Evaluation of the distribution model and mode of transportation of PT X

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Abstract. Logistics contribute to cost efficiency accompanied by increased productivity and profits along with improvements in service to consumers or customers. Transportation issues are related to how companies reduce logistics costs by building efficient transportation networks. So far, the company PT.X has been sending products to all consumers using the Direct Shipment with Milk Runs distribution model with the truck transportation mode. The highest transportation costs at PT. X reached 19% and the average percentage of costs was 14% of the company's net income (total Revenue). It appears that the cost of distribution of PT.X products has been Out of Control due to reaching more than 10% of the company's net income. A percentage of this amount is included in the Major Opportunity for Savings or an opportunity for improvement. In this study a solution is proposed in the form of the best type of delivery and the mode of transportation that is suitable for the type of delivery. The right type of shipping at the company is Direct Shipment Milk Runs which has two alternative transportation. From the latest delivery route arrangement, transportation costs drop to 8% of total revenue when using truck and 4% of total revenue when using motorized rickshaw.

1. Introduction
PT.X is a company engaged in the production of dry food including shrimp crackers and red and white crackers. Shrimp crackers and red and white crackers are additional food dishes. So that consumers or customers of PT.X are retail stores, restaurants and second-hand distributors.

So far, PT. X companies that deliver products to all consumers use the Direct Shipping with Milk Runs distribution model with truck transportation modes from the company to several consumers and then back to the company. The distribution model and transportation mode used so far have an impact on the company's transportation costs. Even in 2019, PT. X's transportation costs have reached the highest percentage of 19% of the company's net revenue (Revenue Total). According to Ruffin et al, a company if the cost component has a percentage exceeding 10% of the company's total Revenue, then the cost component is declared Out of Control. If a percentage of these costs occur in a company, then the cost component is included in the Major Opportunity for Savings or an opportunity to be repaired [1]. The transportation network design influences Supply Chain performance by building infrastructure where operational transportation decisions regarding scheduling and routing are made. A well-designed transportation network allows the Supply Chain to achieve the desired response rates at low costs [2].
Types of Supply Chain networks, namely Direct Shipment Network to Single Destination, Direct Shipping with Milk Runs, All Shipments via Intermediate Distribution Center (DC) with Storage. [3]

Transportation is the company's main cost component in reducing costs incurred by the company. Transportation issues relate to how companies reduce logistics costs by building efficient transportation networks, increasing truck utilization, increasing fleet utilization and utilizing information technology [4]. The objective of the transportation system aims to minimize the distance and cost. ensure that all vehicles are not allowed to carry more than their capacity, and choose better route for transportation process. So that the transportation system running with optimal and efficient condition to meet right place, right time, right quantity, right quantity [5]. Those are the NP-hard complex problem that need soft computing approach (i.e. genetic algorithm) to solve the problem. The soft computing approach can tolerance uncertainty, partial truth, imprecision, and approximation with near optimum value can reached with fast calculation [6-8].

This research will conduct a study by comparing distribution models and types of transportation modes and determining the order of delivery in Direct Shipping with Milk Runs by using the concept of Traveling Salesman Problem (TSP) to determine the route of product delivery from companies to consumers (Business to Consumer) with the aim of minimizing costs travel. In the case of TSP, the goal is to find the best way to visit all cities exactly once and return to the starting point and minimize travel costs or possible distances between each route [9,10]. Many researchers have begun to use the ACO algorithm to solve TSP and they claim that ACO outperforms other algorithms inspired by nature such as simulated annealing and evolutionary computation [11].

ACO-TSP research as has been done [12] applies theoretical determination of the shortest route using ACO-TSP. Research on fuel costs (fuel cost) from public vehicles to get satisfactory results from ACO-TSP in vehicle efficiency [13]. ACO can also be used to improve the performance of a TSP in minimizing the transportation costs of the resulting route [14,15].

2. Research methodology

2.1. Object of Research
The object under study is the delivery route on each company's shipping schedule using a vehicle to meet consumer demand.

