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DECISION OF DELIVERY QUANTITY AND WAREHOUSE SIZE FOR DISTRIBUTOR: A SIMULATION STUDY

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ABSTRACT

PT X is one of leading cement industry in Indonesia which has a big role in meeting society's need for housing and building infrastructure. In order to always satisfy the demand for their customer, the company should have enough products on each district of distribution. The distribution scope will be the entire java and several islands in Indonesia. Nowadays, PT X doesn't have definite policy about the delivery quantity that should be distributed for each district. Therefore, this research will lead the company to have a certain policy for delivery quantity. This research will consider the critical level of stock on each district by using days of supply. The stock level will be concluded as critical if the condition of stock on each district below the desire days of supply. In order to answer this problem, this research will suggest the company about the amount of delivery quantity that should be distributed for the several critical levels. A method that will be used is discrete-event simulation by using ARENA software as the supporting tools. In addition, this research will also evaluate the existing utilization of warehouse for each district and also give a suggestion for warehouse size on the certain district. In the end of this research, PT X will consider the delivery quantity base on critical level of stocks and the cost gained from the simulation.

Keywords: Average Inventory Days of Supply, Discrete-Event Simulation, Warehouse Capacity & Fill-Rate, Holding Cost.

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At last, the author realized that this research needs a lot of improvement and far from perfect. Therefore, the author welcomes any suggestion in term to improve this research. May this research contributes to academic world and inspire other people to always believe that everything is possible.

Surabaya, July 2016
Author

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CHAPTER I
INTRODUCTION

This chapter consists of several explanations about the background of conducting the research, and problem formulation that should be answered. In addition, this chapter is also completed by defining objectives, and research scope in purpose to solve the problem in PT X.

1.1 Background

PT X is one of leading cement industry in Indonesia which has a major role in meeting society's need for housing and building infrastructure. Nowadays, the utilization of production has reached 70% which means that domestic demand can still be covered by the local industry. The tendency of demand in this sector

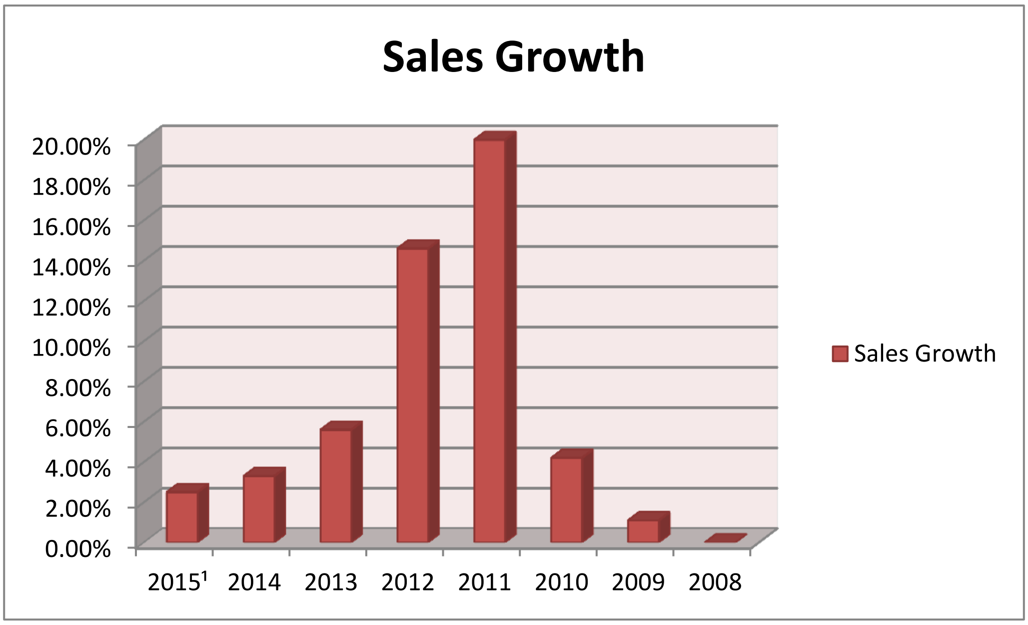

Figure 1. 1 Sales Growth for Cement Industry (Source: Indonesia Cement Association)

has been fluctuated for past several years. The incremental of demand is about 7%/ year which mostly distributed in Java and Sumatra. As the respond to the existing condition, PT X as the member of PT.Semen Indonesia Tbk group, plan to upgrade their old factory and come up with 39.3 million tons/year by the end of 2017.

In purpose to be more competitive in fulfilling demand, there are several factors that need to be considered as the parameter of improvement. It's been mentioned previously that rate of utilization is still in amount of 70% and this rate of utilization can produce about 33-35 million tons/year while the consumption rate is almost 33 million tons/year. While the company starts to build their new plant, another consideration that needs to be improved is the efficiency of delivering the product. PT X needs to have a precise quantity of delivery products by considering the demand for each city, capacity for each warehouse, and critical level for each warehouse. Warehouse is essential supplies of materials moving efficiently through supply chains and providing a crucial service to operations (Waters, 2003). PT X needs to know the critical level for each warehouse because it will determine the quantity of product that should be distributed to each city. In addition, related to the utilization of warehouse in each city, PT X need to give a suggestion to their distributor about the require quantity of the area for each warehouse. This number will prevent the warehouse to have an excess product.

In process of distributing the product, PT X has 2 types of deliveries. Those 2 types are land and sea transportation. The distribution will be accommodated by using truck for land transportation and ship for their sea transportation. PT X will cover several points of demand in Indonesia including Java and Sumatra. As been mentioned in the first paragraph, the growth of demand in Java and Sumatra are significantly increased about 4.9% /year and the company needs to have more concern especially in this district.

Nowadays, PT X has covered all the demand for the entire Java which consists of Banten, DKI Jakarta, West Java, Central Java, D.I.Y, and East Java. As the condition of demand in Java Island that tends to increase constantly, PT X needs to evaluate their performance while fulfilling the demand in this district. PT X has used their sales target for each distributor in each city to determine the quantity of product that should be distributed. In fact, this strategy mostly increases the probability of stock out level in each distributor for each city. The reason why does the probability of stock out level will increase because the number of demand for every day is uncertain and the stock level for each distributor is also differs for one to another. This research will take the scope of

Central Java and D.I.Y which of those two are districts that contribute about 40 % of the total target in Java. In the historical sales of Central Java and D.I.Y showed that the number of sales every month still fluctuated below and above the target. This condition will make the company to have loss in their income because they cannot achieve their target.

PT X has several demand point that should be fulfilled by their distributor. Related with the uncertain demand, PT X will always have stock out condition for each distributor in each city. As been mentioned in the first paragraph, PT X should have a suggestion to their distributor about the optimum size of warehouse that should be provided. In scope of Central Java and D.I.Y, PT X has about 9 partners of distributors which are covering about 43 cities. The capacity of warehouse owned by each distributor in each city is differ from one to another. The conditions of existing warehouse for each city mostly have less space to accommodate the distribution from the company. This condition affects the warehouse to stop the order from PT X and it will make the company loss their opportunity of demand. When PT X loss their demand, the company will not able to achieve their target sales. The reason of this research is conducted to decrease the stock out level in each warehouse by giving information about the optimum size of warehouse.

In conclusion, the strategy of PT X in distributing the product is not effective because the probability of stock out level for each distributor has been increased for past several years. For the purpose to decrease the stock out level for each warehouse, PT X needs to set up their target of days of supply to cover the critical level of fluctuated demand. This research will lead the company to consider the level of criticality by looking at the example of demand distribution in Central Java and D.I.Y. The level of criticality will also lead the company to determine the decision about the quantity that should be delivered to the demand point.

1.2 Problem Formulation

Based on the background, this research is conducted to answer these several question. Those questions are:

1. How to determine the number of delivery quantity by considering the stock criticality (days of supply) at the distributor.
2. How to determine the size of warehouse for each distributor that need to be provided for the purpose of maximizing the utilization and decrease the probability of stock out.

1.3 Research Objectives

The objectives of this research are:

1. Develop a model to determine the number of delivery product by considering the stock criticality (days of supply) for each warehouse in each city and decision to cover the demand base on optimum days of supply.
2. Determining the optimal size of warehouse for each distributor in each city by considering the number of inbound product to the warehouse and probability sales for each day.

1.4 Research Benefits

The benefits of this research are:

1. This research gave a consideration for PT X to determine the number of delivery product.
2. This research helps the distributor to determine the optimum size of warehouse in purpose to increase the utilization.
3. This research suggested the company to have more consideration in critical level for each warehouse.

1.5 Research Scope

This subchapter explains about the research scope and several assumptions that were implemented during the research. The research scope of this research consists of:

1) The distributions of sales are limited for only in Central Java and D.I.Y district.

2) The simulation model is limited from defining the delivery target, the criticality, number of trucks, delay during lead time, and process occurred on each warehouse.

1.5.1 Assumption

The assumptions of this research are

1. Proportion of demand for each warehouses are same for every single entity in each day.
2. The sales distribution during simulation followed the same distribution.
3. Truck is used as transportation mode to distribute the product on each warehouse. The capacity of 32 tons was used and always in good condition.
4. The plant can always fulfill the delivery order.
5. The observation is only for 40 kg sack of cement.
6. After the number of delivery order is determined, the product was directly distributed go to the warehouse.
7. The trucks that have arrived to the warehouse will be unloaded directly. The unloading process takes 30 minutes for every single truck.
8. There is a time windows for each warehouse start from 07.00 AM to 17.00 PM. Trucks that arrived after the time windows will be processed on the next day.

1.6 Report Outline

In this section, it explains about the outline of this research. The report outline consist of several parts such as CHAPTER I, II, III, IV, V, and CHAPTER VI

CHAPTER I INTRODUCTION

In this chapter, it explains about the reason why do this research is conducted which is consist of background, the problem formulation, objective, benefit, research scope and also the report outline. The problem formulation is explained about the actual problem that needs to be solved through this research.

If this research can solve the problem, then the objective and also the benefit for this research can be accomplished.

CHAPTER II LITERATURE REVIEW

In this chapter explains about the literature review and also the theoretical aspect that was used related with the topic of this research. There are several references that can be used for supporting the calculation of the model. Those references are books, journal, previous research, etc. The theoretical aspect that explains in this chapter consists of distribution management, inventory management, warehouse size and also the shipment quantity.

CHAPTER III RESEARCH METHODOLOGY

In this chapter explains about the sequences of this research in purpose to solve the problem. This methodology helps the researcher to solve the problem systematically. This methodology guides the researcher to achieve the goals of research and visualized by using flowchart and followed by the explanation for each step on it. This chapter becomes the guidance for the next chapter while processing the data. Each step of flowchart divided into several parts of model which is done by using simulation software.

CHAPTER IV DATA COLLECTION AND PROCESSING

In this chapter was discussed about the data collection and data processing during the research. All the data inside this chapter consist of collecting and processing process in purpose to achieve the goals of the researcher. While processing the data, this research was supported and visualized by using simulation which consists of existing condition of the process and also the improvement for the process.

CHAPTER V ANALYSIS AND INTERPRETATION

In this chapter explains about the comparison between the existing conditions with the improvement scenario that already simulate in the previous chapter. The analysis consists of number of product that should be delivered, the service level between the existing condition and after the improvement, and comparison between the optimum areas of warehouse with the existing condition for each warehouse. This analysis was supported by the data of simulation.

CHAPTER VI CONCLUSION AND RECOMENDATION

In this chapter explains about the conclusion for all process inside the research base on the objective that already stated in the first chapter. In this chapter is also explained about the recommendation related with the object of improvement.

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CHAPTER II
LITERATURE REVIEW

This chapter describes the theoretical aspect that used to support this research. All the theoretical aspect in this chapter based on the literatures that have been developed in the past several years. The idea of this chapter divided into some section of explanation such as inventory management, distribution management, warehouse size, shipment quantity and simulation.

2.1 Inventory Management

There are many ways to classify inventories. One often-used classification is related to the flow of materials into, process, and out of manufacturing (Arnold et al, 2008). The classification of inventory can be determined as:

1) Raw Material: these are purchased items received that have not entered the production process. they include purchased materials, component parts, and subassemblies
2) Work-in-process (WIP) : Raw material that have entered the manufacturing process and are being worked on or waiting to be worked on
3) Finished goods: The finished products of the production process that are ready to be sold as completed items. They may be held at a factory or central warehouse or various points in the distribution system.
4) Distribution inventories : Finished goods located in the distribution system
5) Maintenance, repair, and operational supplies (MROs): Items used in production that do not become part of the product. These include hand tools, spare parts, lubricants, and cleaning supplies

Based on its function, inventories can also be classified as fluctuation inventory (safety stock), transportation inventory (in-transit), etc. Fluctuation inventory is held to cover random unpredictable fluctuations in supply and demand or lead time. If demand or lead time is greater than forecast, a stock out occurred. Safety stock is carried to protect against this possibility. Its purpose is to prevent disruption in manufacturing or deliveries to customer. Safety stock is also called buffer stock or reserve stock (Arnold et al, 2008). Transportation inventory is used to call as pipeline inventory. Pipeline inventory is defined as the product that still in the process of distribution. This inventory is caused by the location of plant and warehouse or customer differs from one to another.

Managing the inventories surely affect the cost of supply chain system. One of cost consideration related with the inventory is carrying cost which includes all expenses incurred by the firm because of the volume of inventory carried. The carrying cost is usually defined as a percentage of the price value of inventory per unit of time in one year (Arnold et al, 2008).

As the financial point, inventory is a representative of income which needs certain time to be on the market. In this point of view, the goals are to have little inventoried as possible and needs some measure of the level of inventory. One of measurement that should become a consideration is days of supply (DoS). DoS is a measure of the equivalent number of days of inventory on hand, based on usage (Arnold et al, 2008). In context of calculating the DoS, the formulation is:

$$Days\ of\ Supply = \frac{On\ hand\ Invetory}{Average\ daily\ usage\ (sales)} \qquad (2.1)$$

The expected days of supply for each warehouses are going to be a critical level that should be considered by the company while distribute the product. This formulation leads this research to the expected days of supply for each distributor in purpose to cover the uncertain demand. This uncertain demand can be covered by several techniques. A technique to determine when the order needs to be put for replenishment by defining the threshold called reorder point (RoP) (Pujawan & Mahendrawati, 2010). In content of covering the uncertain demand, DoS can also be used as the parameter of distribution. For example, a company set their DoS is 2 days, then each distributor should give a signal to the plant if their stock below the DoS. This signal leads the company to distribute the product precisely before the stock level of each warehouse cannot cover the uncertain demand. This signal minimizes the stock out level because the distributor has enough products to fulfill the demand.

2.2 Distribution Management

In purpose of generate the objective of distribution, there are several function that should be accomplished by the distribution process. According to Pujawan and Mahendrawati (2010), those functions are:

1) Create segmentation and determine the target of service level.
2) Determine the transportation mode used by the company. Each transportation mode has their strength and weakness. The utilization of transportation should be adjusted as efficient as possible to reduce the cost.
3) Create an integrated information system and shipment schedule
4) Create a shipment schedule should done as efficient as possible to minimize the distribution cost and carrying cost.
5) Provide some additional service as their competitive advantage. Some of Distribution Company provides several services such as packaging, labeling, etc.
6) Carrying inventory and responsible with the product return.

In context of distribution, a company may have several plants to cover their demand. Product from the plant was directly distributed to the customer or passing through their warehouse first. According to Daskin, S Mark (1995), the key issues that should be concerned in distribution is (i) how many warehouse to have, (ii) where to locate warehouse, and (iii) how the products should flow through the system. From those points, the company should have a consideration about the distance between their plant to their warehouse or customer. The longer of the distance affected the cost of distribution and may increase the possibility of loss. In case to decrease the cost, the company should have a distribution schedule and demand portion for each city. Whenever production, distribution, and / or warehousing are considered, it is important to explore the inventory implication associated with the plant production schedules and with the shipping plans to and from the warehouses (Daskin, 1995). Shipping plans leads the company to allocate a transportation mode to carry the products and it has mentioned in the previous point that company need to decide the transportation mode base on their needs in order to decrease the cost.

2.3 Visibility in Supply Chain

Fundamental ways to manage a company to remain competitive in the global competition is by trigger the company to increase their flexibility. The notion of supply chain flexibility attempts to characterize the ability of a supply chain to perform satisfactorily in the face of uncertainty (Wang, 2015). Considering about the flexibility, there are two dimensions of flexibility: range and response (Slack, 1987). Range refers to the range of states that can be reached by the warehouse or plant and response refers to the capability of warehouse or plant to fulfill the order from several demand points. In order to manage the information flow from inbound to outbound process, flexibility helps the company to have more comprehensive strategy in fulfilling every demand from the customer. According to previous research, by managing the information visibility between points, the performance creates an increment in several aspects. Those aspects are:

1) Cost: consist of several distribution cost such as inventory cost, stock out cost, shortage cost, backorder cost, and the total cost. Through the good information flow, the consideration of cost becomes more precise and reduces the possibility of loss during the distribution process. This aspect is important to become the first concern because the income of the company is highly related with the expense of every process on the distribution. If the information flow or the visibility is bad, the company and warehouse or customer gains a gap of information which affects the product that should be delivered to them.
2) Quality: consist of supplier quality, internal quality level, and external quality level. Visibility affects the performance of each stakeholder to be more cooperative one to another. By using the good information flow, the company has a consideration about what kind of decision that should be done if the quality of each supplier decrease or even

increase. In line with decrement of quality for each supplier, then the company should have a concern to improve the supplier's quality.

3) Service Level: consist of on time delivery, customer response time, and product availability. The quantity of product that distributed by the plant should cover the order from each distributor. The highest of the service level, the satisfaction level of customer also increase. In fact, the company needs to evaluate their distribution quantity that frequently not equal with the demand point for each district. Through the information visibility, it is possible to tighten up the communication between one to another. With good communication, the requirement for each district can be delivered well to the distribution process.
4) Flexibility: there are five types of supply chain flexibility (product, volume, new product, distribution, and responsiveness), with most of these types of flexibility covering the responsibilities of a particular are or function of the organization (Vickery et al, 1999).
5) Time: Consist of production lead time, time for developing new product, cycle time, and responsiveness. This aspect surely decreases by implementing comprehensive communication between one to another company. Through the integration of time, the company knows the schedule of producing the product; distribute the product, and doing the replenishment. Through the good information flow, the company has a target for each processing time to be more efficient and effective.

2.4 Warehouse Design

Demand fulfillment is highly related with the capability of warehouse to accommodate the supply from the company. There are several important warehouses which include the number and size of warehouses, and their locations (Waters, 2003).

Warehouse has also several elements that need to be considered for purpose to conduct a good layout. These elements are summarized into several points, such as:

1) An arrival bay, or dock, where materials coming from suppliers are delivered, checked and sorted.
2) A storage area, where materials are kept in stock.
3) A departure bay, or dock, where customers orders are assembled and sent out
4) A material handling system, for moving materials around.
5) An information system, which records the location of all materials, arrival from suppliers, departures to customer, and other relevant information.

As been mentioned in the points above, the size of warehouse is mainly determined by allocating the size of storage for the materials or finished goods. There are some informations that need to be provided to determine the size of storage. Those informations are consisting of the size of each zac of cement, the size of average pallets, and the stacking limitation for each pallet. First, PT X has determined the limitation of stacking the cement for their distributor is up to 20 level of stacking. This limitation means that the zac of cement can be stacked up to 20 levels. Second, the size for each pallet is about 110 cm x 110 cm x 12 cm which means this pallet has an area of 12,100 cm^2. There are many size of pallets that can be used in the industry, even though this size is the most frequent pallet that used by the company. Third, the size for each zac of cement is about 10 cm x 40 cm x 60 cm which has an area of 2400 cm^2. Through this information, the company was determining their minimum size of warehouse for each distributor in order to fulfill the demand for each city. The company uses a formula to determine the minimum size of warehouse.

$$Warehouse\ Size = \left(\frac{In\ transit\ inv + on\ hand\ inv}{\left\{ \left(\frac{Pallet\ Size}{Cement\ Size} \right) \times Stacking\ Level \right\}} \right) \times Pallet\ Size \qquad (2.2)$$

2.5 Shipment Quantity

Determining the quantity of shipment is a priority in term of supply chain system. First, the shipment quantity affected several costs that tied up to the shipment. Shipment quantity is also need to consider about the condition of demand point and capability of production. The decision of shipment quantity creates balance between the demand and capability of production. In order to fulfill the demand, the one that need to be adjusted is the capability of production which needs to be upgraded as equal with demand. The reason why did the production need to be adjusted because the service level creates an increment aligns with the improvement of production. The higher of the service level, the satisfaction level also increase and tighten up the trust between the company and customer. Aligns with the increment of service level, there was a trade off in term of cost. According to Pujawan and Mahendrawati (2010), the order quantity highly related with the ordering cost and inventory cost. The higher of the service level, the stock level for each warehouse also need to be added equal with the demand occurred every day. It means that, higher stock level leads the company to gain more cost in term of inventory. Otherwise, if the company plans to reduce the inventory cost which equal with reducing the order quantity, the frequency of order also increase and affect to the ordering cost. Solve this problem, the shipment quantity can be determined by using economic order quantity which already considered the ordering cost and inventory cost.

$$Order\ Quantity = \sqrt{\frac{2\ \times Demand\ \times Ordering\ Cost}{Inventory\ Cost}} \qquad (2.3)$$

In case of this research, the order quantity formula is not used because the order quantity was determined by looking the inventory days of supply for each warehouse. The inventory cost is needed as a measurement of the improvement regarding to the result. If the condition of warehouse is critical (below the require days of supply), then the company tend to fulfill the order by multiplying their target with a variable “k” in purpose to increase the service level. The delivery quantity for each warehouse can be determined by using this formula:

$$Delivery\ Quantity =\ k * Sales\ Target \qquad (2, 4)$$

Through this formula, the company able to define the delivery quantity for each warehouse. By fulfilling the demand equal with the minimum requirement of inventory days of supply leads the company to have better service level. While the average inventory days of supply above 1 day or more, the condition of stock in warehouse is concluded as stable stock and able to fulfill the demand in the certain day.

2.6 Simulation

Simulation is a model determination used for helping people to understand, forecast, and anticipate the future evolution for a variety of applied environmental problems (Olmedo, 2015). Through the simulation, the related company able to visualize the movement of information or even product in purpose to evaluate the improvement of system. Simulation of certain problem can be started by making a model that represents the idea of existing condition. As the representative of the existing condition, model can visualize the movement of goods, and characteristic of a system itself. The consideration of making the model is the limitation of scope that cannot fully supported the entire system. This is the reason that the model leads to several assumptions and approach in order to simplify the system. In purpose to simplify the system, simulation is usually performed by several soft wares such as Arena, Promodel, etc. Doing the simulation is equal with doing an experiment of new or existing system. There are several steps that should be done while conducting the simulation. Those steps are:

1) Formulating a hypothesis
2) Setting up an experiment
3) Testing the hypothesis through experiment
4) Drawing conclusions about the validity of the hypothesis

Conducting the simulation also leads the company to have a decision whether it is appropriate or not. Simulation is appropriate if these criteria are fulfilled. Those criteria such as an operational (logical or quantitative) decision is being made, the process being analyzed is well defined and repetitive, the activities and events are interdependent and variable, the cost impact of the decision is greater the cost of doing the simulation, and also the cost to experiment on the actual system is greater than the cost of simulation. Before determining the system is appropriate or not, the company is also need to categorize the simulation as it function. There are several types of simulation which consist of static or dynamic, stochastic or deterministic, and discrete event or continuous. This research categorized as the discrete event of simulation because the model created an output related with the number of items which means the distribution represents a finite or countable number of possible values. According to Kelton D.W.et all (2006), there were several characteristic that conclude the simulation as the powerful tools for decision making. Those characteristic such as the ability in order to solve the complicated model capture some uncertainty and inter correlation between the entities, etc.

