Route Optimization Using Saving Matrix Method – A Case Study at Public Logistics Company in Indonesia

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Abstract

This research discusses the optimization of the route design to distribute rice by Indonesia Public Logistics Company which is Company X. The method used in this research is Saving Matrix. Saving Matrix is a method to determine the distribution route by specifying the distribution route to be passed and the number of vehicles based on the capacity of the vehicle to obtain the shortest route and minimal transportation costs. The results from the data processing and analysing shows that the routes change from 18 to 9 new routes, and it obtained the distance saving of 752.2 Km or 45.91% from the initial distance of 1638.3 Km to 886.2 Km. The initial transportation cost before applying the saving matrix method is Rp 1,925,120/month, and the transportation cost after the implementation of the saving matrix method on Route 1 to route 9 amounted to Rp 1,041,285/month. Therefore, the savings transportation costs are Rp 888,835/month or 45.91%.

Keywords
Logistics, Route Optimization, Vehicle, Saving Matrix Method, Optimization

1. Introduction

Nowadays, logistics is one of the crucial aspects that must be considered by the company because there are many obstacles faced by the company in distributing products. Common barriers faced by the companies include fluctuating and the different number of requests for each distribution point, limited number and capacity of vehicles owned, delivery time limits, and the number of points that are numerous and scattered. Every company is required to have proper logistics management. Logistics is part of the supply chain management process that oversees the planning, implementing, controlling, and execution of storage, capable forward and reverse flow of goods and services and related information between points in the supply chain to meet customer requirements (Hayati, 2014). Based on Council of Supply chain Management, logistics referred as "the method of preparing and implementing and controlling the secure, productive movement and storage of products, resources and details relevant to it, from source to point of usage for consumer enforcement," including the incoming, outgoing and related information.

Activities that are included in logistics performance are warehousing, packing, activities of third parties, inbound and outbound transportation, distribution, inventory control, purchasing, location planning, and management of production maintenance and customer satisfaction. A great logistics system can be obtained through efficient logistics activities. A company must be able to optimize the logistics system so it can compete with other competitors. That is because the physical distribution of a company has a significant influence on costs and the level of service to consumers. According to Zaroni (2017), in general, the cost of logistics is grouped into three classifications, namely: (1) transportation costs, (2) inventory costs, and (3) administrative costs. Logistics costs include various cost components, such as transportation costs for each mode; storage costs for any warehousing activity; working capital investment costs; marking products and packaging; application fees and Information Communication Technology (ICT); and fees incurred due to absence of stock out.

One of the factors that highly affect logistic cost are transportation costs. Transportation costs are the most significant cost component in the logistics cost structure. No less than 60% of the company's total logistics costs are transportation costs (Zaroni, 2015). Therefore, various efforts are needed to minimize transportation costs. One way to reduce transportation costs is to optimize the route design and number of vehicles owned by the company. By finding the best route, the company can find the shortest distance in distributing their product, and only utilize the number of vehicles needed to distribute the products. This research will be focusing on the problem that occurs in a logistics company, that has an issue in delaying to deliver their products to the customer. Facing this problem, the company chooses third-party logistics to supply vehicles to help the distribution of the company's product, which will affect the rising of transportation costs, only for distribution of products.

This problem is also faced by Company X, a company that works in the field of logistics. This company is experiencing delays in distributing products due to limited time, the number of vehicles, and the capacity of the vehicles to distribute products. To overcome the problem, the company is collaborating with third-party logistics to provide vehicles to distribute their products. With the description of the problem above, this research conducted by the researchers in Company X. This research only focuses on obtaining the best route of Company X to distributing the rice without containing the financial cases.

In general, issues with preparation and delivery route determination may require several goals, such as the determination of the delivery path, the schedule of such visits or the minimisation of the distance. This research would clarify by using saving matrix from the above definition. The purpose of this research is to define Company X's track distance matrix, by applying the saving matrix on the route. The advantage of using this saving matrix method lies in its ease of adjustment. If there is a limitation on the delivery time, the capacity of the vehicle, the number of transportation or other restrictions and can provide a quick and practical solution (Yuniarti & Astuti, 2013).

