ANALYSIS OF DAY-OLD CHICK DISTRIBUTION ROUTES WITH SAVING MATRIX METHOD AND DETERMINATION OF VEHICLE OPERATIONAL COSTS AT PT. BERDIKARI (PERSERO)

Muhamad Dipa Adri Juan Utama
Bagas Wicaksono
Rangga Wirabuana
Diva Maulana
Guruh Kartanegara
Riki Ridwan Margana

DOI: https://doi.org/10.37178/ca-c.23.1.400

Muhamad Dipa Adri Juan Utama, *Widyatama University, Bandung, Indonesia*

Bagas Wicaksono, *Widyatama University, Bandung, Indonesia*

Rangga Wirabuan*,Widyatama University, Bandung, Indonesia*

Diva Maulana, *Widyatama University, Bandung, Indonesia*

Guruh Kartanegara*, Widyatama University, Bandung, Indonesia*

Riki Ridwan Margana*, Widyatama University, Bandung, Indonesia*

Corresponding author: adri.juan@widyatama.ac.id

Abstract

PT Berdikari (Persero) has started to produce DOC (Day-Old Chick) which is distributed to smallholder breeders and is spread across Java and other regions throughout Indonesia. One of the problems with CVRP in the distribution process is that PT Berdikari (Persero) must use 4 car body trucks in the process of distributing DOC on each route to 12 cities/districts so that the DOC distribution process is deemed not optimal in terms of distance, vehicle fleet capacity, and transportation costs. The purpose of this study is to provide a more effective delivery route for DOC products and is also expected to obtain a minimum cost. Determining the solution to this CVRP problem using the saving matrix method, this method allows route optimization by considering the capacity of the vehicle fleet. The results of the discussion using the saving matrix method showed a decrease in distribution routes from 12 cities/districts to 4 routes with a travel time of 21.84 hours, the improvement process accelerated the delivery of goods from 3 days to 1 day. The total distribution distance of 12 cities/districts is 1069.4 km. The total vehicle operating costs incurred by PT Berdikari (Persero) in the existing condition is Rp.9.191.549,91 and after using the saving matrix method, it is Rp.3.733.549,84. Total savings of vehicle operating costs are Rp. 5.458.045,07 or 59,38%.

Keywords: Distribution, CVRP, Saving Matrix method, route, cost

Introduction

PT Berdikari (Persero) is a state-owned company that is engaged and operates in the livestock sector and has a responsibility to meet the needs of providing food and protein for the wider community (PT Berdikari Persero). The company produces DOC (Day-Old Chick) which will then be distributed throughout Indonesia through smallholder breeders who have spread across Java and some other areas. Business processes, especially those engaged in industry and there is transportation as well as distribution of goods in it will have an impact on competitive advantage, this is because the decreased transportation costs will greatly benefit the company. The type of transportation used and creating an efficient distribution system is one way that companies can use to reduce existing transportation costs. Technological developments that are increasingly advanced over time have resulted in increasingly high and very competitive competition in the industrial world, this makes it a demand for every company to create ways and strategies for distributing goods to consumers to be better and optimal than previous strategies. Planning and determining routes quickly in the process of distributing goods can be used as an alternative strategy that companies can implement. Selection of the right route will produce a truly optimal distribution channel.