As been mentioned in the previous paragraph, there are several soft wares that can be used to implement the new or existing condition of a system. One of software that frequently used to cover the discrete event is ARENA. This software is computer based system that can provide a simulation of a system and supported with some features such as animation and various report of outputs. Through this software, the company can do an implementation of several improvements for their system. The improvement was accommodated by creating some scenarios in ARENA.

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CHAPTER III
RESEARCH METHODOLOGY

This chapter describes about the methodology of research start from collecting data to analysis and result. This chapter consists with several ideas and explanation about the flowchart of doing the research. The explanation of flowchart consisted of the data collection process, data processing, experiment with the simulation, and also the scenario for the improvement. The flowchart of this methodology is given as follow

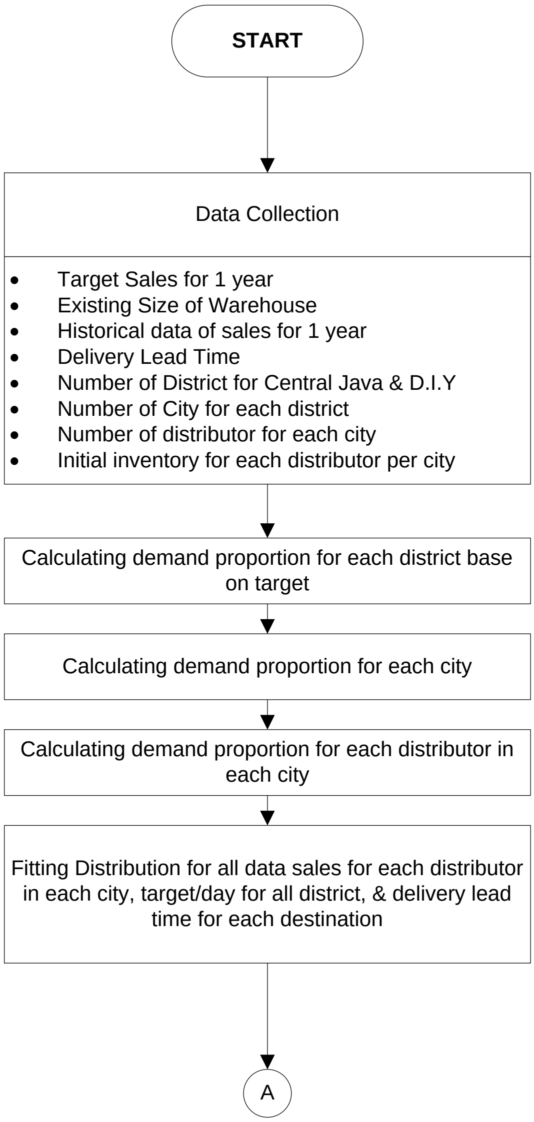


Figure 3. 1 Flowchart of Research Methodology

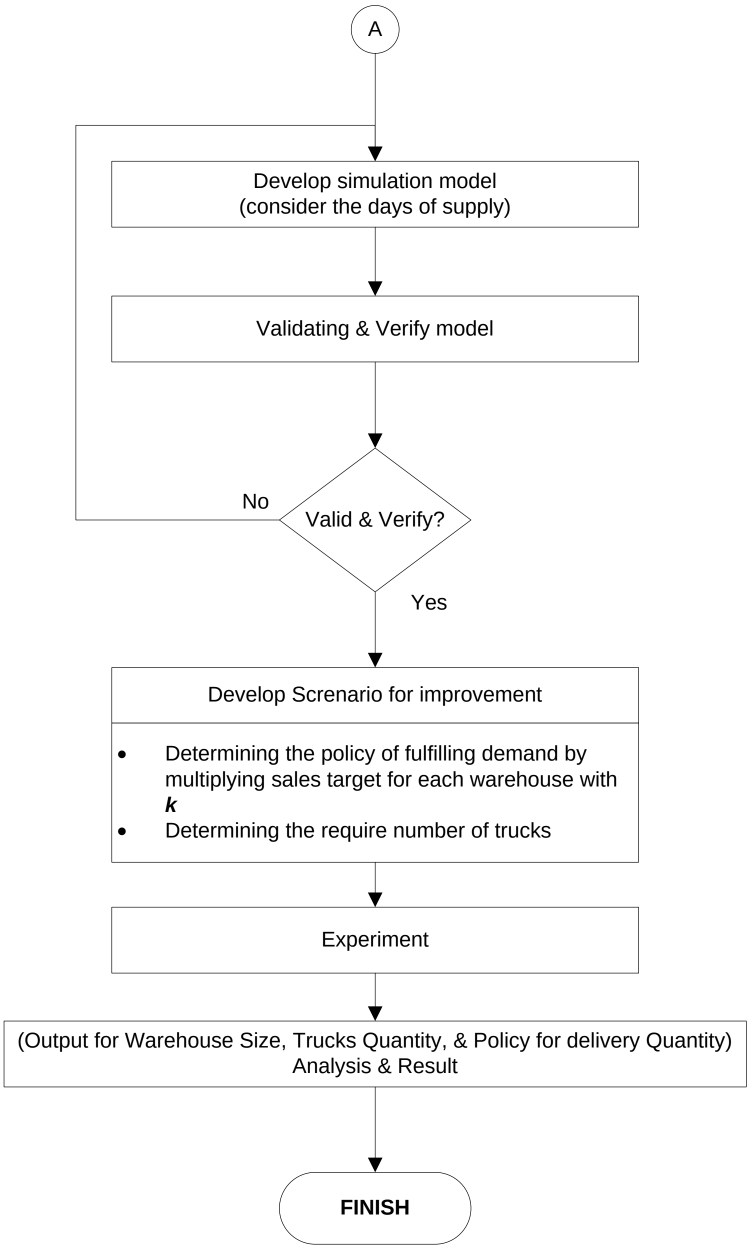


Figure 3. 1 Flowchart of Research Methodology (Con't)

3.1 Data Collection

The first section in term of fulfilling the objective is data collection. While creating the model, there are several data that need to be collected. As been mentioned in the flowchart, those data consist of target sales for 1 year, historical data of sales for 1 year, number of district for Central Java & D.I.Y, number of city for each district, number of distributor for each city, and initial inventory for each distributor per city. Every collected data is used to be processed in the model. As the overview, target sales for 1 year triggered the model to have an aggregate demand distribution during the simulation for each day. Historical data of sales for 1 year is used to update the sales data during the simulation. Number of city for each district and distributor for each city triggered the proportion of demand that need to be allocated for each warehouse. At last, the initial inventory is used to trigger the first creation during the simulation.

3.2 Data Processing & Fitting Distribution

All the data that have collected processed for further utilization. First, the data that need to be processed is determining the demand proportion for each district. In this case, Jateng & D.I.Y have a total of 6 districts which each of those also have a different portion of demand. The determination of demand is triggered by the target sales for 1 year for each district. Through this data, the assumption is the portion for each district during a year was the same for every month. Therefore, the process of determining the portion was supported by using the historical target sales in certain month which in this case using the historical target in February. This sequence of steps was implemented to determine the proportion for demand in each city. The number of city for each districts were different from one to another and it also be assumed that the proportion for the demand during a year was the same for every month. The next calculation is to determine the proportion of demand for each city. Each city has about 2 to 3 distributor which each of them has their own warehouse. This condition leads the company to have a consideration about the proportion of demand for each warehouse. The proportion of warehouse is determined by looking at the target sales for each city in different warehouse. It is the same with the previous sequence which is the number of proportion for every day is assumed stable during a year.

The next step of calculation is determining the distribution for each data that used for the model. The distribution of data can be defined by using a software and use the tools of fitting distribution. The data that need to be fitted are the historical data of sales for a year, the data of target sales in scope of Jateng & D.I.Y. The distribution of sales used as the updater of the existing condition of sales. Because the demand for each distributor in each city are different from one to another, then the fitting distribution need to be implemented to all the warehouse. The total warehouses for each city that needs to be fitted are 83 warehouses. Afterwards, the target sales from the company are also need to be fitted. This distribution helps the model to have a trigger in simulating the demand. In conclusion, all these fitting distribution helps the model to face several situations in term of evaluating the existing condition and also plan to have an improvement.

3.3 Simulation Model

The next sequence of this research is by conducting a simulation model based on the existing condition and data that have processed previously. The simulation model was developed by using software of ARENA. This software gives a visualization of existing condition and also the impact after implementing the improvement. The simulation model was started by dividing the entity into several districts and multiplies it with the proportion. All the entities were followed by the distribution of aggregate target sales from the fitting distribution result. The entity was continuously divided until the value of demand in warehouse for each city. After obtaining the amount of target for each warehouse in each city, the model was considered the critical level on the existing stock for each warehouse. The amount of target becomes a consideration of determining the quantity of product that should be distributed. Through this section, the model gives information about the amount of quantity and also the size of warehouse required. In addition, the simulation model covers the number of sales that possibly out for each day. So, there is also a model of updating the sales for each day. This model is supported by the data that have fitted previously. At last, the model measure the service level before and after improvement, and give a suggestion of warehouse size in term of maintaining the service level.

3.4 Validation & Verification

After conducting the model, the next step that needs to be done is validation and verification. The validation process is obtained to compare the simulation model with the real existing data. In this case, the company has a specific demand for each warehouse in each city and also actual historical sales for 1 year. This data becomes an indicator of comparison to the output of simulation model. If the output of simulation equal with the value of demand for each warehouse and historical sales for 1 year than it may conclude as valid, otherwise the model need to be revised until the value between model and demand is equal. Furthermore, the model can be concluded as verify if the model have followed the logic and correspond to the expectation.

3.5 Scenario Model

After conducting the validation and verification process, the next sequence is implementing the improvement in term of increasing the service level. The scenario is consisting of a possibility of days of supply which affect the service level and also the capability of each warehouse in term of receiving the products from the company.

3.6 Analysis & Result

The output of the model determines what size of warehouse that needs to be provided by the distributor. The distributor needs to evaluate the existing size of their warehouse whether it is needed to be improved or not. In the company point of view, this model give a suggestion to about the delivery quantity that should be distributed by considering the critical level of inventory days of supply and utilization of warehouse in each city. The delivery quantity also considers the carrying cost.

3.7 Conceptual Model

In order to explain the scope of distribution, this conceptual model explains the activities occurred from the beginning to the end. The process started from determining the target and finished by unloading process on each warehouses. The process was shown on figure 3.2.

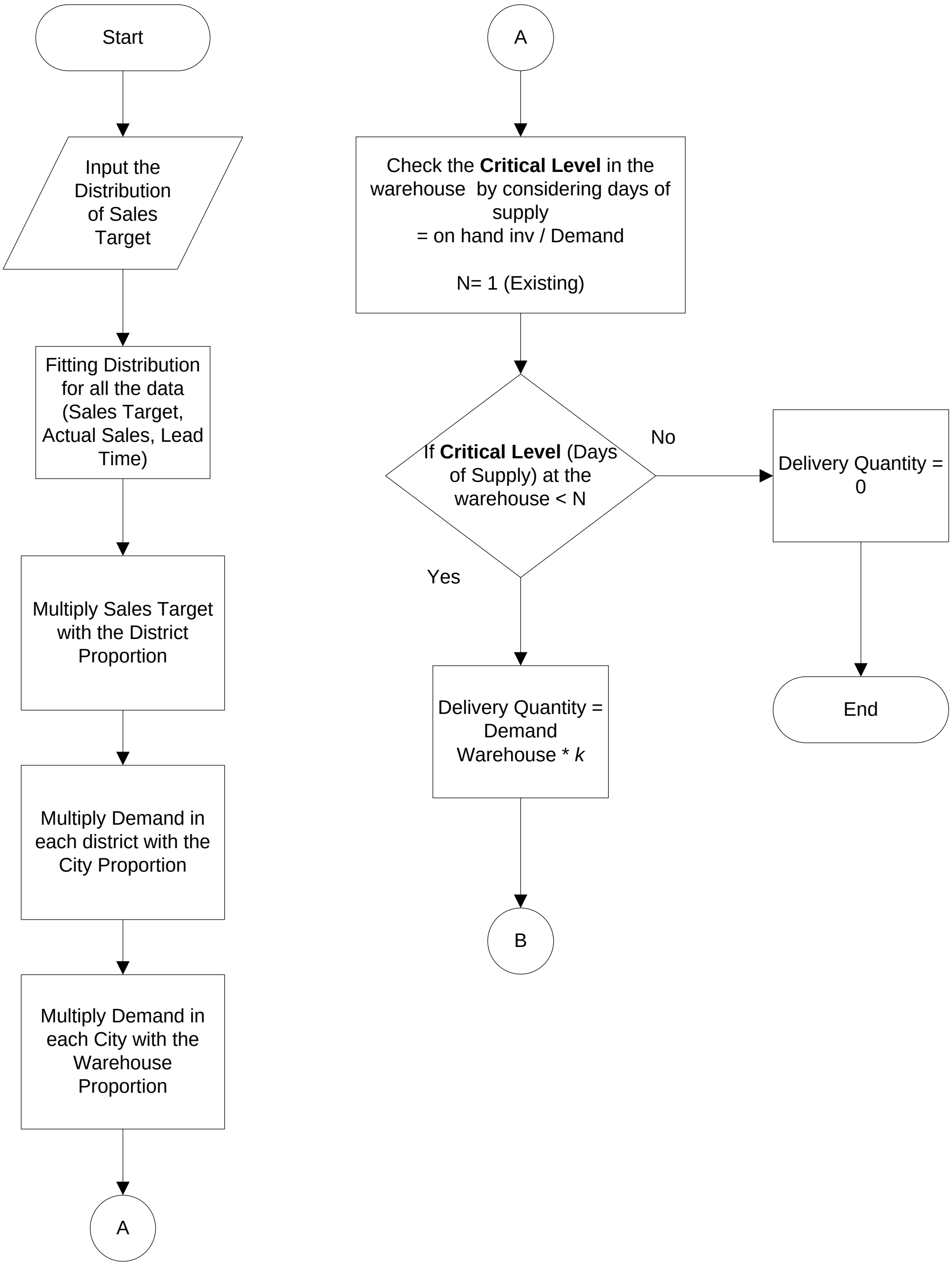


Figure 3. 2 Conceptual Model

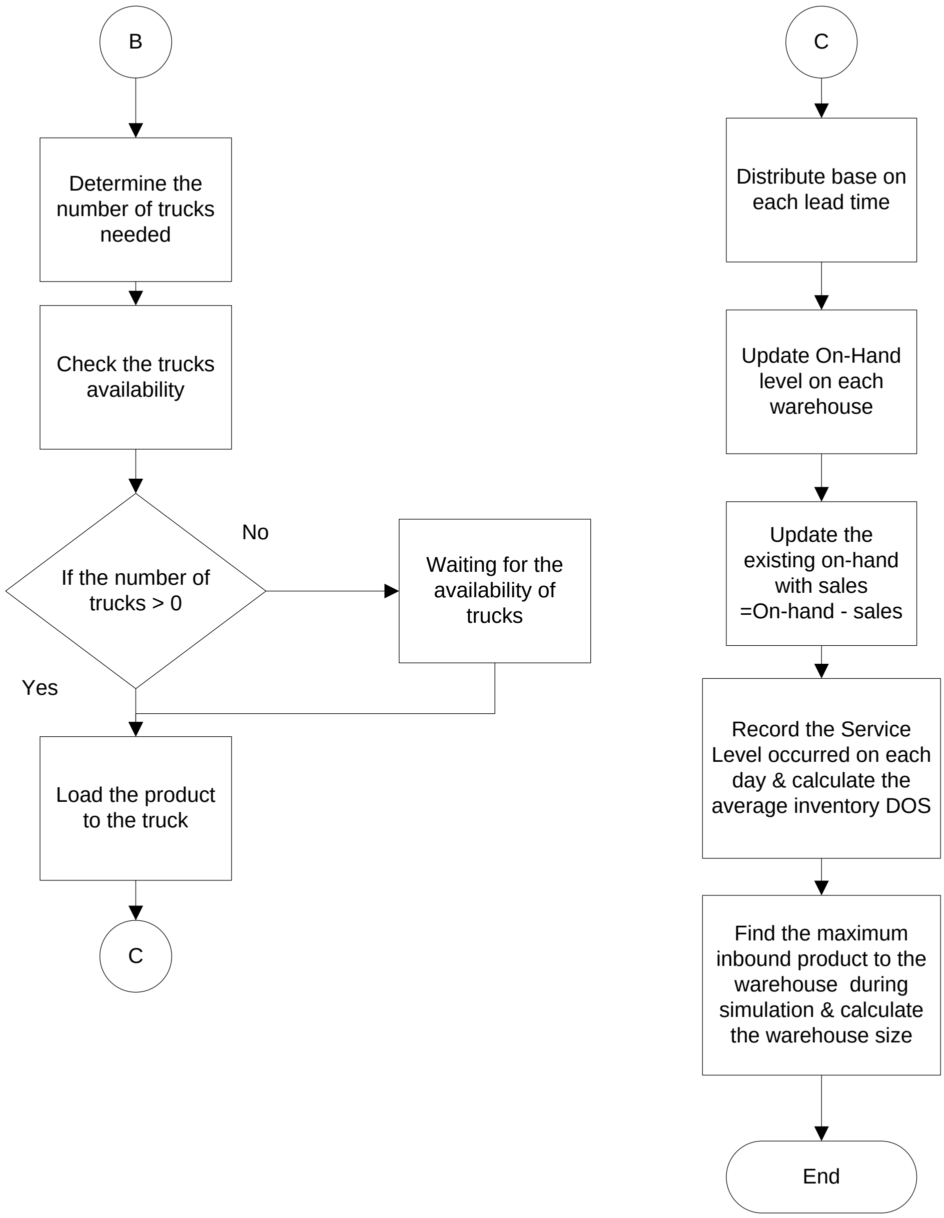


Figure 3.2. Conceptual Model (con't)

The conceptual model shown on figure 3.2 explains all the process from the beginning to the end. First, the model was triggered by implementing sales target as the input. Sales target was defined by the company which consider the target income that want to be achieved. Afterwards, the sales target was multiplied by each proportion for districts, cities, and warehouses. The critical level was checked after all the sales target have multiplied by each proportion. If the criticality below the desire requirement, then the delivery quantity was defined equal with the sales target multiplied with "k" variable. The process was continued to determining the number of truck needs and also the truck availability. The product should not be delivered if the trucks were not available. The distribution process occurred as long as lead time for each city. At the end of process, the on-hand inventory was updated and warehouse size was determined.

CHAPTER IV
DATA COLLECTION & PROCESSING

This chapter explains about the process from data gathering to the output of simulation model. Before developing the model of simulation, there are several data that need to be collected as the input of the model. The building process of the model accommodates the existing condition of distribution process in PT X, conducting the scenario to improve the performance and also the best output regarding to the objectives of this research.

4.1. Data Collection

Regarding to the objectives of this research, there are several data that need to be collected to support the process of model building. In term to find the solution of determining a policy of delivery quantity that need to be distributed needs several data such as sales target for each warehouse, a historical data of sales during a year, and recording data about the lead time of distribution to each warehouse. In addition, to evaluate the utilization or the require size that should be allocated to each warehouse also need the existing size of warehouses.

4.1.1. Sales Target

PT X has used their sales target as the parameter or indicator to determine the delivery quantity for each warehouse. The sales target was periodically changed for every month following the demand pattern in a certain season. The target should be divided into several districts, cities, and warehouses. Regarding the data acquired from the company, the distribution section should be processed into 6 districts. Each district has their own number of cities and also warehouses. The total number of cities that become the research object is 46 which each of them has a different number of warehouses. This following table is showing the name of districts, cities, and warehouses.

Table 4. 1 Name of Districts, Cities, & Warehouses

District	City	Warehouse		
Kudus	Lasem	KWSG	Sekawan Niaga Jaya	-
	Rembang	KWSG	Sekawan Niaga Jaya	-
	Kudus	KWSG	-	-
	Jepara	KWSG	Varia Usaha	-
	Blora	Varia Usaha	Sekawan Niaga Jaya	-
	Cepu	Varia Usaha	Sekawan Niaga Jaya	-
	Pati	Varia Usaha	Sekawan Niaga Jaya	-
	Purwodadi	Varia Usaha	Hasil Anugrah	-
	Juwana	Sekawan Niaga Jaya	-	-
Semarang	Salatiga	Bangunan Jaya	-	-
	Semarang	KWSG	Varia Usaha	Sekawan Niaga Jaya
	Ambarawa	KWSG	Varia Usaha	-
	Demak	Varia Usaha	Sekawan Niaga Jaya	-
	Ungaran	Varia Usaha	Sekawan Niaga Jaya	-
	Weleri	Varia Usaha	Sekawan Niaga Jaya	-
	Kendal	Sekawan Niaga Jaya	-	-
Solo	Sragen	KWSG	Kebakramat Elang	-
	Surakarta	Kebakramat Elang	Setia Tunggal	-
	Gemolong	Kebakramat Elang	-	-
	Karanganya r	KWSG	Varia Usaha	Kebakramat Elang
	Sukoharjo	Varia Usaha	Kebakramat Elang	Setia Tunggal
	Boyolali	KWSG	Varia Usaha	Kebakramat Elang
	Wonogiri	Kebakramat Elang	-	-

Table 4. 1 Name of Districts, Cities, & Warehouses

District	City	Warehouse		
	Purwantoro	Kebakramat Elang	-	-
	Klaten	Varia Usaha	Setia Tunggal	-
DIY	Purworejo	KWSG	Setia Cahaya Sarana	-
	Magelang	KWSG	Setia Cahaya Sarana	-
	Temanggung	KWSG	Setia Cahaya Sarana	-
	Sleman	KWSG	Setia Cahaya Sarana	-
	Bantul	KWSG	Varia Usaha	Setia Cahaya Sarana
	Kuloprogo	KWSG	Varia Usaha	-
	Wonosari	KWSG	-	-
	Gunung Kidul	Setia Cahaya Sarana	-	-
Tegal	Pekalongan	KWSG	Sekawan Niaga Jaya	-
	Pemalang	KWSG	-	-
	Tegal	KWSG	Sekawan Niaga Jaya	-
	Brebes	KWSG	-	-
	Batang	Sekawan Niaga Jaya	-	-
Purwokerto	Kebumen	KWSG	Sahabat	-
	Banjarnagara	KWSG	Sahabat	-
	Purbalingga	KWSG	Sahabat	-
	Purwokerto	KWSG	Sahabat	-
	Banyumas	KWSG	-	-
	Majenang	KWSG	Sahabat	-
	Wonosobo	KWSG	Sahabat	-
	Cilacap	KWSG	-	-

The number of warehouses for every city is different from one to another. In total, there are 83 warehouses which each of it has different capacity and demand. Related to the sales target for each warehouse, the company has determined the proportion. This proportion should be multiplied by the aggregate target for every single day; therefore the company knows the target for each warehouse. This following table is showing the aggregate sales target for each month.

Table 4. 2 Aggregate Sales Target / month

Month	Aggregate Sales Target (Tons)
January	203,996
February	190,976
March	197,747
April	193,280
May	202,680
June	197,486
July	196,277
August	197,486
September	197,486
October	203,996
November	197,486
Desember	203,996

The proportion for each warehouse should be multiplied with the target above and gained a distribution for aggregate target on each day. After generate an aggregate data of sales target on each day, the data was fitted by using ARENA Input Analyzer. This process shows the type of distribution of sales target. The sales target have distribution of TRIA(3.52e+003, 7.42e+003, 7.53e+003) and sequence error below 10%.

