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Analysis of Location and Decision-Making of Fleet Vehicle Type With Cvrp Multi Trip and Gravity Location Model for Operational Cost Efficiency (Case Study CV. XYZ, Wonoayu-Sidoarjo)

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ABSTRACT

Transportation has an important role in the logistics of a company, both in services and products. Increased orders in 2020 for wooden speaker products at CV. XYZ (Wonoayu-Sidoarjo) makes this company try to minimize transportation costs at their operational level. This study focuses on determining the relationship between changes in the type of fleet vehicle and the depot location on the operational costs of product delivery and the time to return to the depot in terms of adding trips. The methodology used in this study is the CVRP Multi Trip with Heterogeneous fleet vehicle and the Gravity Location Model based on the heuristic method. Saving heuristic method and nearest neighbor are heuristic methods used in computational studies to determine the order of visits to the formed sub-routes. There are 4 scenarios that are modeled to further analyze the results of these computations, namely: (1) CVRP multi-trip of existing location with wings box truck, (2) CVRP multi-trip of existing location with Fuso truck, (3) CVRP multi-trip of the new location with wings box truck, and (4) CVRP multi-trip of the new location with fuso truck. The results of the study concluded that there is a relationship between: (1) changes in fleet vehicle type with total traveling distance, (2) changes in depot location with total traveling distance, (3) fuel consumption rate on vehicle operating costs, (4) average vehicle speed on the time back to the depot. Scenario 4 is the best scenario in terms of traveling distance, fuel costs and delivery time. However, moving the depot center is not easy, so the scenario 2 is the most applicable condition considering that the fuso truck is available and has a higher utility than the wings box truck

***Keywords:** CVRP Multi Trip; HFVRP; Gravity Location Model; Fuel Consumption Rate; Heuristic Method*

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ABSTRACT

Transportasi memiliki peran penting dalam logistik suatu perusahaan baik di bidang jasa maupun produk. Peningkatan order di tahun 2020 untuk produk wooden speaker di CV. XYZ (Wonoayu-Sidoarjo) membuat perusahaan ini berusaha untuk meminimalkan biaya transportasi di level operasional mereka. Penelitian ini berfokus untuk mengetahui keterkaitan perubahan jenis armada dan lokasi depot terhadap biaya operasional pengiriman produk serta waktu kembali ke depot dalam hal penambahan ritase. Metodologi yang digunakan dalam penelitian ini adalah CVRP Multi Trip with Heteregeneous Fleet dan Gravity Location Model yang berbasis metode heuristik. Saving heuristic method dan nearest neighbor adalah metode heuristik yang digunakan dalam studi komputasi untuk menentukan urutan kunjungan pada subrute yang terbentuk. Terdapat 4 skenario yang dimodelkan untuk menganalisa lebih jauh hasil dari komputasi tersebut, yakni: (1) CVRP multi trip lokasi lama dengan truk wingsbox, (2) CVRP multi trip lokasi lama dengan truk fuso, (3) CVRP multi trip lokasi baru dengan truk wingsbox, dan (4) CVRP multi trip lokasi baru dengan truk fuso. Hasil penelitian menyimpulkan bahwa terdapat hubungan antara: (1) perubahan jenis armada dengan total traveling distance, (2) perubahan lokasi depot dengan total traveling distance, (3) fuel consumption rate terhadap biaya operasional kendaraan, (4) kecepatan rata-rata kendaraan terhadap waktu kembali ke depot. Adapun skenario ke-4 adalah yang terbaik dalam hal traveling distance, biaya BBM dan delivery time. Namun memindahkan pusat depot bukan hal mudah, sehingga skenario 2 adalah kondisi yang paling bisa diaplikasikan mengingat kendaraan truk fuso sudah ready dan memiliki utilitas yang lebih tinggi daripada truk wingsbox

Kata kunci: *CVRP Multi Trip; HFVRP; Gravity Location Model; Fuel Consumption Rate; Heuristic Method*

INTRODUCTION

Logistics is a series of processes for planning, organizing, and controlling the flow of materials and services from suppliers to consumers. In logistics, there are activities of transportation, storage, inventory management, material handling, and information processing related to logistics. Logistics aims to optimize transportation costs related to distance, time and route reliability. Transportation costs include the cost of using fuel. Transportation costs and delivery times are the main part of logistics to carry out distribution with a regular frequency to many destinations [1]. Transportation costs are not less than 60% of the total logistics costs.