The Vehicle Routing Problem (VRP) is closely related to planning for determining vehicle routes in terms of distributing goods to consumers who use more than one vehicle to meet requests from customers with different requests. Customer requests are met with the existing capacity not exceeding the maximum limit and using the Capacitated Vehicle Routing Problem (CVRP) method where each vehicle has a limited capacity. The distribution of goods is very limited by the capacity of each vehicle that will distribute and supply-demand from consumers. The method that has been suggested for the Capacitated Vehicle Routing Problem (CVRP) is the classical heuristic optimization approach, one of which is the Saving Matrix. The saving matrix method is applied in determining the route of distribution of goods to consumers by determining which paths must be passed and how many vehicles are available based on the capacity of the vehicle so that the company will obtain optimal transportation costs with effective routes. One of PT Berdikari's (Persero) CVRP problems is the delivery route for DOC (Day Old Chick) to the buyer's place. PT Berdikari (Persero) uses 4 units of car body trucks in the process of distributing docs with a vehicle capacity that is only able to carry a maximum of 198 doc boxes. The locations of the targeted consumers are scattered in the Central Java region and its surroundings. The current distribution of DOC is still not fully optimal, starting from the available vehicle capacity, the cost of transportation, and the distance traveled by the vehicle, so the company must make route improvements from previously existing routes to be more effective. The problems currently faced by PT Berdikari (Persero) are included in the CVRP, due to the limited capacity of the available vehicles. The transportation route is said to be effective if it can produce cost savings, minimize mileage, and can also shorten travel time by maximizing the existing capacity on the vehicle tap in the ongoing goods distribution process. The purpose of this study is expected to provide an overview of the current transportation flow and provide optimal alternative routes so that the supply chain process becomes more effective and efficient, also produces the shortest transportation route by maximizing the capacity of the conveyance so that it can speed up distribution time and save fuel. Effectiveness will be seen based on the results of mileage that has the largest difference with the company's current total mileage.

Literature Review

Supply Chain is a network of companies that work together to create and deliver a product into the hands of end-users [1]. These companies usually include suppliers, manufacturers, distributors, warehouses, shops, or retailers, as well as supporting companies such as logistics service companies.

Distribution and Transportation

Distribution is an activity to move products from suppliers to consumers in the form of a supply chain [2]. Distribution is one of the most important functions of marketing. That is the development and expansion of the flow of goods or services from producers to consumers in a certain amount and time. Distribution is a key advantage that will be obtained by the company because the distribution will directly affect the costs of the supply chain and consumer needs, the right distribution network can be used to achieve various kinds of supply chain needs ranging from low costs and high response to consumer demand [3, 4] In principle, this function aims to create high service to customers which can be seen from the level of service achieved, speed of delivery, the perfection of goods to the hands of customers, as well as satisfactory post-journal service. Poor distribution system planning will lead to waste of transportation costs and a decrease in customer satisfaction which in turn causes a loss of trust [5]. Transportation can mean the movement of products from one place to another that makes the product reach the hands of consumers [6]. Transportation is the main key in the supply chain because products are rarely produced and consumed at the same place or location. Transportation is a significant cost component of most expenses.

Vehicle Routing Problem

The Vehicle Routing Problem (VRP) was first introduced by [7]and has been widely studied since then. [8] defines VRP as a search for efficient use of many vehicles that must travel to visit many places to drop off and pick up people or goods [8]. The term customer is used to indicate a stop to drop off and pick up people or goods. Each customer must be served by only one vehicle. The determination of this vehicle-customer pair is carried out by considering the capacity of the vehicle in one transportation, to minimize the required costs. Usually, the determination of the minimum cost is closely related to the minimum distance [9]. VRP can also be seen as a combination of two other optimization problems, namely the Bin Packing Problem (BPP) and the Traveling Salesman Problem (TSP) [10]BPP can be described as follows: "Given a number, representing the size of the number of items, and a constant K, representing the capacity of the bin. What is the minimum number of bins required?" Of course, one item can only be in one bin, and the total capacity of items in each bin should not exceed the capacity of that bin [11]Besides, TSP is a problem for a salesman who wants to visit several cities. He had to visit each city only once, starting and ending from the starting city. The crux of the problem is to find the shortest path through all existing cities. The relationship between the two with VRP is that vehicles can be connected to customers using BPP, and the order of vehicle visits to each customer is completed using TSP[12, 13].

Saving Matrix

The Saving Matrix method itself has the goal of delivering goods effectively and efficiently so that there are savings in aspects of costs, labor, and delivery time [14]. Saving Matrix also aims to minimize the total distance traveled by all vehicles and to indirectly minimize the number of vehicles needed to serve all stops, considering the

existing constraints. The logic of this method starts with the vehicles serving each stop and returning to the depot.

Vehicle Operating Cost

Vehicle Operational Costs (VOC) are costs that are economically incurred due to the operation of one vehicle under normal conditions for a purpose which is economically incurred due to the operation of one vehicle under normal conditions for a particular purpose as well. Vehicle Operating Costs are divided into two, namely Fixed Costs and Variable Costs [13, 15].

