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

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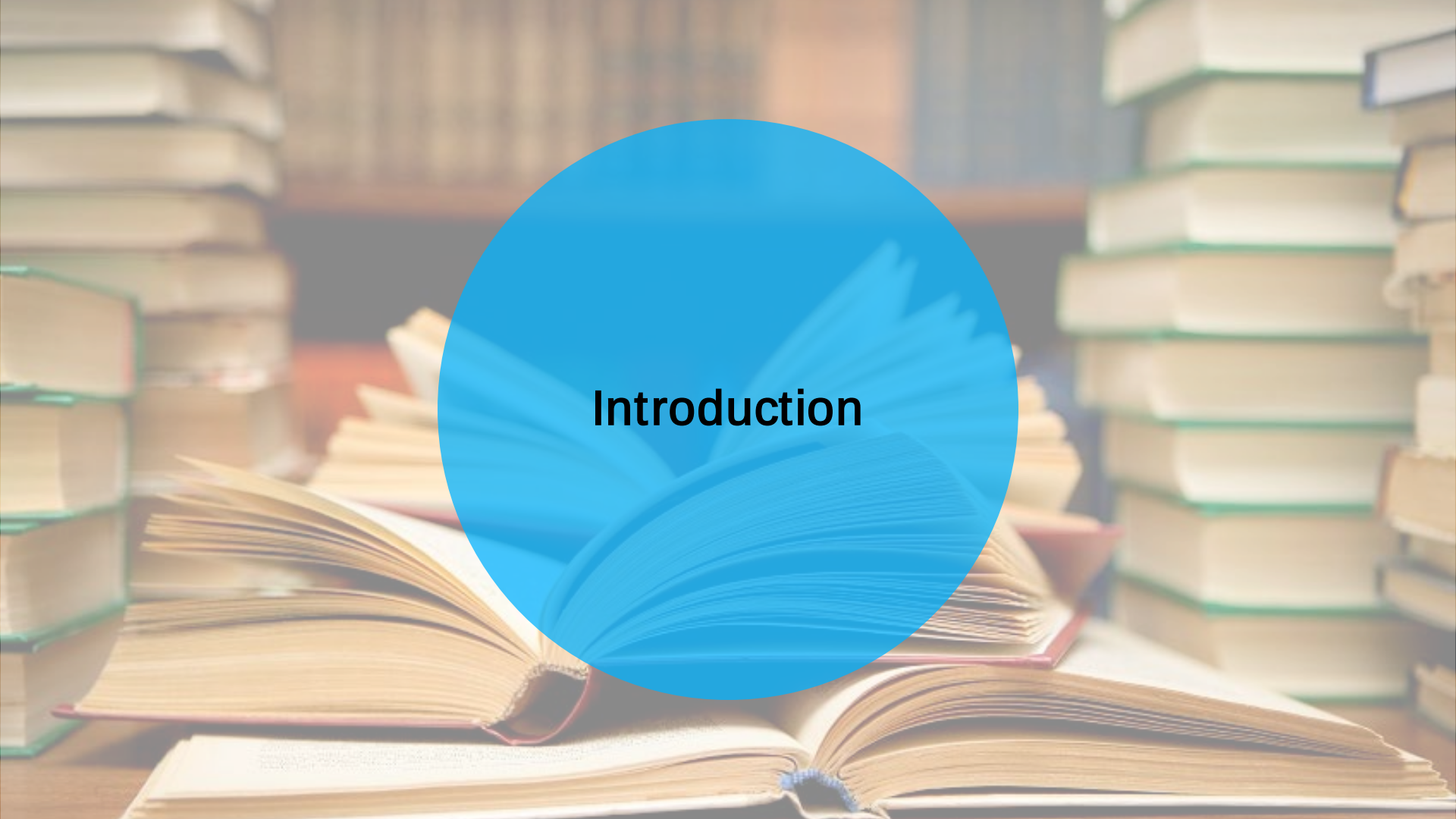
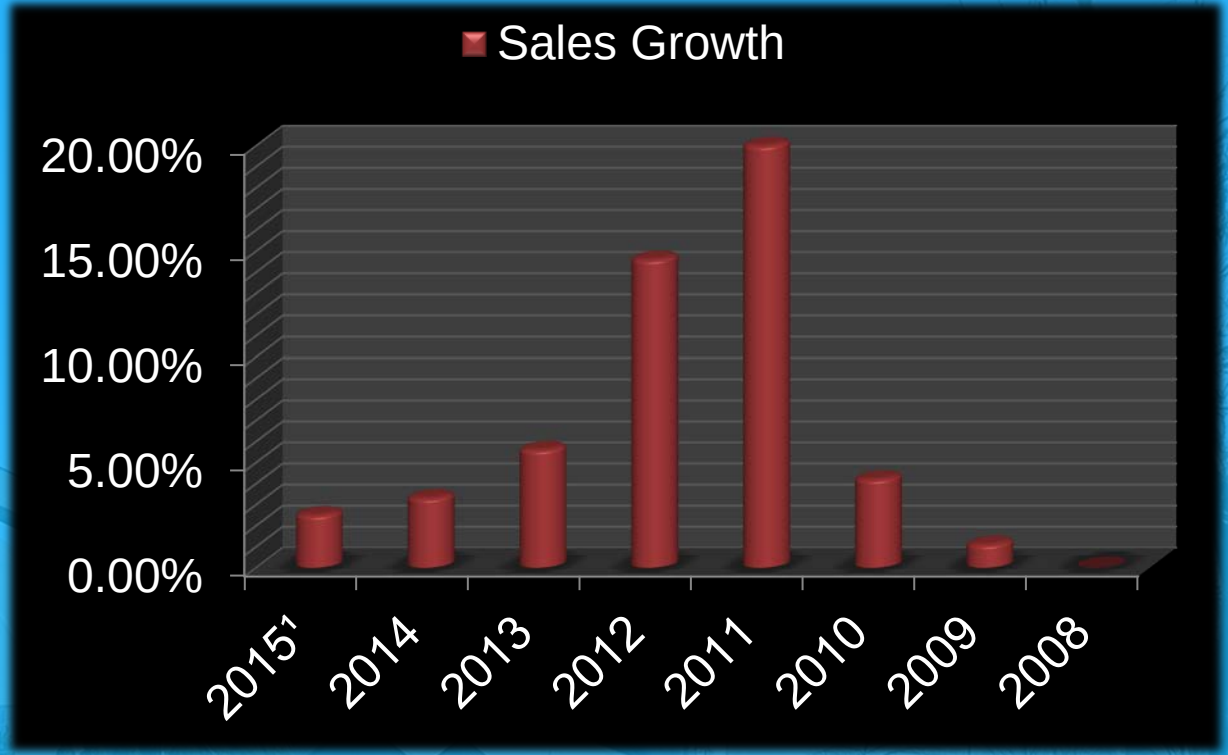
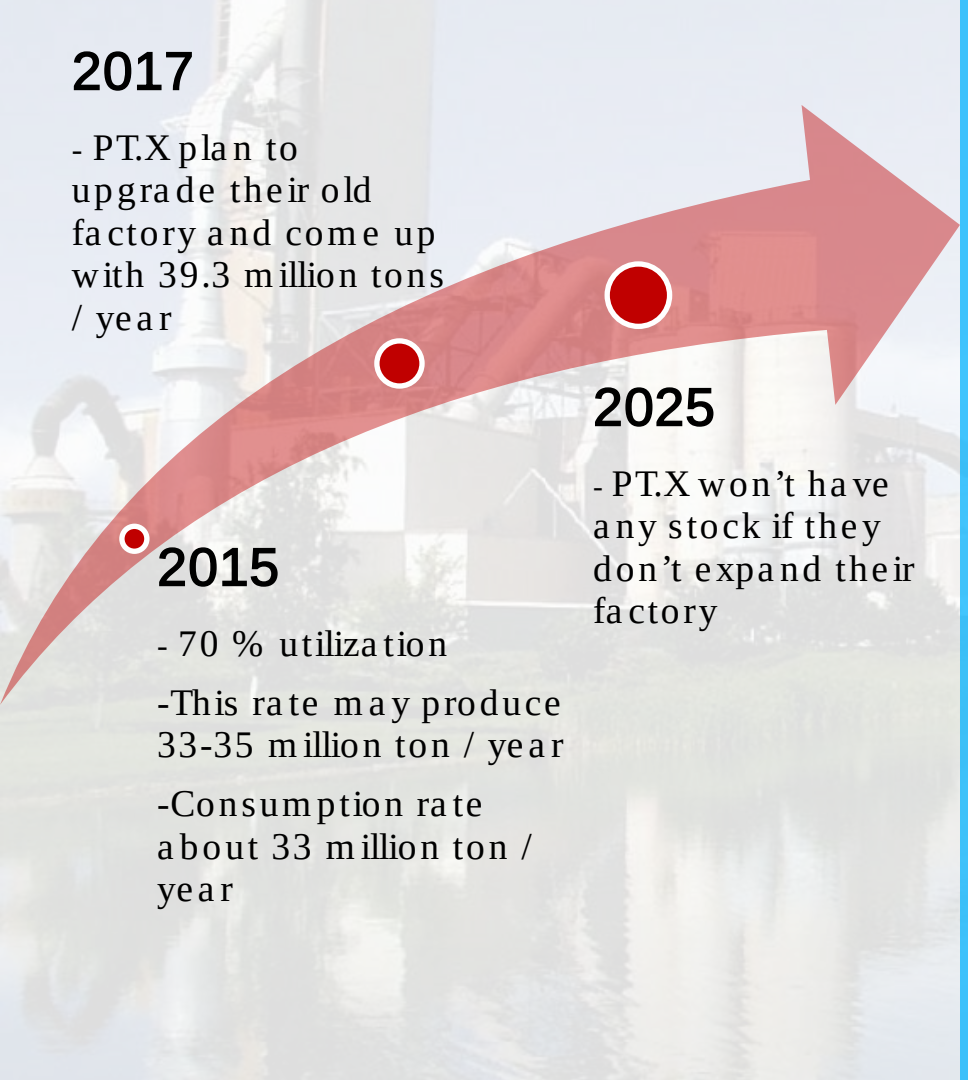
Outline

