Analysis of Bulk Cement Distribution Network Considering Market Share and Operating Income after Acquiring the Competitor

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Abstract—The distribution network is the most important strategic decision issues that need to be optimized for the efficient operation of whole supply chain. When a company make a business acquisition that brings more distribution facilities, the location allocation planning of the distribution network needs to be reconsidered. The distribution network includes the link from factories to packing plants and from factories or packing plants to demand points. The linear programming model was developed as a solution to solve optimization problem which involves multisource, multiproduct, and multiipored in multi-echelon distribution network. We build numerical experiments from two scenarios to show the behaviour of this model. This model will determine the decision of distribution facilities location should be used and quantities should be allocated to achieve the optimal operating income considering the market share policy to satisfy the customer demands.

Keywords—Distribution Network, Linear Programming, Location Allocation, Market Share, Operating Income.

I. INTRODUCTION

The network design is a fundamental thing done in supply chain management, where it will affect all other decisions that exist in a supply chain and has a great influence on investment returns and overall supply chain performance, it was further conveyed that mergers and acquisitions can make the company integrates different logistics networks [1]. The design of the supply chain network involves strategic decisions including determining the number, location and capacity of distribution facilities to meet customer demand effectively and efficiently [2]. Decisions in supply chain design can result in a supply chain configuration that has a significant impact on logistics and responsive costs [3]. The supply chain network can be used to achieve the company's supply chain objectives, namely low supply chain operating costs to a high level of responsiveness to customer demand. So if an organization / company wants to increase its productivity and profitability, an effective and efficient supply chain network design is absolutely necessary. The benefits of managing supply chain networks by integrating operational, design and financial decisions that have an objective to determine the optimal configuration of production and distribution networks with operational constraints, including quality, production (ie supply restrictions related to production allocation and capacity balance) and finance (i.e. production costs, transportation costs, and other costs incurred along the network through which materials and products flow) [4].

The design of the distribution network consists of three parts including location-allocation, vehicle routing problems, and inventory control [5]. Location-allocation is defined as the unity of the location of the customer whose request is known and the unity of the location of available facilities. When the facilities have been determined there will be a fixed fee, there will also be a delivery fee between the candidate location that will be used and the location of the customer. So the facility location and delivery pattern between the facility and its customers will be sought to achieve the desired objectives [6][7]. These objectives are classified into four categories namely minimizing costs, demand orientation, profit maximization, and environmental problems [8].

In this paper, we developed linear programming model to solve the location allocation model of the distribution network after the business acquisition policy done by cement company in Indonesia by considering the market share. Therefore, this study aims to develop a location allocation model of the distribution network to optimizing the operating income by considering the market share of the cement company which recently make a business acquisition policy of a similar company. This paper divided into 5 section. Section 1 describe the research background. Section 2 provides literature review especially for proposed model. Section 3 present the proposed model. Section 4 provides the case of the location allocation of the distribution network of an Indonesian cement company. And the last section will be discuss about conclusion and future research.

II. LITERATURE REVIEW

Pujawan describe the location of allocations in the supply chain network [2]. Decisions on the establishment or use of a production facility or place of storage are often made simultaneously with other decisions such as the allocation of production and delivery. And it becomes more complex when the capacity constraints of production and storage are included in the decision. Where if there are a number of distribution facilities (both factory and storage) that are in several different places with a limited capacity to serve the entire marketing area of the company that has a different level of demand from one another. Therefore a linear programming is needed to determine simultaneously which production facilities will serve the marketing area and which factories will supply the inventory in the storage area.

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The proposed model is determining the allocation of volume of the products to be distributed to sales area from each plant (factory, packing plant, grinding plant) in order to satistying the demand. The objective is maximizing the operating income that generated by income from the sales price minus by cost of good sold, cost of sales marketing, cost of general and administrative, and cost of last miles delivery. The model restricted by some assumptions. The volume of the demand using the forecasting demand from the company. Demand fulfillment modelled as two scenarios, delivered in full and delivered it based on the market share policy. The both scenarios aims it based on the market share policy. The both scenarios aims to optimizing the operating income by considering the market share.