There are many considerations in supporting transportation activities, not only based on low-cost considerations but also having to consider aspects of service quality. Accurate delivery of goods will help companies to reduce inventory, storage costs, and material handling. Therefore, transportation activities are not as simple as moving goods from one location to another.

CV XYZ which is located at Jalan Raya Pilang Km 8, Wonoayu-Sidoarjo is one of the subsidiaries that are members of the Sinar Baja Electric Group and is engaged in the speaker sector. ACR, Sphinx, Prestige, and Road Master are brands of the company's products that have been proven to dominate the speaker market in Indonesia. Currently, CV XYZ is taking care of licensing to start producing speakers that use a combination of wood-based materials that can function as furniture. This leads to a potential increase in orders in 2018 so that the company seeks to improve the efficiency of using transportation in terms of sending finished products to customers as a responsive measure.

The selection of the right transportation route aims to ensure fast and economical delivery. This will be a consideration for managerial decision-making in terms of the allocation of the fleet vehicle. The main problem in the field of transportation, distribution, and logistics is called the Vehicle Routing Problem (VRP).

VRP was first introduced by Dantzig and Ramser in 1959, which is about the problem of a vehicle that can serve several consumers demands from a depot by minimizing the distance [2]. VRP is often used for determining the route of delivery of goods [3]. VRP aims to find the optimal delivery for vehicles that serve a number of customers by minimizing costs and meeting a number of limitations that reflect the characteristics of the real situation [4]. The limitation must be taken into consideration for company stakeholders to reduce operational costs, especially those related to transportation.

The basic form of VRP assumes that the vehicles used for distribution have the same capacity (homogeneous), serve only one route, and the total demand from all agents in one route does not exceed the capacity of the vehicles serving that route, whereas, in reality, the company does not always have a fleet vehicle with the same carrying capacity [5]. Every company has vehicles with different capacities, so the classic VRP solution method nowadays is difficult to implement. Therefore, a new VRP variant emerged to solve problems with different types and capacities of vehicles, known as the Heterogeneous Fleet Vehicle Routing Problem (HFVRP).

In today's times, almost all companies have fleet vehicles with different capacities, specifications, and types, so that their capacity is also different and the number of fleet vehicles is limited [6]. Heterogeneous or mixed fleet VRP considers different types of vehicles in terms of capacity, variable and fixed costs [7]. Fixed vehicle costs are costs incurred for the purchase of vehicles and maintenance costs, while variable costs relate to costs for traveling routes at the time of delivery of goods.

Regarding transportation costs, the HFVRP method also considers the Center of Gravity (COG) method. According to Efendi [8] the COG method is used by considering the cheapest transportation cost factor to determine a location in the distribution route. The calculation of the COG method involves the volume of goods to be transported from one point to another, regional coordinates and transportation costs. This COG method is used to find the best location for a single distribution point that serves several regions [9].

In the study of Zhafarina [10], COG method is used to determine the location of the new warehouse for textile dye company because the old warehouse location has a higher transportation cost of 21% per week compared to the new warehouse. This study uses distance and cost variables to determine the location of a new warehouse, where the cheapest transportation costs are the goal of determining the location of a new warehouse. In addition, this study states that the COG method has advantages over the hub location model method (p-median, p-center, and covering problem) because it does not require predetermined location candidate facilities. The COG method is also used by Ruwiyanto [11] in his research to determine the distribution center for sending competency test certificates to various regions on Java Island where the location of the distribution center chosen is a location that has minimum transportation costs.

