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COST OPTIMIZATION IN DETERMINING THE DISTRIBUTION ROUTE OF FABRIC PRODUCT USING THE SAVINGS MATRIX METHOD

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ABSTRACT

PT X is a supplier of dyed fabrics which has several customers in the Bandung area including PT Mentari Mandiri, PT KSM, CV SAM, CV Mulya Jaya, PT Sunny and PT Badjatex. The problem that PT Waitex is currently experiencing is an increase in the cost of shipping fabrics. This can be seen from the average shipping cost in the last three years (2015 - 2017) which amounted to Rp. 156,290,000, an increase in 2018 to Rp. 169,780,000 or 7.94%. The factors that increase shipping costs and can also cause potential losses for companies according to Badria (2008) are product allocation and determination of delivery routes. This study aims to determine the optimal route in the distribution of fabric products and to determine the minimum distribution cost savings after repairs. Data collection is done by collecting secondary data in the company. Data processing is done by using the Saving Matrix method. The Savings Matrix method is a method used to determine the product distribution route to the marketing area by determining the distribution route that must be traversed and the number of vehicles based on vehicle capacity in order to obtain the shortest route and minimal shipping costs. The route resulting from the calculation of the Saving Matrix method has been reduced from 6 routes to 4 delivery routes. The initial route of the company's delivery, which originally amounted to 143.4 Km, has decreased to 133.7 Km using the Saving Matrix method or reduced by 9.7 Km. The shipping cost incurred from the calculation of the Saving Matrix method is IDR 856,595.21 / day, reduced from the initial route of IDR 1,260,701.22 / day. Thus it can be concluded that the Saving Matrix Method is better than the initial method of the company with distance savings of 32.05% and cost savings of Rp. 404,106.01 / day.

INTRODUCTION

Distribution and transportation are activities that have a very vital role in connecting the interests of producers and consumers, so it needs to be done

efficiently in order to obtain proportional benefits for producers. Decisions in determining the schedule and determining the route of product delivery are very important in an effort to drink shipping costs and minimize time and distance (Pujawan, 2010). Determining the best route is the route with the shortest vehicle mileage, as this can affect transportation costs (Sarjono, 2014). A distribution system that aims to create an optimal route with known transport vehicle capacities so that it can meet demand with a predetermined location and number of requests is called the Vehicle Routing Problem (Yuniarti & Astuti, 2013).

One type of VRP is the Capacitated Vehicle Routing Problem (CVRP), namely VRP which has a vehicle capacity limit (Rohmah, 2020). To determine the delivery route, several methods can be used, including the savings matrix method. The savings matrix method is a heuristic method that can be used to solve transportation problems in determining distribution routes and schedules (Yuliana et al., 2017). Saving Matrix is a method to minimize distance, time, and cost to produce efficient shipping routes. With this method, it is hoped that it can help the company in terms of its distribution network (Pattiasina et al., 2018). Research that discusses the use of the Saving Matrix has been done many times before, including the use of the savings matrix to determine the distribution route for beverage products (Supriyadi et al., 2017), savings matrix to determine schedules and distribution routes for automotive products (Yuliana et al., 2017) as well as using a savings matrix to determine vehicle scheduling and using the Nearest Neighbor, Nearest Insertion, and Farthest Insertion methods in determining the location.(Ikfan Noer & Masudin Ilyas, 2014).

This research is also strengthened by Damayanti et al. (2020), this study discusses the optimization of the design of rice distribution routes by the Indonesian General Logistics Company.

This research was conducted at one of the dyed fabric suppliers that have several customers in the Bandung area including PT Mentari Mandiri, PT KSM, CV SAM, CV Mulya Jaya, PT Sunny and PT Badjatex. PT X experienced an increase in fabric shipping costs from the average shipping cost of the last three years (2015 - 2017), which was Rp. 156,290,000.00, increasing in 2018 to Rp. 169,780,000.00 or 7.94% and this resulted in the emergence of excess shipping costs. that year. the target expenditure is IDR 150,000,000.00. This study tries to optimize the use of the deposit matrix method to determine the optimal route for the distribution of fabric products at PT X. Based on this, this study aims to determine the route and cost of shipping fabric products using the Savings Matrix method and provide suggested repair routes to minimize costs, shipments issued by the company. The benefits of this research are expected to provide input for companies in designing an effective distribution schedule by minimizing transportation costs, determining capacity, and using the right number of vehicles.

