# Decision of Delivery Quantity and Warehouse Size for Distributor: A Simulation Study

Pius Doni Surya Gumilang, Prof. Ir. I Nyoman Pujawan, M.Eng, Ph.D, CSCP
Teknik Industri, Fakultas Teknologi Industri, Institut Teknologi Sepuluh Nopember (ITS)
Jl. Arief Rahman Hakim, Surabaya 60111 Indonesia
*e-mail*: pujawan@ie.its.ac.id

**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 conluded 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 descrete-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, Descrete-Event Simulation, Warehouse Capacity & Fill-Rate, Holding Cost.**

## I. INTRODUCTION

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 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. PT.X need 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 with 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.

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.

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.

## II. RESEARCH METHODOLOGY

### A. 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.

### B. Data Processing & Fitting Distribution

All the data that have collected, then it will be 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 will be the same for every month.

The next step of calculation is determining the distribution for each data that will be 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 will be used as the updater of the existing condition of sales.

### C. 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 will be developed by using software of ARENA. This software will give a visualization of existing condition and also the impact after implementing the improvement. In the end of the research, At last, the model will measure the service level before and after improvement, and give a suggestion of warehouse size in term of maintaining the service level.

### D. Validation & Verification

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. Furthermore, the model can be concluded as verify if the model have followed the logic and correspond to the expectation.

### E. 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.

### F. Analysis & Result

The output of the model will determine 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 will 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 will consider the carrying cost.

