EVALUATION OF THE DISTRIBUTION SYSTEM OF FERTILIZER STATE-OWNED COMPANY

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ABSTRACT
Purpose: This paper is aimed to evaluate the distribution system of one of Indonesia Fertilizer State-owned company which is obliged to apply specific distribution regulations dedicated for public service obligation of the company.

Methodology: The distribution cost of the existing system is compared with the proposed ones through some scenarios of distribution to improve the system and a mixed integer programming is developed to represent the optimization problem of the proposed system.

Findings: It is found that the proposed system could reduce the distribution cost by simplifying the distribution channelization and rearranging the clustering system of distribution warehouses while it keeps guarantee the security of supply.

Practical Implications: The proposed system may help to diminish the delay problem on product delivery due to shorter distance and more simple channelization . Moreover, the reduction of the distribution cost may come to the reduction of the subsidy that should be provided by the government. Finally, this current research must be followed by detail analysis of the feasibility of the implementation of the proposed system, particularly of the social impact of the closure of the warehouses.

Originality: The idea of public service obligation in distribution system becomes the originality of this paper and its value is to show that the government may increase the efficiency while the supply is kept secure at the same time.

Keywords: Distribution System, Public Service Obligation State-Owned Company

Paper type: Case Study

Introduction

This research work is a part of a series of research on distribution system of Public Service Obligation State-Owned Company (PSO-SOC). In Indonesia, PSO-SOC has an obligation to serve the entire demand on public commodities or services . Its working orientation is not for profit but for security of supply. Government gives subsidy as well as fee when the expenditure of the PSO-SOC larger than the revenue and in the other way PSO returns back the balance to the government if the expenditure smaller than revenue. However, the PSO-SOCs are still permitted to conduct their own programs beyond their main task but it is undertaken under limitation and controlling of the government. Hence, beyond their task on public commodities or services, some of PSO-SOCs expand their business to commercial market (Soehodho *et al*., 2009) .

The PSO-SOC under consideration deals with production and distribution of fertilizer in various types of products for both public and commercial market. Fertilizer is an important commodity for agriculture industries, hence the government concerns to regulate its distribution system in order to ascertain the fulfillment of its demands, especially of public demands. For public demands, government stipulates the maximum selling price of the products and it is constituted in the Minister of Agriculture Regulation.

Today, the public demands still encounter the shortage of fertilizer due to some problems . One of them concerns to the distribution or transportation issues. As continuation of our previous researchs which concern to one of the issues of PSO-SOC strategic plan, namely Location Model, this current research is focused to apply the proposed Location Model to the current system of the PSO-SOC under consideration. The objective of this current research is to evaluate the operation of PSO-SOC's distribution system.

From the existing distribution system, we investigate some scenarios which may be implemented in order to improve the efficiency of the distribution system of public commodity, in the context of reduction on transportation cost. The scenarios are focused on the rearrangement of the existing distribution network, and the best scenario is attained through the use of network flow problem-based model , namely Minimum Cost Flow problem (Ahuja *et a.l*, 1993). We focus the investigation to the primary distribution from plant to distributor's warehouses.

Furthermore, the structure of this paper is as follows. Section 2 introduces the distribution system of the PSO-SOC under consideration. Section 3 deals with the model development. In section 4 we analyze the existing system and then the improvement will be analyzed in section 5. Finally, section 6 provides conclusions and future research directions.

Distribution System of the PSO-SOC Under Consideration

The company under consideration is one of the five affiliated companies of Indonesia Fertilizer Holding Company (PSO-SOC) which deals with fertilizer. Since fertilizer is an important substance which affect the productivity of agriculture, government regulates the distribution channel from the plant to the point of final customer, that is retailer, in the form of regulations of Minister of Agriculture and Minister of Trade. The company under consideration manages its own plant and the 3-stage distribution network which consists of :

- Plant / Plant Warehouse
- Producer's Distribution Warehouses (31 warehouses)
- Distributor's Distribution Warehouses (∓ 250 warehouses)
- Retailers (∓ 4864 kiosks)

Fig.1 shows the distribution network of the company. Such kind of distribution channel is particularly applied only for subsidized products whereas it is not necessary for the commercial products to follow the regulation. The commercial products are distributed based on the least cost distribution principle which thoroughly depends on the location and amount of the demand. Moreover, their distribution systems utilize the logistics facilities of subsidized products.