III. MODEL FORMULATION

A. Problem Description

The supply chain distribution network based on product flow as depicted in Figure 1. This complex supply chain network includes multisources, multichelon, multiproduct multiperiode with considering market share policy for optimizing operating income.

A hypothetical capacity allocation problem will be considered based on the network, where multiple products can be distributed within a time horizon of 12 months. The aim is to determine how capacities should be allocated optimally to distribute the product items in a complete supply chain, whereby the capacity constraints of supply, distribution, and market share are considered simultaneously. Here, distribution facilities capacity is defined as the available supply volume in each plant and each period, and the capacity of each plant is independent of the others; the supply capacity is the maximum amount of product that can be provided by each distribution facility in each period. In addition, some other factors, such as type of product and market share policy, are considered.

The problem for the proposed model is determining the allocation of volume of the products to be distributed to sales area from each plant (factory, packing plant, grinding plant) in order to satisfying the demand. The objective is maximizing the operating income that generated by income from the sales price minus by cost of goods sold, cost of sales marketing, cost of general and administrative, and cost of last miles delivery. The model restricted by some assumptions. The volume of the demand using the forecasting demand from the company. Demand fulfillment modelled as two scenarios, delivered in full and delivered it based on the market share policy. The both scenarios aims to get the maximum operating income. The boundary of this model is the use of distribution facilities only in Java because it can already represent the entire distribution network.
network. The product is in bulk and using one of the brand of the company that has the most high market share. The product, transportation, and distribution facilities is always available and unlimited. The inbound cost already captured product, transportation, and distribution facilities is always available and unlimited.

### Table 1. Distribution Facilities Capacity (Tonnage)

| Product | OPC | PCC |
|---------|-----|-----|
| Plant   | Tuban | Rembang | Narogone | Banyuwangi | Gresik | Priok | Clawandau |
| Jan     | 465.000 | 150.000 | 77.500 | N/A | 62.000 | 77.500 | 77.500 |
| Feb     | 420.000 | 140.000 | 70.000 | N/A | 56.000 | 70.000 | 70.000 |
| Mar     | 465.000 | 150.000 | 77.500 | N/A | 62.000 | 77.500 | 77.500 |
| Apr     | 450.000 | 150.000 | 75.000 | N/A | 60.000 | 75.000 | 75.000 |
| May     | 465.000 | 150.000 | 77.500 | N/A | 62.000 | 77.500 | 77.500 |
| Jun     | 450.000 | 150.000 | 75.000 | N/A | 60.000 | 75.000 | 75.000 |
| Jul     | 465.000 | 150.000 | 77.500 | N/A | 62.000 | 77.500 | 77.500 |
| Aug     | 450.000 | 150.000 | 75.000 | N/A | 60.000 | 75.000 | 75.000 |
| Sep     | 450.000 | 150.000 | 75.000 | N/A | 60.000 | 75.000 | 75.000 |
| Oct     | 450.000 | 150.000 | 75.000 | N/A | 60.000 | 75.000 | 75.000 |
| Nov     | 450.000 | 150.000 | 75.000 | N/A | 60.000 | 75.000 | 75.000 |
| Dec     | 465.000 | 150.000 | 77.500 | N/A | 62.000 | 77.500 | 77.500 |
| Total   | 5.475.000 | 1.825.000 | 912.500 | N/A | 730.000 | 912.500 | 912.500 |

* N/A = not available

### Table 2. Market Share Policy (Lower Bound and Upper Bound)

| Market Competition | Market Share (d_f) in % | Boundary Formulation |
|---------------------|-------------------------|----------------------|
| Nicher              | 0 – 99%                 | M_d = 0%             |
| Follower            | 30 – 29%                | 5%                   |
| Challenger          | 30 – 39%                | 5%                   |
| Leader 1            | 40 – 59%                | 3%                   |
| Leader 2            | 60 – 89%                | 2%                   |
| Leader 3            | 90 – 100%               | M_d                   |

B. Proposed Mathematical Model

The notations that will be used to describe the problem are as follows:

1) Indices:
- d, index of sales area, where \( d = 1, ..., D \), \( D \) is the number of sales area
- f, index of factory plant, where \( f = 1, ..., F \), \( F \) is the number of the factory
- p, index of packing plant, where \( p = 1, ..., P \), \( P \) is the number of the packing plant
- g, index of grinding plant, where \( g = 1, ..., G \), \( G \) is the number of the grinding plant
- t, index of time periods, where \( t = 1, ..., T \), \( T \) is the number of month in a year
- j, index of product types, where \( j = 1, ..., J \), \( J \) is the type of product that distributed
- k, index of the market, where \( k = 1, ..., K \), \( K \) is the type of the market competition

2) Capacity parameters:
- \( CPP_{pj} \), capacity of packing plant \( p \) in time period \( t \) with type of product \( j \)
- \( CFT_{pj} \), capacity of main factory \( f \) in time period \( t \) with type of product \( j \)
- \( CFN_{pj} \), capacity of factory \( f \) in time period \( t \) with type of product \( j \)
- \( CGI_{gj} \), capacity of grinding plant \( g \) in time period \( t \) with type of product \( j \)

3) Market & demand parameters:
- \( M_d \), market share for sales area \( d \)

4) Financial parameter:
- \( E_{diff}/p/g \), operating income of product type \( j \) in sales area \( d \) with time period \( t \) from factory \( f \) / packing plant \( p \) / grinding plant \( g \)
- \( HT_{diff}/p/g \), price of of product type \( j \) in sales area \( d \) with time period \( t \) from factory \( f \) / packing plant \( p \) / grinding plant \( g \)
- \( BC_{diff}/p/g \), cost of goods sold of product type \( j \) in sales area \( d \) with time period \( t \) from factory \( f \) / packing plant \( p \) / grinding plant \( g \)
- \( BM_{diff}/p/g \), cost of sales marketing of product type \( j \) in sales area \( d \) with time period \( t \) from factory \( f \) / packing plant \( p \) / grinding plant \( g \)
- \( BA_{diff}/p/g \), cost of general administration of product type \( j \) in sales area \( d \) with time period \( t \) from factory \( f \) / packing plant \( p \) / grinding plant \( g \)
- \( BO_{diff}/p/g \), cost of last miles delivery of product type \( j \) in sales area \( d \) with time period \( t \) from factory \( f \) / packing plant \( p \) / grinding plant \( g \)

5) Decision Variables:
- \( XF_{diff} \), volume of product type \( j \) in time period \( t \) from main factory \( f \) for sales area \( d \)
- \( XFN_{diff} \), volume of product type \( j \) in time period \( t \) from factory \( f \) for sales area \( d \)
The objective function maximizes the total operating income of the supply chain by maximizing the operating income from each factory, packing plant, and grinding plant generated by multiplied the total volume distributed to area sales from factory f / packing plant p / grinding plant g for time period t and type product j with the operating income obtained from distributing to area sales from factory f / packing plant p / grinding plant g for time period t and type product j. Where the operating income calculation for each factory f / packing plant p / grinding plant g given by:

a. Factory operating income calculation formula

\[
\text{EFN}_{qfp} = \sum_{d_{i}} \sum_{j} \sum_{t} (HT_{qfp} - BC_{qfp} - B_{qfp} - BM_{qfp} - BO_{qfp})
\]  

(2)

c. Grinding plant operating income calculation formula

\[
\text{EGP}_{qg} = \sum_{d_{i}} \sum_{j} \sum_{t} (HT_{qg} - BC_{qg} - B_{qg} - BM_{qg} - BO_{qg})
\]  

(3)

Subject to:

1. Volume delivery from main factory to area sales & packing plant ≤ main factory capacity

\[
\sum_{d_{i}} \sum_{j} \sum_{t} X_{f_{i}j_{t}} \leq \text{main factory capacity}
\]  

(5)

This constrains ensure that the capacity of the main factory enough for delivering product both to the area sales and to the packing plant.

2. Volume delivery from factory to area sales ≤ factory capacity

\[
\sum_{d_{i}} \sum_{j} \sum_{t} X_{f_{i}j_{t}} \leq \text{factory capacity}
\]  

(6)

This constrains ensure that the capacity of the factory enough for delivering product to the area sales.

