source: (Waters,2003)

Usually, deliveries from supplier are relatively large and infrequent, while demands from customer are smaller and more numerous, giving the typical pattern. The main purpose of stocks is to give a buffer between supply and demand.

2.2.3. Types of Inventory

The organizations has different types of stock or inventory. A useful classification has (Waters, 2003:9):

a. Raw material, which have arrived from supplier and kept until needed for operations.
b. Work in progress, which are units currently being worked on
c. Finished goods, which are waiting to be shipped to customers.
d. Spare parts, for machinery, equipment, etc

e. Consumable, such as oil, paper, cleaners, etc.

Raw material inventory has been purchased but not process yet. This kind of inventory can be used to seperates supplier from the production process. Nevertheless, a preferred approach is to remove the variability of suppliers in quality, quantity or delivery time so that there are no need to be separated(Heizer & Render,2014:554). The example for raw material are woods, fabrics and so on waiting to be made into articles. Work in progress inventory is components or raw materials that has passed through several processes of change, but not complete yet. There are work in process to make an product needs time (cycle time). Decrease the cycle time also will decrease the work in process inventory (Heizer & Render,2014:554). The example of work in process is the articles being worked on at the moment. Finishied good inventory is the finished product and already to be delivered. The finished good can be entered into the inventory because customer demand in the future is unknown(Heizer & Render,2014:554). The example of finished goods are articles waiting to be delivered to the customers. The example of inventory spare parts are kept for the knitting machines and other equipment and for consumable inventory include cleaners, stationery and other material to keep operations going.

2.2.4. Function of Inventory

Planning and inventory control is useful to make a stable condition for the production process and marketing. The aim of stock the raw material is to reducing production uncertainty due to raw material fluctuations. Inventory can have a variety of functions that add to the flexibility of the company's operations. There are four function of inventory (Heizer & Render,2014:553) :

a. To provides a large selection of goods in order to meet anticipated customer demand and separates the company from fluctuations in demand. This kind of inventory generaly uses for retail company.
b. To separates the multiple stages of the production process. For example, if a company inventory fluctuates, additional inventories may be required in order to separate the production process of the supplier.
c. To takes advantage of a number of pieces for large purchases can decrease the cost of delivery the goods.
d. To avoids the inflation and price increases

2.2.5. Inventory Cost

All stocks incur costs. Therefore the organizations want to minimize the inventory cost but the organization can not reducing the stocks. Actually low cost give a minimum cost, but low stock can lead to shortages. The usual approach describes four types of cost such as (Waters, 2003:52) :

a. Unit Cost

   This is the price charged by suppliers for one unit of the item or the cost to the organization of acquiring one unit. In general, it is fairly easy to find values for the unit cost by looking at quotations or recent invoices from suppliers.

b. Reorder Cost

   This is the cost of placing a repeat order for the item and mightinclude allowances for drawing-up an order (with checking, obtaining authorization, clearance and distribution), correspondence and telephone costs, receiving (with unloading, checking and testing), supervision, use of equipment and follow-up. Sometimes costs such as quality control, transport, delivery, sorting and movement of received goods are included in the reorder cost.

c. Holding Cost

   Holding many stock is expensive. This is the cost of holding one unit of an item in stock for one period of time. The most obvious cost of holding stock is money tied up- which is either borrowed (in which case there is interest to pay), or could be put to other use(in which case there are opportunity costs). Other holding costs are due to storage space(supplying a warehouse, rent, rates, heat, light, etc), loss(due to damage, obsolescence and pilferage), handling (including all movement, special packaging, refrigerator, putting on pallets, etc), administration (stock checks, computer updates, etc) and insurance.

d. Shortage Cost

   If an organization runs out of stock for an item and there is demand from a customer, then there is a shortage that has an associated cost. Any shortage of parts for production might cause considerable disruption and force emergency procedures, rescheduling of operations, retiming of maintenance period, laying-off employees, and so on.

2.2.7. Probabilistic Inventory

There is uncertainty in almost all inventory systems. Some of this is under the control of an organization, including costs, demand, lead time and supplier reliability (Waters,2003:152). Probabilistic models can be used when the demand of product is unknown but can be determined by using probability distribution. An probabilistic model is the adjustment in the real world because of the demand and the waiting time is not always known and it is constant (Heizer & Render,2014:575). The unconstant demand can increase the probability of inventory stockout.