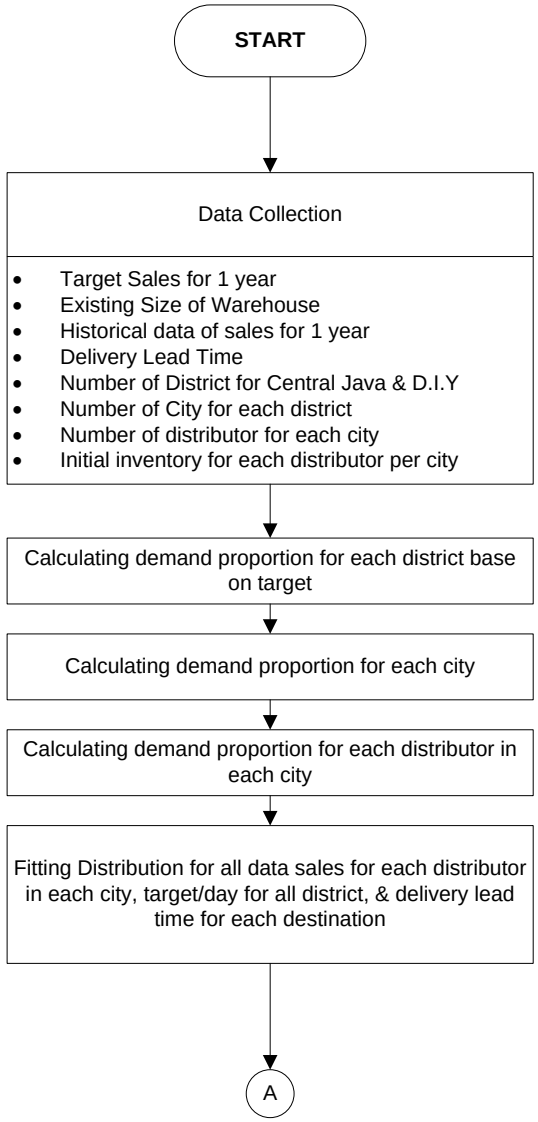


Figure 1. Flowchart of Research Methodology

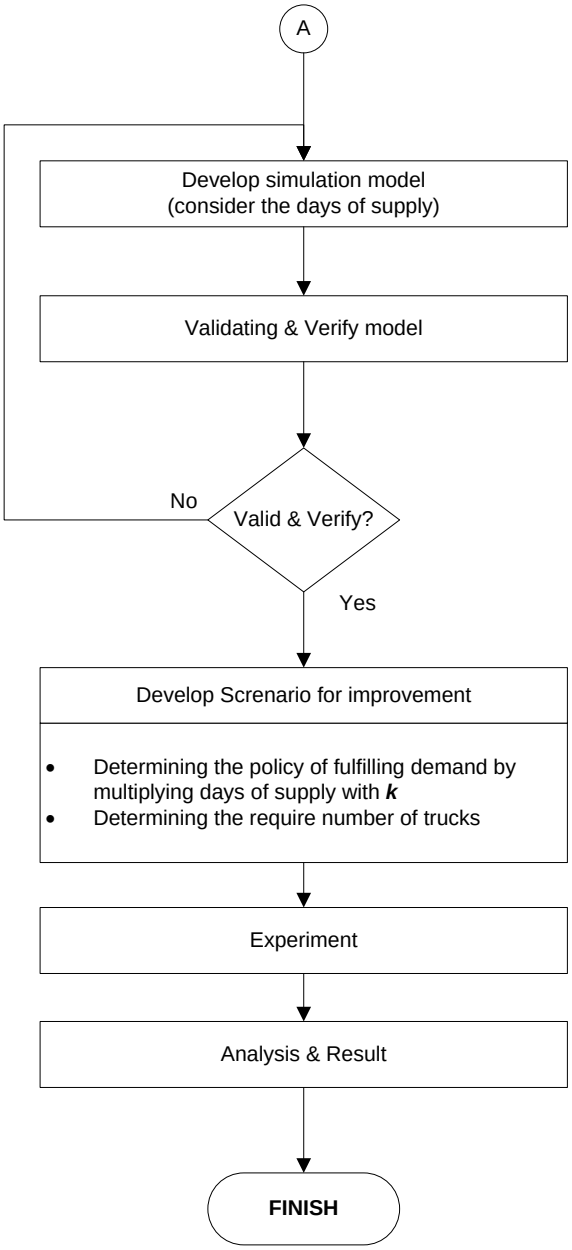


Figure 1. Flowchart of Research Methodology (con't)

## III. DATA COLLECTION AND PROCESSING

### A. 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 will periodically change for every month following the demand pattern in a certain season. The target should be divided into several districts, cities, and warehouses.

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 with 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 will know the target for each warehouse.

Table 1. Agregate Sales Target / month

| Month | Aggregate Sales (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 will show 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%.

### B. 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.

### C. Historical Sales Data

The model of this research will embrace 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 it will affect 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.

### D. 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 will 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.

E. Average Inventory Days of Supply & Service Level

Days of supply was used as the constraint of optimization in the simulation model. The optimization inside the simulation will 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.

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

The optimization that was calculated in the simulation will create 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 will affect the higher service level but it will gain higher cost due to the holding process. The value of fill rate can be determined by using this following equation:

$$Fill\ Rate = \frac{Fulfilled\ Demand}{Total\ Demand}$$

F. Verification & Validation

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 will be done by checking the error within the model.

Validation process was used to comparing the existing data with the result from the simulation. There were 2 data that will be 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.

G. Scenario Model Building

Regarding to the objective of this research, the model will come up with several decision such as policy of delivery quantity & suggestion for warehouse capacity / size. The decision will 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

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 will change the critical level and find 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 (> 0.5 days) and all the constraint had satisfied.

Table 2. Output Summary for all Scenarios

| Trigger DOS | Average SL | Holding Cost | Average Inv.Dos | Range Inv. Dos | Truck Needs | Constraint |
|---|---|---|---|---|---|---|
| < 1.5 days | 99.73 % | IDR 2,044,412,001 | 1.13 | 0.5 - 1.5 days | 504 | AvgInv > 0.5 & SL > 0.85 |
| < 2 days | 99.93 % | IDR 3,058,986,563 | 1.65 | 1 - 2 days | 528 | AvgInv >1 & SL > 0.85 |
| < 2.5 days | 100% | IDR 4,299,860,330 | 2.30 | 1.5-2.5 days | 600 | AvgInv>1.5 & SL > 0.85 |

The following figure will explain 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.

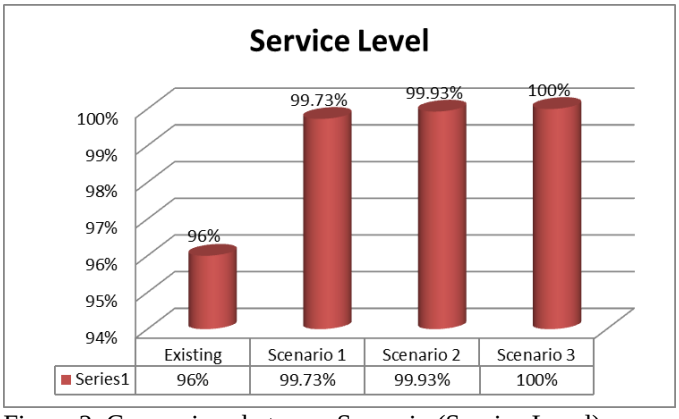


Figure 2. Comparison between Scenario (Service Level)

The other measurement from the output was total cost (holding cost). Along with the increment of service level, the total cost will 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.