4.1.2. Warehouse Size of Distributor

Regarding to the objective of this research which determining the optimal size of warehouse for each distributor, the existing size of warehouse is needed as the comparison to the outputs of simulation. The data gained from the company is limited to several warehouses only because they do not have the data for all warehouses. That is the reason why this research is conducted which to give a suggestion about a minimum size that should be allocated to the certain city.

Table 4. 3 Warehouse Capacity

District	City	Warehouse	Capacity (sacks)
Kudus	Lasem	KWSG	-
		Sekawan Niaga Jaya	-
	Rembang	KWSG	27,959
		Sekawan Niaga Jaya	-
	Kudus	KWSG	22,929
	Jepara	KWSG	41,538
		Varia Usaha	18,225
	Blora	Varia Usaha	32,663
		Sekawan Niaga Jaya	38,314
	Cepu	Varia Usaha	12,676
		Sekawan Niaga Jaya	12,426
	Pati	Varia Usaha	28,757
		Sekawan Niaga Jaya	48,521
	Purwodadi	Varia Usaha	50,888
		Hasil Anugrah	38,817
	Juwana	Sekawan Niaga Jaya	-
Semarang	Salatiga	Bangunan Jaya	45,266
	Semarang	KWSG	40,030
		Varia Usaha	35,947
		Sekawan Niaga Jaya	76,331
	Ambarawa	KWSG	15,385
		Varia Usaha	-
	Demak	Varia Usaha	-
		Sekawan Niaga Jaya	27,515
	Ungaran	Varia Usaha	32,101
		Sekawan Niaga Jaya	-
	Weleri	Varia Usaha	23,964
		Sekawan Niaga Jaya	48,521
	Kendal	Sekawan Niaga Jaya	-
Solo	Sragen	KWSG	36,876
		Kebakramat Elang	36,391
	Surakarta	Kebakramat Elang	-
		Setia Tunggal	16,775
	Gemolong	Kebakramat Elang	-
	Karanganyar	KWSG	42,456
		VARIA USAHA	91,716
		Kebakramat Elang	52,811

Table 4. 3 Warehouse Capacity

District	City	Warehouse	Capacity (sacks)
	Sukoharjo	Varia Usaha	32,663
		Kebakramat Elang	-
		Setia Tunggal	-
	Boyolali	KWSG	38,817
		Varia Usaha	36,391
		Kebakramat Elang	18,639
	Wonogiri	Kebakramat Elang	22,929
	Purwantoro	Kebakramat Elang	-
	Klaten	Varia Usaha	22,929
		Setia Tunggal	32,101
DIY	Purworejo	KWSG	32,101
		Setia Cahaya Sarana	26,006
	Magelang	KWSG	13,314
		Setia Cahaya Sarana	22,929
	Temanggung	KWSG	17,012
		Setia Cahaya Sarana	-
	Sleman	KWSG	15,533
		Setia Cahaya Sarana	36,391
	Bantul	KWSG	49,704
		Varia Usaha	24,852
		Setia Cahaya Sarana	-
	Kulonprogo	KWSG	15,976
		Varia Usaha	6,509
	Wonosari	KWSG	23,964
	Gunungkidul	Setia Cahaya Sarana	29,349
Tegal	Pekalongan	KWSG	17,707
		Sekawan Niaga Jaya	-
	Pemalang	KWSG	8,136
	Tegal	KWSG	52,811
		Sekawan Niaga Jaya	12,071
	Brebes	KWSG	8,876
	Batang	Sekawan Niaga Jaya	5,207
Purwokerto	Kebumen	KWSG	20,237
		Sahabat	-
	Banjarnegara	KWSG	16,216
		Sahabat	-
	Purbalingga	KWSG	-
		Sahabat	-
	Purwokerto	KWSG	77,633
		Sahabat	90,533

Table 4. 3 Warehouse Capacity

District	City	Warehouse	Capacity (sacks)
	Banyumas	KWSG	-
	Majenang	KWSG	18,491
		Sahabat	35,048
	Wonosobo	KWSG	-
		Sahabat	-
	Cilacap	KWSG	25,222

In total of 83 different warehouses, there are 20 which have no capacity and need a suggestion about the minimum require size. The other 60 is used to measure the utilization after knowing the output of simulation. The flow of inbound product to the warehouses becomes a comparison to the existing condition.

4.1.3. Historical Sales Data

The model of this research embraces the whole process of distribution start from the product allocation before departure until the selling activity at the warehouses on each day. The distribution of sales at the warehouses required updating the on-hand inventory and affected a decision of delivery quantity on the next day. The data gained from the company showed about the aggregate sales in 2015. This condition necessitates the model to divide the aggregate sales into the specific sales for each warehouse. Similar with the sales target, the aggregate sales should be divided to the specific sales for each warehouse.

Table 4. 4 Historical Sales 2015

Month	Aggregate Sales (Tons)
January	166,176.43
February	146,909.67
March	165,106.43
April	146,485.90
May	170,125.43
June	169,324.16
July	168,985.16
August	193,790.52
September	166,176.43
October	169,402.16
November	198,076.32
Desember	169,444.16

Similar with the sales target, the data generate from dividing the proportion to the aggregate sales for every month was fitted by using ARENA Input Analyzer and result various type of distribution with the square error below 10% and it is shown by the Table 4.5.

Table 4. 5 Distribution of Sales

District	City	Warehouse	Distribution (tons)
Kudus	Lasem	KWSG	3.02 + 10.9 * BETA(2.44, 1.93)
		Sekawan Niaga Jaya	NORM(3.66, 0.937)
	Rembang	KWSG	NORM(91.1, 23.3)
		Sekawan Niaga Jaya	1.49 + 5.38 * BETA(2.45, 1.94)
	Kudus	KWSG	40 + 94 * BETA(1.58, 1.21)
	Jepara	KWSG	14 + 35 * BETA(1.67, 1.23)
		Varia Usaha	NORM(36.1, 9.25)
	Blora	Varia Usaha	49 + 116 * BETA(1.59, 1.21)
		Sekawan Niaga Jaya	NORM(104, 26.5)
	Cepu	Varia Usaha	NORM(46, 11.8)
		Sekawan Niaga Jaya	NORM(34.4, 8.82)
	Pati	Varia Usaha	NORM(69, 17.7)
		Sekawan Niaga Jaya	7 + 19 * BETA(1.88, 1.48)
	Purwodadi	Varia Usaha	26 + 64 * BETA(1.67, 1.26)
		Hasil Anugrah	NORM(153, 39.2)
	Juwana	Sekawan Niaga Jaya	1 + 2.81 * BETA(2.03, 1.79)
Semarang	Salatiga	Bangunan Jaya	NORM(291, 59.9)
	Semarang	KWSG	NORM(242, 49.9)
		Varia Usaha	NORM(156, 32.2)
		Sekawan Niaga Jaya	NORM(160, 32.9)
	Ambarawa	KWSG	NORM(104, 21.4)
		Varia Usaha	NORM(7.43, 1.53)
	Demak	Varia Usaha	NORM(3.72, 0.766)
		Sekawan Niaga Jaya	NORM(43.2, 8.9)
	Ungaran	Varia Usaha	NORM(186, 38.3)
		Sekawan Niaga Jaya	2 + 3.97 * BETA(2.23, 1.58)
	Weleri	Varia Usaha	NORM(18.6, 3.83)
		Sekawan Niaga Jaya	NORM(60.5, 12.5)
	Kendal	Sekawan Niaga Jaya	29 + 50 * BETA(1.73, 1.02)
Solo	Sragen	KWSG	33 + 78 * BETA(1.33, 0.752)
		Kebakramat Elang	48 + 110 * BETA(1.3, 0.774)
	Surakarta	Kebakramat Elang	10 + 24 * BETA(1.41, 0.813)
		Setia Tunggal	NORM(36.1, 8.86)
	Gemolong	Kebakramat Elang	1.39 + 4.61 * BETA(1.95, 1.02)
	Karanganyar	KWSG	36 + 82 * BETA(1.25, 0.743)

Table 4. 5 Distribution of Sales

District	City	Warehouse	Distribution (tons)
		VARIA USAHA	NORM(130, 31.9)
		Kebakramat Elang	NORM(167, 41.1)
	Sukoharjo	Varia Usaha	17 + 41 * BETA(1.57, 0.998)
		Kebakramat Elang	15 + 36 * BETA(1.41, 0.811)
		Setia Tunggal	NORM(3.28, 0.805)
	Boyolali	KWSG	36 + 82 * BETA(1.25, 0.743)
		Varia Usaha	NORM(70.3, 17.3)
		Kebakramat Elang	NORM(113, 27.7)
	Wonogiri	Kebakramat Elang	59 + 136 * BETA(1.26, 0.727)
	Purwantoro	Kebakramat Elang	7 + 19 * BETA(1.83, 1.12)
	Klaten	Varia Usaha	NORM(109, 26.8)
		Setia Tunggal	119 + 272 * BETA(1.53, 0.921)
DIY	Purworejo	KWSG	NORM(80.3, 19.3)
		Setia Cahaya Sarana	NORM(61.9, 14.9)
	Magelang	KWSG	NORM(60.2, 14.5)
		Setia Cahaya Sarana	14 + 32 * BETA(1.78, 1.29)
	Temanggung	KWSG	NORM(45.2, 10.8)
		Setia Cahaya Sarana	4 + 10 * BETA(1.98, 1.45)
	Sleman	KWSG	NORM(45.2, 10.8)
		Setia Cahaya Sarana	NORM(55.4, 13.3)
	Bantul	KWSG	NORM(135, 32.5)
		Varia Usaha	NORM(149, 35.7)
		Setia Cahaya Sarana	NORM(107, 25.8)
	Kulonprogo	KWSG	14 + 32 * BETA(1.78, 1.28)
		Varia Usaha	16 + 36 * BETA(1.73, 1.22)
	Wonosari	KWSG	NORM(103, 24.7)
	Gunungkidul	Setia Cahaya Sarana	NORM(68.4, 16.4)
Tegal	Pekalongan	KWSG	TRIA(38, 85.5, 183)
		Sekawan Niaga Jaya	0.49 + GAMM(0.315, 5.03)
	Pemalang	KWSG	TRIA(33, 72.4, 156)
	Tegal	KWSG	TRIA(25, 54.3, 119)
		Sekawan Niaga Jaya	TRIA(18, 39.7, 86)
	Brebes	KWSG	TRIA(17, 37.2, 81)
	Batang	Sekawan Niaga Jaya	TRIA(27, 59.6, 129)
Purwokerto	Kebumen	KWSG	NORM(41.1, 10.4)
		Sahabat	NORM(1.68, 0.424)
	Banjarnegara	KWSG	NORM(38.5, 9.72)
		Sahabat	NORM(1.57, 0.397)
	Purbalingga	KWSG	NORM(2.93, 0.741)
		Sahabat	NORM(1.68, 0.424)

Table 4. 5 Distribution of Sales

District	City	Warehouse	Distribution (tons)
	Purwokerto	KWSG	NORM(52.1, 13.2)
		Sahabat	NORM(128, 32.3)
	Banyumas	KWSG	NORM(2.93, 0.741)
	Majenang	KWSG	NORM(27.4, 6.93)
		Sahabat	NORM(33.6, 8.49)
	Wonosobo	KWSG	NORM(49.3, 12.5)
		Sahabat	NORM(1.68, 0.424)
	Cilacap	KWSG	NORM(65.8, 16.6)

4.1.4. Delivery Lead Time

The reason of this research was using ARENA as the tools of simulation because the uncertainty aspects of delivery lead time. This uncertainty make the simulation was included as discrete-event simulation which means that the whole process of simulation always associated with the certain condition of time. The number of warehouses which were located specifically on the certain city result a various distribution of delivery lead time. The data of delivery lead time was conducted by using several assumptions. The assumption was used because the company didn't have log of delivery lead time for each city. The calculation was only conducted for each city because the warehouse which located on the same city assumed had the same duration of delivery lead time. The calculation was done by dividing the distance to each city with several speeds of 30 km/h, 40 km/h, 50 km/h, & 60 km/h. The reason why this speed was selected because in condition of full-load, the truck had an average speed starts from 30-60 km/h. Afterwards, a random number was generated between the ranges of these speeds. The number generated from the calculation was fitted to the ARENA Input Analyzer and result various type of distributions.

Table 4. 6 Delivery Lead Time Distribution

District	City	Distribution (hours)
Kudus	Lasem	1.02 + EXPO(1.06)
	Rembang	1.18 + EXPO(1.01)
	Kudus	2.08 + EXPO(1.56)
	Jepara	3 + EXPO(2.14)
	Blora	1.3 + EXPO(0.902)
	Cepu	1 + EXPO(1.02)

Table 4. 6 Delivery Lead Time Distribution

District	City	Distribution (hours)
	Pati	1.78 + EXPO(1.18)
	Purwodadi	2.14 + EXPO(1.58)
	Juwana	1.54 + EXPO(1.27)
Semarang	Salatiga	4 + EXPO(2.46)
	Semarang	3 + EXPO(2.25)
	Ambarawa	3.53 + EXPO(2.48)
	Demak	2.55 + EXPO(1.85)
	Ungaran	3.13 + EXPO(2.63)
	Weleri	4 + EXPO(2.76)
	Kendal	4 + EXPO(2.55)
Solo	Sragen	2.23 + EXPO(2.02)
	Surakarta	3 + EXPO(1.96)
	Gemolong	3 + EXPO(2.06)
	Karanganyar	3 + EXPO(2.05)
	Sukoharjo	3 + EXPO(2.09)
	Boyolali	3.11 + EXPO(2.73)
	Wonogiri	3 + EXPO(2.15)
	Purwantoro	2.5 + EXPO(1.84)
	Klaten	3.3 + EXPO(2.59)
DIY	Purworejo	5 + EXPO(3.13)
	Magelang	4.14 + EXPO(3.05)
	Temanggung	4 + EXPO(3.41)
	Sleman	4 + EXPO(2.56)
	Bantul	5 + EXPO(4.04)
	Kulonprogo	5 + EXPO(3.15)
	Wonosari	4 + EXPO(2.45)
	Gunungkidul	4 + EXPO(2.62)
Tegal	Pekalongan	5 + EXPO(3.09)
	Pemalang	5.04 + EXPO(3.65)
	Tegal	6 + EXPO(3.44)
	Brebes	6.01 + EXPO(4.5)
	Batang	4 + EXPO(3.33)
Purwokerto	Kebumen	6 + EXPO(3.67)
	Banjarnegara	5.33 + EXPO(3.69)
	Purbalingga	6 + EXPO(4.03)
	Purwokerto	6 + EXPO(4.21)
	Banyumas	6.16 + EXPO(4.18)
	Majenang	7.16 + EXPO(5.27)
	Wonosobo	5 + EXPO(3.13)
	Cilacap	7 + EXPO(4.16)

The distribution above was assigned to all the trucks need while distributing the product to the warehouses. The model creates a different delivery lead time for every truck, even though it has the same destination. This process was conducted to represent the existing condition that might happen while assigning the trucks.

4.2. Data Processing

Start with the input gained from the company, the model would be processed to obtain an output as the expectation. The output of the model should be the policy of delivery quantity, and warehouse size for each distributor. In order to gain the desire output, there were several data that should be processed. Those data were condition of on-hand inventory for each day, an average inventory day of supply, fill rate to measure the service level to the sales, and the utilization of warehouse capacity that might happen during the simulation. In term to find all these output, the model would be triggered by the certain condition and limited with several constraint. This subchapter was going to explain the process to obtain an output as the expectation.

4.2.1. On-hand Inventory

On-hand inventory was used as the consideration to the model to decide neither distribute the product nor not. The level of on-hand inventory on each day was different because of the uncertainty of sales that might happen on each day. The level of on-hand inventory should be minimized for the purpose of decreasing the holding cost. The higher level of on-hand inventory affected higher cost to the warehouses. The model of this research calculates the total cost (holding cost) occur every day and find the best solution that might decrease the cost and keep the performance as the expectation of the company.

In purpose to decrease the total cost (holding cost), the percentage of holding cost that was used by the model was 25% / year for average on-hand inventory that might happen. The holding cost related with storage space (supplying a warehouse, rent, rates, heat, light, etc.), loss (due to damage, obsolescence & pilferage), handling (including all movement, special packaging, etc), administration (stock checks, computer updates) and insurance (Waters, 2007). In purpose to calculate the average inventory happened every day, the model read-write the on-hand condition into the excel spreadsheet. In the end of each day, the on-hand condition would be recorded to excel file and manually processed to find the average inventory. During the simulation for existing, the inventory level has a possibility of zero inventories because of uncertain demand.

4.2.2. Average Inventory Days of Supply

The simulation come up with several possibilities of condition happened on each warehouses. As been mentioned in the sub chapter 4.2.1, the model has a data record of on-hand condition for every single day. During the simulation which was determined to run for 365 days, the average on-hand inventory for each day should covering a certain days of average sales on each warehouse. In purpose to cover several days of average sales, the equation that was used same with the equation (2.1). This equation is used to calculate the equality of sales regarding to on-hand inventory. Regarding to the equation, days of supply was determined by dividing on-hand inventory by average sales of each warehouse. The average sale for each warehouse was determined by looking at the distribution pattern in the sub chapter 4.1.3. Afterwards, the on-hand inventory consists of the inventory which had been unloaded and still on the truck.

Days of supply was used as the constraint of scenarios in the simulation model. The OptQuest inside the simulation has done a process to find the best combination of variable multiplier related with a decision of delivery quantity. This tool is also possible to generate a constraint base on the output. For example related with this research, the output of combination should create the days of supply above 1 day, and then the constraint of days of supply should be modeled above 1 day.

4.2.3. Service Level

The scenarios that were calculated in the simulation creates a combination with a consideration of service level. Service level means the number of product which successfully fulfills the total demand. In this case, the ability of warehouse to fulfill the demand highly related with the condition of on-hand inventory on each day. The higher of the stock level of inventory affects the higher service level but it gains higher cost due to the holding process. That was the reason why the scenarios were conducted. The OptQuest considered all the constraint due to a result of output as expectation. In the sub chapter 4.2.1 the objective is to find the minimum cost due to the stock-level, afterwards this subchapter and subchapter 4.2.2 enforce the output to have a certain average days of supply and certain service level.

In addition, service level can also be known as fill rate. The value of fill rate can be determined by using this following equation:

$$Fill\ Rate = \frac{Fulfilled\ Demand}{Total\ Demand} \text{ x } 100\% \tag{4.1}$$

The output of fill rate / service level was recorded to the excel spreadsheet as befits for on-hand inventory. The simulation interprets the equation (4.1) and calculates the fill rate for each warehouse on each day.

4.2.4. Utilization of Warehouses

Different with service level and average inventory days of supply, the warehouse utilization could be known after the simulation was done. The warehouse utilization was an impact of delivery quantity decision for each day. The quantity of inbound product was compared to the existing capacity on each warehouse in order to know the utilization.

$$Utilization = \frac{On{=}hand\ Inventory}{Total\ Capacity} \text{ x } 100\% \tag{4.2}$$

Related with the objective of this research which to evaluate and give a suggestion of warehouse size base on the inbound flow. The value of size / capacity that was used was the highest number of inbound product happened during the simulation. In the other hand, to evaluate the utilization of warehouse which has existing capacity, the initial utilization was assumed equal with 2 days of sales. The simulation generates various result of on-hand inventory in the form of sacks. By using this result, then the suggested value of size was generated by using the equation (2.2).

4.3. Existing Model Building

In purpose to generate an output as the expectation, the existing model was built and followed the logic that was implemented by the company. In general, the logic was started with the sales target for each warehouse. Regarding to the historical data of sales target, each warehouse followed a specific proportion to define the number of product that should be delivered. Afterwards, the level of inventory on each warehouse was checked in order to create a decision whether distribute the product or not. In the existing condition, the company doesn't have certain consideration about the number of product that should be distributed. Therefore, the model creates a limitation related with the critical level for each warehouse. If the level of inventory below the desire level, the company distributed the product equal with target multiplied by "k" variable. Thereafter, the company assigned the destination base on the priority. The delivery priority was defined with the highest target among the warehouse and distributed base on each lead time. In the end, the model updates the on-hand inventory level and calculates the service level & total cost occurred every day.

4.3.1. Determining Target for Warehouses

The model was started by determining the target for each warehouse by considering the distribution of aggregate sales target on each day. The aggregate target occurred every day was multiplied by certain proportion that was determined previously. The model building for this part was supported by several modules which are shown by the figure 4.1.

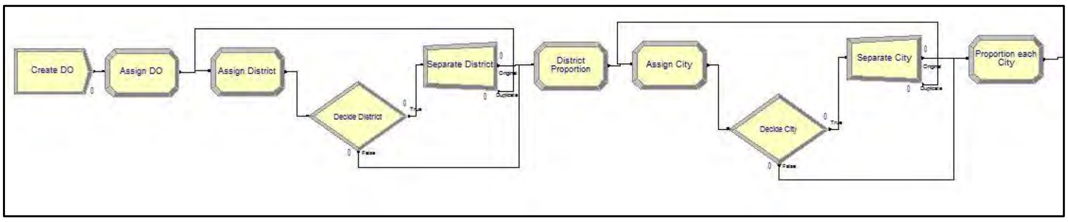


Figure 4. 1 Determining Sales Target for Warehouses (#1)

In purpose to determine the target for each warehouse, the process was started with assigning the entity which come up from create module with the aggregate sales target on each day. Afterwards, the entity was duplicated into 6 districts, 46 cities, and 83 warehouses. On each process of duplication, the entity brought a different amount of sales target.

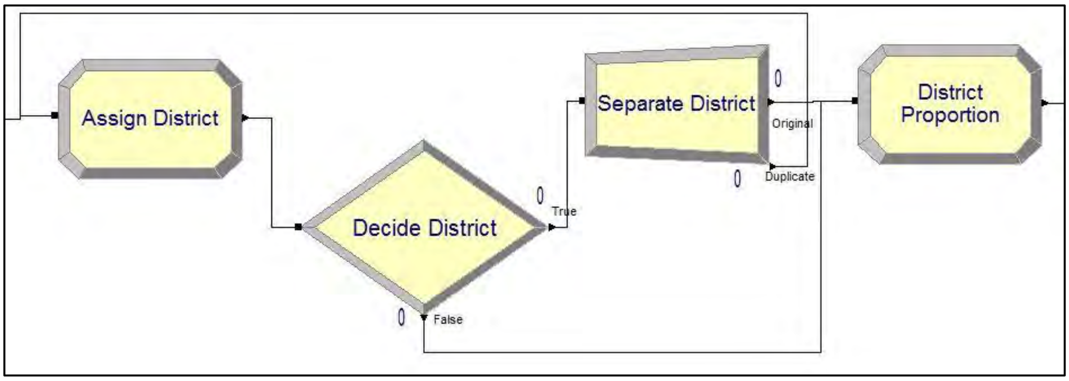


Figure 4. 2 Determining Sales Target for Districts

The figure 4.2 was consisted of module assign, decide, and separate which the main objective of this section were dividing the target into 6 districts. The proportion for each district was concluded as the variable of percentage district. Inside this variable, there were 6 value of proportion related with each district.