2. Research Method

The first step in this research is by doing problem identification using direct observation which is to know the real problem faced by Company X and also using literature review to give an overview and to support the information needed in the research. The data needed in the research divided into two categories: they are primary data and secondary data. The primary data used to get the real idea or view of the problems facing by the company, obtained from observations and interviews. Meanwhile, the secondary data is obtained by the researcher from existing sources, based on the historical data. The secondary data that researchers used are the number of distribution points, location, and demand for each distribution point, distribution route, number of vehicles.

2.1 Saving Matrix Method

After all the required data has been collected, the next step is data processing, which used the saving matrix method. Saving Matrix is a method used to determine the distance, route, time, or cost in the implementation of the delivery of goods from the company to the consumer (Suparjo, 201). This method aims to make delivery of goods suitable for customer's orders can be done effectively and efficiently so that the company can save cost, effort, and delivery time (Istantiningrum, 2010). The advantage of using this method lies in its ease of adjustment. If there is a limitation on vehicle capacity, number of vehicles, delivery time or other limitations, it can give a quick and practical solution (Yuniarti & Astuti, 2013). Several assumptions should be considered when using the saving matrix method. They are, the road that passed by the vehicle is a two-way street, so the distance from the original to the destination or vice versa is the same. The las assumption is, the traffic conditions such as traffic light, traffic jam, etc. do not affect the vehicle speed. The Saving Matrix method consists of several steps. According to (Istantiningrum, 2010) the steps in the method of saving matrix are shown in the Figure 1.

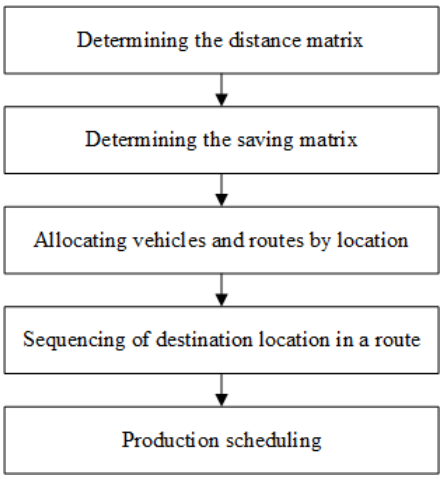

Figure 1. The Steps of Saving Matrix Method

Based on Figure 1, it can be shown that there are five steps that used while using saving matrix method, for more detaile about the steps are explained as follows:

1. Determining the distance matrix

The distance data between companies with location and one location to other locations is indispensable. After knowing the coordinates of each location, the distance between the two locations can be calculated using the formula as follows:

$$S(1, 2) = \sqrt{(x1 - x2) + (y1 - y2)^2} \quad (1)$$

However, if the distance between the two coordinates is known, then the calculation using the formula is not used and using the actual distance.

2. Determining the saving matrix

After knowing the overall distance; therefore, in this step, it assumed that the location would be passed by one truck exclusively. This means that there will be several different routes that will be passed for their purposes. Thus, there will be a saving when there is a route merger that is assessed in one direction with the other route. To look for the saving matrix can be used formula as follows:

$$S(x, y) = S(x, y) + S(x, y) - S(x, y) \quad (2)$$

3. Allocating vehicles and routes by location

The next step is to allocate the location to a route or vehicle. This means that in this step, the new delivery route will be determined based on the merging route in the second step above. The result is delivered to the 1st location, and 2nd location will be done using one route.

4. Sequencing of destination location in a route

This step determines the order of the visit. There are several methods in determining the order of visits, but in this research, the authors used the Nearest Neighbor as the methods. This method determines the visit by prioritizing the location that is closest to the last visited location. The Nearest Neighbor method is a heuristic method used in troubleshooting route problems, and problem-solving is done by starting the starting point and then looking for the closest point. (Hutasoit, Susanty, & Imran, 2014).