Djamal [12] also carried out other research related to the COG method to choose the most optimal location out of 48 locations in the distribution network to customers. The saving matrix method is used to determine the maximum load or combine product loads to be combined. The use of both methods is proven to save 45% of the costs applied by companies engaged in this steel coating. The COG method is also developed by Sanjaya [13] in determining the location of a new feed warehouse by considering the saving matrix and VRP methods. Transportation cost analysis is carried out by comparing the results of the saving matrix and VRP methods.

This study emphasizes the relationship between several factors that affect the efficiency of the company's operational costs, namely: traveling distance, fuel cost, and operational time by considering both depot location relocation and the use of fleet vehicle types. The aims of this study are: (1) to determine the effect of the type of fleet vehicle used on the total traveling distance as a whole, (2) to determine the effect of changing the location of the depot with the Gravity Location Model on the total traveling distance as a whole, (3) to determine the effect of the ratio of fuel consumption on the operational costs incurred for each type of fleet vehicle, (4) determine the effect of the average vehicle speed on the time of delivery and return to the depot with a predetermined route, (5) determine the best and most likely scenario for the company's status quo both in terms of time, distance traveled and operational costs.

STUDY DESCRIPTION

The heuristic approach aims to determine the relationship between factors that affect the minimization of operational costs. The flow chart below shows the steps to find The Best Solution of transportation problems at CV.XYZ.

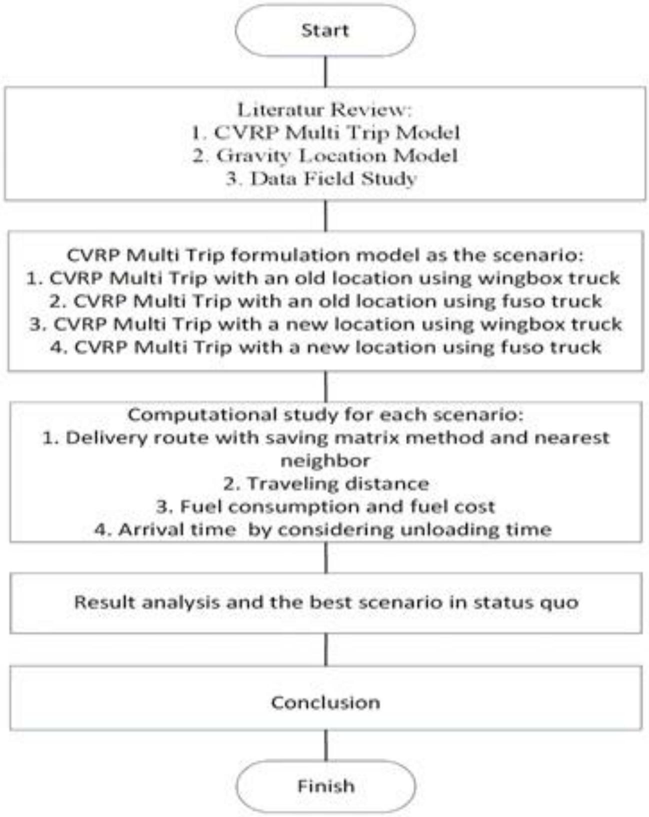

Figure 1. Flowchart of the study at CV. XYZ

Primary data has been taken from the company starting from the type of vehicle used to the time of unloading at each destination node. For the calculation of fuel consumption for each type of vehicle, data on the fuel consumption rate of each fleet vehicle is added. Products delivered are still assumed to be homogeneous in terms of packaging with standard box sizes for large speakers.