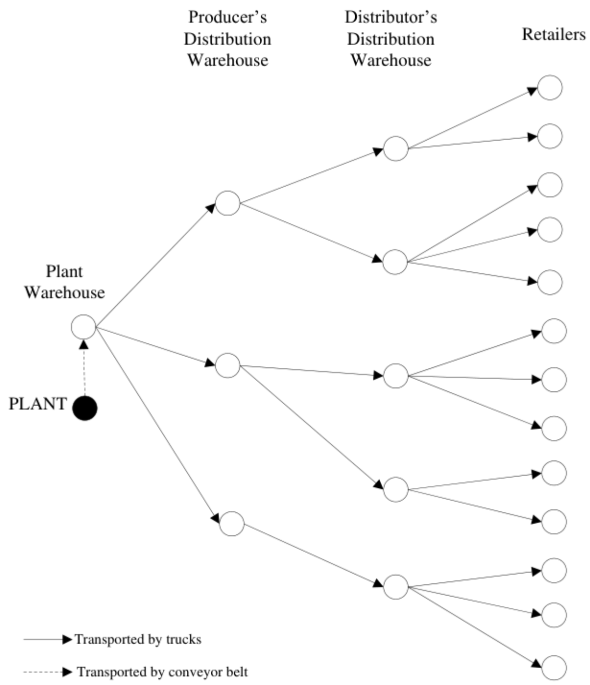

Figure 1. Distribution network of subsidized products

From the plant, fertilizers are transported to the plant warehouse by the conveyor belt to be packed and loaded onto the trucks. Furthermore, the products are transported to the producer's distribution warehouses (PWs) by trucks of third party company. PWs are designated to be a buffer and maintain certain amount of products to guarantee the security of supply for the public demand. Though the minimum stocks in such warehouses are fulfilled, the trucks from the plant still have to drop the products in the warehouses due to regulation. Consequently, there will be loading and unloading process before the products transported to the following distributor's warehouses. Furthermore, from PWs the products are transported to distributor's warehouses (DWs) by trucks of third party also and then distributed to the retailers by local transporters.

From the economic point of view, we found that the primary distribution (from plant to DWs) of such system is lack of efficiency. We argue, firstly that in order to guarantee the minimum stock, the company is not always required to drop in on the PW. As long as the minimum stocks are fulfilled, the trucks may go directly to the DW. It will save both time and cost due to keeping away from loading and unloading, warehouse rental cost as well as inventory cost. This argument is supported by the fact that the company has made use of IT-based inventory system, so they could control the stock easily.

Model Development

In order to represent the problem of the efficiency of the distribution system, we base our model on the idea that there is tradeoff between the number of facility and the cost of distribution. Cost of distribution can be classified into primary (trunking/line-haul) cost and secondary (final) delivery cost (Rushton *et al.*, 2006). Primary distribution concerns to the movement of the full pallets of the product from point of production (finished product) to points of distribution, whereas secondary distribution concerns to the movement from point of distribution to the end consumers. For the primary transportation, the bigger the number of distribution points, the bigger the primary cost is. However, for secondary transportation the increase of the number of distribution points will reduce the transportation cost. In our case, the primary distribution is from plant to DWs, so as the final points of the primary distribution are DWs and the PWs are functioned as distribution centers. From this point, it raises the idea to reduce the number of PWs to diminish the cost of primary distribution, while the number of DWs is assumed to be fixed.

The development of mathematical model which represent the problem of the efficiency of the primary distribution between plant and DWs is focused to the variables of transportation cost and loading/unloading cost, as well as fixed cost of facility. However, since the company under consideration includes the loading/unloading cost into the transportation cost, so we unite both variables into one variable, namely transportation cost.