LITERATURE REVIEW

Supply Chain Management

According to Pujawan (2005), Supply Chain Management is an activity of coordination between materials, information and financial flows between companies participating in all types of basic commodity activities to the sale of final products to consumers. The functions of Supply Chain Management include the function of purchasing or procuring products, producing goods, distribution activities, shipping, marketing, serving consumers after purchase (Customer) and planning activities (Yuniarti & Astuti, 2013). Logistics management is a part of supply chain management which has a very important function for the process of implementing, planning, and controlling the effectiveness and efficiency of storage and distribution of goods, services, and information to a consumption level in order to meet the needs of consumers (Siahaya, 2012). Acoording to Salim (2012) in the implementation process, logistics management has various important functions that will always be in contact with one another.

Basically, logistics management aims to make the goods or materials needed for the production process or operational activities available in the quantity, quality, time and place needed in the most efficient cost possible. This is through the application of the concept of standardization (technical standards, storage standards, destruction, procurement), optimization (as needed) and accuracy.

Vehicle Routing Problem

Vehicle Routing Problem is a distribution system that aims to create an optimal route. By knowing the capacity of the transport vehicle for a group of vehicles, this is in order to fulfill customer requests with a known location and number of requests (Yuniarti & Astuti, 2013). An optimal route is a route that meets various operational constraints, namely having the shortest total distance and travel time covered in meeting customer demands and using a limited number of vehicles. Vehicle Scheduling Problem is a Vehicle Routing Problem which is related to various activities that must be carried out, so that successive vehicle movements refer to changes in time and place (Omar, 2008).

Vehicle Scheduling Problem is a Vehicle Routing Problem with additional limitations related to the time when various activities must be carried out so that sequential vehicle movements refer to changes in time and place (Bertsimas et al., 2020).

Savings Matrix Method

Savings matrix is one of the heuristic methods used to solve transportation problems in determining transportation schedules and determining transportation (Supriyadi et al., 2017). According to Indrawati et al. (2016), the savings matrix method can be used to schedule vehicles by paying attention to the maximum capacity of the vehicle by combining several delivery points.

The Saving Matrix method is a method used to determine the product distribution route to the marketing area by determining the distribution route that must be traversed and the number of vehicles based on the capacity of the

vehicle in order to obtain the shortest route and minimal transportation costs (Demez, 2013).

Meanwhile, according to Raharjo (2011), the Savings Matrix method is a Clarke and Wright saving method invented by Clarke and Wright in 1964 and then published as an algorithm that is used as a solution to vehicle route problems where a set of routes at each step is exchanged to get a set of routes better, and this method is used to solve a fairly large problem, in this case is a large number of routes. The essence of this method is to calculate savings as measured by how much it can be done to reduce the distance traveled and the time used by linking the existing nodes and making it a route based on the largest saving value, namely the distance between the source node and the destination node. This method is used because in the calculation process, it does not only use distance as a parameter, but also time to obtain the largest saving value and then arrange it into the best route.

Saving Matrix is a method used to determine the distance, route, time or cost in the delivery of goods from companies to consumers. This method aims to ensure that the delivery of goods according to consumer orders can be done in an effective and efficient manner, so that companies can save costs, energy and delivery time (Salahuddin Sri Hartati, 2012). The steps in the saving matrix method are as follows (Suparjo, 2017):

Determine the Distance Matrix

In determining this distance matrix, data on the distance between the company and location and location to other locations is needed. After knowing the coordinates of each location, the distance between the two locations can be calculated using the following formula:

$$j_{(1,2)} = \sqrt{(x_1 - x_2) + (y_1 - y_2)}^2 \quad \text{.....(1)}$$

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

Determine the Savings Matrix

After knowing the overall distance, namely the distance between the factory and the location and the location to another location, in this step it is assumed that each location will be passed by one truck exclusively. This means that several different routes will be passed to each destination. Thus savings occur when there is a merger of routes that are assessed in one direction with other routes. To find a savings matrix, the following formula can be used:

$$S_{(x,y)} = j_{(i,x)} + j_{(i,y)} - j_{(x,y)} \quad \text{.....(2)}$$

Information:

$S_{(x,y)}$ = the distance savings from combining route x with route y.