2.2. Research variable
A variable is something that has a different or varied value. The value of the variable can be quantitative or qualitative. The variables contained in this study are:

1. Independent Variable
   The independent variable is the variable that influences or is the cause of the change or the emergence of the dependent variable both positively and negatively. The independent variables in this study include:
   a. Coordinates / addresses of companies and consumers
   b. Route distance
   c. Travel time in transportation mode
   d. Ant trail intensity controller (Pheromone) ($\alpha$)
   e. Visibility controller ($\beta$)
   f. Evaporation of ant tracks (Pheromone evaporation) ($\rho$)
   g. Number of ants ($m$)
   h. The intensity of the initial ant trail (Pheromone) ($\tau_0$)
   i. Ant iteration constant ($Q$)

2. Dependent Variable
   The dependent variable is a variable whose value is influenced or determined by other variables. The dependent variables that are affected in this study are as follows:
   a. Distance Invers ($\eta_{ij}$)
   b. The intensity of the ant trail (Pheromone) between point i and point j ($\tau_{ij}$)
c. Pheromone value changes at point (i, j) made by ant k \( (\Delta \tau_{ij}^k) \)
d. Ant probability k at point i to point j \( k (P_{ij}^k) \)

2.3. Method of collecting data
The data used in this study are secondary data that is data obtained from the company in the form of a company delivery location and the location of the consumer to which the company is going. Determination of location can use the address of each shipment and calculation of distance and time from the point of the company (sender) to the point of consumer (recipient) can use the google maps application.

2.4. Data processing method
Data processing is performed for alternative delivery using the Direct Shipment Network with Single Destination method as follows:
1. Constructing the problem into a graph \( G = (V, E) \) with \( V \) the set of vertices that represent the set of points, and \( E \) is the set of edges that represent the distance between two points.
2. Calculating the time needed between the company to each consumer
3. Perform travel distance calculations between companies to each consumer
4. If the shipment exceeds working hours, then the delivery continues on the next day

![Diagram](image.png)

Figure 1. Data processing direct shipment network with single destination.
Data processing is performed for alternative delivery using the Direct Shipping with Milk Runs method is as follows:
1. Constructing the problem into a graph $G = (V, E)$ with $V$ the set of vertices that represent the set of points, and $E$ is the set of edges that represent the distance between two points.
2. Calculating the time needed between the company to each consumer
3. Perform travel distance calculations between companies to each consumer
4. Initiating the initial parameters and placement of ants at a number of $n$ points.
5. Perform the calculation of the probability of the ant to choose the next point by considering distance and time
6. All ants complete each tour and the length of the ant tour is calculated and the best tour is obtained.
7. Pheromone updates are performed with consideration of distance and time
8. If all ants have found the same tour with the same distance (convergence) or the Maximum Number of Iterations ($NC_{max}$) fulfilled then the search is stopped, if not then the search process will be continued until convergence or $NC_{max}$ is met.

![Figure 2. Data processing direct shipping with milk runs.](image-url)
3. Result and discussion

3.1. Direct shipment network with single destination results

Direct Shipment Network to Single Destination is a type where the company arranges a transportation network so that all shipments come directly from each supplier to each buyer’s location. The distance that must be traveled from the company to each consumer can be seen in Table 1.

| Table 1. Total distance to be taken by the three means of transportation |
| Company | Consumer 1 | 13.800 |
| Company | Consumer 2 | 3.000 |
| Company | Consumer 3 | 28.000 |
| Company | Consumer 4 | 7.200 |
| Company | Consumer 5 | 30.400 |
| Company | Consumer 6 | 11.000 |
| Company | Consumer 7 | 31.200 |
| Company | Consumer 8 | 13.400 |
| Company | Consumer 9 | 20.200 |
| Company | Consumer 10 | 11.400 |
| Company | Consumer 11 | 10.600 |
| Company | Consumer 12 | 14.400 |
| Company | Consumer 13 | 9.200 |
| Company | Consumer 14 | 13.400 |
| Company | Consumer 15 | 11.400 |
| ... | ... | ... |
| Company | Consumer 88 | 39.000 |
| Total Mileage | 2,623.800 |