Materials and Methods

The data collected is data on the number of DOC parts of the Hatchery Grabbag unit at PT. BERDIKARI (PERSERO) for 12 cities/districts distributed (Bawen, Madiun, Magetan, Kulon Progo, Pati, Semarang, Purworejo, Sleman, Suruh, Temanggung, Wonosobo, Yogyakarta), then size or dimension data from haul trucks, specification data box size for distribution, as well as fixed cost and variable cost data from PT. Independent (Persero). The data collected is based on existing or real data to be processed directly.

In this research, the method used is Saving Matrix. 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 passed and the number of vehicles based on the capacity of the vehicle to obtain the shortest route and minimal transportation costs [16, 17].

Steps to Solve Saving Matrix Problems are to identify the distance matrix. In this step, it is necessary to know the distance between the company's warehouse to each store and the distance between stores. By knowing the coordinates of each location, the distance between the two locations can be calculated. The results of the distance calculation will then be used to determine the savings matrix.

$$j(1,2) = \sqrt{(x_1 - x_2) + (y_1 - y_2)} \qquad (1)$$

Information:
j = Location of Company Warehouse Center
x = Coordinate of Initial location
y = Coordinate of Next Location

The next step is to identify the savings matrix, the Savings matrix represents savings that can be realized by combining two stores/consumers into one route. To find the saving matrix, the following formula can be used:

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

Information:
S (x, y): is a distance saving that is from combining route x with route y to minimize distance and time so using a combined route will save all aspects.

Then allocating consumers to vehicle travel routes. At this stage, consumers are divided into a vehicle travel route by considering consumers and the capacity of the vehicle used. A route is said to be feasible if the total demand from all consumers does not exceed the vehicle capacity and the number of requests from one customer can be accommodated by one vehicle. The procedure used for grouping consumers is based on the largest saving matrix value. So, first, sort the value of the largest saving matrix until the vehicle capacity used can accommodate all requests. If the

capacity is maximum, then the procedure will be repeated until all consumers are allocated in a travel route.

Finally Sort stores (destinations/consumers) in a route that has been defined, this stage is the final stage of the saving matrix method. The purpose of this stage is to sort the visits from the vehicle to each consumer that has been grouped in a travel route so that the minimum distance can be obtained.

Results and Discussions

This section will contain data collection regarding demand, distance traveled, distribution container and the type of transportation used. PT. BERDIKARI (PERSERO) Hatchery Grabag unit will distribute DOC to 12 cities/districts as shown in Table 1 below:

Table 1

Demand of DOC

City/district Name	Node	Distance (Km)	Amount of DOC (tail)
Bawen	A	33,5	4998
Madiun	B	184	10200
Magetan	C	185	3060
Kulon Progo	D	70,2	2040
Pati	E	140	15300
Semarang	F	63,4	1530
Purworejo	G	62,7	3570
Sleman	H	61	2142
Suruh	I	35,8	3060
Temanggung	J	34,4	6630
Wonososbo	K	60,4	3570
Yogyakarta	L	80,3	7140
Total			63240

The data collected is then processed to determine the distance of each city using Google maps tools, then determine the distance matrix for each city and provide notation to facilitate the data processing, the results of the distance matrix can be seen in Table 2 below:

Table 2

Distance Matrix

		Destination Point												
		O	A	B	C	D	E	F	G	H	I	J	K	L
Starting Point	O	-	33,5	184	185	70,2	140	63,4	62,7	61	35,8	34,4	60,4	80,3
	A	33,5	-	178	183	96,3	120	39,5	89,2	87,5	33,1	44,1	85	91,8
	B	184	178	-	27,6	207	182	205	243	178	163	216	255	180
	C	185	183	27,6	-	210	176	208	246	181	166	219	258	183
	D	70,2	96,3	207	210	-	242	136	43,7	37,8	105	79,9	95,1	28,4
	E	140	120	182	176	242	-	83,1	201	205	137	156	195	207
	F	63,4	39,5	205	208	136	83,1	-	124	128	60,9	79,1	118	130
	G	62,7	89,2	243	246	43,7	201	124	-	55,5	95,2	59,5	53,9	50,9
	H	61	87,5	178	181	37,8	205	128	55,5	-	86,4	63,8	93,6	10,1
	I	35,8	33,1	163	166	105	137	60,9	95,2	86,4	-	58,6	111	88,6
	J	34,4	44,1	216	219	79,9	156	79,1	59,5	63,8	58,6	-	39,1	69,5
	K	60,4	85	255	258	95,1	195	118	53,9	93,6	111	39,1	-	94
	L	80,3	91,8	180	183	28,4	207	130	50,9	10,1	88,6	69,5	94	-