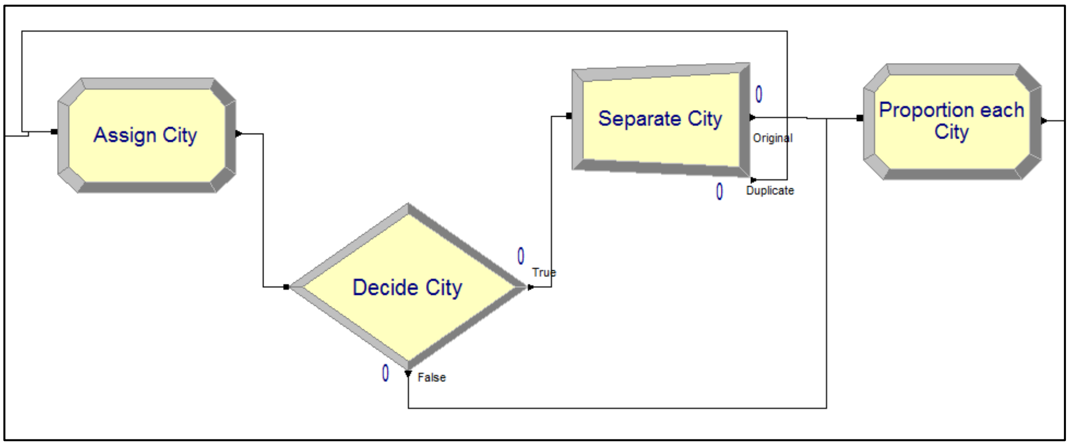


Figure 4. 3 Determining Sales Target for Cities

The logic of figure 4.3 same with the figure 4.2 while determining the sales target for cities. Start with module assign, decide, and separate which all of them were divided into certain proportion for each city. Proportion for each city was also conducted as the variable as well as percentage district.

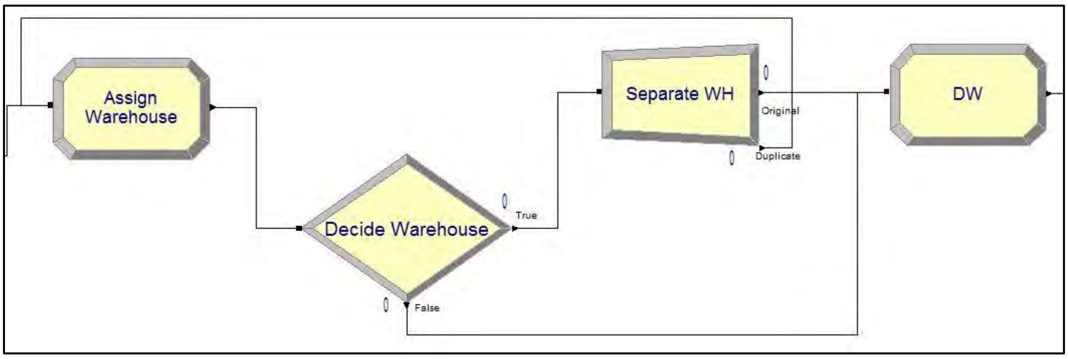


Figure 4. 4 Determining Sales Target for Warehouses (#2)

After determining the target for each city, the process was continued to the warehouses. The logic was still the same with district and city which also create a variable of proportion for each warehouses.

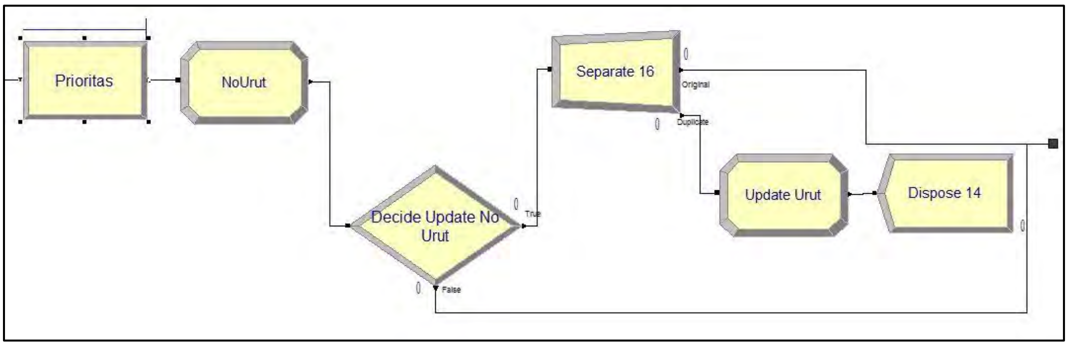


Figure 4. 5 Determining Priority for Sales Target

The output of the previous process started from district 1 to district 6 which the target for each of entities haven't sort by the highest value. Therefore, the figure 4.5 was used to sort the entity by the highest value of target. This process needs a hold module to create a condition of priority base on the highest value. The entity coming from the previous process was hold until the number of them was 83 or equal with the total number of warehouses.

4.3.2. Setup the Critical Level

After knowing the specific target that occurred on each warehouse, the model calculates the criticality/critical level for each warehouse. The criticality/critical level were based on the amount of inventory days of supply. The inventory days of supply should be below the desire value. As the existing model, the critical level was 1 day which means the on-hand inventory should be below 1 day then the company was decided to distribute the product. The equation to determine the critical level was the same with the equation (2.1) and the assumption of on-hand inventory equal with the product that has unloaded or still on the truck. The following figure consists of assign & decide module. Assign module was used to calculate the critical level on each warehouse & decide module was used to determine whether to distribute or not. The delivery quantity was multiplied by variable “k” when the criticality below 1 days.

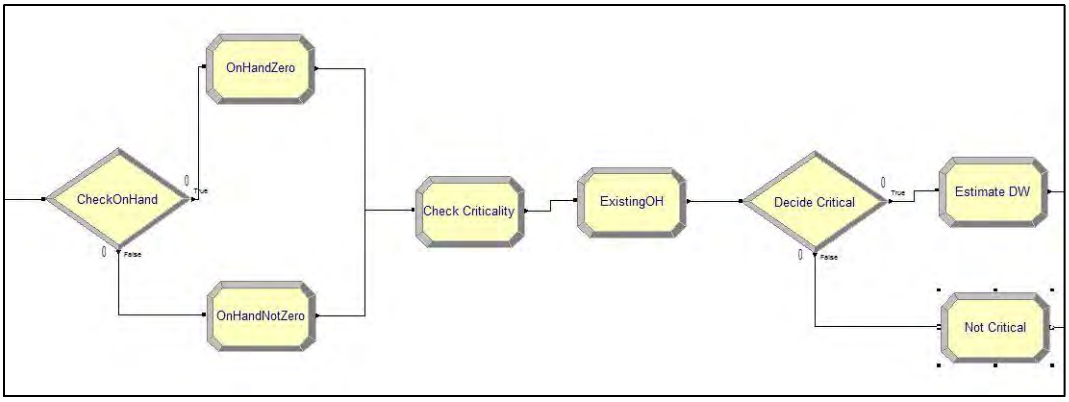


Figure 4. 6 Decide the Criticality

Regarding to the figure 4.6, the criticality was checked after determining the level of on-hand inventory. There were 2 assign modules which each of it has different command. The first assign module has an instruction to create the same value of on-hand inventory if the level of inventory was above 0. In the other hand, the second assign module has an instruction to change the value of on-hand inventory if the value was negative or below 0.

4.3.3. Determine the Delivery Quantity

The product was distributed after the criticality has checked previously. The quantity of delivery based on the value of variable “k” for each warehouse. As been mentioned previously, the target that was determined in the previous process was multiplied the variable “k” in purpose to create a safety stock related with the uncertain sales. The variable “k” has a range of 1 to 1.4 and inputted to the variable Dos inside the simulation. In total, there were 83 “k” variables which each of warehouse has different value. There was different “k” for each warehouse. Therefore, the best combination of “k” variables can be known through several scenarios. The process of determining the best scenario has done by using OptQuest in ARENA simulation. This process was explained on the scenario model building.

4.3.4. Assigning destination

In the previous process, the sales target was determined and ordered base on the highest value and it was continued by determining the criticality and delivery quantity for each warehouse. Afterwards, the amount of delivery was divided and loaded into trucks (capacity of 32 tons each). The number of trucks needed becomes a decision variable in term to create the performance level higher. Therefore, the trucks conclude as variable and it’s going to be assigned to the destination which has the highest value of sales target.

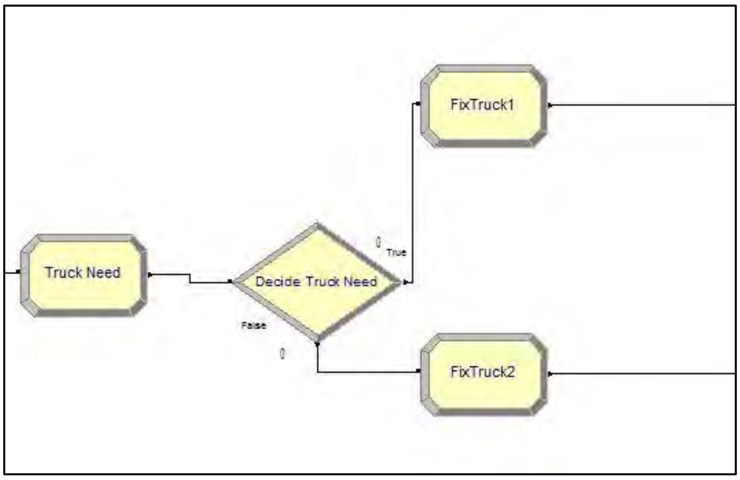


Figure 4. 7 Decide the Truck Needs

In this certain part of model, the truck needs was calculated based on the delivery quantity that had been determined previously. The delivery quantity was divided with 32 tons and the result was rounded up. The next process, the model checked the availability of trucks. The product can be loaded if the trucks available and ready to be assigned. In the opposite, the product should be delayed for distribution when the trucks not available. Later on, the trucks were delayed as long as it leads time.

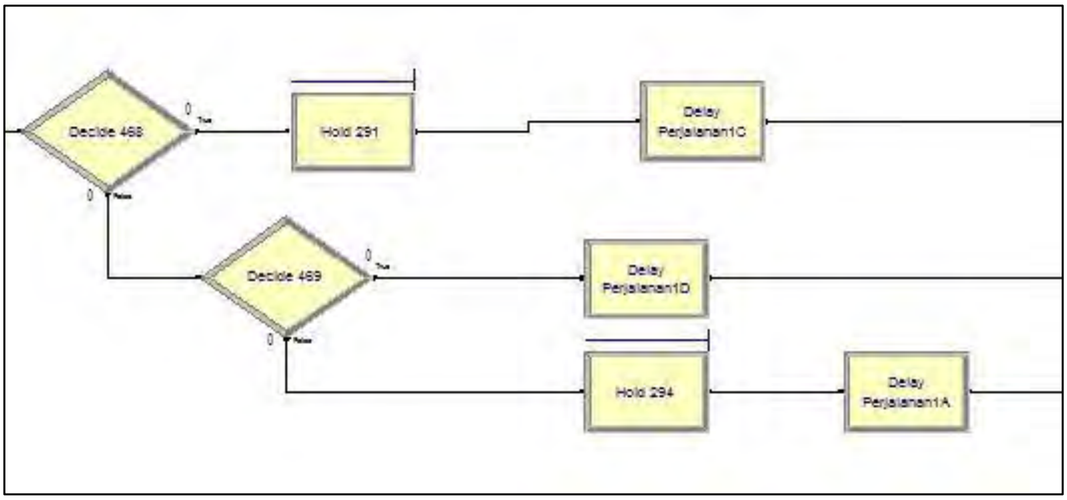


Figure 4. 8 Delay during Lead Time

The figure 4.8 showed the logic of assigning lead time for each warehouse. First, lead time for each warehouse was categorized into 3 main groups. These 3 groups were lead time less than 3 hours, less than 7 hours, and higher than 7 hours. On each group also contains several rules for scheduling the departure process. Lead time with the duration less than 3 hours was allowed to go in range of 7-12 A.M. When the loading process finished more than 12 A.M, then the trucks were assigned and departed on the next day. When the process of loading had finished before 7 A.M. then the trucks should wait till the time showed at 7. This logic was also implemented to the lead time less than 7 hours. Higher than 7 hours, there was no boundary or rules about the departure process and the product can be distributed directly.

4.3.5. Updating Oh-hand Inventory

The on-hand inventory level was updated continuously in the end of the day. The model assumes that the product must be unloaded to the warehouse on the range of time windows start from 7 A.M to 5 P.M. Within this range of time, the on-hand inventory was not deductible with the sales. The updating process on each warehouse also considered the queue of trucks base on the arrival of trucks to the warehouse. The resource for each warehouse was assumed able to facilitate the unloading process for one truck at the time.

4.3.6. Calculating Service Level & Total Cost

In the end of process, service level and total cost was calculated in term of analyzing the performance. The equation of (4.1) was implemented to measure the fill rate occurred on each day. Afterwards, it has mentioned in the previous sub chapter that the total cost related with holding cost occurred on each warehouse. The holding cost was 25 % / year for average inventory happened during 1 year. The simulation model updated the service level after the entire on-hand inventories were updated. In opposite, the holding cost was calculated after the inventory has been deductible with the sales.

In purpose to gain the service level & total cost, the model used a tool called OptQuest. The total cost becomes an objective of this tool which should be minimized. Therefore, the service level becomes an output constraint which should be higher than 85%. It has mentioned in the subchapter 4.3.3., that the combination of "k" variables also found through the OptQuest.

4.4. Goodness Assessment

There are 2 processes that should be done before implementing the model as a suggestion. The first process was verification which concerned with building the "model right". It was used to compare the logical or conceptual model of simulation represent the actual condition. In the other hand, validation concerned with building the "right model". It was used to decide whether the model represent the real data or not. Related with the model, the validation process was done by conducting a significance F-test & t-test.

4.4.1. Verification

Verification of simulation model can be determined by checking the logical flow by looking at the code & test run followed by the example of calculating certain formulation. The code & test run was done by checking the error within the model. This tool was done by ARENA called as Trace & Debug facility. In addition, to check the implementation of certain formulation has corrected then the manual calculation and simulation result of days of supply.

4.4.1.1. Trace & Debug Facility

Trace & debug facility can be used in the ARENA software to check whether the model is error or not. Before assessing this facility, the model file should be opened. This facility can be done by clicking Ctrl + F4 or by following these steps (Click Run→Check Model). After following the steps, the ARENA software showed a notification same with the figure 4.9.

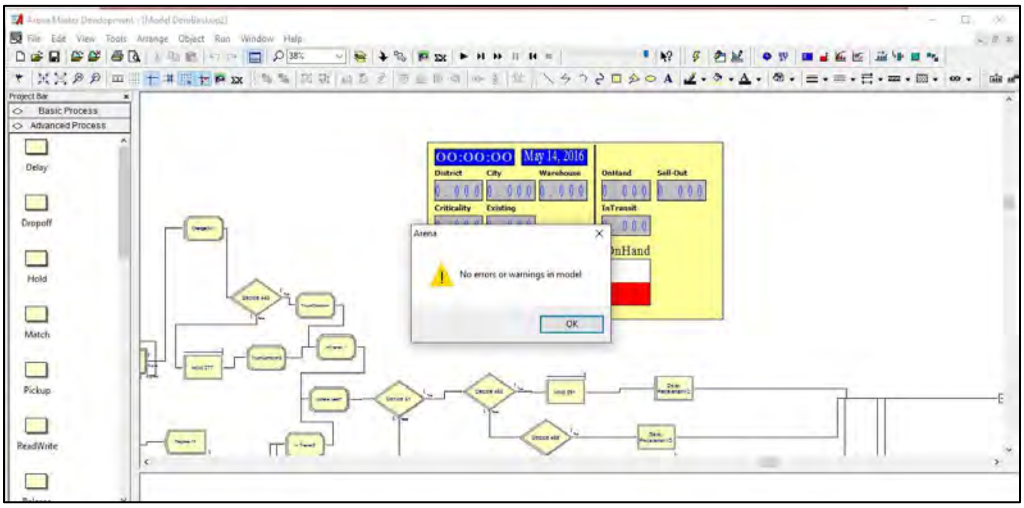


Figure 4. 9 Trace & Debug Facility

4.4.1.2. Inventory Days of Supply Calculation

Regarding to the equation of (2.1), days of supply can be determined by dividing the inventory level by the average sales on each warehouse. This subchapter compares the result occurred in the simulation with the manual calculation of inventory days of supply. There were 83 warehouses that should be checked for the days of supply, but this calculation was taking an example of district 3(Solo), City 9(Klaten), & Warehouse 2(Setia Tunggal).

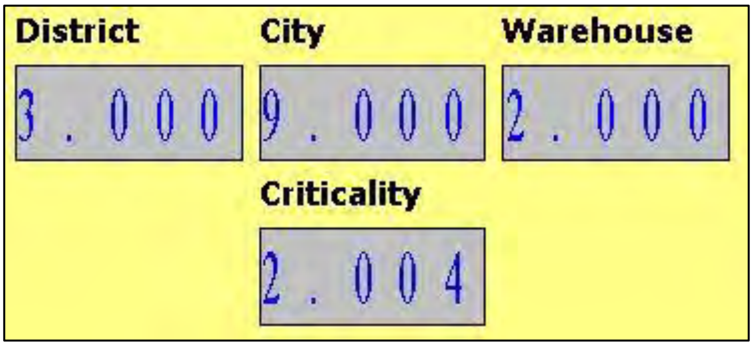


Figure 4. 10 Inventory Days of Supply

The figure 4.10 showed that the criticality or equal with days of supply for the certain warehouse was 2.004 days. This result was compared with the manual calculation which of in this warehouse the average sales was 7214 sacks of cement and the initial condition of on-hand was 14450. Therefore, the inventory day of supply was done by dividing 14450 with 7214 and the result was 2.003 days.

4.4.2. Determination of Replication Number

Before doing the validation process, the number of replication should be defined first. The replication number is needed to lead the simulation close with the real condition. There is a sequence of steps to define the replication number. The process of determining the replication number was started with replicated the model 10 times. This number was done because 10 was the minimum number suggested by the expert. On each replication the average service level was recorded in term to determine the replication number. The criticality was 2 days and the delivery quantity was calculated with the "k" variables = 1 to all warehouses. The equation to determine the replication number was:

$$hw = \frac{\left(t_{n-1}, {}^{\alpha}/_{2}\right) * s}{\sqrt{n}} \tag{4.3}$$

$$n^{I} = \left[\frac{(Z\alpha/_{2}) * S}{hw}\right]^{2} \tag{4.4}$$

hw = half width

n = replication number

n^I = required replication number

α = significance level = 0.05

$t_{n-1},\alpha/2$ = 2.26

$Z\ \alpha/2$ = 1.96

S = standard deviation

It has been mentioned that the initial model run 10 times before determining the number of replication. This following table was the result of 10 replications.

Table 4. 7 Service Level for 10 Replications

Replication	Average Service Level
1	0.96791
2	0.96405
3	0.96645
4	0.96703
5	0.96626
6	0.96929
7	0.96708
8	0.96759
9	0.96345
10	0.96622

According to the table 4.7, the calculation of replication number can be determined through this following calculation.

$$hw = \frac{(t_{10-1},{}^{0.05}/_{2}) * 0.001542}{\sqrt{10}} = \frac{2.26 * 0.001732}{\sqrt{10}} = 0.001238$$

$$n^I = \left[\frac{(z_{\alpha/2}) * S}{0.001238}\right]^2 = \left[\frac{1.96 * 0.001732}{0.001238}\right]^2 = 7.521 \approx 8 \text{ replications}$$

4.4.3. Validation

Validation process was used to comparing the existing data with the result from the simulation. There were 2 data that was validated using significance F-test and t-test. Those data were aggregate sales target for all the warehouses every month for 8 replications and the actual sales for all the warehouses every month with the same 8 replications.

4.4.3.1. Validation for Aggregate Sales Target

The existing data of sales target was accumulated for each month on each warehouse. The existing sales target was contained several assumptions. The data gained from the company was only for February. The other month was calculated by adding the target with average target for each warehouse. For example, on February there was 29 days which different with other month that commonly has 30 or 31 days. Therefore, a month that has 30 days was added 1 days of target. It was also implemented for a month which has 31 days.

The simulation result was conducted by sum up the aggregate targets occurred for each day and create the total aggregate target for each month. In the table 4.8 was showed the average output of aggregate sales target on each month for 8 replications. Regarding this following data, then the significance f-test and t-test has done.

Table 4. 8 Output of Sales Target & Existing

	Sales Target	
	Simulation	Existing
January	192,682.30	203,996.08
February	200,103.14	190,976.05
March	193,964.18	197,747.00
April	199,991.46	193,280.00
May	192,455.05	202,680.00
June	195,673.27	197,486.07
July	200,585.82	196,277.00
August	200,003.03	197,486.07
September	201,210.40	197,486.07
October	203,355.00	203,996.08
November	196,034.19	197,486.07
December	200,006.88	203,996.08

The table 4.9 was the result of F-test for variance between the existing & simulation data. Basically, variance was used to know the distribution of data within the sample. Within the 2 samples, the null hypothesis for this test was variance between two data were equal. The alternative hypothesis was variance between two data were not equal. The decision of this test can be determined by looking at the F value & F critical one-tail. It can also be supported by looking at the value P (probability). If the F value was higher than the F Critical one-tail, the null hypothesis should be rejected and conclude as the variance between two data were not equal. The p value was also considered while creating a decision if the P value was lower than the significance level (α=0.05).

Looking through the result, table 4.9 was showed that the F value lower than the F Critical one-tail which means that the null hypothesis should be accepted.

Table 4. 9 F-test for Variance Sales Target

	Existing	*Simulation*
Mean	198574.3808	198005.3932
Variance	18318715.8	13335266.04
Observations	12	12
df	11	11
F	1.373704562	
P(F<=f) one-tail	0.303742264	
F Critical one-tail	2.81793047	

The next validation process that should be done was t-test for both variances. This process was done to determine whether the output between two data were significantly different or not. The null hypothesis for this test was the mean among the data were similar. Therefore, the alternative hypothesis was the mean among the data were not similar. The null hypothesis was rejected if the t stat value was not in the range of negative to positive t critical two-tail.

From the table 4.10, it can be seen that the t sat value was in the range of negative to positive t critical two-tail. It means that the null hypothesis should not be rejected and it may conclude that the mean were similar.

Table 4. 10 t-test for Equal Variance Sales Target

	Existing	*Simulation*
Mean	198574.38	198005.3932
Variance	18318716	13335266.04
Observations	12	12
Pooled Variance	15826991	
Hypothesized Mean Difference	0	
df	22	
t Stat	0.3503316	
P(T<=t) one-tail	0.3647109	
t Critical one-tail	1.7171444	
P(T<=t) two-tail	0.7294219	
t Critical two-tail	2.0738731	

4.4.3.2. Validation for Actual Sales

The simulation result was conducted by sum up the actual sales occurred for each day and convert to each month. In the table 4.11 was showed the average output of aggregate actual sales on each month for 8 replications.

Table 4. 11 Output of Actual Sales & Existing

	Actual Sales	
	Simulation	Existing
January	177,470.60	166,176.43
February	176,240.55	146,909.67
March	177,372.78	165,106.43
April	176,964.22	146,485.90
May	176,306.36	170,125.43
June	176,783.83	169,324.16
July	179,518.01	168,985.16
August	177,679.20	193,790.52
September	177,250.81	166,176.43
October	177,121.19	169,402.16
November	177,989.54	198,076.32
December	177,319.36	169,444.16

The logic significance F- test for variance in this section was the same with the previous F-test process. Looking through the table 4.12, The F value was higher than the F Critical one-tail. This condition decided that the null hypothesis should be rejected and concludes as a different variance.