From the table above, if the company applies the Direct Shipment Network to Single Destination in shipping, the company must travel 2,623.8 km to send all products to 88 consumers. So the time needed to send products to 88 consumers uses the transportation mode of trucks and motorized rickshaws. The time needed to deliver products to 88 consumers using the modes of transportation of trucks and motorized tricycles can be seen in Table 2.

| Table 2. Time to be taken by trucks and motorcycles |
| Time Distribution (Hours)(PM) | 12:30-1:30 | 1:30-2:30 | 2:30-3:30 | 3:30-4:30 | 5:30-6:30 |
| Company | Consumer 1 | 62 | 36 | 46 | 48 | 50 |
| Company | Consumer 2 | 62 | 24 | 26 | 44 | 38 |
| Company | Consumer 3 | 36 | 88 | 30 | 26 | 46 |
| Company | Consumer 4 | 40 | 32 | 34 | 84 | 32 |
| Company | Consumer 5 | 24 | 42 | 84 | 38 | 40 |
| Company | Consumer 6 | 24 | 88 | 36 | 32 | 34 |
| Company | Consumer 7 | 30 | 48 | 24 | 66 | 48 |
| Company | Consumer 8 | 32 | 36 | 42 | 66 | 36 |
| Company | Consumer 9 | 38 | 36 | 46 | 38 | 66 |
| Company | Consumer 10 | 92 | 68 | 102 | 122 | 122 |
| Total Time taken | 7048 Minutes |
So to deliver products to 88 consumers with the Direct Shipment Network to Single Destination using trucks and motorized rickshaw, it takes 7048 minutes or 20 working days to deliver. The time needed to ship products to 88 consumers using motorcycle transportation modes can be seen in Table 3.

Table 3. Time to be taken by trucks and motorcycles

| Motorcycle Travel Time | Explanation       |
|------------------------|------------------|
| Time Distribution (Hours)(PM) | 12:30-1:30 | 1:30-2:30 | 2:30-3:30 | 3:30-4:30 | 4:30-5:30 |
| Company                | Consumers       |           |           |           |           |
| Company Consumer 1     | 26              | 36        | 40        | 44        |          |
| Company Consumer 2     | 14              | 16        | 36        | 32        |          |
| Company Consumer 3     | 38              | 20        | 18        | 40        |          |
| Company Consumer 4     | 30              | 62        | 24        | 34        | Day 1, Until the Company Returns at 5:58 |
| Company Consumer 5     | 14              | 32        | 30        | 26        |          |
| Company Consumer 6     | 22              | 24        | 20        | 28        |          |
| Company Consumer 7     | 20              | 38        | 16        | 42        |          |
| Company Consumer 8     | 22              | 26        | 32        | 30        |          |
| Company Consumer 9     | 28              | 26        | 36        | 24        |          |
| Company Consumer 10    | 82              | 58        | 92        | 114       |          |
| Company Consumer 11    | 58              | 58        | 42        | 50        | 88       |
| Company Consumer 12    | 58              | 46        | 54        | 58        | 46       |
| Company Consumer 13    | 54              | 60        | 46        | 54        | 62       |
| Company Consumer 14    | 56              | 60        | 50        | 54        |          |
| Company Consumer 15    | 48              | 58        | 60        | 58        | 60       |
| Company Consumer 16    | 54              | 52        | 48        | 58        | 108      |
| Company Consumer 17    | 42              | 56        | 50        | 60        |          |
| company Consumer 87    | 94              | 74        | 78        | 98        | 128      |
| Company Consumer 88    | 78              | 90        | 106       | 126       | 128      |
| Total Time taken       | 6496 Minutes    |

So to send products to 88 consumers with Direct Shipment Network to Single Destination using a motorcycle, it takes 6496 minutes or 19 working days to send. Direct Shipment Network to Single Destination delivery is done by sending one product to one customer from the company directly. The advantage of this method is a simpler transportation network. Distance traveled time and transportation costs of the three modes of transportation using the DSNSD distribution model can be seen in Table 4.