$j_{(i,x)}$ = The distance from the company to one customer
$j_{(i,y)}$ = Distance from the company to other customers
$j_{(x,y)}$ = Distance from one customer to another customer

Allocation of Vehicles and Routes by Location

After the savings matrix is known, the next step is to allocate locations to routes or vehicles. This means that in this step a new delivery route will be determined based on the merging of the routes in the second step above. The result is that the delivery of location 1 and location 2 will be carried out using route 1.

Sequencing of Destination Locations in a Route

This step determines the order of visits. There are several methods in determining the order of visits, namely:

Nearest Insert method

This method determines the sequence of visits by prioritizing locations which, when included in an existing route, produce the minimum distance.

Nearest Neighbor Method

This method determines the visit by prioritizing the location that is closest to the last visited location.

RESULTS AND DISCUSSION

The research was conducted at one of the dyeing fabric suppliers which has several customers in the Bandung area including PT Mentari Mandiri, PT KSM, CV SAM, CV Mulya Jaya, PT Sunny and PT Badjatex. PT X experienced an increase in fabric shipping costs from the average shipping cost of the last three years (2015 - 2017), which was Rp. 156,290,000.00, an increase in 2018 to Rp. 169,780,000.00 or 7.94% and this resulted in the shipping costs incurred in that year exceeding the expenditure target is IDR 150,000,000.00.

The following is the address of the PT X customer and the travel map who ordered the gray cloth, namely:

Table 1. List of PT X's Customers

No	*Customer's name*	Adress
1	PT Mentari Mandiri	Jl. Cigondewah Kaler No.63, Bandung Kulon, Kota Bandung
2	PT KSM	Jl. Batujajar No. 168, Giriasih, Kab. Bandung Barat
3	CV SAM	Jl. KH Wahid Hasyim, Margasuka, Babakan Ciparay, Kota Bandung
4	CV Mulya Jaya	Jl. Rancasaar 177, Majalaya, Bandung
5	PT Sunny	Komp. Industri Tri Kencana Sarana Indah 35
6	PT Badjatex	Jl. Cisirung No.87, Pasawahan, Kec. Dayeuhkolot, Bandung