Table 1. Depot Location and Destination Node

Nodes	X	Y	
DEPOT	5.27	96.1	Load
1	16.47	94.44	8
2	20.09	85.54	10
3	22.39	70.67	13
4	25.23	97.24	10
5	25.27	95.67	10
6	20.47	97.02	13

Table 2. Specification of Vehicle Type at CV. XYZ

Type	Capacity	Fuel Consumption Rate	
Wings box Truck (9.3mx2.5mx2.5m) Tonnage : 18 ton Dimension : 45 cbm	36	2 litre	4,5 km
Fuso Truck (5.7mx2.3mx2.4m) Tonnage : 7 ton Dimension : 25 cbm	24	1 litre	3 km

Meanwhile, the heuristic method used in determining the optimal sequence of routes is the Saving Heuristic Method combined with Nearest Neighbor. The computational study was conducted using Microsoft Excel 2010 with the aim of determining: (1) sequence of delivery routes, (2) traveling distance, (3) fuel consumption and fuel cost, (4) arrival time back to the depot after completing the route.

Data processing has been carried out by calculating the distance matrix, then calculating the saving matrix so that the sequence of the destination node can be determined with the capacity of the vehicle used. If the load from the node exceeds the capacity of the vehicle, it is transferred to the next vehicle with a different route. So, each node must be served by a vehicle.

Table 3. Distance Matrix

Distance Matrix							
	0	1	2	3	4	5	6
0	0	11.3	18.2	30.7	20.0	17.5	15.2
1	11.3	0	9.6	24.5	9.2	8.9	4.8
2	18.2	9.6	0	15.0	12.8	11.4	11.5
3	30.7	24.5	15.0	0	26.7	25.2	26.4
4	20.0	9.2	12.8	26.7	0	1.6	4.8
5	20.0	8.9	11.4	25.2	1.6	0	5.0
6	15.2	4.8	11.5	26.4	4.8	5.0	0

Table 4. Saving Matrix

Saving Matrix							
	1	2	3	4	5	6	Load
1	0						8
2	19.9	0					10
3	17.5	33.8	0				13
4	22.1	25.4	23.9	0			10
5	22.4	26.8	25.5	38.4	0		10
6	21.8	21.9	19.5	30.5	30.2	0	13

After the route has been obtained for each vehicle, the Nearest Neighbor method was used to determine the sequence of routes that produces the minimum total distance on the sub route. This is shown in Table 7, while in Table 5 and Table 6 there are 2 clusters or 2 sub-routes which are shown as examples of cluster determination.

Table 5. The First Cluster of Load Allocation

Cluster 1	**4,5,3**			
Sequence of routes	Saving value	Node	Load	Capacity
1	38.4	4	10	
		5	10	
				20
2	33.8	3	13	
		2		
			Total	33

Table 6. The Second Cluster of Load Allocation

Cluster 2	**2,6,1**			
Sequence of routes	Saving value	Node	Load	Capacity
1	33.8	2	10	
		3		
				10
2	30.5	4		
		6	13	
				23
3	22.4	5		
		1	8	
			Total	31

Table 7. Order of Visits from Subroutes

Order of visits 1	0	5	4	3	0	Total Dist
		20.0	1.6	26.7	30.7	79.0
Order of visits 2	0	6	1	2	0	
		15.2	4.8	9.6	18.2	47.8
					Total	126.8

To find out some of the effects related to the VRP model used, the variables for the type of vehicle used and the location of the depot were changed. The type of vehicle used was initially a wings box truck with a capacity of 36 boxes, then changed to a Fuso truck with a shorter dimension with a capacity of 24 boxes. The depot location which was originally listed in table 1 has been changed using the Gravity Location Model for the new location to be analyzed. The calculation of of fuel consumption and fuel costs taking into account the fuel consumption rate and traveling distance of each vehicle were also added.

In addition, an analysis was carried out regarding the return time of each vehicle to the depot to ensure operational time efficiency. So if there is additional trip, this can be fulfilled with a certain time limit. Thus, the vehicle used has reliability in terms of cost and time. Therefore, data on the unloading time of each node and the average vehicle speed are needed for this analysis.