Table 4. Third comparison of DSNSD transportation

| Analysis | Transportation Mode |
|----------|---------------------|
|          | Truck               | Motorcycles | Motorized Rickshaw |
| Mileage  | 1.311.9 km          | 1.311.9 km  | 1.311.9 km          |
| Time Taken | 117.5 Hours       | 108.3 Hours | 117.5 Hours         |
| Transportation Costs | Rp 6.690.690,00 | Rp 716.859 | Rp1.338.138,00 |

3.2. Results of direct shipping with milk runs

3.2.1. Measurement of ant colony optimization parameters. The recapitulation of the entire experimental results of testing the parameter value of ant trail intensity $\alpha$, $\beta$ and $\rho$ for delivery by truck transportation mode is shown in Table 5.

Table 5. Testing results for $\alpha$, $\beta$ and $\rho$ parameters for trucks

| Delivery Schedule | Parameter | $\alpha$ | $\beta$ | $\rho$ |
|-------------------|-----------|----------|---------|--------|
| Week-1            | Delivery 1 | 1.0      | 5.0     | 0.3    |
|                   | Delivery 2 | 1.0      | 4.0     | 0.2    |
| Week-2            | Delivery 1 | 0.8      | 5.0     | 0.3    |
|                   | Delivery 2 | 1.0      | 5.0     | 0.5    |
| Week-3            | Delivery 1 | 1.2      | 5.0     | 0.5    |
|                   | Delivery 2 | 1.0      | 8.0     | 0.7    |
| Week-4            | Delivery 1 | 1.0      | 5.0     | 0.5    |
|                   | Delivery 2 | 0.6      | 5.0     | 0.5    |
As for the recapitulation of all experimental results testing the parameter values of the ant trail intensity of $\alpha$, $\beta$ and $\rho$ all shipments for the motorized rickshaw transportation mode are shown in Table 6.

Table 6. Testing Results for $\alpha$, $\beta$ and $\rho$ parameters for motorized rickshaw

| Delivery Schedule | $\alpha$ | $\beta$ | $\rho$ |
|-------------------|----------|---------|---------|
| Week-1            | Delivery 1 | 1.0     | 5.0     | 0.3     |
|                   | Delivery 2 | 1.2     | 4.0     | 0.2     |
|                   | Delivery 3 | 1.1     | 3.0     | 0.2     |
|                   | Delivery 4 | 0.9     | 6.0     | 0.4     |
| Week-2            | Delivery 1 | 0.8     | 5.0     | 0.3     |
|                   | Delivery 2 | 1.0     | 5.0     | 0.5     |
|                   | Delivery 3 | 1.0     | 7.0     | 0.6     |
|                   | Delivery 4 | 0.9     | 6.0     | 0.4     |
| Week-3            | Delivery 1 | 1.2     | 5.0     | 0.5     |
|                   | Delivery 2 | 1.0     | 8.0     | 0.5     |
|                   | Delivery 3 | 1.2     | 7.0     | 0.5     |
|                   | Delivery 4 | 0.9     | 5.0     | 0.3     |
| Week-4            | Delivery 1 | 1.0     | 5.0     | 0.5     |
|                   | Delivery 2 | 0.7     | 5.0     | 0.4     |
|                   | Delivery 3 | 0.6     | 5.0     | 0.5     |
|                   | Delivery 4 | 1.1     | 7.0     | 0.6     |

3.2.2. Order of shipment mode of transportation. After all processing steps have been carried out, then the results of the ant travel are simulated to produce the order of delivery of the two modes of transportation. The design of the company shipping sequence using DSMDSMR ACO-TSP truck transportation results can be seen in Table 7.