2.2.8. Definition of Simulation

Simulation is based on an appropriate model. Simulation gives a dynamic representation of a real operations (Waters, 2003). A simulation model is however in principle associated with the same limitations as all other mathematical models. A simulation model can never give a complete illustration of the real system. Note especially that if a simulation model is based on the same assumption as some other inventory model the result will of course be the same and simulations will therefore not give any additional insight. Simulation can give valuable information, though if the simulation model illustrates the real system better in some way. Assume, for example that the determination of safety stocks in an inventory control system is based on the assumption of a certain demand distribution and that it has not been possible to analition. A simulation model based on real historiical demand data can then be used for analyzing whether the demand distribution used is reasonable (Axsater,2000:182).

2.2.9. System, Models and Simulations

A great simulation is determined by resulting the great model. While the great model will be resulted through a great observation for the system. Figure 2.3. shows the system, model and simulation relationship (Law and Kelton, 2000)

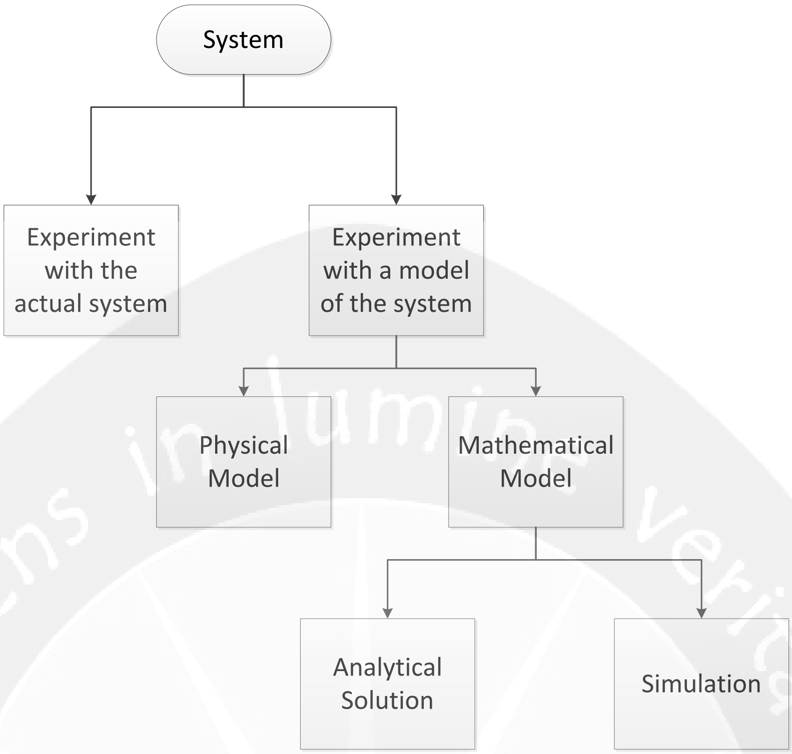

Figure 2.3. System, Models, and Simulation Relationship

Source : Law and Kelton, 2000

a. Experiment with the actual system vs Experiment with a model of the system
   If the experiment with the actual system can be performed then no need to conduct a validation experiment. But the actual system spends more cost and contains enough risks if this experiment failed or does not appropriate to the system. Therefore, the actual system requires to represented in the simple model and perform a validation to the model.
b. Physical Model vs Mathematical Model
   Physical model is a miniatur of actual system which is found to build physical model. Mathematical model must be represented a system in terms of logical and quantitative relationship that are then manipulated and changed to see how the model reacts and thus how the system would react (if the mathematical model is a valid one)
c. Analytical Solution vs Simulation
   After creating the model mathematic there will be an analysis to know whether the model can be used to obtain a solution. If the model is simple enough, it may be a possible to work with its relationship and quantities to obtain an

exact, analytical solution. But for the complex model, the mathematical model is difficult to perform using analytical solution and needs more time, so that simulation can be performed to obtain the solution from the complex system.