- Introduction
- Data Collection
- Data Processing
- Data Interpretation & Analysis
- Conclusion & Recommendation


Introduction

Research Background





2017

- PT.X plan to upgrade their old factory and come up with 39.3 million tons / year

2015

- 70 % utilization

-This rate may produce 33-35 million ton / year

-Consumption rate about 33 million ton / year

2025

- PT.X won't have any stock if they don't expand their factory

Existing Condition

- 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 & Sumatra

What should the company do while waiting for their new factory?

Maintain the Customer Satisfaction

Set up the target of service level

Decrease the expense in supply chain system

Create a policy for delivery quantity

Evaluate the existing condition

Analyzing the requirement for warehouse capacity

Problem Formulation

➜How to determine the number of **delivery quantity** by considering the stock criticality (days of supply) at the distributor.

➜ 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.

Research Objectives

➜ **Develop a model** to determine the number of delivery product by considering the stock criticality (days of supply).

➜ 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.

Research Benefits

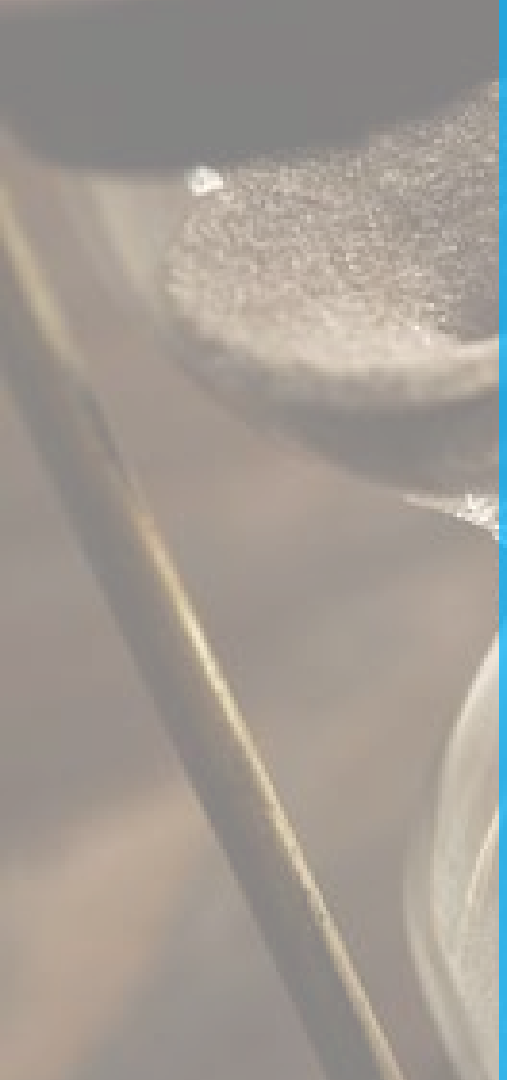
➜This research will give a consideration for PT.X to **determine the number of delivery product.**

➜This research will help the distributor to **determine the optimum size of warehouse** in purpose to increase the utilization.