In terms of presenting the results of the computational study, several scenarios were made to be compared depending on the variables analyzed. The scenarios are as follows: (1) scenario 1 is CVRP Multi Trip with an old location using wings box truck, (2) scenario 2 is CVRP Multi Trip with an old location using Fuso truck, (3) scenario 3 is CVRP Multi Trip with a new location using a wings box truck, (4) scenario 4 is a new CVRP Multi-Trip location using a Fuso truck.

The new location of the six nodes from the excel solver results by taking into account the distance of the node from the depot and the load on each node. The method used is known as the Gravity Location Model. This model may produce a central point around the existing node.

Table 8. Gravity Location Model

Nodes	X	Y			
DEPOT	22.04320648	94.19857228	L	d	L*d
1	16.47	94.44	8	5.578433272	44.62746617
2	20.09	85.54	10	8.876141582	88.76141582
3	22.39	70.67	13	23.53112787	305.9046624
4	25.23	97.24	10	4.405216859	44.05216859
5	25.27	95.67	10	3.546448364	35.46448364
6	20.47	97.02	13	3.230392085	41.9950971
					560.8052937

The depot which was originally in position (5.27; 96.1) changed to (22.04; 94.44) based on the table above. This new point acts as a comparison if the depot is moved and to find out its relationship with route changes and operational costs that may be incurred for the same type of vehicle. The following are the results of the computations and a picture of the sequence of routes formed from each scenario:

Table 9. Computation Result of Scenario 1

Scenario 1	Old location of wings truck							
	Sequence 1	0	5	4	3	0	Total Dist	
	Distance (km)		20.0	1.6	26.7	30.7	79.0	
	Time (minutes)		30.0	2.4	40.1	46.1		
	Unloading (minutes)		60.0	60.0	60.0			Average speed 40 km/h
	Total time(minutes)		90.0	62.4	100.1	46.1		
	Start	8:00	9:30	10:32	12:12	**13:00**	Finish	
	Sequence 2	0	6	1	2	0		
	Distance (km)		15.2	4.8	9.6	18.2	47.8	
	Time (minutes)		22.8	7.1	14.4	27.3		
	Unloading (minutes)		60.0	60.0	60.0			
	Total time(minutes)		82.8	67.1	74.4	27.3		
	Start	8:00	9:22	10:29	11:43	**12:10**	Finish	
					Total			**126.8** km
					Fuel consumption			**56.4** liter
					Total fuel cost			**IDR 290,215.42**

Based on Table 9, it is known that the total traveling distance for the old location using a wings box truck is 126.8 km which is distributed by 2 trucks. From the comparison between fuel consumption and the distance that can be travelled, it is found that the fuel consumption is 56.4 litres with a diesel cost of IDR 290,215, 42.

When depicted using a graph, the order of nodes visited by vehicles in scenario 1 for each subroute is as follows.