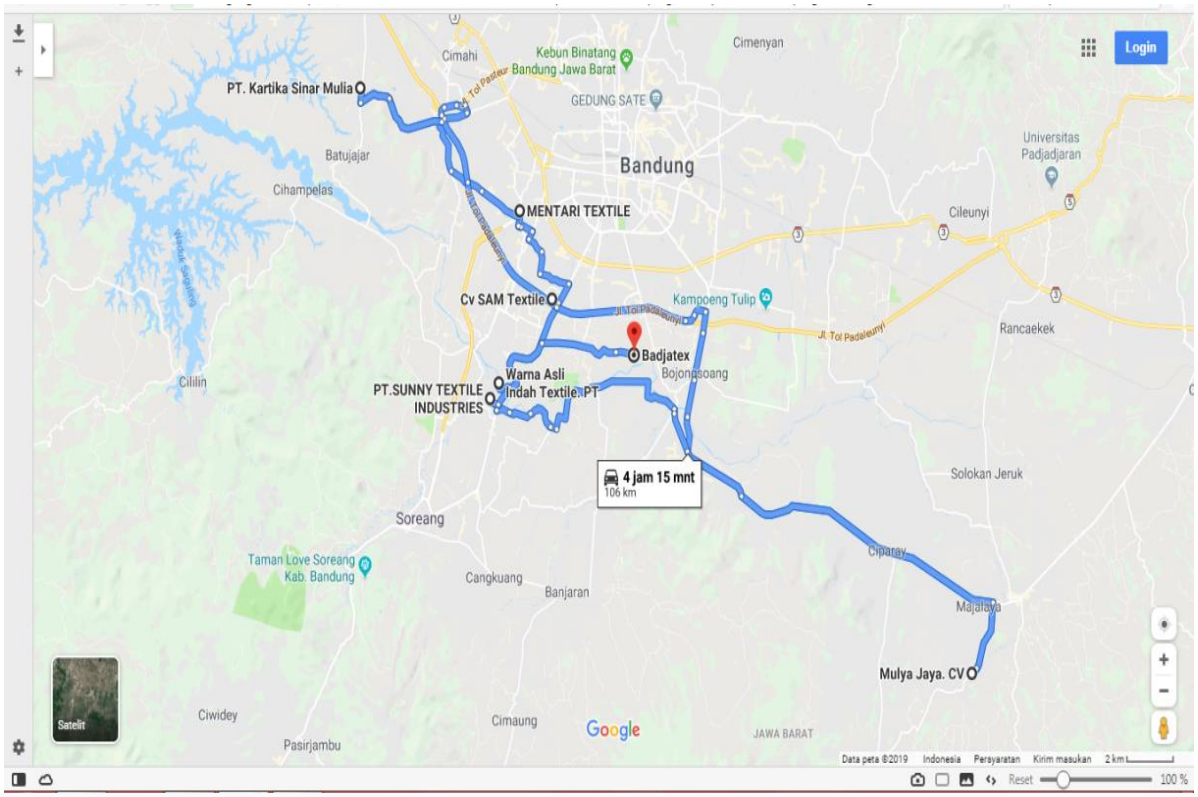

Figure 2. Travel Map of PT X

The process of sending fabric by PT Waitex from the company to customers is carried out using 2 pickups with a box length of 312.4 cm, a box width of 173.8 cm and a box height of 174.5 cm. The capacity of the pickup car to transport cloth (average dimensions) are as follows:

$$Capacity = \frac{P\ Box}{P\ fabric} \times \frac{l\ Box}{l\ fabric} \times \frac{T\ Box}{T\ fabric}$$

$$Capacity = \frac{430}{89{,}75} \times \frac{185}{53} \times \frac{190}{14{,}52}$$

Capacity = 4 × 3 ×13
Capacity = 156 *pcs*

Load Weight = *Capacity* × *Fabric weight*
Load Weight = 156 × 6,5
Load Weight = 1170 kg

Because the average weight of fabric is 1170 kg less than the maximum weight that can be transported by a pickup truck, which is 3500 kg, the maximum amount of cloth that can be transported is 156 pcs. The distance matrix obtained from determining the distance between the company and the customer using the help of Google Maps is as follows:

Table 2. Distance Matrix

DARI/KE	PT Waitex	CV SAM	PT Mentari	PT KSM	CV Mulya	PT Sunny	PT Badjatex
PT Waitex		5.6	8.1	17.5	30.6	2	7.9
CV SAM			5.6	20.8	31.6	6.1	5.5
PT Mentari				10.3	32.8	8.9	10.1
PT KSM					45.4	17.8	22
CV Mulya						31.1	22.7
PT Sunny							8.4
PT Badjatex							

The delivery route currently used by PT Waitex is using the shortest route, which is as follows:

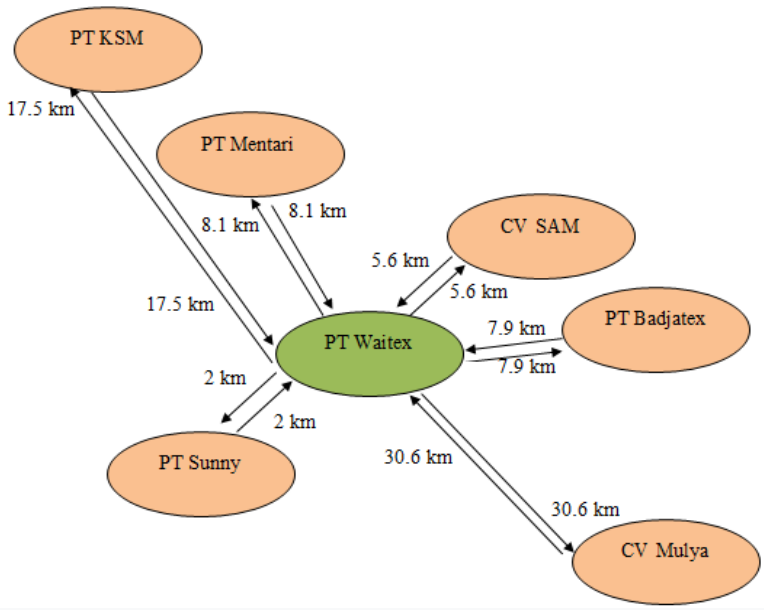

Figure 3. Initial Route

So that, the shipping costs obtained are as follows:

Cost = (Freight × Driver Fee) + (Total Distance × Fuel Cost)
Cost = (6 × IDR 200,000.00) + (143.4 km × IDR 423.30 / km)
Cost = IDR 1,200,000 + IDR 60,701.22
Cost = IDR 1,260,701.22

The proposed route of delivery obtained from the calculation of the Saving Matrix method is as follows:

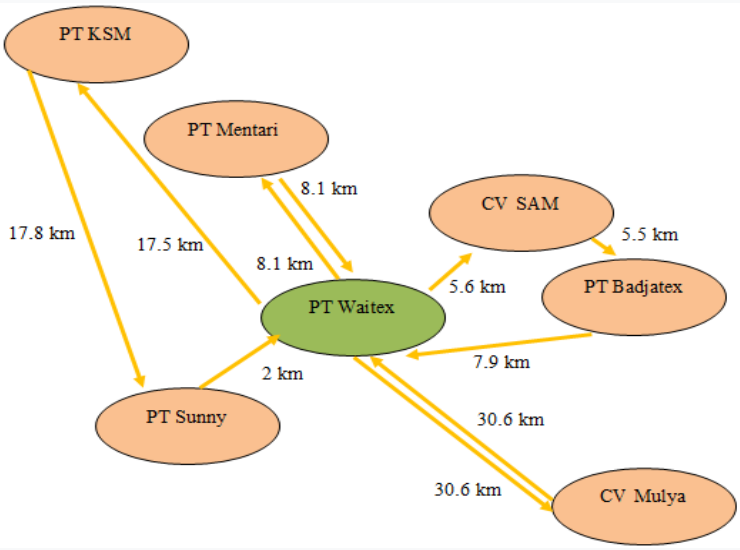

Figure 4. Proposed Route

The distance matrix obtained from determining the distance between the company and the customer using the help of Google Maps is as follows:
So that, the shipping costs obtained are as follows:

Cost = (Freight × Driver Fee) + (Total Distance × Fuel Cost)
Cost = (4 × IDR 200,000.00) + (133.7 km × IDR 423.30 / km)
Cost = IDR 800,000.00 + IDR 56,595.21
Cost = IDR 856,595.21

The cost comparison between the initial route and the route resulting from the Saving Matrix method can be seen in the following table:

Table 3. Comparison of Costs

Route	Vehicle	Mileage (Km)		Transportation Cost (IDR)	
		Initial Route	*Savings Matrix*	Initial Route	*Savings Matrix*
1	Pickup 1	4	19	Rp 201,693.20	Rp 208,042.70
2	Pickup 1	11.2	37.3	Rp 204,740.96	Rp 215,789.09
3	Pickup 1	15.8		Rp 206,688.14	
4	Pickup 1	16.2	16.2	Rp 206,857.46	Rp 206,857.46
5	Pickup 2	35		Rp 214,815.50	
6	Pickup 2	61.2	61.2	Rp 225,905.96	Rp 225,905.96
Total		143.4	133.7	Rp 1,260,701.22	Rp 856,595.21

A fabric delivery route that can be proposed to minimize transportation costs at PT Waitex is to use the Saving Matrix method where the initial delivery route, which originally amounted to 6 routes, can be reduced to only 4 routes. The distance that has to be traveled has also decreased from the initial 143.4 km / day to 133.7 km / day with transportation costs of IDR 856,595.21 / day. Thus, the company can reduce shipping distances by 6.76% or 9.7 km and can save transportation costs by up to 32.05% or as much as Rp 404,106.01 / day.

The initial route used by the company was only to send goods to the nearest customer without considering the distance between the customer and the capacity of the conveyance. The initial route used by the company was 6 routes, namely PT Waitex - PT Mentari Mandiri - PT Waitex, PT Waitex - PT KSM - PT Waitex, PT Waitex - CV SAM - PT Waitex, PT Waitex - CV Mulya Jaya - PT Waitex, PT Waitex - PT Sunny - PT Waitex and PT Waitex - PT Badjatex - PT Waitex. Using this route may result in unused cargo utilities being delivered to each customer, as follow:

1) The average shipment of cloth per day from PT Waitex to PT Mentari is 120 pcs with a transport capacity of 156 pcs, so there is an unused cargo utility, which is 23.1%.
2) The average shipment of fabrics per day from PT Waitex to PT KSM is 71 pcs with a transport capacity of 156 pcs, so there is a cargo utility that is not used, which is 54.5%.
3) The average shipment of fabrics per day from PT Waitex to CV SAM is 67 pcs with a transport capacity of 156 pcs, so there is a cargo utility that is not used, which is 57.1%.
4) The average shipment of fabrics per day from PT Waitex to CV Mulya is 136 pcs with a transport capacity of 156 pcs, so there is a cargo utility that is not used, which is 12.8%.
5) The average shipment of fabrics per day from PT Waitex to PT Sunny is 52 pcs with a transport capacity of 156 pcs, so there is a cargo utility that is not used, which is 66.7%.
6) The average shipment of cloth per day from PT Waitex to PT Badjatex is as many as 65 pcs with a transport capacity of 156 pcs, so there is a cargo utility that is not used, which is 58.3%.

From the results of the above calculations, the average fabric shipment has unused transportation utility which is 45.4%. However, this route was chosen by the company because this method of delivery has the advantage that it is delivered to only one customer so that it does not allow fabrics to be mixed with fabrics from other customers. Another advantage is that loading and unloading times are faster because the placement of the fabric does not consider the fabric to be mixed with other customers so that the delivery time to one customer will be faster. The drawback of this delivery method is of course the lack of cargo utility that can be entered so that there will be a waste of shipping costs.

Proposed Route Analysis

Determination of shipping routes using the Saving Matrix method can be done by considering the value of saving the distance and the capacity of the transportation equipment used in delivering fabrics. Merging customers in one route starts from the greatest distance savings value, but by taking into account the total capacity that can be transported. Merging routes is considered feasible if the total combined capacity is smaller than the capacity of the transportation means, which is 156 pcs.

Using this route may result in unused cargo utilities being delivered to each customer, as follows:

1) The average shipment of fabrics per day from PT Waitex to CV SAM and PT Badjatex is 133 pcs with a transport capacity of 156 pcs, so there is a cargo utility that is not used, which is 14.7%.
2) The average shipment of cloth per day from PT Waitex to PT KSM and PT Sunny is as many as 123 pcs with a transport capacity of 156 pcs, so there is a cargo utility that is not used, which is 21.2%.
3) The average shipment of fabrics per day from PT Waitex to PT Mentari is 120 pcs with a transport capacity of 156 pcs, so there is a cargo utility that is not used, which is 23.1%.
4) The average shipment of fabrics per day from PT Waitex to CV Mulya is 136 pcs with a transport capacity of 156 pcs, so there is a cargo utility that is not used, which is 12,8 %.

From the results of the above calculations, the average fabric shipment has unused transportation utility which is 17.95%. Determination of the delivery route from the results of the Saving Matrix method has advantages and disadvantages compared to using the shipping method currently applied in companies. The advantage is of course it can cut shipping mileage so that transportation time and costs can be reduced. The downside is that the driver will work twice as far but for the same wage for each delivery. This can cause a decrease in the performance of the driver and driver. Meanwhile, the time for the delivery of cloth can be influenced by several factors, including:

1) Traffic Density The route chosen must take into account the delivery time where during peak hours or in a traffic jam, the delivery time can be long even though the distance from the customer is very close. The road conditions also

affect traffic density, both the width of the road and the damaged roads that are difficult to pass by vehicles.
2) Condition of Transport Equipment in addition to the traffic density, the delivery time is also influenced by the condition of the transportation means used where the condition of the transportation means affects the speed of the vehicle in sending the cloth to the customer, not to mention if the vehicle experiences an engine shutdown when sending the cloth.
3) Driver Another factor that affects the travel time is the condition of the driver himself, how they drive the vehicle whether they run the vehicle fast or slow.

CONCLUSION

After conducting research using the Saving Matrix method, it can be concluded that:

1) The initial route used by the company is currently 6 shipping routes with a delivery cost of Rp 1,260,701.22 / day.
2) Delivery routes that can be proposed using the Saving Matrix method are 4 routes at a cost of IDR 856,595.21 / day.
3) The proposed route can reduce shipping costs by up to 32.05% or IDR 404,106.01 / day by combining fabric shipments to CV SAM with PT Badjatex and shipments to PT KSM and PT Sunny so that the route used is reduced to 4 shipping routes.

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