Table 4. 12 F-test for Variance Actual Sales

	Existing	*Simulation*
Mean	169166.8991	177334.7041
Variance	226124648.1	734768.7043
Observations	12	12
df	11	11
F	307.7494275	
P(F<=f) one-tail	4.82492E-12	
F Critical one-tail	2.81793047	

The next validation process that should be done was t-test for both variances. This process was done to determine whether the output between two data were significantly different or not. The null hypothesis for this test was the mean among the data were similar. Therefore, the alternative hypothesis was the mean among the data were not similar. The null hypothesis should be rejected if the t stat value was not in the range of negative to positive t critical two-tail.

From the table 4.13, it can be seen that the t sat value was in the range of negative to positive t critical two-tail. It means that the null hypothesis should not be rejected and it may conclude that the mean were similar.

Table 4. 13 t-test for Unequal Variance Actual Sales

	Existing	*Simulation*
Mean	169166.8991	177334.7041
Variance	226124648.1	734768.7043
Observations	12	12
Hypothesized Mean Difference	0	
df	11	
t Stat	-1.878527585	
P(T<=t) one-tail	0.043526432	
t Critical one-tail	1.795884819	
P(T<=t) two-tail	0.087052864	
t Critical two-tail	2.20098516	

4.5. Scenario Model Building

Regarding to the objective of this research, the model comes up with several decision such as policy of delivery quantity & suggestion for warehouse capacity / size. The decision related with the combination of “k” variables as the multiplier of the sales target. The “k” variables were very critical in purpose to create higher service level with the consideration of holding cost as the total cost. It has mentioned in section of 4.3.2 that the critical level for each warehouse for initial condition was 1 day & the value of “k” was 1 for each warehouse. This condition means that the product was distributed if the condition of on-hand inventory below 1 day and it was distributed at amount of 1 multiply with the sales target. In the previous section 4.4.2 was showing the result during 10 replications and it showed different service level for each replication. Even though the service level were quite high, the condition for each warehouse on each day usually come up with the small inventory level and has a risky safety stock to cover the possibility of sales for next day. The inventory level was in average of 0.48 day (appendix 1).

In term to find the best combination, there were several scenarios conducted. There were 3 main scenarios which of each has different possibility of “k” variable and truck. Those 3 main scenarios change the level of criticality. The criticalities were 1.5 days, 2 days, and 2.5 days. For each criticality, the best combination searched by using OptQuest in ARENA software. This tool leads the result to have the best combination with the objective of minimizing the total cost (holding cost) and keep the service level higher than 85 %. On each scenario also contains a constraint of inventory days of supply that should be higher than the desire one. For the criticality below 1.5 days the constraint of inventory days of supply should be higher than 0.5 days, higher than 1 for criticality below 2 days, and higher than 1.5 for criticality below 2.5 days. The interval for criticality was 0.5 because by using this increment, there was significant different in term of total cost (holding cost).

In order to run the OptQuest, the process can be started by opening the model first and followed by clicking Tools→ OptQuest for ARENA. Afterwards, the model of OptQuest should be defined start with determining the decision variable, constraint, and the objectives. Each of scenarios has the same sequence of modelling the OptQuest. The following figure showed the sequence of conducting the model.

Figure 4. 11 OptQuest for ARENA

The figure 4.11 was the surface of OptQuest for ARENA. The next process that should be done was determining the decision variable. The decision variable was the "k" variables which named of Dos variable inside the ARENA software. Each of Dos was specified for each warehouse. The surface of changing the Dos can be seen in the figure 4.12.

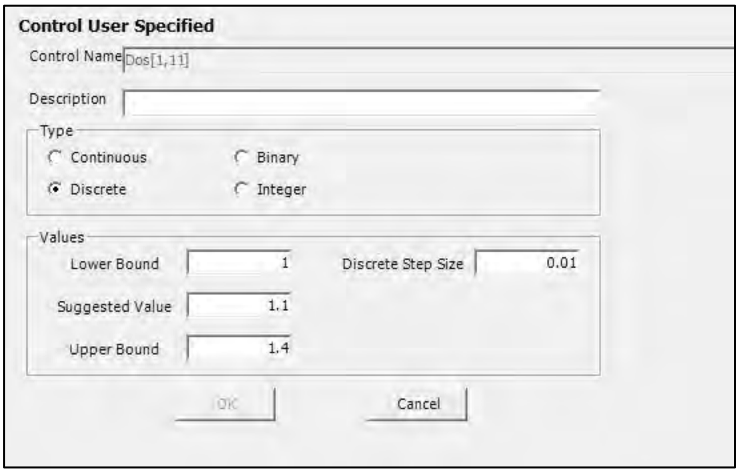
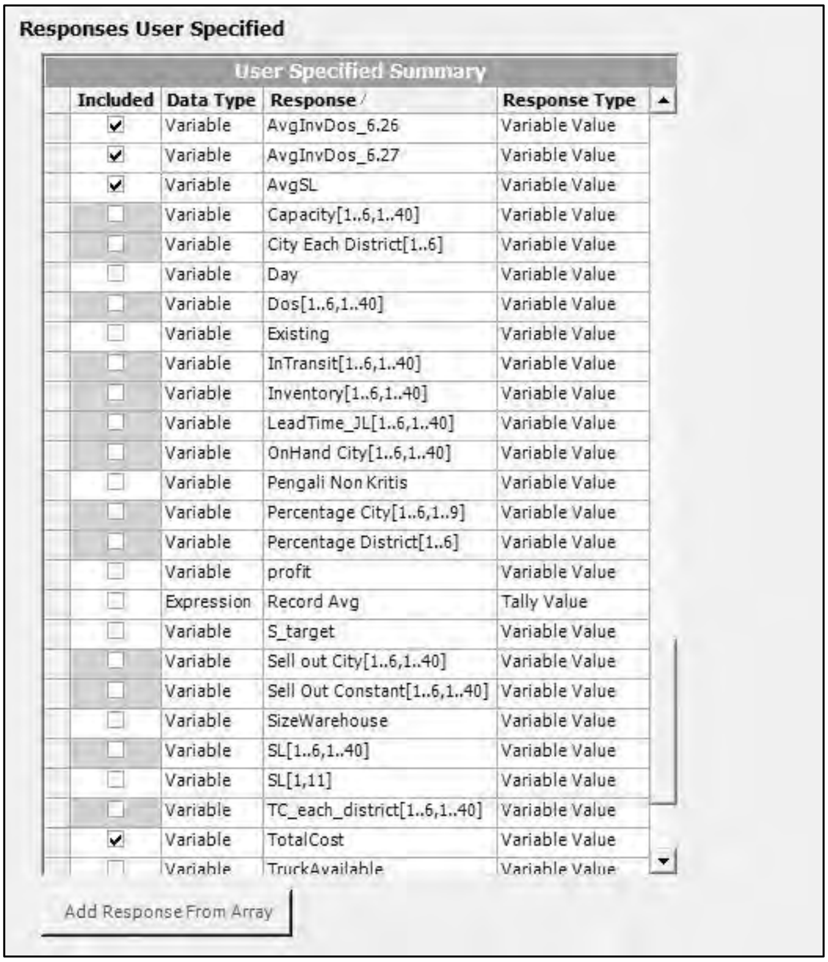


Figure 4. 12 Decision Variable for DoS

From the figure 4.12, the control name showed Dos(1,11) which it refer to the district 1, city 1, and warehouse 1. This logical was also implemented to the other Dos for 83 warehouses. The value was in the range of 1 to 1.4 with a discrete step size of 0.01. The other decision variable was truck availability which also has the same logic and use a certain range in term to test all the possible solution. Afterwards, the next process was determining the desire response. In this model, the desire output were the average inventory days of supply, the total cost, and the average service level for all the warehouses. The figure 4.13 was showing the surface of modelling the response.


Responses User Specified

User Specified Summary

Included	Data Type	Response	Response Type
✔	Variable	AvgInvDos_6.26	Variable Value
✔	Variable	AvgInvDos_6.27	Variable Value
✔	Variable	AvgSL	Variable Value
☐	Variable	Capacity[1..6,1..40]	Variable Value
☐	Variable	City Each District[1..6]	Variable Value
☐	Variable	Day	Variable Value
☐	Variable	Dos[1..6,1..40]	Variable Value
☐	Variable	Existing	Variable Value
☐	Variable	InTransit[1..6,1..40]	Variable Value
☐	Variable	Inventory[1..6,1..40]	Variable Value
☐	Variable	LeadTime_JL[1..6,1..40]	Variable Value
☐	Variable	OnHand City[1..6,1..40]	Variable Value
☐	Variable	Pengali Non Kritis	Variable Value
☐	Variable	Percentage City[1..6,1..9]	Variable Value
☐	Variable	Percentage District[1..6]	Variable Value
☐	Variable	profit	Variable Value
☐	Expression	Record Avg	Tally Value
☐	Variable	S_target	Variable Value
☐	Variable	Sell out City[1..6,1..40]	Variable Value
☐	Variable	Sell Out Constant[1..6,1..40]	Variable Value
☐	Variable	SizeWarehouse	Variable Value
☐	Variable	SL[1..6,1..40]	Variable Value
☐	Variable	SL[1,11]	Variable Value
☐	Variable	TC_each_district[1..6,1..40]	Variable Value
✔	Variable	TotalCost	Variable Value
☐	Variable	TruckAvailable	Variable Value

Add Response From Array

Figure 4. 13 Response for OptQuest

From the figure 4.13, the one which had checklist becomes the response of OptQuest. It has mentioned previously that the constraint related with the output / response of the OptQuest. Afterwards, the constraint was determined by looking at the response on figure 4.13. The constraint was shown by the figure 4.14.

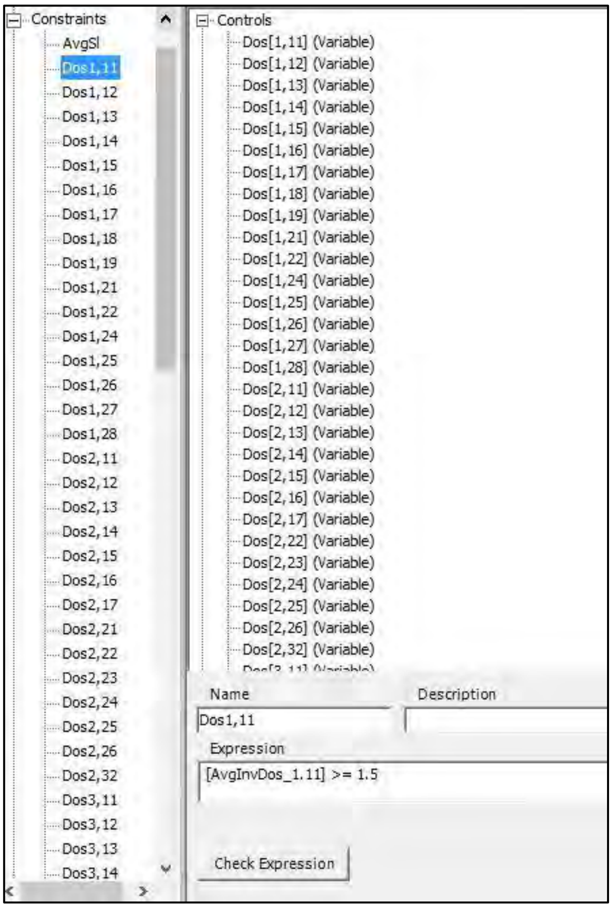


Figure 4. 14 Constraint for OptQuest

It has mentioned that the average inventory was a constraint for each warehouse. From the figure 4.14 it can be known that the average inventory should be higher than 1.5. This value was also implemented into the other warehouse. The average service level was also a constraint which the value should higher than 85%. Afterwards, the objective of this optquest should be defined by minimizing the total cost (total holding cost). The last section of modelling the optquest was setting up the running options.

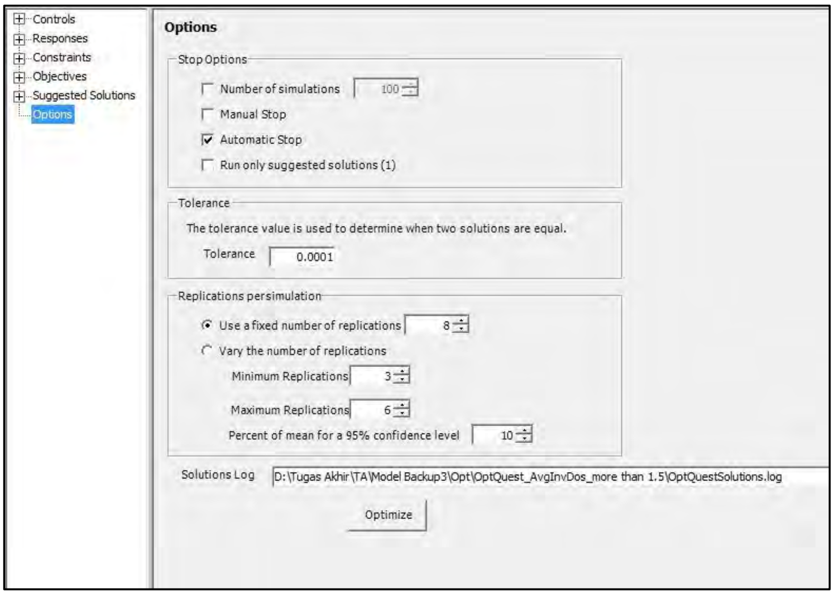


Figure 4. 15 Set up the Simulation

In the figure 4.15, the setup process consists of the number of simulations that should be tested, the value of tolerance if the possible solution has the same value, and also the number of replication that should be tested. For the number of simulation, the optquest automatically stop if the best solution had been found. Afterwards, the number of replication was filled by the result of minimum number of replication in the section 4.4.2. This logic was implemented to all main scenarios. The following section was the result for each scenario. Each of scenarios has a different iteration number. The iteration number was defined by the OptQuest after passing several trial of combination. The iteration stops automatically if the OptQuest did all the possibilities regarding to the model.

Scenario 1 (Distributed if the Days of Supply < 1.5 days)

Objective **:** Minimize Total Cost = ∑ Holding Cost for each Warehouse
S.T. **:** Total Average Service Level >= 85%
Average Inventory Days of Supply ≥ 0.5

Decision Var. **:** Combination of "k", Truck Needs

OptQuest Result:

- Total Iteration = 78
- Best Iteration = 66
- Truck Needs = 504

Table 4. 14 Combination for Scenario 1

District, WH	"k"	2,26	1.18	4,15	1.26
1,11	1.2	2,17	1.16	4,25	1.19
1,21	1.11	3,11	1.25	4,35	1.23
1,12	1.24	3,21	1.19	4,16	1.28
1,22	1.21	3,12	1.19	4,26	1.13
1,13	1.29	3,22	1.15	4,17	1.29
1,14	1.24	3,13	1.28	4,18	1.21
1,24	1.25	3,14	1.28	5,11	1.17
1,15	1.21	3,24	1.23	5,21	1.19
1,25	1.16	3,34	1.23	5,12	1.19
1,16	1.18	3,15	1.27	5,13	1.28
1,26	1.27	3,25	1.22	5,23	1.21
1,17	1.2	3,35	1.13	5,14	1.16
1,27	1.28	3,16	1.26	5,15	1.16
1,18	1.13	3,26	1.19	6,11	1.25
1,28	1.2	3,36	1.16	6,21	1.27
1,19	1.28	3,17	1.29	6,12	1.17
2,11	1.26	3,18	1.14	6,22	1.27
2,12	1.28	3,19	1.16	6,13	1.25
2,22	1.19	3,29	1.19	6,23	1.22
2,32	1.1	4,11	1.19	6,14	1.16
2,13	1.26	4,21	1.14	6,24	1.23
2,23	1.19	4,12	1.22	6,15	1.18
2,14	1.19	4,22	1.21	6,16	1.22
2,24	1.21	4,13	1.28	6,26	1.21
2,15	1.23	4,23	1.16	6,17	1.29
2,25	1.24	4,14	1.25	6,27	1.2
2,16	1.25	4,24	1.28	6,18	1.22

The best decision variable for "k" value was shown on the table 4.14. Each of the "k" variables refers to the specific district. For example for the district 1 (Kudus), city 1 (Lasem) and warehouse 1 (KWSG) the "k" value was 1.2. It means that if the days of supply below 1.5 days, then the product should be distributed at the quantity of target multiply with 1.2. The total cost gained while implementing scenario 1 was IDR 2,017,044,432. This objective was obtained from the iteration number 66 out of 78 trials with the following truck needs was 504 (32 tons capacity). The following figure was showing the graphs related with total holding cost and the average service level.

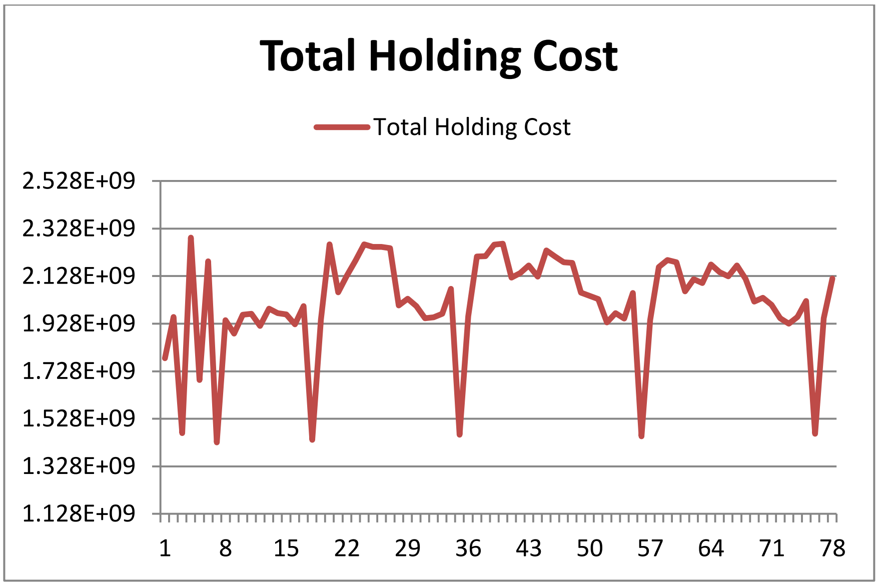


Figure 4. 16 Holding Cost for each Iteration (Scenario 1)

The figure 4.16 was showing the output of total holding cost during the iteration. At a glance, for the purpose to get the minimum total holding cost the iteration that showed the minimum value was be the best solution. The OptQuest would not choose the minimum value because the other constraint had not satisfied yet. In the other hand, the average service level graph was showing that all the iterations were satisfied the constraint that should higher than 85 %. It has mentioned in the optquest result that the best iteration that satisfies all the constraints was iteration 66 with the service level of 99.37%.

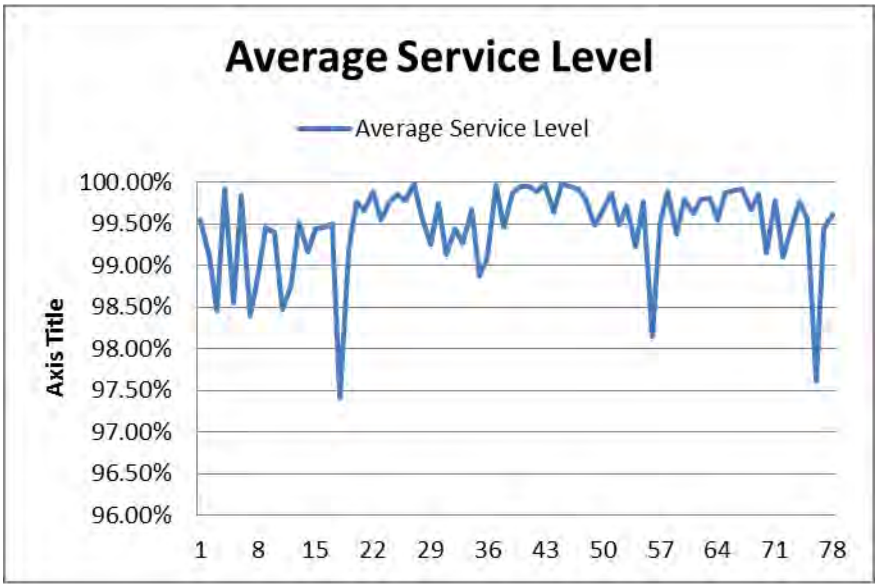


Figure 4. 17 Averge Service Level for each Iteration (Scenario 1)

<u>Scenario 2 (Distributed if the Days of Supply < 2 days)</u>

Objective : Minimize Total Cost = ∑ Holding Cost for each Warehouse
S.T. : Total Average Service Level >= 85%
Average Inventory Days of Supply ≥ 1

Decision Var. **:** Combination of "k", Truck Needs

OptQuest Result:

- Total Iteration = 710
- Best Iteration = 342
- Truck Needs = 528

Table 4. 15 Combination for Scenario 2

District, WH	"k"	2,26	1.24	4,15	1.23
1,11	1.15	2,17	1.23	4,25	1.29
1,21	1.21	3,11	1.27	4,35	1.24
1,12	1.21	3,21	1.26	4,16	1.21
1,22	1.26	3,12	1.24	4,26	1.21
1,13	1.27	3,22	1.25	4,17	1.26
1,14	1.24	3,13	1.23	4,18	1.2
1,24	1.22	3,14	1.25	5,11	1.27
1,15	1.23	3,24	1.28	5,21	1.25
1,25	1.27	3,34	1.24	5,12	1.2
1,16	1.15	3,15	1.13	5,13	1.28
1,26	1.27	3,25	1.25	5,23	1.21
1,17	1.24	3,35	1.23	5,14	1.21
1,27	1.28	3,16	1.2	5,15	1.28
1,18	1.22	3,26	1.23	6,11	1.22
1,28	1.28	3,36	1.29	6,21	1.28
1,19	1.21	3,17	1.26	6,12	1.28
2,11	1.24	3,18	1.25	6,22	1.28
2,12	1.19	3,19	1.29	6,13	1.27
2,22	1.22	3,29	1.18	6,23	1.25
2,32	1.25	4,11	1.28	6,14	1.21
2,13	1.28	4,21	1.27	6,24	1.18
2,23	1.25	4,12	1.24	6,15	1.28
2,14	1.25	4,22	1.29	6,16	1.22
2,24	1.22	4,13	1.18	6,26	1.17
2,15	1.23	4,23	1.27	6,17	1.16
2,25	1.28	4,14	1.28	6,27	1.2
2,16	1.19	4,24	1.26	6,18	1.28

The best decision variable for "k" value was shown on the table 4.15. Each of the "k" variables refers to the specific district. The total cost gained while implementing scenario 2 was IDR 2,915,151,534. This objective was obtained from the iteration number 342 out of 710 trials with the following truck needs was 528 (32 tons capacity). The following figure was showing the graphs related with total holding cost and the average service level.

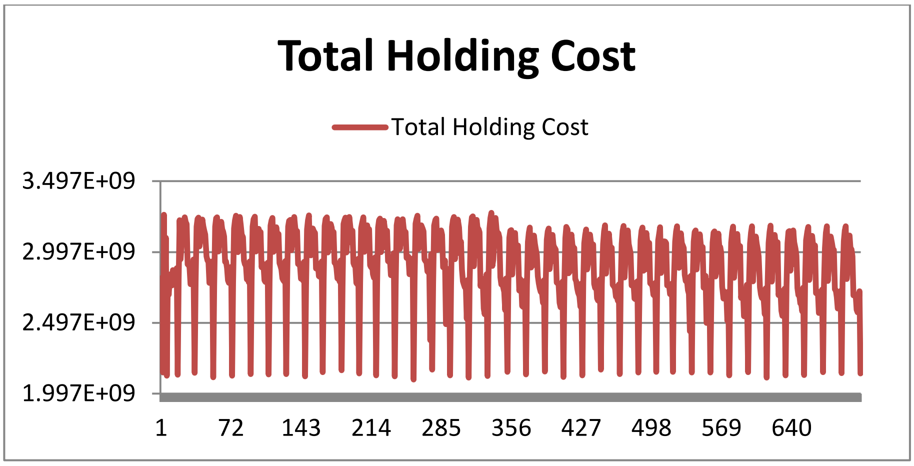


Figure 4. 18 Holding Cost for each Iteration (Scenario 2)

The figure 4.18 was showing the output of total holding cost during the iteration. The average service level graph was showing that all the iterations were satisfied the constraint that should higher than 85 %. It has mentioned in the optquest result that the best iteration that satisfies all the constraints was iteration 342 with the service level of 99.79%.