2.2.10 Advantage and Disadvantage of Simulation

Simulation is a familiar method that used to solved the complex problem. Therefore, the following is advantages of simulation according to Law & Kelton (2000).

a. System in the real life is very complex. Therefore there can not be described accuratly with the mathematical model which can be evaluated in analitic. So , simulation is common to use to analyse the problem.
b. Simulation is possible to performance estimation from the system which is in the setting operation condition that projected.
c. The design of alternative system that proposed can be compared through simulation to know which alternative that fulfill the criteria that needed.
d. Through the simulation, in controlling the experiment condition can be kept better than its system.
e. Simulation is possible to conduct the research in long term.

While that, simulation also has disadavantages. This following shows the disadvantages of simulation.

a. Simulation model just resulting the estimation value from inputed parameter.
b. If the model is not represent the validation of system then the result of simulation only to give an information about the real system.

2.2.11. Simulation Steps

In conducting the simulation, there are some steps that must be done. Simulation's steps not only straight to the next step but also can go back to the base steps. The first step in building a simulation model is to describe the operations in detail. There are several ways of doing this, with the most common using a flow diagram show the sequence of activities. Figure 2.4 shows the steps in a simple inventory simulation (Waters, 2003:293).

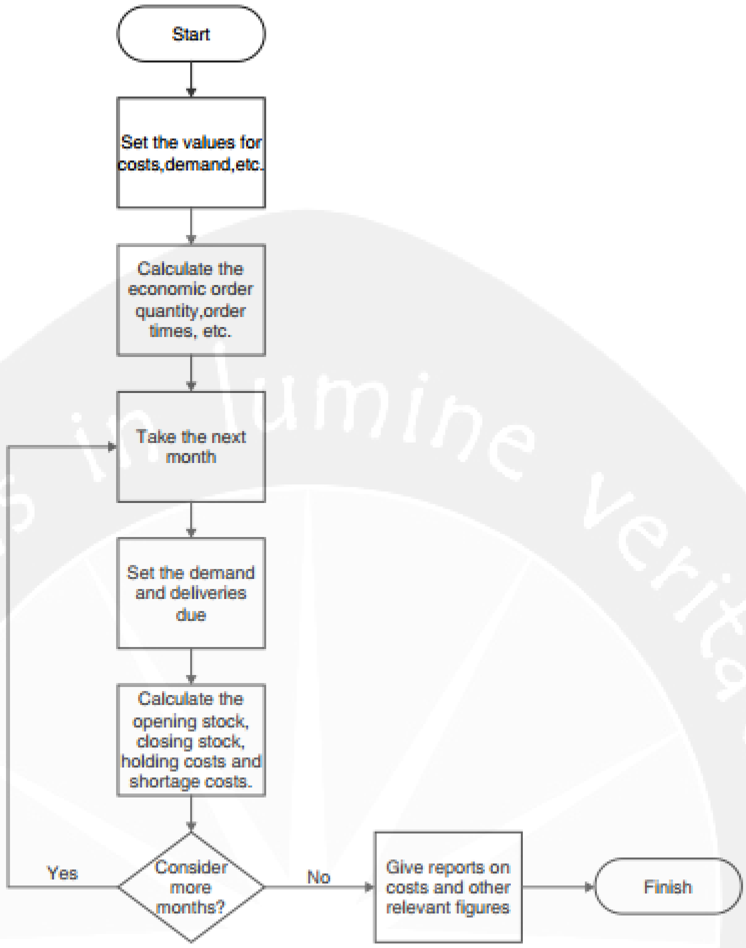

Figure 2.4 Steps in a Simple Inventory Simulation

Source: Waters, 2003

This starts by setting the known data, including costs and demand pattern, and uses this to calculate the economic order quantity, timing of deliveries, and so on. Then take the first month, check the demand and deliveries due, find the opening stock, set the opening stock (which is last month's closing stock), find the closing stock(which is opening stock plus deliveries minus demand) and calculate all the costs. Then go to the second month and repeat the analysis. This can continue for as many repetitions as needed to obtain a longer-term view of the economic order quantity. All the calculations for this are done with appropriate software. That was the basic steps of simulation and can start by adding some more details to give a better picture of the real system. For example, vary the pattern of demand rather than consider one fixed pattern and add a variable lead time and amount delivered(perhaps allowing for quality checks). The way of introducing this kind of variation is to use random numbers. Suppose the company does not know exactly the demand in a month, but know that it is between 30 and 50 units. The spreadsheets can automatically generate random values and in Microsoft Excel the function RANDBETWEEN(30,50) will generate a random value between 30 and 50. The random variations mean that each run will be different. To find the real pattern we would have to repeat the simulation many times, perhaps hundreds or even thousands (Waters, 2003: 294) .