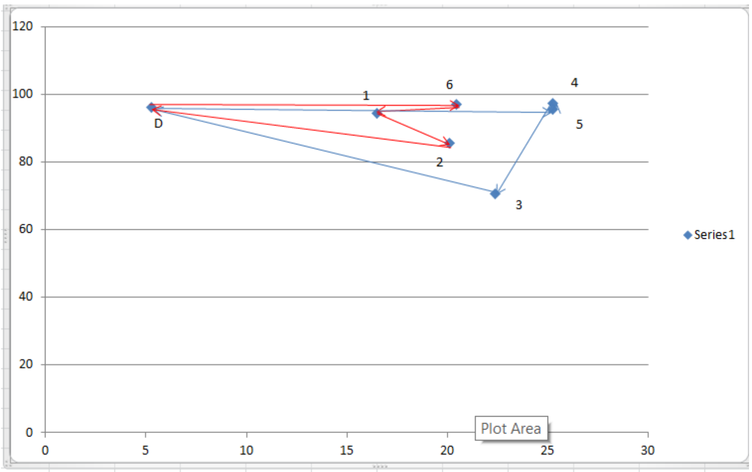

Figure 2. The Order of Visits of The Truck to Nodes on Sub-routes in Scenario 1

The figure above shows the position of the nodes on the Cartesian diagram and the trajectories of visits by the first and second trucks from the depot and back to the depot. The first truck visits node 5-4-3 of the depot and ends up at the depot which has a total distance of 79 km. While the second truck visits node 6-1-2 from the depot and returns to the depot with a total distance of 47.8 km.

The average speed of a wings box truck is 40 km/h with an unloading time for each node of 60 minutes (1 hour). So it can be estimated that the arrival time of the first truck is at 13.10 and the second truck is at 12.10. There is no multi trip in this scenario because the arrival time exceeds 12.00 p.m.

Table 10. Computation Result of Scenario 2

Scenario 2		Old location of Fuso truck						
	Sequence 1	0	4	5	0		Total Dist	
	Distance (km)		20.0	1.6	20.0		41.6	
	Time (minutes)		24.0	1.9	24.0			
	Unloading (minutes)		50.0	50.0				
	Total time (minutes)		74.0	51.9	24.0			
	Start	8:00	9:14	10:06	**10:30**	Finish		
	Sequence 2	0	2	3	0			
	Distance (km)		18.2	15.0	30.7		63.9	Average speed 50 km/h
	Time (minutes)		21.8	18.0	36.8			
	Unloading (minutes)		50.0	50.0				
	Total time (minutes)		71.8	68.0	36.8			
	Start	8:00	9:12	10:20	**10:57**	Finish		
	Sequence 3	0	1	6	0			
	Distance (km)		11.6	4.8	15.2		31.6	
	Time (minutes)		13.9	5.8	18.2			
	Unloading (minutes)		50.0	50.0				
	Total time (minutes)		63.9	55.8	18.2			
	Start	8:00	9:04	10:00	**10:19**	Finish		
					Total		**137.1** km	
					Fuel consumption		**45.7** liter	
					Total fuel cost		**IDR 235,355.00**	

From table 10 it is known that the total traveling distance for the old location using a fuso truck is 137.1 km which is distributed by 3 trucks simultaneously at the beginning of the scenario. If the operational hours of receiving goods are between 08.00 – 17.00, the number of vehicles needed will be 2 units because the vehicles that have arrived can be allocated to complete other sub-routes with a loading time of 60 minutes at the depot. Overall fuel consumption is 45.7 liters with a fuel consumption ratio of 1 liter of diesel for a trip of 3 km using an average speed of 50 km/h. The fuel cost for all routes is IDR 235,355.

Table 11. Computation Result of Scenario 3

Scenario 3		New Location of Wings Truk						
	Sequence 1	0	5	2	3	0	Total Dist	
	Distance (km)		3.5	11.4	15.0	23.5	53.4	
	Time (minutes)		5.3	17.1	22.5	35.3		
	Unloading (minutes)		60.0	60.0	60.0			Average speed 40 km/h
	Total time(minutes)		65.3	77.1	82.5	35.3		
	Start	8:00	9:05	10:22	11:44	**12:19**	Finish	
	Sequence 2	0	6	1	4	0		
	Distance (km)		3.2	4.8	9.2	4.4	21.6	
	Time (minutes)		4.8	7.2	13.8	6.6		
	Unloading (minutes)		60.0	60.0	60.0			
	Total time (minutes)		64.8	67.2	73.8	6.6		
	Start	8:00	9:05	10:12	11:26	**11:33**	Finish	
					Total		**75.0** km	
					Fuel consumption		**33.3 liter**	
					Total fuel cost		**IDR 171,666.67**	

The calculation of the distance matrix and saving matrix in scenario 3 uses the new depot point from the results of the Gravity Location Model, this is to compare how much minimum operational costs can be incurred. The total traveling distance from the table above is 75 km using 1 wings box truck because it can still be reused for the next route. Trucks on the first subroute can return to the depot for loading and depart again for the second subroute because the total time is still between 08.00 and 17.00. Fuel consumption for all routes is 33.3 liters with a total fuel cost of Rp 171,666.67.