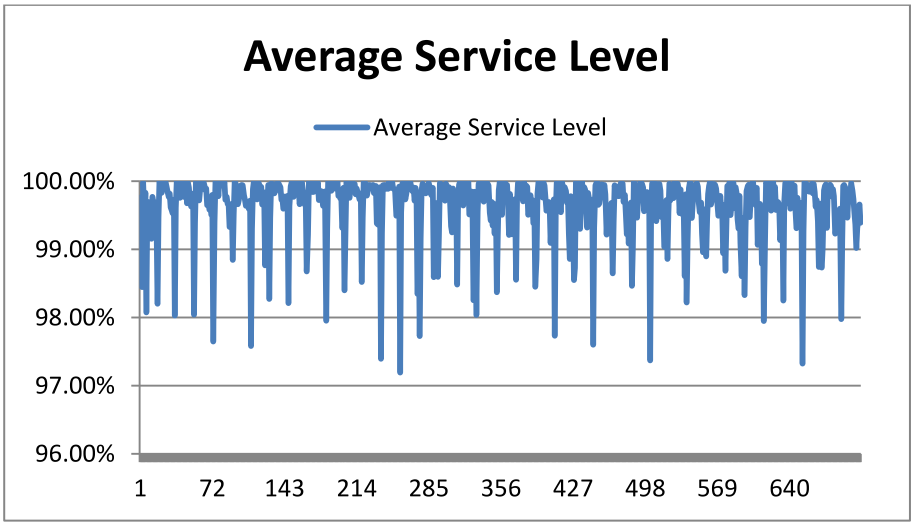


Figure 4. 19 Average Service Level for each Iteration (Scenario 2)

Scenario 3 (Distributed if the Days of Supply < 2.5 days)

Objective **:** Minimize Total Cost = ∑ Holding Cost for each Warehouse

S.T. **:** Total Average Service Level >= 85%

Average Inventory Days of Supply ≥ 1.5

Decision Var. **:** Combination of "k", Truck Needs

OptQuest Result:

- Total Iteration = 329
- Best Iteration = 8
- Truck Needs = 600

Table 4. 16 Combination for Scenario 3

District, WH	"k"				
1,11	1.34	2,26	1.4	4,15	1.4
1,21	1.4	2,17	1.4	4,25	1.4
1,12	1.4	3,11	1.4	4,35	1.4
1,22	1.4	3,21	1.4	4,16	1.4
1,13	1.4	3,12	1.4	4,26	1.4
1,14	1.4	3,22	1.4	4,17	1.4
1,24	1.4	3,13	1.4	4,18	1.4
1,15	1.4	3,14	1.4	5,11	1.4
1,25	1.4	3,24	1.4	5,21	1.4
1,16	1.4	3,34	1.4	5,12	1.4
1,26	1.4	3,15	1.4	5,13	1.4
1,17	1.4	3,25	1.4	5,23	1.4
1,27	1.4	3,35	1.4	5,14	1.4
1,18	1.4	3,16	1.4	5,15	1.4
1,28	1.4	3,26	1.4	6,11	1.4
1,19	1.4	3,36	1.4	6,21	1.4
2,11	1.4	3,17	1.4	6,12	1.4
2,12	1.4	3,18	1.4	6,22	1.4
2,22	1.4	3,19	1.4	6,13	1.4
2,32	1.4	3,29	1.4	6,23	1.4
2,13	1.4	4,11	1.4	6,14	1.4
2,23	1.4	4,21	1.4	6,24	1.4
2,14	1.4	4,12	1.4	6,15	1.4
2,24	1.4	4,22	1.4	6,16	1.4
2,15	1.4	4,13	1.4	6,26	1.4
2,25	1.4	4,23	1.4	6,17	1.4
2,16	1.4	4,14	1.4	6,27	1.4
		4,24	1.4	6,18	1.4

The best decision variable for “k” value was shown on the table 4.16. Each of the “k” variables refers to the specific district. The total cost gained while implementing scenario 3 was IDR 4,222,374,103. This objective was obtained from the iteration number 8 out of 329 trials with the following truck needs was 600 (32 tons capacity). The following figure was showing the graphs related with total holding cost and the average service level.

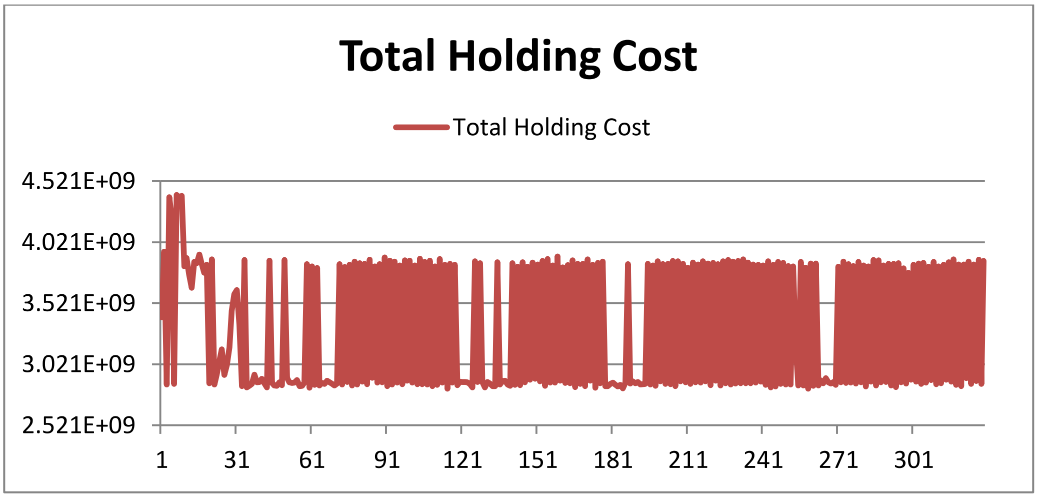


Figure 4. 20 Holding Cost for each Iteration (Scenario 3)

The figure 4.18 was showing the output of total holding cost during the iteration. The average service level graph was showing that all the iterations were satisfied the constraint that should higher than 85 %. It has mentioned in the optquest result that the best iteration that satisfies all the constraints was iteration 8 with the service level of 99.99%.

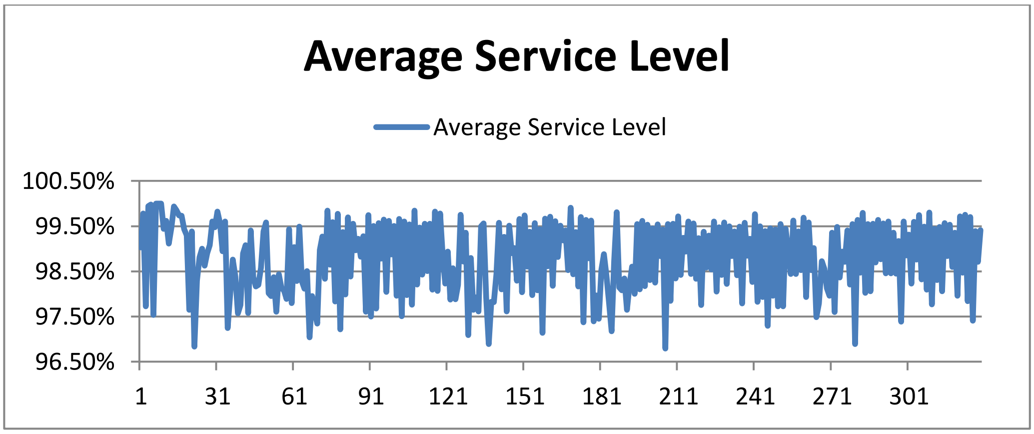


Figure 4. 21 Average Service Level for each Iteration (Scenario 3)

Summary

Base on the output occurred for each scenario, the following table was showing the comparison among the scenario. It has mentioned that the main scenario changes the critical level and finds the best combination of "k" variable for each. The following table was showing that all the average inventory days of supply above the existing simulation (> 0.48 days) and all the constraint had satisfied.

Table 4. 17 Output Summary for all Scenarios

Scenario	Trigger DOS	Average SL	Holding Cost	Average Inv.Dos	Range Inv. Dos	Truck Needs	Constraint	Loss
Existing	<1 day	95.49%	IDR 816,711,497	0.48	0-0.5 day	-	-	IDR 29,853,920,000.00
1	< 1.5 days	99.37%	IDR 2,017,044,432	1.10	0.5 - 1.5 days	504	AvgInv > 0.5 & SL > 0.85	IDR 3,527,530,000.00
2	< 2 days	99.79%	IDR 2,915,151,534	1.60	1 - 2 days	528	AvgInv >1 & SL > 0.85	IDR 1,474,210,000.00
3	< 2.5 days	99.99%	IDR 4,222,374,103	2.26	1.5-2.5 days	600	AvgInv>1.5 & SL > 0.85	IDR 15,740,000.00

CHAPTER V
DATA INTERPRETATION AND ANALYSIS

This chapter explains about the analysis for each condition occurred during the simulation. The explanation consists of the existing and the output for each scenario.

5.1. Analysis of Existing Condition

In the existing condition, the company didn't have a clear policy about the number of product that should be distributed. If there was an order from each warehouse, the company started from checking the on-hand condition & usually distributes the product at the amount of the target for that day. The delivery quantity will not always following the target because in the existing condition the company often to distribute more than target or slightly below the target. In addition, there was no strict policy about what level of inventory concludes as critical. Therefore in the existing model, the critical level was assumed with 1 day of sales. It has mentioned in the section 4.5 that the average service level for the existing was quite high but the average level of inventory for each day was too risky. The detail result after running the simulation can be seen on the appendix 1.

Through the appendix 1, it can be seen that the average service level was about 95.49% and the average inventory days of supply was 0.48 day. It means that during 1 year and implementing this policy, the total average of days of supply was 0.48 day which each of warehouse has different average for inventory days of supply. From the appendix 1, it can also be known about the output of warehouse utilization. A warehouse which has a data of existing size used to create an evaluation about the utilization and it can be seen that the entire warehouse were not exceeding the capacity. It concludes that the space for each warehouse was too big compare with the output of existing simulation. The other warehouse that didn't have a data of capacity creates a suggestion about the minimum size that should be provided. In conclusion, the existing model creates quite high service level but too risk in the inventory level.

5.2. Analysis of Scenario 1

In the scenario 1, the critical level was set up at 1.5 days. The result of this scenario was explained in the previous chapter. In term of service level, scenario 1 create higher service level than the existing condition. The average inventory days of supply also increased because the OptQuest set the constraint that the average inventory days of supply should be higher than 0.5 day. Afterwards, even though the average inventory days of supply on the existing equal with 0.48 day but the detail result happened on each day mostly less than 0.48 day. In the simulation record on each day, the existing model creates minus on-hand inventory in the certain day but for the scenario 1, the on-hand inventory level was tend to gain positive value.

The detail result for scenario 1 can be seen at the appendix 2. This result was showing the aggregate inventory days of supply for each warehouse, the utilization for each warehouse, and also the suggested size for each warehouse. The utilization was quite higher along with the increment on average inventory days of supply. Similar with the existing model, even though the average inventory days of supply for all warehouses were 1.10 days the variation of each warehouse was different but it still satisfy the constraint of OptQuest. In addition, in term of service level the changing from existing to scenario 1 was quite significant although the cost also increased significantly. The level of inventory on this scenario was affected by the combination of “k” variable as the multiplier. In the section 4.5 for scenario 1, the combination for all warehouses that gained from OptQuest higher than 1. It means that the company has a definite policy about the delivery quantity if they implemented the critical level below 1.5 days for each warehouse. All the “k” variable was quite safe to be implemented into the system even though in several warehouses on district 2 (Semarang) the average inventory days of supply was quite small than the another district. In conclusion, the optimum result for this scenario leads the company to consider the level of criticality below 1.5 days and the total cost (holding cost) certainly lower among the other scenarios.

5.3. Analysis of Scenario 2

The different among the scenarios of this research was in the critical level. The 2nd scenario, the critical level was 2 days. Similar with the previous analysis for scenario 1, in this scenario the output consists of average service level, the total cost (holding cost), utilization, and average inventory days of supply. The total cost occurred in the scenario 2 higher than scenario 1 and existing. Another output such as utilization, average inventory days of supply and average service level also higher than scenario 1 and existing. The condition of service level which higher than the previous scenario was good news for the company, but the increment of total cost (holding cost) was a bad news for them. This decision was quite a trade-off for the company because they should decide what kind of performance that should be their priority. The 2nd scenario was better in the average inventory days of supply rather than scenario 1 and better in term of total cost rather than scenario 3. The difference between the average service levels was not really significant because the value was above 98%. Therefore, the service level occurred among the scenario was not the main consideration to determine the best scenario. The entire scenarios were assumed that have similar service level and only significantly different with the existing model.

The detail result for scenario 2 can be seen at the appendix 3. The average inventory day of supply was 1.60 days, the service level was 99.79 % and the total cost was IDR 2,915,151,534. It has mentioned in the section 4.5 at summary that the range of inventory days of supply was around 1 – 2 days. In addition, in the scenario 2 was showing that the district 2 (Semarang) on the certain warehouse was quite lower in term of days of supply. Therefore, the "k" variable for the certain warehouse can be changed with the value that occurred on the scenario 3. In this certain warehouse, the first and second scenarios were showing that the average inventory days of supply quite lower. Therefore, the scenario 3 which was shown at the appendix 4 specifically at this warehouse has a quite safe value for the average inventory days of supply.

5.4. Analysis of Scenario 3

In the scenario 3, the critical level was set up at 2.5 days. The result of this scenario has explained in the previous chapter. In term of service level, scenario 3 creates higher output than the existing condition and the other scenario. The average inventory days of supply also increased because the Opt Quest set the constraint that the average inventory days of supply should be higher than 1.5 days.

The detail result for scenario 3 can be seen at the appendix 4. This result was showing the aggregate inventory days of supply for each warehouse, the utilization for each warehouse, and also the suggested size for each warehouse. The utilization was quite higher along with the increment on average inventory days of supply. In addition, the 3rd scenario was better value of average inventory days of supply especially for the district 2(Semarang) Therefore; the company should consider implementing the “k” variable for the certain warehouse at the district 2 and also using a different critical level for this certain warehouse.

5.5. Comparison between Existing & Scenario

The following figure explains about the comparison for each performance measure such as service level, total cost (holding cost), and average inventory days of supply. First, the figure 5.1 was showing the difference of service level among the scenario. The service level for each scenario was quite higher even the existing model also has high service level. From the figure, it can be seen that the difference between the existing and all scenarios were significant. Afterwards, the difference between scenarios was not significant. Through this output, it can be concluded that the service level of all scenarios better than the existing and indicate that the company should change the existing model in order to increase the service level.

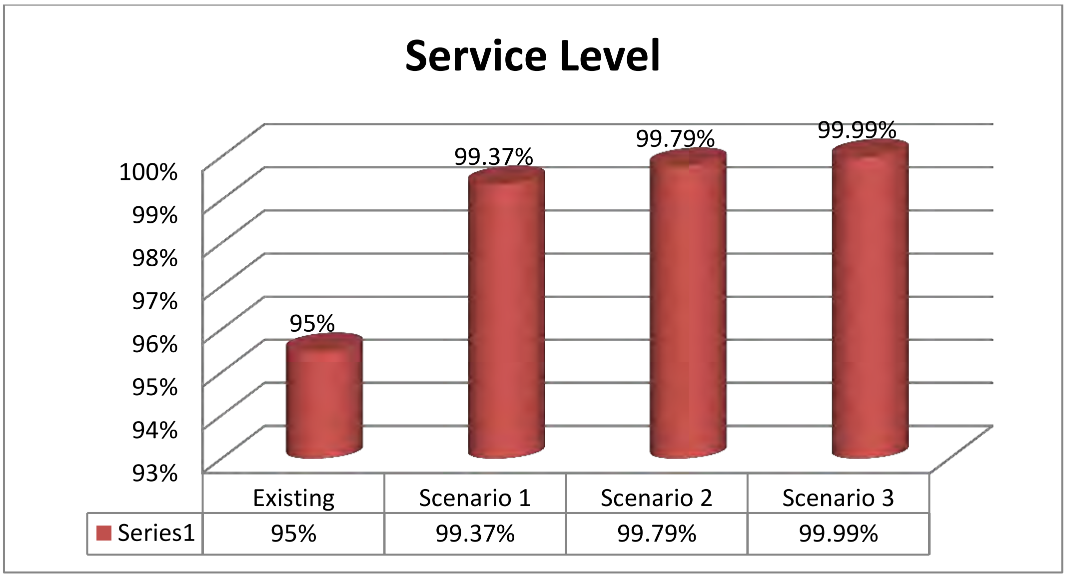


Figure 5. 1 Comparison between Scenario (Service Level)

The other measurement from the output was total cost (holding cost). Along with the increment of service level, the total cost also increase and affect the value of average inventory days of supply. Even though all scenarios were significantly higher than the existing, the level of inventory occurred on each day during the simulation always shows a positive number.

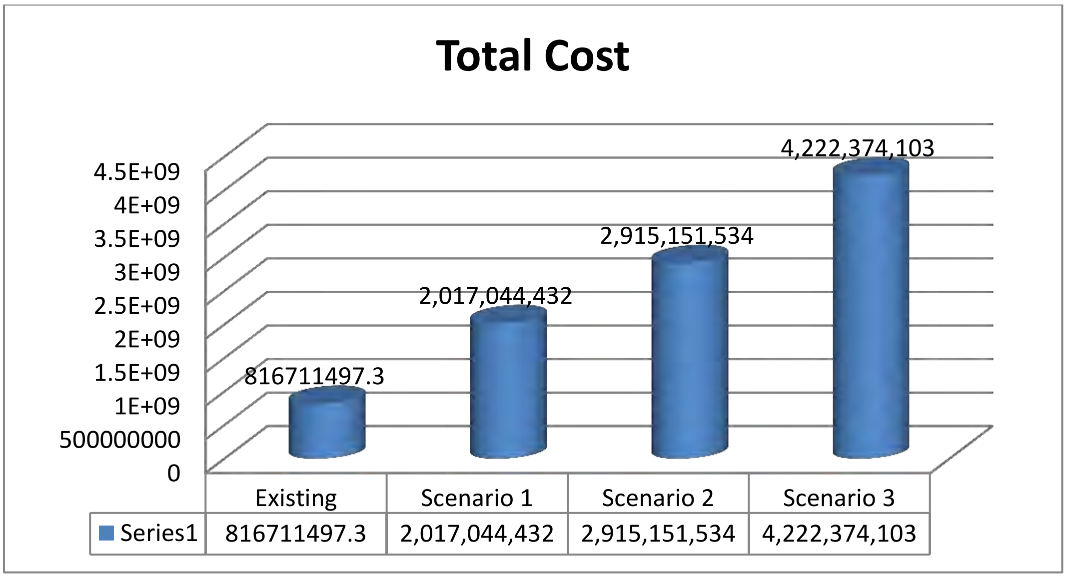


Figure 5. 2 Comparison between Scenario (Total Cost)

A modification on critical level for each scenario affects the level of average inventory days of supply. The figure 5.3 was showing that all scenarios creates higher average inventory day of supply. It has mentioned previously that the entire scenario always shows a positive amount of inventory level.

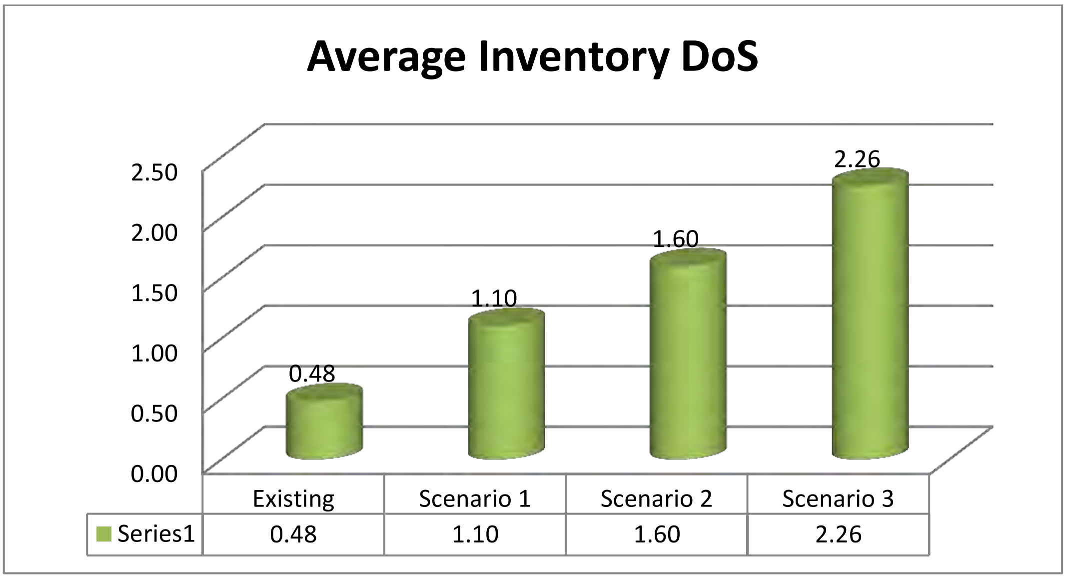


Figure 5. 3 Comparison between Scenario (Average Inventory Dos)

After knowing the output for each scenario, the figure 5.4 was showing a comparison between total cost and service level. It can be seen that the higher of service level creates higher cost. Scenario 1 to 3 has slightly difference in service level and it can be assumed that among of the scenario, the service level already satisfy all the demand.

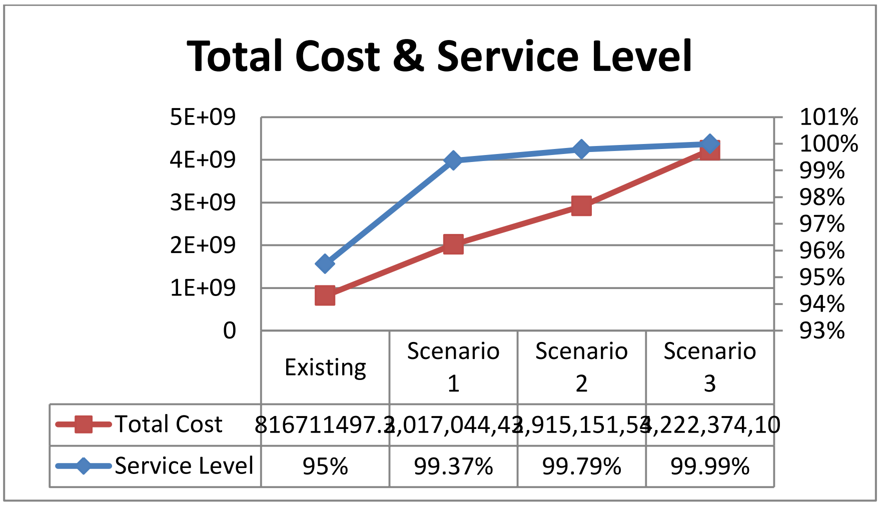


Figure 5. 4 Comparison between Total Cost & Service Level

It has mentioned in the previous paragraph that the output for service level on each scenario was not significantly different. Therefore, the decision about which scenario was the best to be suggested to the company refer to cost and average inventory days of supply. Because the service level among the scenario was not significantly different, the 1st scenario was the best in term of minimizing total cost. In addition, the 3rd scenario was the best solution in term of providing the average inventory day of supply. Both of these scenarios have a deficiency such as for the 1st scenario the level of inventory was risky in order to capture the uncertain demand. In opposite, 3rd scenario was very costly for the company.