Furthermore, our model is applied to the 2-stage distribution network as shown in Fig.2. Such network enables the products to be transported either from plant to DWs via PWs, or from plant to DWs directly. The formulation of the model is set up as cost minimization problem with quantity of products distributed on each link as decision variable, along with the decision to open or close warehouses. The formula of our model is as follows :

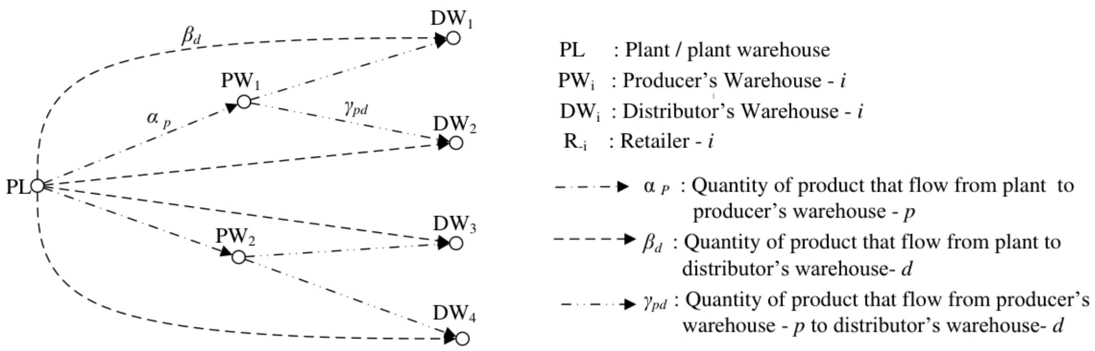

Figure 2 An example of primary distribution network

$$\min Z(\alpha_p, \beta_d, \gamma_{pd}) = \sum_{p\in P} u_p\, \alpha_p + \sum_{d\in D} v_d\, \beta_d + \sum_{p\in P}\sum_{d\in D} w_{pd}\, \gamma_{pd} + \sum_{p\in P} X_p\, FC_p\ . \tag{1}$$

subject to :

$$\alpha_p = \sum_{d\in D} \gamma_{pd}\ , \qquad \forall p \in P\ . \tag{2}$$

$$\sum_{p\in P} \gamma_{pd} + \beta_d = \lambda_d\ , \qquad \forall d \in D\ . \tag{3}$$

$$\sum_{p\in P} \alpha_p + \sum_{d\in D} \beta_d = S\ . \tag{4}$$

$$\alpha_p \le X_p . \sum_{d\in D} \lambda_d\ , \qquad \forall p \in P\ . \tag{5}$$

$$X_p = [0,1]\ , \qquad \forall p \in P\ . \tag{6}$$

$$\alpha_p \le Cp_p\ , \qquad \forall p \in P\ . \tag{7}$$

$$\alpha_p \ge 0\ , \qquad \forall p \in P\ . \tag{8}$$

$$\beta_d \ge 0\ , \qquad \forall d \in D\ . \tag{9}$$

$$\gamma_{pd} \ge 0\ , \qquad \forall p \in P, \forall d \in D\ . \tag{10}$$

Subscripts:
p : indicate Producer's Distribution Warehouse
d : indicate Distributor's Distribution Warehouse

Sets :
P : Set of Producer's Distribution Warehouses
D : Set of Distributor's Distribution Warehouses

Decision Variables:

α_p is quantity of product that flow from plant to producer's warehouse - *p*

β_d is quantity of product that flow from plant to distributor's warehouse- *d*

γ_{pd} is quantity of product that flow from producer's warehouse - *p* to distributor's warehouse- *d*

X_p = 1 if Producer's warehouse - *p* is opened , 0 otherwise

Input Parameters:

u_p : unit transportation cost from plant to producer's warehouse - *p*

v_d : unit transportation cost plant to distributor's warehouse- *d*

w_{pd} : unit transportation cost from producer's warehouse - *p* to distributor's warehouse- *d*