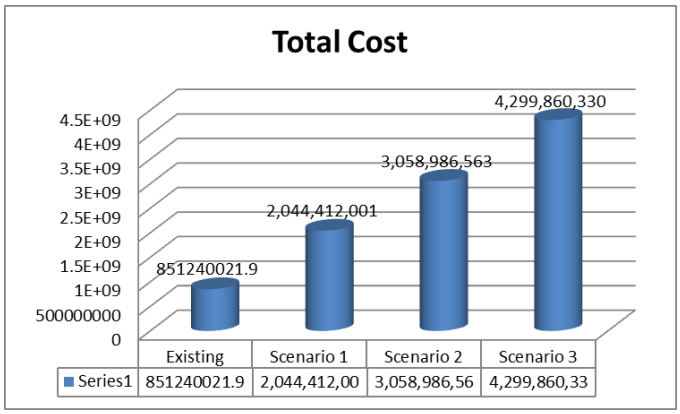


Figure 3. Comparison between Scenario (Total Cost)

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 will create 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.

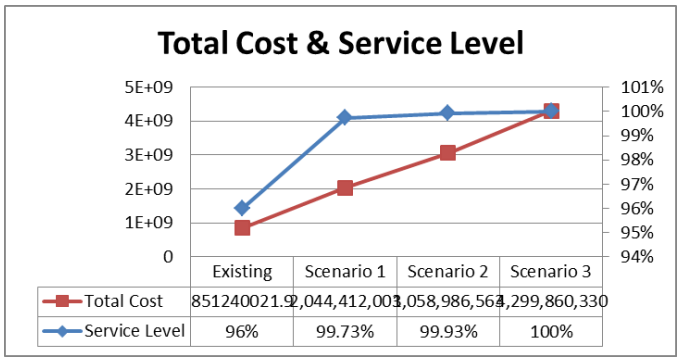


Figure 4. Comparison between Total Cost & Service Level

## IV. CONCLUSION/SUMMARY

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 model built in this research leads the company to consider the policy of delivery quantity if the condition on the days of supply below the certain condition. The policy for each warehouse will be different base on the criticality that was used. Previously, there were 3 value of critical level which below 1.5 days, 2 days, and 2.5 days. On each critical level, there will be a combination of "k" variable that will become the multiplier of the target and become the policy if the critical level below the desire one. This process will affect the total holding cost, the average inventory days of supply, and also the service level. The model built also give a different suggestion of truck needs on each critical level. Regarding to each scenario, the scenario that should be implemented was scenario 2. This scenario was better on the service level rather than scenario 1 and better on the total cost rather than scenario 3. The average inventory day of supply for scenario 2 was also better in order to prevent the uncertain demand. In conclusion, the 1st scenario still have low average inventory days of supply which make it risky. In the opposite, the 3rd scenario was very costly compare with the others.

2. The simulation result was showing a various types of data. One specific data that become a consideration was the utilization and suggested size of warehouse. The utilization was used to evaluate the condition of existing warehouse and the suggested size was used to give a suggestion to the company which has no existing data of warehouse capacity. From the different critical level, the utilization for each warehouse will tend to increase which it was good if it compares to the existing model. The existing model creates lower utilization than the result of each scenario. The utilization and suggested size was shown at the appendix 2-3 for each scenario.

## BIBLIOGRAPHY


Arief, M. M., 2014. *An Integrated Planning and Storage Capacity: A Simulation Study.* Surabaya: ITS.

Arnold, J. T., Chapman, S. M. & Clive, L. M., 2008. *Introduction to Material Management.* New Jersey: CGS Book Service.

Cristina, E., 2014. *Penentuan Keputusan Pengiriman Berbasis Informasi Stock Criticality dan Segmentasi Waktu Kirim.* Surabaya: ITS.

Daskin, M. S., 1995. *Network and Descreate Location-Models, Algorithm, and Application.* Canada: John Wiley & Sons, Inc.

Kelton, D. W., Sadowki, R. & Sturrock, D. T., 2007. *K.E Case & P.M. Wolfie Simulation With Arena.* NewYork: McGraw-Hill: s.n.

Olmedo, M. T. C., Pontius Jr, R. G., Paegelow, M. & Mas, J. F., 2015. Comparison of simulation models in terms of quantity and allocation. *Environmental Modelling & Software*, Issue 69, pp. 214-221.

Pujawan, I. N. & ER, M., 2010. *Supply Chain Management.* 2nd ed. Surabaya: Penerbit Guna Widya.

Slack, N., 1987. The Flexibility of manufacturing system. *Int J Oper Prod Manag*, Issue 7, pp. 35-45.

Vickery, S., Calantone, R. & Droge, C., 1999. Supply Chain Flexibility, an emphirical study. *J Suppy chain manag*, Issue 35, pp. 16-24.

Wang, H., Mastragostino, R. & Swartz, C. L., 2015. Flexibility analysis of process supply chain networks. *Computers & Chemical Engineering*, Issue 84, pp. 409-421.

Waters, D., 2007. *Inventory Control & Management.* 2nd ed. London: British Library.