Table 7. Truck Delivery Order

| Delivery Schedule | Truck |
|-------------------|-------|
| Delivery 1        | Company, K-17, K-03, K-33, K-40, K-37, K-23, K-09, K-01, K-11, K-06, K-27, Company |
| Delivery 2        | Company, K-30, K-44, K-07, K-35, K-16, K-20, K-26, K-08, K-13, K-02, Company |
| Delivery 3        | Company, K-68, K-59, K-46, K-45, K-54, K-63, K-31, K-39, K-22, K-14, K-04, Company |
| Delivery 4        | Company, K-29, K-47, K-05, K-32, K-42, K-38, K-25, K-10, K-12, K-15, K-18, Company |
| Delivery 5        | Company, K-60, K-48, K-55, K-41, K-19, K-36, K-64, K-79, K-72, K-69, K-28, Company |
| Delivery 6        | Company, K-43, K-50, K-53, K-21, K-24, K-85, K-80, K-76, K-71, K-67, K-61, Company |
| Delivery 7        | Company, K-49, K-52, K-34, K-57, K-88, K-81, K-86, K-83, K-78, K-74, K-70, Company |
| Delivery 8        | Company, K-51, K-58, K-62, K-56, K-82, K-87, K-84, K-73, K-75, K-77, K-65, K-66, Company |

The design of the company's shipping sequence using motorized rickshaw transportation resulting from ACO-TSP DSMDSMR can be seen in Table 8.

Table 8. Testing Results for $\alpha$, $\beta$ and $\rho$ parameters for motorized rickshaw

| Delivery Schedule | Motorcycle Rickshaws |
|-------------------|----------------------|
| Delivery 1        | Company, K-6, K-11, K-9, K-1, K-3, Company |
| Delivery 2        | Company, K-27, K-23, K-37, K-40, K-33, K-17 |
| Delivery 3        | Company, K-2, K-8, K-20, K-7, K-16, K-13, Company |
| Delivery 4        | Company, K-30, K-50, K-10, K-35, K-26, Company |
| Delivery 5        | Company, K-14, K-31, K-39, K-22, K-4, Company |
| Delivery 6        | Company, K-69, K-46, K-45, K-54, K-63, Company |
| Delivery 7        | Company, K-15, K-5, K-42, K-12, K-10, Company |
| Delivery 8        | Company, K-29, K-18, K-47, K-32, K-38, K-25, Company |
| Delivery 9        | Company, K-28, K-48, K-41, K-19, K-36, Company |
| Delivery 10       | Company, K-69, K-64, K-72, K-79, K-55, K-60, Company |
| Delivery 11       | Company, K-21, K-24, K-53, K-50, K-43, Company |
| Delivery 12       | Company, K-76, K-85, K-80, K-71, K-61, K-67, Company |
| Delivery 13       | Company, K-49, K-52, K-57, K-74, K-70 |

7
The results of distance and time for Direct Shipment Milk Run distribution model using the truck transportation mode are the distance of 826.9 km and the travel time of 1,992 minutes. As for the motorized rickshaw transportation mode, the distance is 1,293.3 km and the travel time is 2,696 minutes. The travel time and transportation costs of the two modes of transportation using the DSMR distribution model can be seen in Table 9.

### Table 9. DSMR transportation third analysis

| Analysis       | Transportation Mode | Truck         | Motorized Rickshaw |
|----------------|---------------------|---------------|-------------------|
| Mileage        | 826.9 km            | 1,293.3 km    |                   |
| Time Taken     | 33.2 Hours          | 44.9 Hours    |                   |
| Transportation Costs | Rp 2,108,595.00  | Rp 632,043.00 |                   |

3.3. Comparison of distribution models and modes of transportation. Comparisons are made to choose which distribution model and mode of transportation is best based on distance, time and transportation costs. This comparison can be seen in Table 10.