In another hand, (Law & Kelton, 2000) a simulation starts from formulate the problem formulation. Then the next step is collecting the data and determine the model according to the real problem. After the model had conducted then check the model, is the model valid or not. If the model is invalid then conduct the re-problem formulation. But if the model is valid then conduct the verification. After all clear, then design the experiment such as determining the lead time, set up time, and the number of replications. The next step is running the program and conduct the data analysis. Analysis data was conducted to decide the system and compare all available alternatives. After the output had already analyzed and compared also got the result, the last steps is documenting the model that will be uses for future and apply the simulation result. Figure 2.4 shows the simulation steps (Law&Kelton, 2000).

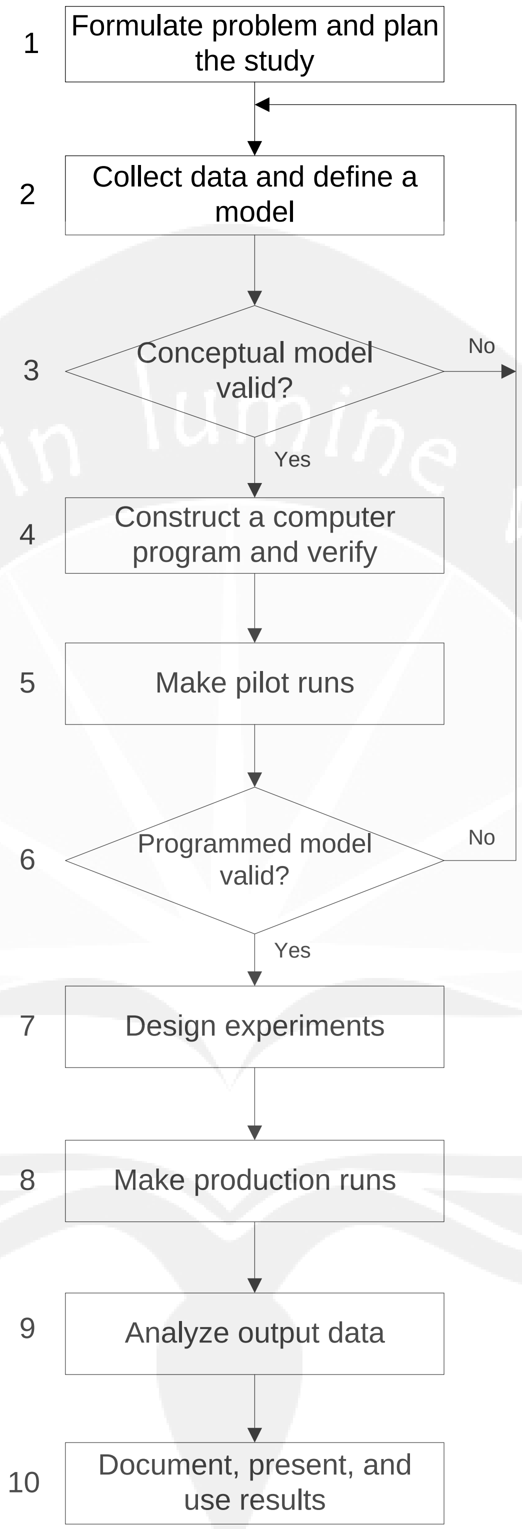

Figure 2.5 Simulation Steps

Source: Law & Kelton, 2000

2.2.12. Verification

Verification is used to decide whether the simulation model is already closed to the real system or not. One of the technique is to conduct the verification by run the simulation under the variety of setting the input parameters, then check whether the output can be accepted or not (Law&Kelton, 2000).