Next calculate the saving value for each matrix. The data whose Saving value has been determined are then sorted from the highest. The result of the Saving Matrix value is carried out iterations to determine whether it can be approved or declined based on the results of the calculation of the transportation capacity. The highest saving matrix value can be seen in Table 3 below:

Table 3

Saving Matrix

Starting Point	Destination Point												
	O	A	B	C	D	E	F	G	H	I	J	K	L
	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	39,5	35,5	7,4	53,5	57,4	7	7	36,2	23,8	8,9	22
	-	-	-	341,4	47,2	142	42,4	3,7	67	56,8	2,4	-10,6	84,3
	-	-	-	-	45,2	149	40,4	1,7	65	54,8	0,4	-12,6	82,3
	-	-	-	-	-	-31,8	-2,4	89,2	93,4	1	24,7	35,5	122,1
	-	-	-	-	-	-	120,3	1,7	-4	38,8	18,4	5,4	13,3
	-	-	-	-	-	-	-	2,1	-3,6	38,3	18,7	5,8	13,7
	-	-	-	-	-	-	-	-	68,2	3,3	37,6	69,2	92,1
	-	-	-	-	-	-	-	-	-	10,4	31,6	27,8	131,2
	-	-	-	-	-	-	-	-	-	-	11,6	-14,8	27,5
	-	-	-	-	-	-	-	-	-	-	-	55,7	45,2
	-	-	-	-	-	-	-	-	-	-	-	-	46,7
			-	-	-	-	-	-	-	-	-	-	-

The initial route is determined by finding the largest value of the distance saving matrix. Then analyze the number of goods that are distributed with the limitation of transport capacity. The destination node B and node C have a combined demand of 130 boxes so that they meet the carrying capacity limit (198 boxes). So that iteration 1 produces routes B – C. The iteration is continued by finding the next largest Saving Matrix value, then analyzing the combined demand and distribution transport capacity (198 boxes). The next route is route C – I with the total demand for the combined route (B – C – I) being 160 boxes. The iteration starts again for the next route with the same iteration stages but does not consider the destination that has been selected in the previous iteration of the route. Table 4 shows a summary of the results of the iteration route distribution doc.

Table 4

Saving Matrix

Starting Point	Destination Point												
	O	A	B	C	D	E	F	G	H	I	J	K	L
O	-	-	-	-	-	-	-	-	-	-	-	-	-
A	-	-	39,5	35,5	7,4	53,5	57,4	7	7	36,2	23,8	8,9	22
B	-	-	-	341,4	47,2	142	42,4	3,7	67	56,8	2,4	-10,6	84,3
C	-	-	-	-	45,2	149	40,4	1,7	65	54,8	0,4	-12,6	82,3
D	-	-	-	-	-	-31,8	-2,4	89,2	93,4	1	24,7	35,5	122,1
E	-	-	-	-	-	-	120,3	1,7	-4	38,8	18,4	5,4	13,3
F	-	-	-	-	-	-	-	2,1	-3,6	38,3	18,7	5,8	13,7
G	-	-	-	-	-	-	-	-	68,2	3,3	37,6	69,2	92,1
H	-	-	-	-	-	-	-	-	-	10,4	31,6	27,8	131,2
I	-	-	-	-	-	-	-	-	-	-	11,6	-14,8	27,5
J	-	-	-	-	-	-	-	-	-	-	-	55,7	45,2
K	-	-	-	-	-	-	-	-	-	-	-	-	46,7
L	-	-	-	-	-	-	-	-	-	-	-	-	-