### Table 10. Analysis of distribution models and modes of transportation

| Distribution model | Direct Shipment Network to Single Destination | Direct Shipment Milk Runs |
|--------------------|-----------------------------------------------|---------------------------|
| Mode of transportation | Truck         | Motorcycles | Motor Rickshaw | Truck         | Motor Rickshaw |
| Mileage (km)       | 1,311.9        | 1,311.9     | 1,311.9        | 826.9         | 1,239.3       |
| Time Taken (Hours) | 117.5          | 108.3       | 117.5          | 33.2          | 44.9          |
| Transportation Costs (Rp.) | 6,690,690.00 | 716,859.00 | 2,007,207.00  | 2,108,595.00  | 632,043.00    |

From this table it can be concluded that a better distribution model is the Direct Shipment Network to Single Destination by using a motorcycle transportation mode in terms of cost. However, the shortest distance and smaller travel time is better to use the Direct Shipment with Milk Runs distribution model with the modes of transportation of trucks and motorized rickshaws. This is because in this model the mode of transportation does not need to go back to the company to load the next consumer product.

3.4. Comparison of transportation costs and revenue total

The transportation costs of the two means of transportation survived 2019 by comparing the company's net income, then in Table 11. a comparison of the percentage of costs before repair and after route repair is shown.

### Table 11. Comparison of transportation costs with total revenue in 2019

| Year | Transportation Costs | Revenue Total |
|------|----------------------|---------------|
| Dec-19 | Rp 3,177,300,00 | Rp 2,108,595,00 | Rp 632,043,00 | Rp 26,477,500,00 |
| Nov-19 | Rp 3,421,000,00 | Rp 2,108,595,00 | Rp 632,043,00 | Rp 26,315,384,62 |
| Oct-19 | Rp 3,442,120,00 | Rp 2,108,595,00 | Rp 632,043,00 | Rp 24,586,571,43 |
| Sep-19 | Rp 2,950,200,00 | Rp 2,108,595,00 | Rp 632,043,00 | Rp 26,820,000,00 |
| Aug-19 | Rp 3,279,800,00 | Rp 2,108,595,00 | Rp 632,043,00 | Rp 25,498,750,00 |
| Jul-19 | Rp 3,264,210,00 | Rp 2,108,595,00 | Rp 632,043,00 | Rp 29,674,636,36 |
| Jun-19 | Rp 3,334,588,00 | Rp 2,108,595,00 | Rp 632,043,00 | Rp 33,345,880,00 |
| May-19 | Rp 3,001,122,00 | Rp 2,108,595,00 | Rp 632,043,00 | Rp 23,085,553,85 |
| Apr-19 | Rp 3,876,500,00 | Rp 2,108,595,00 | Rp 632,043,00 | Rp 22,802,941,18 |
| Mar-19 | Rp 3,966,741,00 | Rp 2,108,595,00 | Rp 632,043,00 | Rp 20,877,584,21 |
| Feb-19 | Rp 2,978,321,00 | Rp 2,108,595,00 | Rp 632,043,00 | Rp 19,855,473,33 |
| Jan-19 | Rp 3,300,213,00 | Rp 2,108,595,00 | Rp 632,043,00 | Rp 23,572,950,00 |
| Total  | Rp 39,992,115,00 | Rp 25,303,140,00 | Rp 11,376,774,00 | Rp 297,913,224,97 |

Percent Cost to Revenue Total (Truck) 8%
Percent Cost to Revenue Total (Motor Rickshaw) 3%
From the above table it can be concluded that before the route is repaired the cost reaches 13% so it is very much needed to repair because it has been out of control or exceeded the 10% limit of total revenue and after the improvement of transportation costs dropped to 8% when using the truck transportation mode and 4% when using motorized rickshaw transportation mode.

4. Conclusion
From the latest arrangement of shipping routes in the DSMR, the savings in truck transportation mode over the mileage were 37% and the travel time was 31% from the actual conditions. While the magnitude of savings in motorized rickshaw transportation modes of mileage is 5% and the travel time is 7% of the actual conditions. Transportation costs dropped to 8% of total revenue when using the truck transportation mode and 3% of total revenue when using motorized rickshaw transportation modes.

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