Table 12. Computation Result of Scenario 4

Scenario 4		New Location of Fuso Truck						
	Sequence 1	0	2	3	0		Total Dist	
	Distance (km)		8.9	15.0	23.5		47.4	
	Time (minutes)		10.7	18.0	28.2			
	Unloading (minutes)		50.0	50.0				
	Total time (minutes)		60.7	68.0	28.2			
	Start	8:00	9:01	10:09	**10:37**	Finish		
	Sequence 2	0	5	4	0			Average speed 50 km/h
	Distance (km)		3.5	1.6	4.4		9.5	
	Time (minutes)		4.2	1.9	5.3			
	Unloading (minutes)		50.0	50.0				
	Total time (minutes)		54.2	51.9	5.3			
	Start	8:00	8:54	9:46	**9:51**	Finish		
	Sequence 3	0	6	1	0			
	Distance (km)		3.2	4.8	5.6		13.6	
	Time (minutes)		3.8	5.8	6.7			
	Unloading (minutes)		50.0	50.0				
	Total time (minutes)		53.8	55.8	6.7			
	Start	8:00	8:54	9:55	**10:02**	Finish		
					Total fuel cost		**70.5** km	
					Fuel consumption		**23.5** liter	
					Total fuel cost		**IDR 121,025.00**	

The calculation in scenario 4 still takes into account the new location but by using a different type of vehicle, namely a fuso truck. From the analysis of operating hours between 08.00 and 17.00, there is 1 unit of fuso truck that can be allocated to meet demand on all nodes with a total traveling distance of 70.5 km. 1 truck unit that has arrived at the depot will be allocated to complete 2 other sub-routes before 17.00 with a loading time of 60 minutes per arrival at the depot. Fuel consumption in this scenario is 23.5 liters with a total diesel cost of IDR 121,025.

The first analysis of the computational results above is by comparing and sorting the total traveling distance from each scenario to find out the minimum total traveling distance.

Table 13. Sorted Total Traveling Distance

No	Scenario	Total Traveling Distance
1	2	137.1 km
2	1	126.8 km
3	3	75.0 km
4	4	70.5 km

The first and second scenarios are different in the change in the type of fleet vehicle, of which the wings box trucks are replaced with Fuso trucks with lower dimensions both in terms of cubication and tonnage. From the calculation of the total distance traveled, the second scenario has a total distance greater than the first scenario, which is 137.1 km. This is because the distance from the depot to the delivery node collection is quite far, the more fleet vehicles used, the greater the total distance traveled.

Meanwhile, the difference between the scenario 1 and 3 is the change in location, that is the type of vehicle used is a wings box truck. However, it can be seen that the total distance covered in the third scenario is smaller than the second scenario, which is 75 km. This is because the location of the depot is in the center around the delivery node. From the fourth scenario, the best total traveling distance with a Fuso truck is 70.5 km.

Table 14. Fuel Consumption and Cost

Scenario	Fuel consumption	Fuel cost
1(wings box truck)	101.4 liter	IDR 290.215
2 (Fuso truck)	45.7 liter	IDR 235.555
3 (wings box truck)	33.3 liter	IDR 176.666
4 (Fuso truck)	23.5 iter	IDR 125.025

Data of fuel consumption rate on each vehicle indicated that the wings box truck requires 2 liters of diesel to cover a distance of 4.5 km. While the Fuso truck requires 1 liter of diesel to cover a distance of 3 km. Then the total fuel consumption will be obtained for each scenario. Fuel costs can be calculated from the amount of fuel consumption. Although scenario 2 has a longer distance than scenario 1, the fuel cost for scenario 1 is greater than scenario 2. This is because the fuel consumption rate for wings box trucks is higher than that for Fuso truckS. The smallest fuel costs are obtained from scenario 4, of which there is a change in the type of vehicle and the location of the depot.