λ_d : demand at distributor's warehouse- *d*

S : quantity supplied from plant

Cp_p : capacity of producer's warehouse- *p*

FC_p : fixed cost of facility of producer's warehouse- *p*

Eq.1 denotes the objective function of our model. The fractions of such equation represent transportation cost (includes loading/unloading cost) from plant to PWs, from plant to DWs, and from PWs to DWs and also fixed cost of facility which represents the rental cost of PWs. Eq.2 shows that total inflow minus total outflow in PWs is set as zero since those nodes are set as intermediate nodes. Eq.3 is related to demand satisfaction of the DWs. Eq.4 shows that total amount of product which are sent from the plant should not be more than its supply capacity. Eq.5 guarantees that there will be no inflow and outflow in every closed PW. Eq.6 concerns with the binary number constraint and Eq.7 is aimed to ensure the capacity of the PW is not violated. Eq.8 ~ Eq.10 are non negative flow constraints.

Since such mixed integer programming is characterized by the problem of finding binary variable X_p to make location decision, hence we must examine all the combinations of composition of PWs and we make use of ADD algorithm to solve this problem (Daskin, 1995; Soehodho *et al.*, 2010). The principle of ADD algorithm is it adds facilities to the solution until the algorithm fails to find a facility whose addition will result in a decrease in the total cost. Each candidate PW added to the solution has to reduce the cost as much as possible , while the previously selected PW is held fixed in the solution.

Analysis of the Existing Condition

Since the size of the existing distribution network is reasonably large, we cluster the network into some zones and this paper is focused on one of the zones and it is shown in Fig.3. The zone consists of 6 PWs and 53 DWs. The product flows from the plant to the plant warehouse through the conveyor belt. Since both the existing system and the improved one use the conveyor belt, in this case we ignore the cost of transport from the plant to the plant warehouse. DW1 ~ DW41 received the products through the PWs, while due to unsettled problem of finding the best place for PW, DW42~DW53 temporarily receive the products directly from the plant warehouse. The clustering system of the DWs along with the associated PW is set based on the administration boundary consideration. From this point of view, we take a note that some DWs are located quite far from the associated PW, and we argue that geographic consideration (distance-based consideration) may be more appropriate to achieve lesser transportation cost and easier access. For that reason, we try to propose a new clustering of DWs, along with the strategy to shorten the trip from plant to DW by design through-trip from plant warehouse to DW without stopping by at the PW. According to the flow and the associated unit cost of the current system (Fig.3), the system costs 736.939.000 IDR.

The Improvement of the System

In order to find better design of distribution network we utilize mathematical model of Eq.1 ~ Eq.10 to achieve the lesser cost (i.e objective function) than the existing one. Therefore, we modify the existing distribution network by 2 scenarios as follows :
Scenario 1 : Direct trips from plant warehouse to DWs are permitted
Scenario 2 : Direct trips from plant warehouse to DWs are not permitted and there must be PWs to buffer minimum stock of product
For both scenarios, we do not change the current condition in which DW42~DW53 receive the products directly from the plant warehouse

In order to exercise the scenario 1, we modify the original network as shown in Fig.2 by adding direct links from plant warehouse to all DWs (scenario 1a) and also by adding such modified network by some links from certain PWs to certain DWs in which there is vague location in term of administration boundary and geographic consideration (scenario 1b). The first notion is related to the strategy of through-trip from plant warehouse to DW without stopping by at the PW, while the second one concerns to both through-trip and the clustering system of DWs. Moreover, scenario 2 is exercised by using original network which is modified by only adding some links from certain PWs to certain DWs. Since we fully utilize all the existing facilities, there is no additional node on the all modified networks. Such modified networks are used to test whether the current system could be enhanced by changing the network design. Furthermore, solution of the mathematical model is found through the use of the developed source code (Nahry, 2010). The solution of the three scenarios along with the existing system are presented in Table 1.