➜This research will suggest the company to **have more consideration in stock criticality (days of supply).**

Research Scope

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



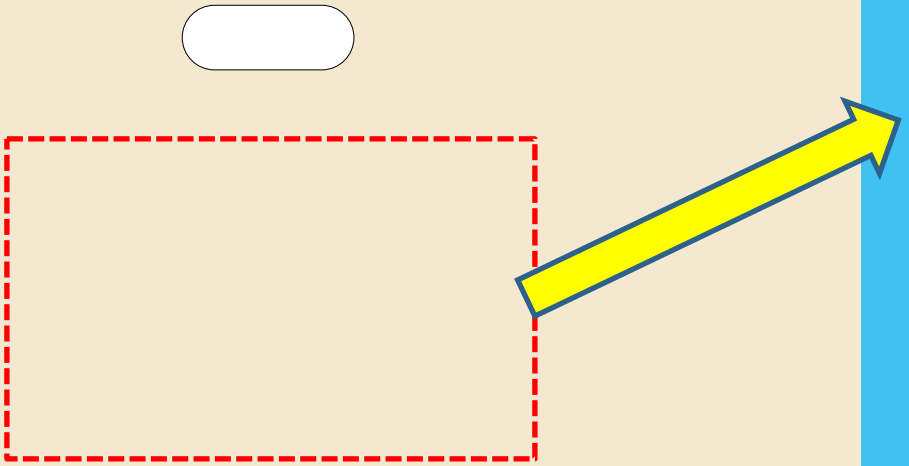
Assumption

- **Proportion of demand** for each district, city, and warehouse are **same for every single entity in each day.**
- Truck is used as transportation mode (**32 tons capacity**)
- The plant can **always fulfill the delivery order.**
- The observation is only for **40 kg sack of cement.**
- After the number of delivery order is determined, **the product will directly go to the warehouse**
- The unloading process will **take 30 minutes** for every single truck
- There will be a time windows for each warehouse start from **07.00 AM to 17.00 PM.**


Data Collection

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 sales target have distribution of **TRIA(3.52e+003, 7.42e+003, 7.53e+003)** and sequence error **below 10%.**



Existing Size of Warehouse

➜The existing size of warehouse is needed as **the comparison to the outputs of simulation.** Shown in table 4.3