3. Volume delivery from packing plant to area sales ≤ packing plant capacity

\[
\sum_{d_{i}} \sum_{j} \sum_{t} X_{p_{i}j_{t}} \leq \text{packing plant capacity}
\]  

(7)

This constrains ensure that the capacity of the packing plant enough for delivering product to the area sales.

4. Volume delivery from grinding plant to area sales ≤ grinding plant capacity

\[
\sum_{d_{i}} \sum_{j} \sum_{t} X_{g_{i}j_{t}} \leq \text{grinding plant capacity}
\]  

(8)

This constrains ensure that the capacity of the grinding plant enough for delivering product to the area sales.
5. Volume flow in to packing plant = volume flow out from packing plant to area sales
\[ \sum_{j \in J} \sum_{p \in P} \sum_{t \in T} X_{pjt} - X_{P_DPT} \leq 0 \quad \forall t \forall p \forall t \forall j \]  
(9)

This constrains guarantee that the flow in volume from the factory to the packing plant is as same as the flow out volume from the packing plant to the area sales

6. Volume fulfillmet of demand \( Y_{dtjk} \) area sales based on market share policy based on equation.
\[ (M_d + K_{Min_d}) Y_{dtj} \leq Y_{dtj} \leq (M_d + K_{Max_d}) Y_{dtj} \quad \forall t \forall j \forall k \]  
(10)

So we have upper bound and lower bound for the demand to be delivered
a. Volume to area sales \( \leq \) upper bound of demand based on market share policy
The distribution network to satisfy the market demand and also to strengthen the market share for achieving the maximum operating income.

C. Data

The data parameter taken from the company shown in Table 1 to Table 5.

D. Result and Discussion

The model run using Open Solver software which a Microsoft Excel 2013 addon in Intel (R) Core (TM) i5-5200U CPU @ 2.20 GHz (4 CPUs) RAM 8.192 GB, experimental firstly calculate the operating income for each plant-destination (Table 6) and setup the lower and upper boundary of the market share policy (Table 7).

After that we setup the constrain in the open solver software. And then we run the Open Solver and get the objective function result presented in Table 8. The Table 8 shows that the operating income tend to higher when the model processed. In scenario all demand will be fulfilled, the operating income had 32.51% higher than the expected value with the same market share. And more higher 34.20% than expected value when the model run with the scenario using market share policy. However, there are decreased volume and declined market share when the model run with scenario market share policy, but it is still within the boundary of the market share policy. This indicate that the model tend to increase the volume that have higher operating income and decrease the volume that have the lower or negative operating income. This shows that the model can effectively conduct location allocation on the distribution network that generate optimal operating income with considering the market share policy.

The distribution facilities utilization is also measured to check wether the distribution facilities utilized properly or not. Table 9 shows that there are no over utilized or no over capacity of the distribution facilities. The new distribution facilities (Narogong Factory) become crucial for the Indonesia cement company with 99,35% of utilization to support the company for distributing the product to the customer and help the company to generate higher operating income.
V. CONCLUSION AND FUTURE RESEARCH

The location allocation of the distribution network plays crucial role in supply chain management. Because of business acquisition policy of a similar company, a supply chain manager must be able to develop new location allocation model of the distribution network to optimize the distribution allocation of the product to achieve maximum operating income for the company and also to satisfy the demand for maintain the market share according to company market share policies. The model using linear programming with two scenario to show the model behaviour towards demand fulfillment based on market share policy, location allocation model of the distribution network can be constructed respect to demand fulfillment at each of the distribution network, distribution facilities capacity, and the market share policy. The optimization result reached optimum condition and shows that all demand satisfied from the distribution facilities at maximum operating income and acceptable market share value based on market share policy. As the higher operating income, the higher volume will be allocated. And conversely as the lower operating income, the smaller volume will be allocated. However, the model still can developed in the future research by considering whether the company will keep or release the distribution facilities, the other financial measurement, or others company policies other than market share policy.

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