Scenario	Feature of modified network	Objective Function (IDR)
Existing		736.939.000
1a	Open potential direct links from plant warehouse to all DWs	476.152.000
1b	Open potential direct links from plant warehouse to all DWs and some links from certain PWs to certain DWs	476.152.000
2	Open potential some links from certain PWs to certain DWs	691.781.000

Table 1. Solutions of 3 scenarios

From table 1 , Fig.4 and Fig.5, it can be seen that even the working networks are different, the optimal solutions of both scenarios 1a and 1b are similar and they show that all the product flow directly from plant warehouse to DWs. Such solutions cost IDR.476.152.000 (64.62% of existing system). From scenario 2 (Fig 6), we can see that if we do not allow the product to flow directly from plant warehouse to DWs, we could still rearrange the existing clustering system in order to reduce the cost. In our case, we can reduce the cost to IDR 691.781.000 (93.87% of existing system) by opening only PW1, PW4 and PW6. The cost reduction comes from avoiding of the rental cost of PW2, PW3, PW5, as well as loading and unloading cost. Eventually, if the PWs must exist and be functioned as a buffer of supply the solution of scenario 2 may be the best solution for the system rather than the existing one.

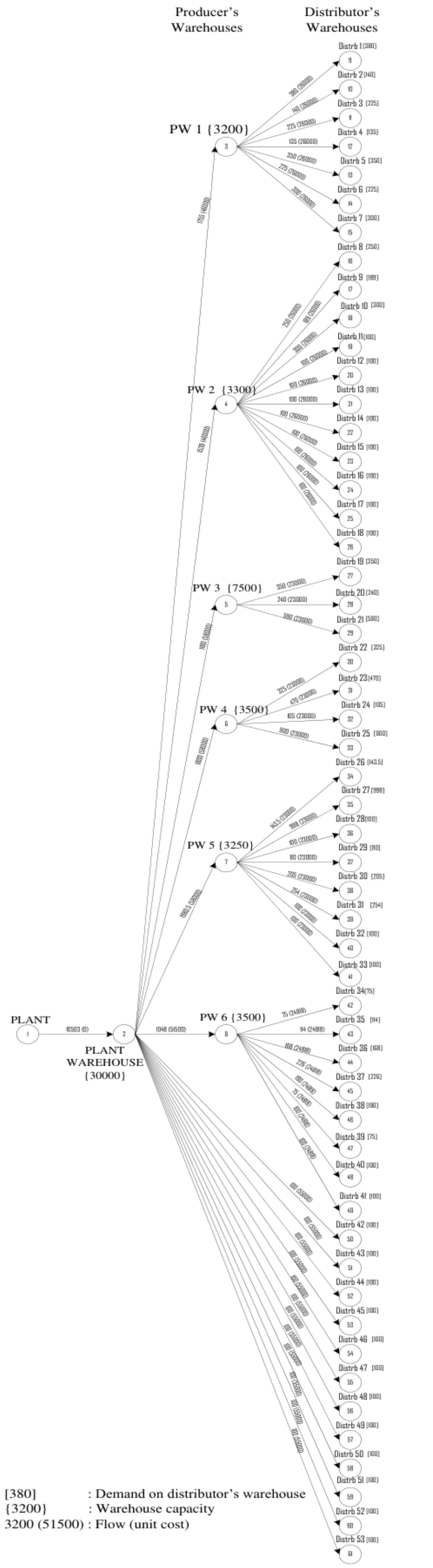

Figure 3 The existing network of zone under consideration

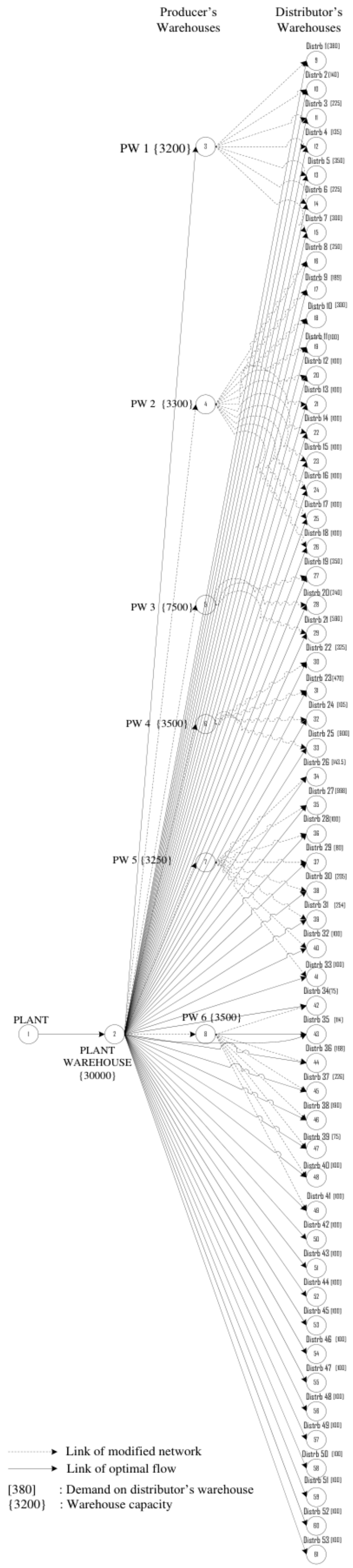

Figure 4 The proposed network of scenario 1a and its optimal solution

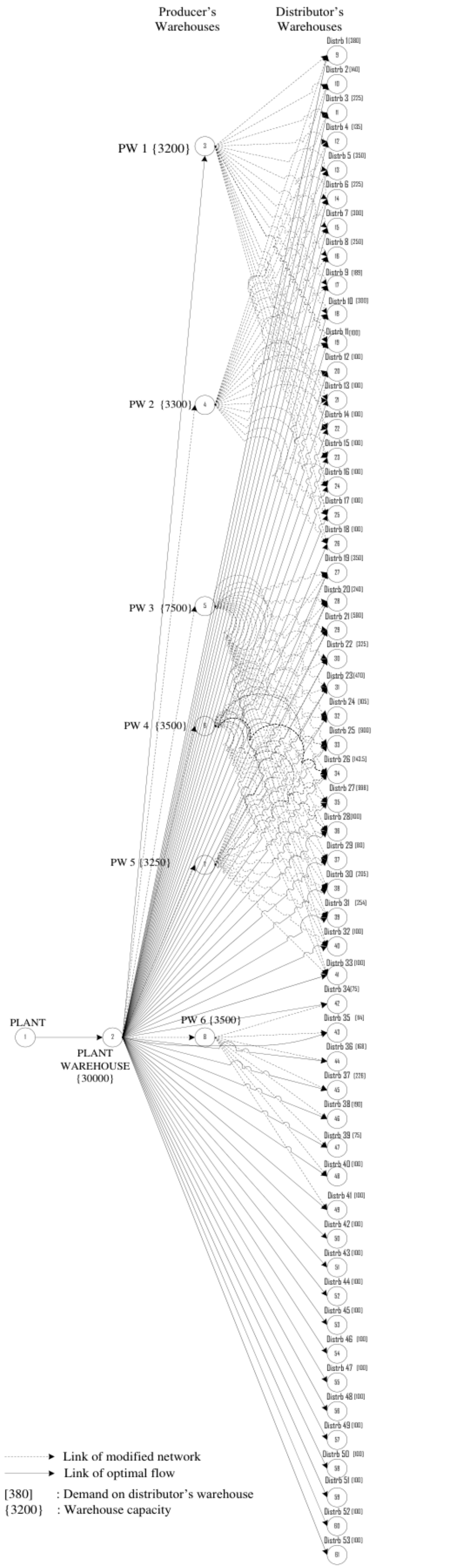

Figure 5 The proposed network of scenario 1b and its optimal solution

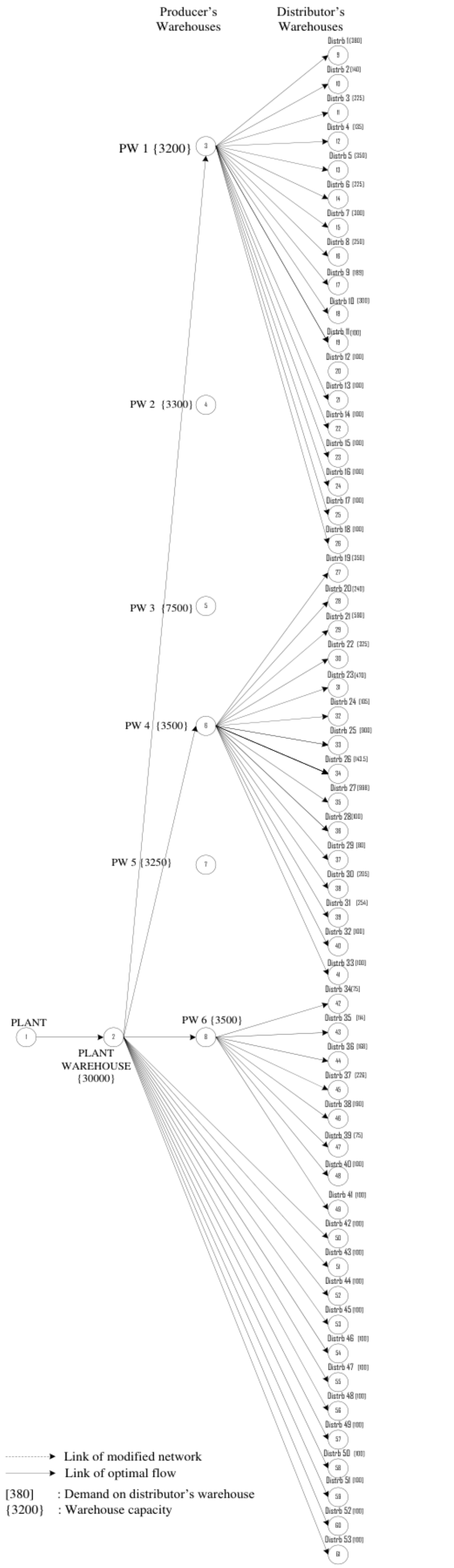

Figure 6 The proposed network of scenario 2 and its optimal solution

Conclusion

A new distribution system has been proposed in order to reduce the distribution cost from plant to the distributor's warehouses of the existing system. The proposed system is based on the idea of reducing the number of producer's warehouses to keep away from loading/unloading cost , rental cost as well as inventory cost. The proposed system also evaluates that the existing clustering of the distributor's warehouses could be enhanced by taking into account the geographic consideration (distance-based consideration) rather than merely administration boundary consideration. Consequently, both ideas may also help to diminish the delay problem on product delivery due to shorter distance and more simple channelization . Moreover, the reduction of the distribution cost may come to the reduction of the subsidy that should be provided by the government. Finally, this current research must be followed by detail analysis of the feasibility of the implementation of the proposed system.

Author Biographies

Nahry is a faculty member in Department of Civil Engineering, Universitas Indonesia. She received her Master and Doctoral degree in Transportation from Universitas Indonesia. She has been doing a lot of research works on Public Transport Planning and Operations as well as Logistics.

Sutanto Soehodho is a Professor of Transportation in Department of Civil Engineering, Universitas Indonesia. He received his Master's and PhD degrees in Transportation Systems and Optimization from Tokyo University. Recently, he is being appointed as member of Public Policy Committee at The Ministry of State Owned Companies of Republic of Indonesia, and Deputy Governor of Jakarta for Trade, Industry and Transportation.

Triana Susanti is student in Master Program of Department of Civil Engineering, Universitas Indonesia. Her thesis is in the area of distribution system of PSO-SOC.

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