➜The data gained from the company is **limited to several warehouses only**

➜In total of 83 different warehouses, there **are 20 which have no capacity**

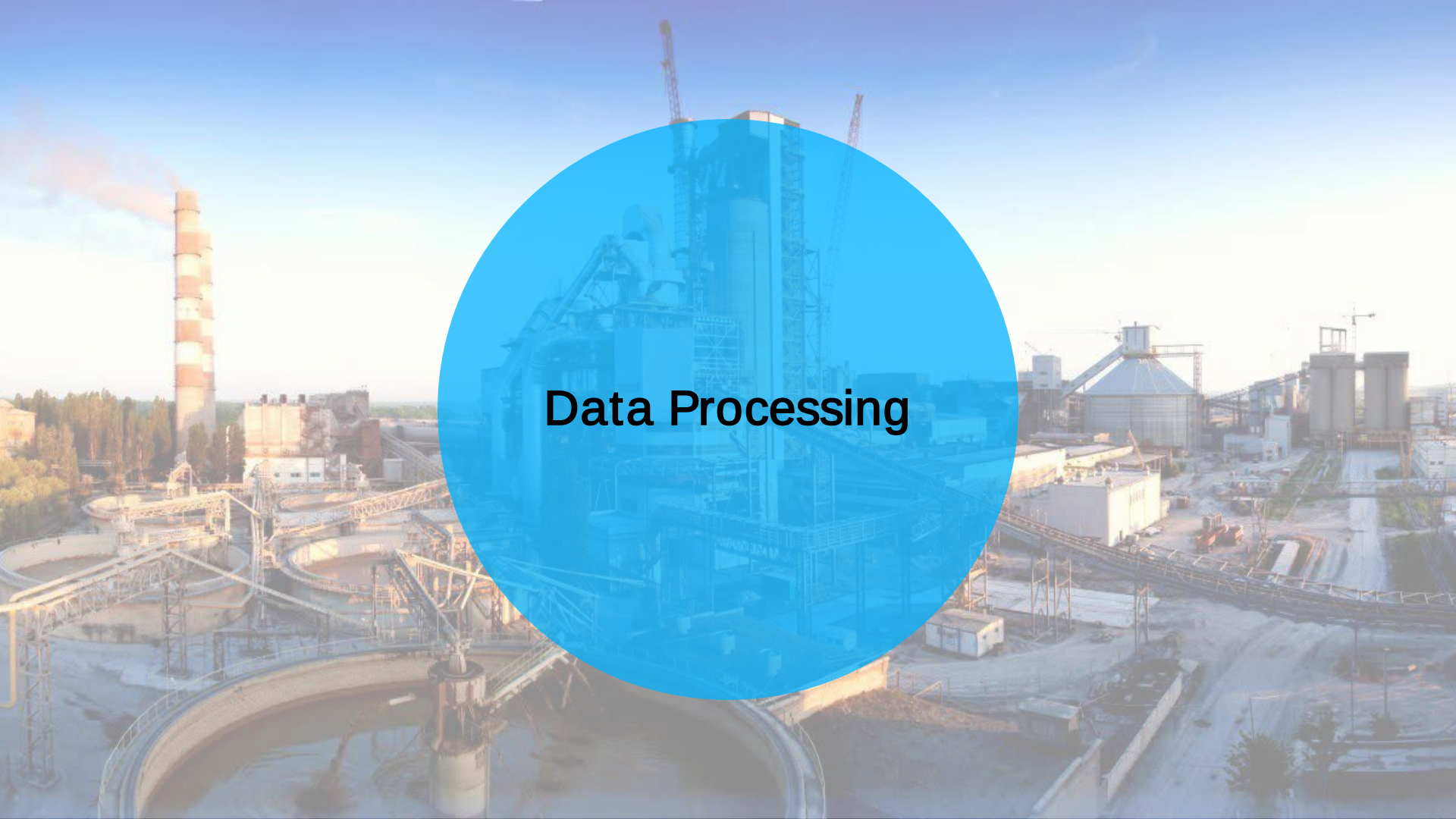
District	City	Warehouse	Distribution (tons)
Kudus	Lasem	KWSG	NORM(9.11, 2.33)
		Sekawan Niaga Jaya	NORM(3.66, 0.937)
	Rembang	KWSG	NORM(91.1, 23.3)
		Sekawan Niaga Jaya	NORM(4.49, 1.15)
	Kudus	KWSG	NORM(93.4, 23.9)
	Jepara	KWSG	NORM(34.2, 8.74)
		Varia Usaha	NORM(36.1, 9.25)
	……	……	……

November	198,076
Desember	191,976

Shown in table 4.5

District	City	Distribution (hours)
Kudus	Lasem	UNIF(1.02, 3)
	Rembang	UNIF(1.18, 3)
	Kudus	UNIF(2.08, 5)
	Jepara	UNIF(3, 7)
	Blora	UNIF(1.3, 3)
	Cepu	UNIF(1, 3)
	…..	…..

Shown in table 4.6


Data Processing

Response of Simulation

1. Average On-Hand Inventory

- On-hand inventory was used as the consideration to the model to decide neither distribute the product nor not

- The percentage of holding cost that was used by the model was 25% / year for average on-hand inventory that might happen.

2. Average Inventory Days of Supply

- The average on-hand inventory for each day should covering a certain days of average sales on each warehouse.

- The equation of Days of Supply was used to measure the average inventory Days of Supply

Response of Simulation

3. Service Level

- Service level means the number of product which successfully fulfills the total demand
- In addition, service level can also be known as fill rate. The value of fill rate can be determined by using this following equation:

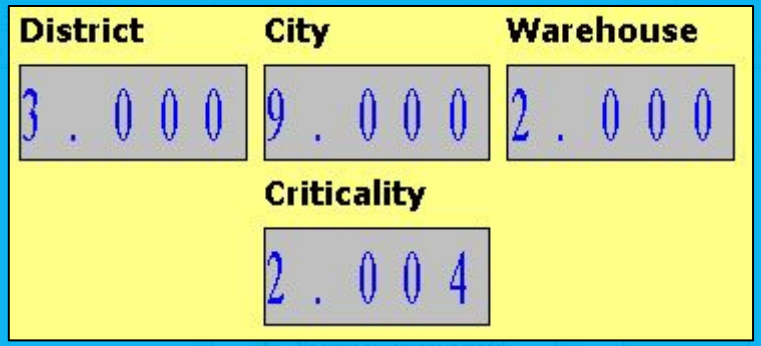
$$Fill\ Rate = \frac{Fulfilled\ Demand}{Total\ Demand} \text{ x } 100\%$$

4. Utilization of Warehouses

- The warehouse utilization could be known after the simulation was done. The warehouse utilization was an impact of delivery quantity decision for each day.