Table 15. Depature and Arrival Times of Each Vehicle

Scenario	Departure Time	Arrival Time
1 (wings box truck)	08.00	13.00
N= 2 unit		12.10
2 (Fuso truck)	08.00	10.30
N= 2 unit		10.57
		10.19
3 (wings box truck)	08.00	12.19
N= 1 unit		11.33
4 (Fuso truck)	08.00	10.37
N= 1 unit		09.51
		10.02

The average speed for a wingbox truck under normal conditions is 40 km/h considering the truck's flexibility in winding due to its long body. While the average speed of the Fuso truck is 50 km/h. The unloading time for wings box trucks is 60 minutes and 50 minutes for Fuso trucks..

This analysis is carried out to estimate the arrival time of each vehicle in each scenario to justify the possibility of additional trips for possible operational times. Of the four existing scenarios, scenarios 2, 3, and 4 can be categorised as multi-trips because the operational hours of receiving goods are 08.00 to 17.00 with the next loading time is 60 minutes, then one vehicle is able to serve more than one sub-route trip. Therefore, the utility of the vehicle increases because it can be used to complete other sub-routes.

Considering the economic value of the supply chain, scenario 4 is the best scenario with minimal costs for fuel because the total traveling distance is the least among other scenarios. The use of fuso trucks in distribution also contributes to speeding up product delivery other than the new depot location, although the total traveling distance may be longer as in scenario 2.

However, ideal conditions such as scenario 4 are unlikely to be realized in the short term. This scenario can be incorporated into long-term plans as a form of response and high flexibility to commitments to customers. Therefore, scenario 2 is a scenario that can be applied directly because the transport vehicle type of fuso truck is already available in the company.

CONCLUSION

This study tried to approach real cases in the field related to the process of distributing a product from the depot to several delivery locations. Therefore, the type of vehicle that is not always the same, the location of the depot that may change, and the utility of the vehicle were the focus of this study analysis for both the short-term and long-term of company plans.

There was an effect of changing the type of fleet vehicle on the total traveling distance; the largest distance was in scenario 2 using a Fuso truck and the smallest total distance was obtained from scenario 4 using the same truck but the location of the depot has changed.

There was a significant effect on the total travel distance when the depot is moved using the Gravity Location Model. For example, scenario 1 and scenario 3 using a wings box truck reduce the total distance from 126.8 km to 75.0 km.

There is an effect of the ratio of fuel consumption on vehicle operating costs, however, the effect of traveling distance is greater. For example, scenario 2 with a fuso truck has a total distance of 137.1 km with a fuel cost of IDR 235,555. While scenario 1 with a wings box truck has a total distance of 126.8 km at a cost of IDR 290,215. This means that a high total traveling distance does not mean that the fuel cost is also high because there are still other technical factors that might affect it, such as the fuel consumption rate.

There is an effect of vehicle speed on the time of delivery and return to the depot. For the wings box truck in scenario 1, the arrival time is around 12.00 p.m past. Thus, it is not possible for multiple trips or repeated trips by the same truck with the loading time at the depot is 60 minutes. Apart from scenario 1, the arrival time is less than 12.00 p.m; thus, trucks may be reused to complete other sub-routes. Therefore, truck utility increases.

Of the various existing scenarios, scenario 4 is the best in terms of traveling distance, fuel costs and delivery time. However, moving the depot center is not easy; hence, scenario 2 is the most likely condition to be implemented considering that the fuso truck is ready and has a higher utility than the wings box truck.

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