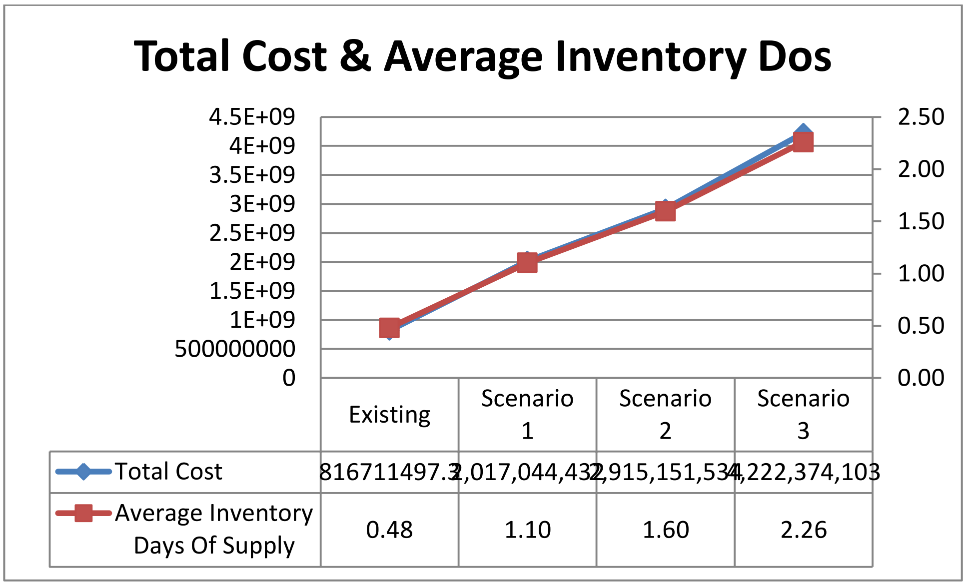


Figure 5. 5 Comparison between Total Cost & Average Inventory Dos

Refer to all the comparison, the best scenario in term of service level and average inventory days of supply was scenario 3. Scenario 3 gained higher cost than the other scenarios. Therefore, the selection of best scenario should be done by comparing the total cost with the product loss occurs for each scenario. It has mentioned in the figure 4.17 that each of scenario has a different product loss due to demand that cannot be fulfilled. The product loss value gain from the total unfulfilled product during the simulation on each warehouse multiplied with the profit 1 product. The profit that used in this calculation was IDR 10,000 for each sack of cement. Afterwards, the comparison was shown in the figure 5.6.

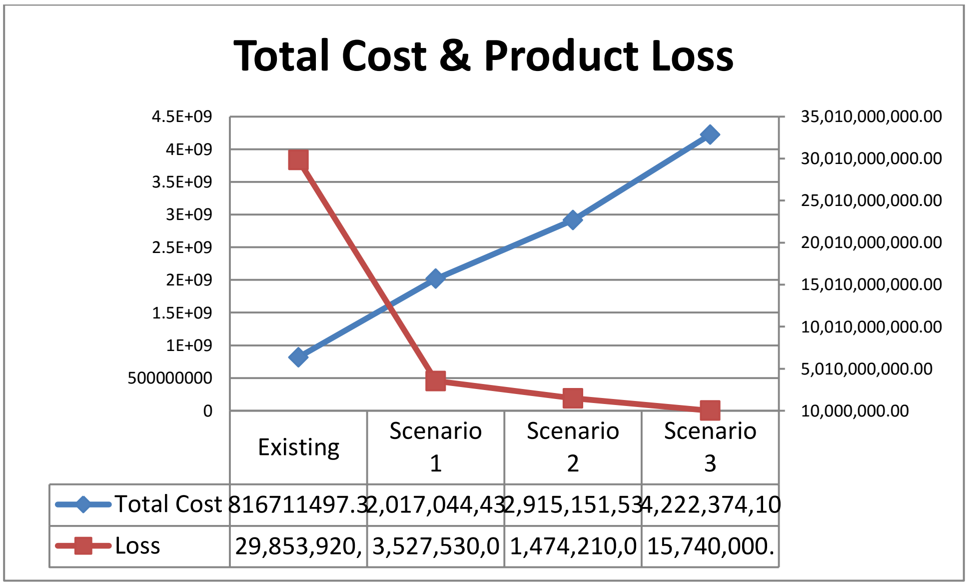


Figure 5. 6 Comparison between Total Cost & Product Loss

Looking at the figure 5.6, the loss occurred in the scenario 3 was the lowest value rather than the other scenario. Even though the cost for implementing the 3rd scenario was higher than the others, the product loss that can be saved was also higher. By implementing the 3rd scenario, the company creates lower loss than the other scenario and the cost used to implement this scenario was also lower than the product loss occurred for existing. Therefore, the 3rd scenario was the best solution for the company.

CHAPTER VI
CONCLUSION AND RECOMMENDATION

This chapter consists of conclusion regarding to the output and also the recommendation related with the policy of delivery quantity & warehouse size.

6.1. Conclusion

The result of simulation leads to these several conclusion in purpose to answer the objectives of this research. The conclusions for this research are:

1. The different level of inventory will create different policy for delivery quantity. If the level of inventory divided with average sales for each warehouse gain a value less than 1.5 days / 2 days / 2.5 days, the delivery quantity equal with sales target multiplied with "k" value. The "k" value for 1.5 days/ 2 days/ 2.5 days can be seen on the subchapter 4.5.
2. The lost sales occurred while implementing existing model was higher than all the scenarios. The lowest loss sales occurred in scenario 3 and gained about 99.95% efficiency in reducing shortage product.
3. The simulation has shown a suggestion for warehouse size on each scenario. The 3rd scenario was selected as the best result and detail information of warehouse size was shown in APPENDIX 4.

6.2. Recommendation

Consider the conclusion and all the result of simulation, the recommendation that can be improved for future research are:

1. Collecting more detail data on each warehouse related with the resource, & the exact unloading time (include the distribution)
2. Consider the another cost that can be implemented as the objectives such as order cost, the variable cost for every departure (Ex: Sallary per km, budget for gas & oil, etc)

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APPENDIX 1 : SIMULATION RESULT FOR EXISTING

District	City	Warehouse	Average SL	Size WH (zak)	Inventory Cost	Existing Size (zak)	Utilization Size	Suggest Size (m^2)	Average Inventory	Average Inv.DoS
Kudus	Lasem	KWSG	97%	516	1,275,768	-	-	6.24	95	0.42
		Sekawan Niaga Jaya	99%	213	706,401	-	-	2.58	52	0.57
	Rembang	KWSG	98%	5036	13,222,714	27959	18%	60.94	979	0.43
		Sekawan Niaga Jaya	98%	249	651,921	-	-	3.01	48	0.43
	Kudus	KWSG	97%	5114	12,793,747	22928.99408	22%	61.88	948	0.41
	Jepara	KWSG	96%	1935	5,289,041	41538	5%	23.41	392	0.46
		Varia Usaha	96%	1961	4,891,179	18225	11%	23.73	362	0.40
	Blora	Varia Usaha	97%	6326	17,004,341	32663	19%	76.54	1260	0.44
		Sekawan Niaga Jaya	98%	5631	16,056,826	38314	15%	68.14	1189	0.46
	Cepu	Varia Usaha	97%	2514	5,922,247	12676	20%	30.42	439	0.38
		Sekawan Niaga Jaya	98%	1903	5,062,167	12426	15%	23.03	375	0.44
	Pati	Varia Usaha	98%	3855	10,754,433	28757	13%	46.65	797	0.46
		Sekawan	98%	963		48521	2%	11.65	195	0.44

District	City	Warehouse	Average SL	Size WH (zak)	Inventory Cost	Existing Size (zak)	Utilization Size	Suggest Size (m^2)	Average Inventory	Average Inv.DoS
		Niaga Jaya			2,630,022					
	Purwodadi	Varia Usaha	98%	3508	9,423,000	50888	7%	42.45	698	0.45
		Hasil Anugrah	97%	8662	22,038,288	38817	22%	104.81	1632	0.43
	Juwana	Sekawan Niaga Jaya	97%	132	320,412	-	-	1.60	24	0.39
Semarang	Salatiga	Bangunan Jaya	88%	14546	14,576,745	45266	32%	176.01	1080	0.15
	Semarang	KWSG	90%	12098	12,768,041	40030	30%	146.39	946	0.16
		Varia Usaha	88%	7837	7,320,810	35947	22%	94.83	542	0.14
		Sekawan Niaga Jaya	88%	7994	8,500,266	76331.36095	10%	96.73	630	0.16
	Ambarawa	KWSG	88%	5196	5,400,555	15384.61538	34%	62.87	400	0.15
		Varia Usaha	88%	372	410,585	-	-	4.50	30	0.16
	Demak	Varia Usaha	89%	189	145,356	-	-	2.29	11	0.12
		Sekawan Niaga Jaya	90%	2160	1,955,540	27514.7929	8%	26.14	145	0.13
	Ungaran	Varia Usaha	89%	9290	10,493,125	32100.59172	29%	112.41	777	0.17
		Sekawan	79%	216		-	-	2.61	9	0.08

District	City	Warehouse	Average SL	Size WH (zak)	Inventory Cost	Existing Size (zak)	Utilization Size	Suggest Size (m^2)	Average Inventory	Average Inv.DoS
		Niaga Jaya			118,060					
	Weleri	Varia Usaha	86%	928	844,138	23964.49704	4%	11.23	63	0.14
		Sekawan Niaga Jaya	89%	3057	4,367,195	48520.71006	6%	36.99	323	0.21
	Kendal	Sekawan Niaga Jaya	85%	3024	2,439,284	-	-	36.59	181	0.12
Solo	Sragen	KWSG	98%	4732	13,823,334	36875.73964	13%	57.26	1024	0.50
		Kebakramat Elang	99%	6812	21,966,941	36390.53254	19%	82.43	1627	0.56
	Surakarta	Kebakramat Elang	99%	1463	4,802,079	-	-	17.70	356	0.57
		Setia Tunggal	98%	2089	6,486,399	16775.14793	12%	25.28	480	0.53
	Gemolong	Kebakramat Elang	97%	262	801,826	-	-	3.17	59	0.54
	Karanganyar	KWSG	98%	5057	15,084,715	42455.6213	12%	61.19	1117	0.51
		VARIA USAHA	98%	7490	22,530,686	91715.97633	8%	90.63	1669	0.51
		Kebakramat Elang	98%	9704	30,072,785	52810.65089	18%	117.42	2228	0.53
	Sukoharjo	Varia Usaha	98%	2490	7,434,321	32662.72189	8%	30.13	551	0.52
		Kebakramat	97%	2129		-	-	25.76	475	0.51

District	City	Warehouse	Average SL	Size WH (zak)	Inventory Cost	Existing Size (zak)	Utilization Size	Suggest Size (m^2)	Average Inventory	Average Inv.DoS
		Elang			6,413,277					
		Setia Tunggal	97%	188	538,705	-	-	2.27	40	0.49
	Boyolali	KWSG	97%	5813	15,042,625	38816.56805	15%	70.34	1114	0.51
		Varia Usaha	98%	4019	12,305,047	36390.53254	11%	48.63	911	0.52
		Kebakramat Elang	98%	6797	19,175,622	18639.05325	36%	82.24	1420	0.50
	Wonogiri	Kebakramat Elang	97%	8347	24,587,827	22928.99408	36%	101.00	1821	0.51
	Purwantoro	Kebakramat Elang	98%	1183	3,332,762	-	-	14.31	247	0.53
	Klaten	Varia Usaha	97%	6433.12225	18,658,442	22928.99408	28%	77.84	1382	0.51
		Setia Tunggal	96%	16757	48,411,000	32100.59172	52%	202.76	3586	0.50
DIY	Purworejo	KWSG	97%	5267	13,855,845	32100.59172	16%	63.73	1026	0.51
		Setia Cahaya Sarana	95%	3647	10,179,592	26005.91716	14%	44.13	754	0.49
	Magelang	KWSG	96%	3598.354139	10,269,690	13313.60947	27%	43.54	761	0.51
		Setia Cahaya Sarana	95%	1921	5,098,562	22928.99408	8%	23.24	378	0.46
	Temang	KWSG	96%	3095.175		17011.8343	18%	37.45	592	0.52

District	City	Warehouse	Average SL	Size WH (zak)	Inventory Cost	Existing Size (zak)	Utilization Size	Suggest Size (m^2)	Average Inventory	Average Inv.DoS
	gung			283	7,989,818	2				
		Setia Cahaya Sarana	94%	675	1,764,653	-	-	8.17	131	0.54
	Sleman	KWSG	96%	2630	7,330,833	15532.54438	17%	31.82	543	0.48
		Setia Cahaya Sarana	96%	3226	10,153,701	36390.53254	9%	39.03	752	0.54
	Bantul	KWSG	96%	8191	21,433,488	49704.14201	16%	99.11	1588	0.47
		Varia Usaha	97%	9300	22,792,549	24852.07101	37%	112.53	1688	0.45
		Setia Cahaya Sarana	96%	6289	16,931,478	-	-	76.10	1254	0.47
	Kulonprogo	KWSG	96%	2189	5,555,749	15976.33136	14%	26.49	412	0.51
		Varia Usaha	93%	2433	5,738,573	6508.87574	37%	29.44	425	0.46
	Wonosari	KWSG	97%	6060	16,951,562	23964.49704	25%	73.33	1256	0.49
	Gunung kidul	Setia Cahaya Sarana	97%	4337	11,248,496	29349.11243	15%	52.48	833	0.49
Tegal	Pekalongan	KWSG	96%	6332	18,030,082	17707.10059	36%	76.62	1336	0.52
		Sekawan Niaga Jaya	94%	136	359,137	-	-	1.65	27	0.52
	Pemalan	KWSG	96%	5184.154		8136.09467	64%	62.73	1126	0.52

District	City	Warehouse	Average SL	Size WH (zak)	Inventory Cost	Existing Size (zak)	Utilization Size	Suggest Size (m^2)	Average Inventory	Average Inv.DoS
	g			028	15,194,342	5				
	Tegal	KWSG	97%	4271	12,207,551	52810.65089	8%	51.68	904	0.55
		Sekawan Niaga Jaya	96%	2975	8,371,701	12071.00592	25%	36.00	620	0.52
	Brebes	KWSG	95%	3103	7,783,693	8875.739645	35%	37.55	577	0.51
	Batang	Sekawan Niaga Jaya	95%	4605.279908	12,371,659	5207.100592	88%	55.72	916	0.51
Purwokerto	Kebumen	KWSG	98%	3576	9,274,981	20236.68639	18%	43.27	687	0.67
		Sahabat	98%	144	527,942	-	-	1.74	39	0.93
	Banjarnegara	KWSG	97%	3018	9,012,156	16215.97633	19%	36.52	668	0.69
		Sahabat	98%	125	545,252	-	-	1.51	40	1.03
	Purbalingga	KWSG	95%	248.9791788	705,551	-	-	3.01	52	0.71
		Sahabat	96%	140	480,082	-	-	1.69	36	0.86
	Purwokerto	KWSG	98%	3969	12,174,781	77633.13609	5%	48.02	902	0.69
		Sahabat	99%	9601	29,052,962	90532.54438	11%	116.17	2152	0.67
	Banyum	KWSG	98%	252		-	-	3.05	61	0.84

District	City	Warehouse	Average SL	Size WH (zak)	Inventory Cost	Existing Size (zak)	Utilization Size	Suggest Size (m^2)	Average Inventory	Average Inv.DoS
	as				828,123					
	Majenang	KWSG	98%	2177	6,349,142	18491.12426	12%	26.34	470	0.69
		Sahabat	98%	2623	7,696,590	35048.07692	7%	31.74	570	0.68
	Wonosobo	KWSG	98%	3475	12,219,201	-	-	42.05	905	0.73
		Sahabat	99%	117	460,775	-	-	1.42	34	0.81
	Cilacap	KWSG	99%	5105	16,920,604	25221.89349	20%	61.77	1253	0.76
			95%		816,711,497					0.48

APPENDIX 2 : SIMULATION RESULT FOR SCENARIO 1

District	City	Warehouse	Average SL	Size WH (zak)	Inventory Cost	Existing Size (zak)	Utilization Size	Suggest Size (m^2)	Average Inventory	Average Inv.DoS
Kudus	Lasem	KWSG	100%	690	3,426,374	-	-	8.35	254	1.11
		Sekawan Niaga Jaya	100%	282	1,491,805	-	-	3.41	111	1.21
	Rembang	KWSG	100%	6810	33,802,632	27959	24%	82.40	2504	1.10
		Sekawan Niaga Jaya	100%	323	1,448,753	-	-	3.91	107	0.96
	Kudus	KWSG	100%	7305	36,429,805	22929	32%	88.39	2699	1.16
	Jepara	KWSG	100%	2614	12,808,356	41538	6%	31.63	949	1.11
		Varia Usaha	100%	2683	13,369,142	18225	15%	32.46	990	1.10
	Blora	Varia Usaha	100%	8659	42,588,099	32663	27%	104.77	3155	1.10
		Sekawan Niaga Jaya	100%	7493	36,309,526	38314	20%	90.67	2690	1.04
	Cepu	Varia Usaha	100%	3384	17,437,858	12676	27%	40.95	1292	1.12
		Sekawan Niaga Jaya	100%	2589	13,047,879	12426	21%	31.33	967	1.12
	Pati	Varia Usaha	100%	5199	25,556,129	28757	18%	62.91	1893	1.10
		Sekawan	100%	1356		48521	3%	16.41	519	1.18

District	City	Warehouse	Average SL	Size WH (zak)	Inventory Cost	Existing Size (zak)	Utilization Size	Suggest Size (m^2)	Average Inventory	Average Inv.DoS
		Niaga Jaya			7,002,505					
	Purwodadi	Varia Usaha	100%	4461	20,046,132	50888	9%	53.98	1485	0.95
		Hasil Anugrah	100%	11490	55,103,005	38817	30%	139.03	4082	1.07
	Juwana	Sekawan Niaga Jaya	100%	179	774,049	-	-	2.17	57	0.92
Semarang	Salatiga	Bangunan Jaya	99%	19990	82,114,878	45266	44%	241.88	6083	0.84
	Semarang	KWSG	99%	16502	74,268,937	40030	41%	199.67	5501	0.91
		Varia Usaha	99%	10611	35,835,140	35947	30%	128.39	2654	0.68
		Sekawan Niaga Jaya	96%	10478	26,638,163	76331	14%	126.78	1973	0.49
	Ambarawa	KWSG	99%	7152	28,149,756	15385	46%	86.54	2085	0.80
		Varia Usaha	98%	500	1,839,810	-	-	6.05	136	0.73
	Demak	Varia Usaha	99%	263	985,389	-	-	3.18	73	0.78
		Sekawan Niaga Jaya	99%	2851	8,741,971	27515	10%	34.50	648	0.60
	Ungaran	Varia Usaha	99%	12657	49,749,164	32101	39%	153.15	3685	0.79
		Sekawan	93%	263		-	-	3.18	44	0.41

District	City	Warehouse	Average SL	Size WH (zak)	Inventory Cost	Existing Size (zak)	Utilization Size	Suggest Size (m^2)	Average Inventory	Average Inv.DoS
		Niaga Jaya			594,370					
	Weleri	Varia Usaha	97%	1270	5,203,492	23964	5%	15.37	385	0.83
		Sekawan Niaga Jaya	98%	4101	13,857,547	48521	8%	49.62	1026	0.68
	Kendal	Sekawan Niaga Jaya	96%	3890	11,415,341	-	-	47.07	846	0.56
Solo	Sragen	KWSG	100%	6477	32,559,892	36876	18%	78.37	2412	1.18
		Kebakramat Elang	99%	8976	43,428,058	36391	25%	108.61	3217	1.10
	Surakarta	Kebakramat Elang	100%	1958	10,140,978	-	-	23.69	751	1.20
		Setia Tunggal	100%	2728	13,555,553	16775	16%	33.01	1004	1.11
	Gemolong	Kebakramat Elang	100%	348	1,607,277	-	-	4.21	119	1.08
	Karanganyar	KWSG	100%	7073	36,763,977	42456	17%	85.58	2723	1.25
		VARIA USAHA	100%	10282	51,562,344	91716	11%	124.41	3819	1.18
		Kebakramat Elang	100%	13128	66,029,462	52811	25%	158.85	4891	1.17
	Sukoharjo	Varia Usaha	100%	3417	17,155,689	32663	10%	41.35	1271	1.21
		Kebakramat	100%	2948		-	-	35.67	1081	1.15

District	City	Warehouse	Average SL	Size WH (zak)	Inventory Cost	Existing Size (zak)	Utilization Size	Suggest Size (m^2)	Average Inventory	Average Inv.DoS
		Elang			14,590,245					
		Setia Tunggal	100%	240	1,117,319	-	-	2.90	83	1.01
	Boyolali	KWSG	100%	6880	33,974,359	38817	18%	83.25	2517	1.16
		Varia Usaha	100%	5445	26,813,700	36391	15%	65.88	1986	1.13
		Kebakramat Elang	100%	8511	43,278,004	18639	46%	102.98	3206	1.14
	Wonogiri	Kebakramat Elang	100%	13081	60,564,033	22929	57%	158.28	4486	1.25
	Purwantoro	Kebakramat Elang	100%	1443	6,937,964	-	-	17.46	514	1.09
	Klaten	Varia Usaha	100%	8291	40,615,804	22929	36%	100.32	3009	1.11
		Setia Tunggal	100%	22341	112,687,570	32101	70%	270.33	8347	1.16
DIY	Purworejo	KWSG	100%	6101	29,278,615	32101	19%	73.82	2169	1.08
		Setia Cahaya Sarana	100%	4687	21,760,299	26006	18%	56.71	1612	1.04
	Magelang	KWSG	100%	4732	22,406,116	13314	36%	57.26	1660	1.10
		Setia Cahaya Sarana	100%	2583	13,114,233	22929	11%	31.25	971	1.19
	Temang	KWSG	99%	3806		17012	22%	46.05	1303	1.15

District	City	Warehouse	Average SL	Size WH (zak)	Inventory Cost	Existing Size (zak)	Utilization Size	Suggest Size (m^2)	Average Inventory	Average Inv.DoS
	gung				17,587,356					
		Setia Cahaya Sarana	99%	771	3,501,752	-	-	9.33	259	1.06
	Sleman	KWSG	99%	3608	17,461,788	15533	23%	43.66	1293	1.15
		Setia Cahaya Sarana	99%	4477	21,430,603	36391	12%	54.17	1587	1.15
	Bantul	KWSG	100%	12399	51,804,160	49704	25%	150.03	3837	1.13
		Varia Usaha	100%	11828	54,887,412	24852	48%	143.12	4066	1.09
		Setia Cahaya Sarana	100%	9771	37,875,415	-	-	118.23	2806	1.04
	Kulonprogo	KWSG	100%	2831	12,918,723	15976	18%	34.26	957	1.17
		Varia Usaha	99%	2978	12,156,251	6509	46%	36.03	900	0.97
	Wonosari	KWSG	100%	8266	40,980,415	23964	34%	100.02	3036	1.18
	Gunung kidul	Setia Cahaya Sarana	100%	5383	25,108,632	29349	18%	65.13	1860	1.09
Tegal	Pekalongan	KWSG	100%	8283	37,710,678	17707	47%	100.22	2793	1.09
		Sekawan Niaga Jaya	98%	196	739,874	-	-	2.37	55	1.06
	Pemalan	KWSG	100%	7320		8136	90%	88.57	2437	1.12