5. Production scheduling

One of the benefits of scheduling is to deliver the products to the specified time and capacity that already determined. The purpose of scheduling is to deliver the products sequentially following the schedule made. The schedule is a time record that is poured into a single calendar that is indispensable for the executor. Some of the results of the scheduling are one of the corresponding delivery routes that are already available in the resulting table so that the shipment does not exceed the capacity in sending the products (Istantiningrum, 2010).

3. Data Collection

Related to the study literature, interviews, and direct observation in Company X, the researchers were able to identify the data that will be considered in the new route distribution, which produces the shorter distance and less

transportation cost to distributing rice. Data were collected from the company's historical data, and it used to know the company's demand, each distribution point (depot), the distance for each depot, initial route distribution, and initial transportation cost. The average of large order size for rice products in the period of January 2019 – December 2019 is shown in Table 1.

Table 1 Average Data of Rice Demand

Average Data on Demand			
No	**Distribution Point**	**Distance (Km)**	**Demand (Kg)**
1	DEPOT 1	47	3925
2	DEPOT 2	45.3	3650
3	DEPOT 3	47.5	3940
4	DEPOT 4	45.2	4778
5	DEPOT 5	54.1	2994
6	DEPOT 6	44.3	3148
7	DEPOT 7	39.8	4898
8	DEPOT 8	42.7	2245
9	DEPOT 9	45.1	2513
10	DEPOT 10	53.2	3505
11	DEPOT 11	38.6	2760
12	DEPOT 12	49	2545
13	DEPOT 13	38.7	2628
14	DEPOT 14	48.3	2790
15	DEPOT 15	53.6	3893
16	DEPOT 16	37.9	3955
17	DEPOT 17	43.4	4140
18	DEPOT 18	45.5	3740

For the initial route, Company X has 18 routes to distribute rice, and rice distribution is done in one shipment. Table 2 will show the initial route that Company X used to distribute its product.

Table 2 Initial Route Distribution of Rice

Initial Route Distribution		
Route	**Initial Route Distribution**	**Distance (Km)**
1	W - D1 - W	94
2	W - D2 - W	90.6
3	W - D3 - W	95
4	W - D4 - W	90.4
5	W - D5 - W	108.2
6	W - D6 - W	88.6
7	W - D7 - W	79.6
8	W - D8 - W	85.4
9	W - D9 - W	90.2
10	W - D10 - W	106.4
11	W - D11 - W	77.2
12	W - D12 - W	98
13	W - D13 - W	77.4
14	W - D14 - W	96.6
15	W - D15 - W	107.2
16	W - D16 - W	75.8
17	W - D17 - W	86.8
18	W - D18 - W	91
	Total	1638.4

Because the distribution of rice is done by one shipment, therefore each distance for the initial route distribution is obtained from the warehouse-depot-warehouse calculation. Then, the calculation shows that the total distance from the initial route distribution is 1638.4 Km. In distributing rice, Company X used truck type Colt Diesel Double (CDD) Bak, which has a capacity of 8 tons and truck type Pick Up L300 Bak with a capacity of 2 tons. The Truck uses the fuel type Bio-diesel with the price of Rp 9400/liters and based on the interview conducted 1 liter of Bio-diesel can run the vehicle as far as ± 8 Km. Therefore, the initial transportation cost is shown in Table 3.

Table 3 Transportation Cost of Initial Route

Route	Initial Route Distribution	Total Distance (Km)	Cost (Rp)
1	W - D1 - W	94	110450
2	W - D2 - W	90.6	106455
3	W - D3 - W	95	111625
4	W - D4 - W	90.4	106220
5	W - D5 - W	108.2	127135
6	W - D6 - W	88.6	104105
7	W - D7 - W	79.6	93530
8	W - D8 - W	85.4	100345
9	W - D9 - W	90.2	105985
10	W - D10 - W	106.4	125020
11	W - D11 - W	77.2	90710
12	W - D12 - W	98	115150
13	W - D13 - W	77.4	90945
14	W - D14 - W	96.6	113505
15	W - D15 - W	107.2	125960
16	W - D16 - W	75.8	89065
17	W - D17 - W	86.8	101990
18	W - D18 - W	91	106925
	Total	1638.4	1925120

The transportation cost that used in this research, focuses on vehicle fuel costs due to information data obtained from company interviews. Vehicle fuel is a variable cost in this research. The total variable cost, in this case, is the use of Bio-diesel, the transportation cost size depends on the volume of activity; in this case, the distance traveled. The higher the volume of activity, the total variable costs also increase, and vice versa. Table 4 and Table 5 shows the distance between the warehouse to every depot and distance between each depot to another depot in Zone 1 and Zone 2.