2.2.13. Validation

Validation is a process of determining whether or not the simulation model is already represent the real condition accurately. It is used to test the model and compare to the real system. Validation is conducted by using one of tools in Ms. Excel Software that is t-test: Two-sample assuming equal variances. This test is assume that both of data is from the population with the same variances. The validation test compares the real data with the data from simulation (Law & Kelton, 2000). If there is no significantly different, then the model can be said as a valid model.

2.2.14. Replication

To run the simulation it is not enough if there just once to represent the real condition. Therefore the simulation needs to run more than once. Replication is needed to determine how many simulations to run. Parameter that used to decide the number of replication is the total end cost of inventory.

In determining the number of replication, first step are decide the coefiecient of confidence interval (α) and level of error (γ). The value of α that used is 0.1 that is mean there is an possible of 0.1 for the value of mean will out of the range $\bar{x} \pm \sigma$. The value of coeficient γ is 0.1 which means the value of deviation of $\bar{x}$ from μ . The value of γ can be obtained with this following formula (Law and Kelton, 2000)

$$\gamma = \left|\frac{\overline{X-\mu}}{\mu}\right| \quad (2.1)$$

$$\gamma' = \left|\frac{\gamma}{1+\gamma}\right| = \left|\frac{0,1}{1+0,1}\right| = 0,09 \quad (2.2.)$$

After that, the number of replication can be obtained when the condition achieved a value of $t_{i-1,1-\alpha/2}$ which is come from t distribution.

$$\text{Nr}^*(\gamma) = \min\left\{ i \geq n; \frac{t_{i-1,1-\alpha/2}\sqrt{\sigma\text{^}2(n)/i}}{|\bar{x}(n)|} \leq \gamma' \right\} \qquad (2.3.)$$

Where;

Nr* (γ)	= Number of Replication
γ	= Level of Error
i	= Number of Sample
α	= Confidence Interval
σ	= Standard Deviation
$\bar{x}$(n)	= Average of N-th Sample

2.2.15. Input Analyzer Arena

Input Analyzer Arena software is used to help in finding the distribution pattern from the base data that available. This is the following step to find the distribution pattern by using Input Analyzer Arena Software:

a. Data was noted vertically from the top to the end in notepad, then save as .dst.
b. Open input analyzer arena program
c. Click file-new. Then there will be occur the new blank sheet
d. After that click file – data file – use existing. Choose the notepad file that already data inputed.
e. Choose fit, and try one by one type of distribution, then choose the higher p value as the chosen distribution pattern.

2.2.16. Generate the random number from the Distribution Pattern.

The following table shows the distribution pattern that usualy used to generate the random number in simulation using Microsoft Excel (Law and Kelton, 2000).

Table 2.1. Generate Distribution Pattern in Microsoft Excel

Name	Distribution	X
Uniform	UNIF (Min, Max)	Min + (Max-Min). U
Exponential	EXPO (µ)	- µ . ln(U)
Weibull	WEIB (β, α)	β [-ln(U)].1/ α
Gamma	GAMM (β, α)	GAMMAINV(U; β; α)
Beta	BETA (α_1, α_2)	BETAINV(U; α_1; α_2; 0 ; 1)
Normal	NORM (µ, σ)	NORMINV(U; µ, σ)

Cont'd Table 2.1.

Triangular	TRIA (Min, Mode, Max)	c = (Mode - Min)/(Max - Min) b = $\sqrt{c.U}$ if U ≤ c X` = $1-\sqrt{(1-c)(1-U)}$ if U ≥ c Min+(Max-Min).X`

Where;

X = The result of generated random value

U = Random value, $0 \le U \le 1$

Min = Minimum value

Max = Maximum value

Mode = The most occur value

μ = Average value

β = Scale parameter

α = Parameter

α_1 = Down parameter

α_2 = Top parameter

σ = standard deviation

2.2.17. Half Width, Upper and Lower Confidence Interval

Half width is the confidence interval which has exact interval in the confidence level to the real average value (Law and Kelton, 2000).

$$HW = \frac{t(n-1,\alpha).\sigma}{\sqrt{n}} \quad (2.4)$$

$$\text{Lower Interval} = \bar{x} - hw \quad (2.5)$$

$$\text{Upper Interval} = \bar{x} + hw \quad (2.6)$$

Where:

HW = Half Width

n = Number of replication

α = Confidence Interval

σ = Standard Deviation

$\bar{x}$ = Average