District	City	Warehouse	Average SL	Size WH (zak)	Inventory Cost	Existing Size (zak)	Utilization Size	Suggest Size (m^2)	Average Inventory	Average Inv.DoS
	g				32,893,249					
	Tegal	KWSG	100%	5386	26,279,137	52811	10%	65.17	1947	1.18
		Sekawan Niaga Jaya	100%	4294	19,178,840	12071	36%	51.96	1421	1.19
	Brebes	KWSG	99%	4236.587332	16,051,907	8876	48%	51.26	1189	1.06
	Batang	Sekawan Niaga Jaya	99%	5538	25,569,518	5207	106%	67.01	1894	1.05
Purwokerto	Kebumen	KWSG	100%	4183.628077	18,192,785	20237	21%	50.62	1348	1.31
		Sahabat	100%	199	945,629	-	-	2.41	70	1.67
	Banjarnegara	KWSG	100%	3806	16,166,786	16216	23%	46.05	1198	1.25
		Sahabat	100%	181	958,204	-	-	2.19	71	1.82
	Purbalingga	KWSG	99%	369	1,380,736	-	-	4.46	102	1.40
		Sahabat	100%	206	903,242	-	-	2.49	67	1.60
	Purwokerto	KWSG	100%	5031	21,979,627	77633	6%	60.88	1628	1.25
		Sahabat	100%	12421	58,719,637	90533	14%	150.29	4350	1.36
	Banyum	KWSG	99%	306		-	-	3.70	100	1.37

District	City	Warehouse	Average SL	Size WH (zak)	Inventory Cost	Existing Size (zak)	Utilization Size	Suggest Size (m^2)	Average Inventory	Average Inv.DoS
	as				1,356,251					
	Majenang	KWSG	100%	3209	11,834,729	18491	17%	38.83	877	1.28
		Sahabat	100%	3828	15,908,659	35048	11%	46.32	1178	1.40
	Wonosobo	KWSG	100%	4943	22,813,816	-	-	59.81	1690	1.37
		Sahabat	100%	192	912,711	-	-	2.32	68	1.62
	Cilacap	KWSG	100%	6205	30,858,411	25222	25%	75.08	2286	1.39
			99.37%		IDR 2,017,044,432					1.10

APPENDIX 3 : SIMULATION RESULT FOR SCENARIO 2

District	City	Warehouse	Average SL	Size WH (zak)	Inventory Cost	Existing Size (zak)	Utilization Size	Suggest Size (m^2)	Average Inventory	Average Inv.DoS
Kudus	Lasem	KWSG	100%	779	4,508,371	-	-	9.43	334	1.46
		Sekawan Niaga Jaya	100%	347	2,220,658	-	-	4.20	164	1.78
	Rembang	KWSG	100%	7862	47,912,721	27959	28%	95.13	3549	1.56
		Sekawan Niaga Jaya	100%	386	2,313,900	-	-	4.67	171	1.53
	Kudus	KWSG	100%	8325	50,265,567	22929	36%	100.73	3723	1.60
	Jepara	KWSG	100%	3045	17,609,141	41538	7%	36.84	1304	1.53
		Varia Usaha	100%	3152	18,047,540	18225	17%	38.14	1337	1.48
	Blora	Varia Usaha	100%	10117	59,740,200	32663	31%	122.42	4425	1.54
		Sekawan Niaga Jaya	100%	9304	56,881,418	38314	24%	112.58	4213	1.63
	Cepu	Varia Usaha	100%	3935	22,566,008	12676	31%	47.61	1672	1.45
		Sekawan Niaga Jaya	100%	3068	18,963,025	12426	25%	37.12	1405	1.63
	Pati	Varia Usaha	100%	6161	36,914,881	28757	21%	74.55	2734	1.59
		Sekawan	100%	1599		48521	3%	19.35	716	1.62

District	City	Warehouse	Average SL	Size WH (zak)	Inventory Cost	Existing Size (zak)	Utilization Size	Suggest Size (m^2)	Average Inventory	Average Inv.DoS
		Niaga Jaya			9,671,918					
	Purwodadi	Varia Usaha	100%	5490	33,155,778	50888	11%	66.43	2456	1.57
		Hasil Anugrah	100%	13596	86,216,881	38817	35%	164.51	6386	1.67
	Juwana	Sekawan Niaga Jaya	100%	199	1,073,675	-	-	2.41	80	1.29
Semarang	Salatiga	Bangunan Jaya	99%	23145	118,017,222	45266	51%	280.05	8742	1.20
	Semarang	KWSG	98%	18752	74,771,137	40030	47%	226.90	5539	0.92
		Varia Usaha	99%	12398	60,070,155	35947	34%	150.02	4450	1.14
		Sekawan Niaga Jaya	100%	12960	68,007,970	76331	17%	156.82	5038	1.26
	Ambarawa	KWSG	99%	8521	43,033,266	15385	55%	103.10	3188	1.23
		Varia Usaha	100%	596	3,152,527	-	-	7.21	234	1.26
	Demak	Varia Usaha	100%	320	1,812,218	-	-	3.87	134	1.44
		Sekawan Niaga Jaya	99%	3407	16,809,978	27515	12%	41.22	1245	1.15
	Ungaran	Varia Usaha	99%	15060	71,244,789	32101	47%	182.23	5277	1.14
		Sekawan	96%	317		-	-	3.84	73	0.68

District	City	Warehouse	Average SL	Size WH (zak)	Inventory Cost	Existing Size (zak)	Utilization Size	Suggest Size (m^2)	Average Inventory	Average Inv.DoS
		Niaga Jaya			990,419					
	Weleri	Varia Usaha	97%	1453	5,843,947	23964	6%	17.58	433	0.93
		Sekawan Niaga Jaya	100%	4831	24,266,268	48521	10%	58.46	1798	1.19
	Kendal	Sekawan Niaga Jaya	100%	4828	24,618,341	-	-	58.42	1824	1.21
Solo	Sragen	KWSG	100%	7574	45,674,495	36876	21%	91.65	3383	1.65
		Kebakramat Elang	100%	10702	66,541,130	36391	29%	129.49	4929	1.69
	Surakarta	Kebakramat Elang	100%	2247	13,910,178	-	-	27.19	1030	1.65
		Setia Tunggal	100%	3335	20,991,945	16775	20%	40.35	1555	1.72
	Gemolong	Kebakramat Elang	100%	397	2,305,245	-	-	4.80	171	1.55
	Karanganyar	KWSG	100%	7988	49,628,330	42456	19%	96.65	3676	1.69
		VARIA USAHA	100%	12085	74,172,144	91716	13%	146.23	5494	1.69
		Kebakramat Elang	100%	15399	95,885,951	52811	29%	186.33	7103	1.70
	Sukoharjo	Varia Usaha	100%	3717	23,368,278	32663	11%	44.98	1731	1.64
		Kebakramat	100%	3439		-	-	41.61	1582	1.68

District	City	Warehouse	Average SL	Size WH (zak)	Inventory Cost	Existing Size (zak)	Utilization Size	Suggest Size (m^2)	Average Inventory	Average Inv.DoS
		Elang			21,350,675					
		Setia Tunggal	100%	286	1,586,490	-	-	3.46	118	1.44
	Boyolali	KWSG	100%	7905	47,541,711	38817	20%	95.65	3522	1.62
		Varia Usaha	100%	6455	39,506,104	36391	18%	78.11	2926	1.67
		Kebakramat Elang	100%	10571	64,088,975	18639	57%	127.91	4747	1.68
	Wonogiri	Kebakramat Elang	100%	13218	81,017,310	22929	58%	159.94	6001	1.67
	Purwantoro	Kebakramat Elang	100%	1760	11,052,579	-	-	21.30	819	1.74
	Klaten	Varia Usaha	100%	10605	62,224,903	22929	46%	128.32	4609	1.69
		Setia Tunggal	100%	25792	153,785,195	32101	80%	312.08	11391	1.58
DIY	Purworejo	KWSG	100%	7449	43,427,984	32101	23%	90.13	3217	1.60
		Setia Cahaya Sarana	100%	6646	34,034,832	26006	26%	80.42	2521	1.63
	Magelang	KWSG	100%	5578	32,619,329	13314	42%	67.49	2416	1.61
		Setia Cahaya Sarana	100%	3091	18,906,695	22929	13%	37.40	1400	1.72
	Temang	KWSG	100%	4071		17012	24%	49.26	1831	1.62

District	City	Warehouse	Average SL	Size WH (zak)	Inventory Cost	Existing Size (zak)	Utilization Size	Suggest Size (m^2)	Average Inventory	Average Inv.DoS
	gung				24,717,797					
		Setia Cahaya Sarana	100%	978.3520302	5,624,100	-	-	11.84	417	1.71
	Sleman	KWSG	100%	4165	25,120,874	15533	27%	50.40	1861	1.65
		Setia Cahaya Sarana	100%	5113	30,524,905	36391	14%	61.87	2261	1.63
	Bantul	KWSG	100%	12359	72,352,788	49704	25%	149.54	5359	1.58
		Varia Usaha	100%	15248	81,363,538	24852	61%	184.50	6027	1.62
		Setia Cahaya Sarana	100%	10894	56,210,856	-	-	131.82	4164	1.55
	Kulonprogo	KWSG	100%	2966	17,399,133	15976	19%	35.89	1289	1.58
		Varia Usaha	100%	3506	19,623,045	6509	54%	42.42	1454	1.57
	Wonosari	KWSG	100%	9601	57,920,733	23964	40%	116.17	4290	1.67
	Gunung kidul	Setia Cahaya Sarana	100%	6219	37,477,886	29349	21%	75.25	2776	1.62
Tegal	Pekalongan	KWSG	100%	10830	57,237,337	17707	61%	131.04	4240	1.66
		Sekawan Niaga Jaya	100%	191	1,094,721	-	-	2.31	81	1.56
	Pemalan	KWSG	100%	8484		8136	104%	102.66	3390	1.56

District	City	Warehouse	Average SL	Size WH (zak)	Inventory Cost	Existing Size (zak)	Utilization Size	Suggest Size (m^2)	Average Inventory	Average Inv.DoS
	g				45,771,325					
	Tegal	KWSG	100%	6322	36,204,263	52811	12%	76.50	2682	1.62
		Sekawan Niaga Jaya	100%	4682	26,259,534	12071	39%	56.65	1945	1.62
	Brebes	KWSG	100%	4454	23,135,338	8876	50%	53.89	1714	1.52
	Batang	Sekawan Niaga Jaya	100%	6814	40,119,559	5207	131%	82.45	2972	1.65
Purwokerto	Kebumen	KWSG	100%	4832	25,414,952	20237	24%	58.47	1883	1.83
		Sahabat	100%	227	1,308,095	-	-	2.75	97	2.31
	Banjarnegara	KWSG	100%	4450	24,037,175	16216	27%	53.85	1781	1.85
		Sahabat	100%	241	1,303,101	-	-	2.92	97	2.49
	Purbalingga	KWSG	100%	361	1,843,286	-	-	4.37	137	1.88
		Sahabat	100%	229	1,238,116	-	-	2.77	92	2.19
	Purwokerto	KWSG	100%	5897	30,788,877	77633	8%	71.35	2281	1.75
		Sahabat	100%	13707	74,670,793	90533	15%	165.85	5531	1.73
	Banyum	KWSG	100%	420		-	-	5.08	145	1.99

District	City	Warehouse	Average SL	Size WH (zak)	Inventory Cost	Existing Size (zak)	Utilization Size	Suggest Size (m^2)	Average Inventory	Average Inv.DoS
	as				1,959,238					
	Majenang	KWSG	100%	3230	16,600,784	18491	17%	39.08	1230	1.80
		Sahabat	100%	3772	20,682,222	35048	11%	45.64	1532	1.82
	Wonosobo	KWSG	100%	5039	29,412,468	-	-	60.97	2179	1.77
		Sahabat	100%	181	1,248,510	-	-	2.19	92	2.19
	Cilacap	KWSG	100%	7256	42,165,789	25222	29%	87.80	3123	1.90
			99.79%		2,915,151,534					1.60

APPENDIX 4 : SIMULATION RESULT FOR SCENARIO 3

District	City	Warehouse	Average SL	Size WH (zak)	Inventory Cost	Existing Size (zak)	Utilization Size	Suggest Size (m^2)	Average Inventory	Average Inv.DoS
Kudus	Lasem	KWSG	100%	958	6,802,595	-	-	11.59	504	2.21
		Sekawan Niaga Jaya	100%	413	3,107,848	-	-	5.00	230	2.50
	Rembang	KWSG	100%	9718	67,714,927	27959	35%	117.59	5016	2.20
		Sekawan Niaga Jaya	100%	457	3,057,399	-	-	5.53	226	2.02
	Kudus	KWSG	100%	9952	69,349,167	22929	43%	120.42	5137	2.20
	Jepara	KWSG	100%	3579	25,051,044	41538	9%	43.31	1856	2.17
		Varia Usaha	100%	3822	26,825,684	18225	21%	46.25	1987	2.20
	Blora	Varia Usaha	100%	12058	87,665,042	32663	37%	145.90	6494	2.26
		Sekawan Niaga Jaya	100%	10787	77,957,026	38314	28%	130.52	5775	2.23
	Cepu	Varia Usaha	100%	4813	34,518,279	12676	38%	58.24	2557	2.22
		Sekawan Niaga Jaya	100%	3625	25,035,916	12426	29%	43.86	1855	2.15
	Pati	Varia Usaha	100%	7403	51,081,522	28757	26%	89.58	3784	2.19
		Sekawan	100%	1848		48521	4%	22.36	980	2.22

District	City	Warehouse	Average SL	Size WH (zak)	Inventory Cost	Existing Size (zak)	Utilization Size	Suggest Size (m^2)	Average Inventory	Average Inv.DoS
		Niaga Jaya			13,234,179					
	Purwodadi	Varia Usaha	100%	6575	46,032,707	50888	13%	79.56	3410	2.19
		Hasil Anugrah	100%	16184	115,580,416	38817	42%	195.83	8562	2.23
	Juwana	Sekawan Niaga Jaya	100%	240	1,522,652	-	-	2.90	113	1.82
Semarang	Salatiga	Bangunan Jaya	100%	28546	196,609,340	45266	63%	345.41	14564	2.00
	Semarang	KWSG	100%	23876	160,566,041	40030	60%	288.90	11894	1.97
		Varia Usaha	100%	15371	108,822,797	35947	43%	185.99	8061	2.07
		Sekawan Niaga Jaya	100%	15896	112,044,600	76331	21%	192.34	8300	2.08
	Ambarawa	KWSG	100%	10206	70,383,785	15385	66%	123.49	5214	2.01
		Varia Usaha	100%	718	4,823,199	-	-	8.69	357	1.92
	Demak	Varia Usaha	100%	382	2,723,227	-	-	4.62	202	2.17
		Sekawan Niaga Jaya	100%	4253	30,620,885	27515	15%	51.46	2268	2.10
	Ungaran	Varia Usaha	100%	18182	127,411,705	32101	57%	220.00	9438	2.03
		Sekawan	100%	378		-	-	4.57	171	1.58

District	City	Warehouse	Average SL	Size WH (zak)	Inventory Cost	Existing Size (zak)	Utilization Size	Suggest Size (m^2)	Average Inventory	Average Inv.DoS
		Niaga Jaya			2,306,281					
	Weleri	Varia Usaha	100%	1844	12,785,721	23964	8%	22.31	947	2.04
		Sekawan Niaga Jaya	100%	5842	40,259,478	48521	12%	70.69	2982	1.97
	Kendal	Sekawan Niaga Jaya	100%	5901	40,850,667	-	-	71.40	3026	2.00
Solo	Sragen	KWSG	100%	8884	63,707,610	36876	24%	107.50	4719	2.30
		Kebakramat Elang	100%	12766	89,897,129	36391	35%	154.47	6659	2.29
	Surakarta	Kebakramat Elang	100%	2733	19,684,258	-	-	33.07	1458	2.33
		Setia Tunggal	100%	3928	27,331,878	16775	23%	47.53	2025	2.25
	Gemolong	Kebakramat Elang	100%	474	3,160,775	-	-	5.74	234	2.13
	Karanganyar	KWSG	100%	9640	67,078,245	42456	23%	116.64	4969	2.28
		VARIA USAHA	100%	14062	99,617,203	91716	15%	170.15	7379	2.27
		Kebakramat Elang	100%	18569	130,402,122	52811	35%	224.68	9659	2.31
	Sukoharjo	Varia Usaha	100%	4625	32,650,471	32663	14%	55.96	2419	2.30
		Kebakramat	100%	4086		-	-	49.44	2123	2.26

District	City	Warehouse	Average SL	Size WH (zak)	Inventory Cost	Existing Size (zak)	Utilization Size	Suggest Size (m^2)	Average Inventory	Average Inv.DoS
		Elang			28,656,801					
		Setia Tunggal	100%	339	2,216,996	-	-	4.10	164	2.00
	Boyolali	KWSG	100%	9603	65,983,229	38817	25%	116.20	4888	2.25
		Varia Usaha	100%	7641	53,337,834	36391	21%	92.46	3951	2.25
		Kebakramat Elang	100%	12402	84,364,385	18639	67%	150.06	6249	2.22
	Wonogiri	Kebakramat Elang	100%	17924	111,535,410	22929	78%	216.88	8262	2.29
	Purwantoro	Kebakramat Elang	100%	2080	14,631,855	-	-	25.17	1084	2.31
	Klaten	Varia Usaha	100%	11881	81,749,195	22929	52%	143.76	6055	2.22
		Setia Tunggal	100%	31792	224,434,097	32101	99%	384.68	16625	2.30
DIY	Purworejo	KWSG	100%	9450	60,446,084	32101	29%	114.35	4477	2.23
		Setia Cahaya Sarana	100%	7065	46,468,332	26006	27%	85.49	3442	2.22
	Magelang	KWSG	100%	6584	46,183,685	13314	49%	79.67	3421	2.27
		Setia Cahaya Sarana	100%	3705	24,741,062	22929	16%	44.83	1833	2.25
	Temang	KWSG	100%	5056		17012	30%	61.18	2521	2.23

District	City	Warehouse	Average SL	Size WH (zak)	Inventory Cost	Existing Size (zak)	Utilization Size	Suggest Size (m^2)	Average Inventory	Average Inv.DoS
	gung				34,033,389					
		Setia Cahaya Sarana	100%	1211	7,524,863	-	-	14.65	557	2.28
	Sleman	KWSG	100%	4976	34,109,433	15533	32%	60.21	2527	2.24
		Setia Cahaya Sarana	100%	6200	41,553,962	36391	17%	75.02	3078	2.22
	Bantul	KWSG	100%	16497.46796	100,257,473	49704	33%	199.62	7426	2.19
		Varia Usaha	100%	17242	108,308,947	24852	69%	208.63	8023	2.16
		Setia Cahaya Sarana	100%	12484	79,310,873	-	-	151.06	5875	2.19
	Kulonprogo	KWSG	100%	3953	24,571,110	15976	25%	47.83	1820	2.23
		Varia Usaha	100%	4040.704542	28,223,877	6509	62%	48.89	2091	2.25
	Wonosari	KWSG	100%	11716	80,150,462	23964	49%	141.76	5937	2.31
	Gunungkidul	Setia Cahaya Sarana	100%	7414	51,978,329	29349	25%	89.71	3850	2.25
Tegal	Pekalongan	KWSG	100%	11262	75,014,285	17707	64%	136.27	5557	2.18
		Sekawan Niaga Jaya	100%	226	1,495,504	-	-	2.73	111	2.13
	Pemalan	KWSG	100%	9922		8136	122%	120.06	4805	2.21

District	City	Warehouse	Averag e SL	Size WH (zak)	Inventory Cost	Existing Size (zak)	Utilization Size	Suggest Size (m^2)	Average Inventory	Average Inv.DoS
	g				64,867,056					
	Tegal	KWSG	100%	7724	49,042,282	52811	15%	93.46	3633	2.20
		Sekawan Niaga Jaya	100%	5533	36,041,523	12071	46%	66.95	2670	2.23
	Brebes	KWSG	100%	5267	33,091,607	8876	59%	63.73	2451	2.17
	Batang	Sekawan Niaga Jaya	100%	8094	54,174,205	5207	155%	97.94	4013	2.23
Purwok erto	Kebume n	KWSG	100%	6057	35,069,375	20237	30%	73.29	2598	2.53
		Sahabat	100%	262.3823 953	1,695,748	-	-	3.17	126	3.00
	Banjarne gara	KWSG	100%	4962	31,639,562	16216	31%	60.04	2344	2.44
		Sahabat	100%	281	1,668,859	-	-	3.40	124	3.18
	Purbalin gga	KWSG	100%	460	2,531,823	-	-	5.57	188	2.58
		Sahabat	100%	242	1,654,582	-	-	2.93	123	2.93
	Purwoke rto	KWSG	100%	6628	43,730,753	77633	9%	80.20	3239	2.49
		Sahabat	100%	16517	105,065,470	90533	18%	199.86	7783	2.44
	Banyum	KWSG	100%	472.8516		-	-	5.72	191	2.62

District	City	Warehouse	Average SL	Size WH (zak)	Inventory Cost	Existing Size (zak)	Utilization Size	Suggest Size (m^2)	Average Inventory	Average Inv.DoS
	as			418	2,577,242					
	Majenang	KWSG	100%	4018.394023	22,636,393	18491	22%	48.62	1677	2.45
		Sahabat	100%	4677	28,592,223	35048	13%	56.59	2118	2.52
	Wonosobo	KWSG	100%	7207	40,948,015	-	-	87.20	3033	2.46
		Sahabat	100%	223	1,673,852	-	-	2.70	124	2.95
	Cilacap	KWSG	100%	8336	56,118,242	25222	33%	100.87	4157	2.53
			99.99%		IDR 4,222,374,103					2.26

BIOGRAPHY

The author, Pius Doni Surya Gumilag was born in Jakarta, on August 21, 1994. The author went to SD Tarakanita Yogyakarta (2000-2003), SD Mardiyuana Depok (2003-2006), SMP Kolese Santo Yusuph Malang (2006-2007), SMP Santo Yoseph Denpasar (2008-2009), SMA Kolese DeBritto Yogyakarta (2009-2012), and Department of Industrial Engineering, 10 Nopember Institute of Technology in 2012.

The author interested with various activities inside the college life. There were several organizations that filled the author's life for about 4 years. The author had been joined the Industrial Engineering student association for 2 years, the catholic student association of ITS for 1 year, and become the assistant of Logistic and Supply Chain Laboratory on 4^{th} year of author's life. The activities of these organizations such as conduct an industrial engineering competition in scope of regional and international named INCHALL and IE GAMES, assisted several courses during the laboratory activity such as logistic management, production and inventory control, industrial planning, etc.

With his interest in industrial engineering, the author worked for his internship in the production line for spinning process in PT.SRITEX, Sukoharjo (Central Java). During the internship, the author was analyzing the needs of employees and suggests an improvement to reduce the worker turnover. The report title was "Improvement of Human Resource Management in Pt Sri Rejeki Isman, Tbk Using Hoq Method". The author can be contacted via email at doni_gumilang@yahoo.com.