Table 4 Distance for Each Depot - Zone 2 (Km)

W					
48.3	D14				
53.6	18	D15			
37.9	11.4	16.6	D16		
43.4	5.6	13.2	6.5	D17	
45.5	10	11.6	8.6	4.9	D18

Table 5 Distance for Each Depot - Zone 1 (Km)

W													
47	D1												
45.3	2.3	D2											
47.5	6.3	6.1	D3										
45.2	3	2.8	3.4	D4									
54.1	11.9	11.7	8.7	9	D5								
44.3	5.2	5.5	5.2	2.9	11.8	D6							
39.8	5.3	8	7.7	5.4	14.3	4.5	D7						
42.7	7	7.3	7	4.7	13.6	2.9	6.3	D8					
45.1	2.4	1.1	6.2	3	11.8	5.6	8.1	7.4	D9				
53.2	6	7.3	5.4	3.3	12.1	5.9	8.4	7.8	6	D10			
38.6	10.3	10.1	9.8	7.5	16.4	5.7	9.1	3.2	10.2	10.6	D11		
49	27.4	27.2	23.4	22.9	24.8	21.1	24.4	18.5	25.5	25.8	17.2	D12	
38.7	19.4	19.2	18.9	16.6	25.5	14.8	18.2	12.3	19.3	19.7	9.2	19.6	D13

Zone division in the distribution of rice refers to the two largest zones and has the closest distance between each depot in its zone.

4. Result and Discussion

On the initial route, there are 18 different routes with one destination per each. After calculated with saving matrix formula with the help of Ms. Excel, the saving matrix for Zone 1 and Zone 2 is shown in Table 6 and Table 7.

Table 6 Saving Matrix - Zone 2 (Km)

W					
48.3	D14				
53.6	83.9	D15			
37.9	74.8	74.9	D16		
43.4	86.1	83.8	74.8	D17	
45.5	83.8	87.5	74.8	84	D18

Table 7 Saving Matrix - Zone 1 (Km)

W													
47	D1												
45.3	90	D2											
47.5	88.2	86.7	D3										
45.2	89.2	87.7	89.3	D4									
54.1	89.2	87.7	92.9	90.3	D5								
44.3	86.1	84.1	86.6	86.6	86.6	D6							
39.8	81.5	77.1	79.6	79.6	79.6	79.6	D7						
42.7	82.7	80.7	83.2	83.2	83.2	84.1	76.2	D8					
45.1	89.7	89.3	86.4	87.3	87.4	83.8	76.8	80.4	D9				
53.2	94.2	91.2	95.3	95.1	95.2	91.6	84.6	88.1	92.3	D10			
38.6	75.3	73.8	76.3	76.3	76.3	77.2	69.3	78.1	73.5	81.2	D11		
49	68.6	67.1	73.1	71.3	78.3	72.2	64.4	73.2	68.6	76.4	70.4	D12	
38.7	66.3	64.8	67.3	67.3	67.3	68.2	60.3	69.1	64.5	72.2	68.1	68.1	D13

Tables 6 and 7 shows the saving matrix, which stores the most significant distance values. By using the saving matrix above the researcher know which depots should be merged into one route to produce the shortest route, maximize the use of delivery time, and pay attention to vehicle capacity. In this case, researchers maximize the use of Colt Diesel Double (CDD) Bak, which has a capacity of 8 tons. The demand capacity carried by truck of merging a depot into one route must not exceed the capacity of the truck to meet safety standards.