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

Goodness Assessment



- This result will be 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 days of supply will be done by dividing 14450 with 7214 and the result was 2.003 days.

Goodness Assessment

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

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

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

Goodness Assessment

	Existing	*Simulation*
Mean	198574.3796	195790.67
Variance	18318717.82	6374267.7
Observations	12	12
Hypothesized Mean		
Difference	0	
df	18	
t Stat	1.940563531	
P(T<=t) one-tail	0.034069593	
t Critical one-tail	1.734063607	
P(T<=t) two-tail	0.068139185	
t Critical two-tail	2.10092204	

- The null hypothesis for this test was that the data were similar. Therefore, the alternative hypothesis will be the data were not similar as the data were not equal
- The null hypothesis will be rejected if the t stat value was not in the range of negative to positive t critical two-tail.

Decision : Accept Null Hypothesis

Goodness Assessment

	Existing	Simulation
Mean	172671.9198	175849.95
Variance	673116776.5	120142.11
Observations	12	12
Hypothesized Mean Difference	0	
df	11	
t Stat	-0.424292297	
P(T<=t) one-tail	0.339765941	
t Critical one-tail	1.795884819	
P(T<=t) two-tail	0.679531881	
t Critical two-tail	2.20098516	


Data Interpretation &
Analysis

Existing Condition

- If there was an order from each warehouse, the company will start from checking the on-hand condition & usually distribute the product at the amount of the target for that day.
- in the existing model, the critical level was assumed with 1 day of sales & ***"k"*** variables for all warehouses are 1
- The detail result after running the simulation can be seen on the appendix 1. it can be seen that the average service level will about 96% and the average inventory days of supply will be **0.5 days** with total cost of **Rp 851.240.022**

Improvement Scenario

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

Opt-Quest Result:

Total Iteration = 78

Best Iteration = 66

Truck Needs = 504

Combination of “k” = shown in table 4.14

Detail Result in Appendix 2

Improvement Scenario

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

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

Opt-Quest Result:

Total Iteration = 710

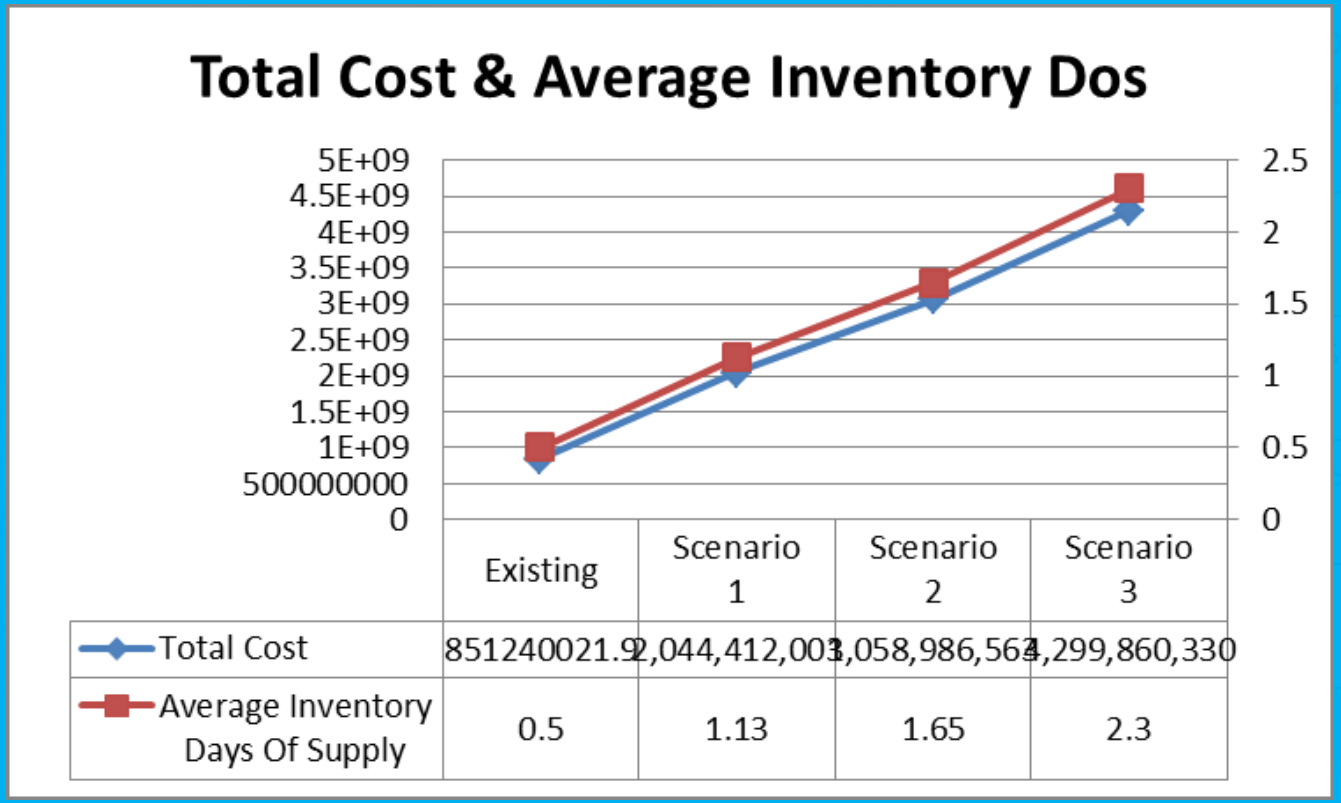
Best Iteration = 342

Truck Needs = 528

Combination of “k” = shown in table 4.15

Detail Result in Appendix 3

Comparison Between Existing & Scenario




Conclusion &
Recommendation

Conclusion

1. The policy for each warehouse will be different **base on the criticality that was used**. 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.

   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.

2. . 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.**

Recommendation

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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Thanks!

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Literature Review

Inventory Management

- One of cost consideration related with the inventory is carrying cost.
  - The carrying cost is usually defined as a percentage of the price value of inventory per unit of time in one year (Arnold, 2008)

- In term of increasing the service level, each warehouse need to measure the equivalent number of days of inventory on hand. This measurement used to call Days of Supply

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

Distribution Management

- Among the function of distribution process, these following function should have more consideration:
  - Create segmentation & determine the target of service level
  - The utilization of transportation should be adjusted as efficient as possible to reduce the cost

- 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 warehouse
  (Daskin, 1995)

Visibility in Supply Chain

By managing the information visibility between points, the performance will increase in several aspects. Those aspects are:

Consist of several distribution cost such as inventory cost, stock out cost, shortage cost, backorder cost, & the total cost.

Consist of supplier quality, internal quality level, & external quality level

Consist of on time delivery, customer response time, & product availability

There are 2 dimensions of flexibility: range & response (Slack, 1987)

Range refers to the range of states that can be reached by the warehouse or plant.

There are 5 types of supply chain flexibility (product, volume, new product, distribution, & responsiveness)

Response refers to the capability of warehouse or plant to fulfill the order from several demand points.

Consist of production lead time, cycle time, & responsiveness

Warehouse Design

According to Waters (2003), there are several consideration to conduct a good layout. Among those criteria, there is one important point related with the main decision of determining the warehouse size.

"The size of warehouse is mainly determined by allocating the size of storage for the materials or finished goods"

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

Shipment Quantity

- In case of this research, the order quantity will be determined by considering the **Critical Level** of stock. If the condition of warehouse is critical, then the delivery quantity will be:

$$\boldsymbol{Delivery\ Quantity = k * Sales\ Target}$$

Why should the company maintaining the customer satisfaction?

Maintain the Customer Satisfaction

Set up the target of service level

- It will affect the trust between the customer and the company.
- The trust between these player may affect the quantity of demand

Why should the company decreasing the expense in supply chain system ?

Decrease the expense in supply chain system

Create a policy for delivery quantity

- It will decrease the distribution cost by reducing the frequency of fulfillment order.
- It will also consider the **critical** level of their stock.

Why should the company decreasing the stock out?

Evaluate the existing condition

Analyze the requirement for warehouse capacity

- It will increase the service level, even though the inventory cost may increase due to the expansion of the warehouse size.