Based on the calculation of the savings matrix distance in table 6 & 7, the next step is to allocate a warehouse and depot to the route. With different starting routes, however, in order to allocate a depot - depot can be held until the capacity limit of the truck available. The merger route will start from the most significant distance saving value to maximize savings. After allocating the route done, the next step is to determine the sorting of the delivery route by using the implementation of the nearest neighbor method—the allocation route shown in Table 8.

Table 8 – Allocation Route After Saving Matrix Calculated

Route	Allocation Route After Saving Matrix Calculated	After Nearest Neighbour Method Applied
1	D1 - D2	D2 – D1
2	D3 - D10	D3 - D10
3	D4 - D5	D4 - D5
4	D6 - D8 - D9	D8 – D6 - D9
5	D7	D7
6	D11 - D12 - D13	D11 - D13 - D12
7	D14 - D17	D17 - D14
8	D15 - W18	D18 - W15
9	D16	D16

From the calculations using the implementation of the Nearest Neighbour method, the new route with the best saving distance, as shown in Table 9.

Table 9 New Route Distribution

Route	New Route Distribution	Distance (Km)	Demand (Kg)
1	W - D1 - D2 - W	94.6	7575
2	W - D3 - D10 - W	106.1	7445
3	W - D4 - D5 - W	108.3	7772
4	W - D6 - D8 - D9 - W	99.7	7906
5	W - D7	79.6	4898
6	W - D11 - D12 - D13 - W	114.1	7933
7	W - D14 - D17 - W	97.3	6930
8	W - D15 - W18 - W	110.7	7633
9	W - D16	75.8	3955
	Total	886.2	62047

From the data processing in Table 9, the new transportation cost of the new route distribution is shown in Table 10.

Table 10 Transportation Cost of New Route

Route	New Route Distribution	Distance (Km)	Cost (Rp)
1	W - D1 - D2 - W	94.6	111155
2	W - D3 - D10 - W	106.1	124,667.50
3	W - D4 - D5 - W	108.3	127252.5
4	W - D6 - D8 - D9 - W	99.7	117147.5
5	W - D7	79.6	93530
6	W - D11 - D12 - D13 - W	114.1	134067.5
7	W - D14 - D17 - W	97.3	114327.5

8	W - D15 - W18 - W	110.7	130072.5
9	W - D16	75.8	89065
	Total	886.2	1041285

The transportation cost of the new route is still using the data obtained by company interviews. The researcher used the price of Bio-diesel, which Rp 9400/liters and based on the interview conducted, 1 liter of Bio-diesel can run the vehicle as far as ± 8 Km. Therefore, the transportation cost of the new route is Rp 1,041,285. From the analysis and discussion of data above, it can be compared between the initial route and the new route distribution, as shown in Table 11.

Table 11 Comparison Between Initial Route with New Route

	Recent Route	**New Route**	**Savings**	**Savings (%)**
Cost of Transportation (Fuels)	Rp 1,925,120	Rp 1,041,285	Rp 888,835	45.91%
Total Distance (Km)	1638.4 Km	886.2 Km	752.2 Km	45.91%

From the Table 11, the researcher can compare the saving of total distance and cost of transportation in distributing the rice before and after the saving matrix method applied to the company's problem.

5. Conclusion

The new route can be obtained by applying the saving matrix method and obtaining the efficiency of distance and transportation costs. After saving matrix method applied on delivery of the product to the depot the truck that has a capacity 8 tons can distribute to the 18 distribution point, for zone 1 (depot 1, depot 2, depot 3, depot 4, depot 5, depot 6, depot 7, depot 8, depot 9, depot 10, depot 11, depot 12, depot 13) and zone 2 (depot 14, depot 15, depot 16, depot 17, depot 18) with an overall distance saving is 752.2 Km or 45.91% per month. The initial transportation cost before using the saving matrix is Rp 1,925,120. After the saving matrix method applied to the system, the transportation cost becomes Rp 1,041,285, and it saves 45.91% of transportation cost. For the result, it will affect the time saving and transportation cost in distributing rice from Company X to each distribution point.

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