Based on the calculation results and the iteration results that have been carried out, the proposed distribution route is obtained. The route before the repair is a distribution route from the depot to the destination and directly back to the depot without sending it to another destination, while the proposed route is a route for merging distribution to several destinations at once. The route before the repair and the route after the repair can be seen in Table 5, Figure 1, and Figure 2 below:

Table 5

Initial Route Matrix and After Repair Route

No	Initial outer	Repair Route
1	O – A – O	O – B – C – I – O
2	O – B – O	O – H – L – D – G – K – O
3	O – C – O	O – E – F – O
4	O – D – O	O – A – J – O
5	O – E – O	
6	O – F – O	
7	O – G – O	
8	O – H – O	
9	O – I – O	
10	O – J – O	
11	O – K – O	
12	O – L – O	

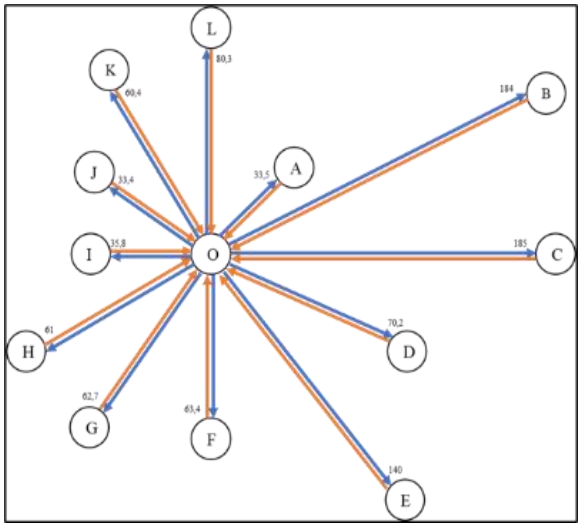

Figure 1. Distribution Route Before Repair Figure 2. Distribution Route After Repair

Distance Efficiency

After determining the repair route, then calculating the efficiency of the repair route. Distance efficiency is calculated by comparing the difference in distance between the repair route and the initial route.

Table 6

Saving Matrix

.

Intial Route	Distance (Km)	Repair Route	Distance (Km)
O – A – O	67	O – B – C – I – O	413,4
O – B – O	368	O – H – L – D – G – K – O	257,5
O – C – O	370	O – E – F – O	286,5
O – D – O	140,4	O – A – J – O	112
O – E – O	280		
O – F – O	126,8		
O – G – O	125,4		
O – H – O	122		
O – I – O	71,6		
O – J – O	68,8		
O – K – O	120,8		
O – L – O	160,6		
Total	2021,4		1069,4

Based on table 6, There is an efficiency of the delivery distance of 952 km or 47.10%

Distribution Time Efficiency

Distribution time efficiency is calculated by comparing the distribution time of the repair route with the distribution time on the initial route assuming a speed of 60 Km/hour. The loading and unloading time are also calculated to total distribution time. Loading and Unloading time is 15 minutes.

Table 7

Distribution Time of Initial Route

Initial Route	Distance (Km)	Distribution Time (Hour)	Loading & Unloading Time (Hour)		Total (Hour)
			Loading	Unloading	
O – A – O	67	1,12	0,25	0,25	1,62
O – B – O	368	6,14	0,25	0,25	6,64
O – C – O	370	6,17	0,25	0,25	6,67
O – D – O	140,4	2,34	0,25	0,25	2,84
O – E – O	280	4,67	0,25	0,25	5,17
O – F – O	126,8	2,12	0,25	0,25	2,62
O – G – O	125,4	2,09	0,25	0,25	2,59
O – H – O	122	2,04	0,25	0,25	2,54
O – I – O	71,6	1,2	0,25	0,25	1,7
O – J – O	68,8	1,15	0,25	0,25	1,65
O – K – O	120,8	2,02	0,25	0,25	2,52
O – L – O	160,6	2,68	0,25	0,25	3,18
Total		33,74			39,74

Table 8

Distribution Time of Repair Route

Repair Route	Distance (Km)	Distribution Time (Hour)	Loading & Unloading Time (Hour)		Total (Hour)
			Loading	Unloading	
O – B – C – I – O	413,4	6,89	0,25	0,75	7,89
O – H – L – D – G – K – O	257,5	4,3	0,25	1,25	5,8
O – E – F – O	286,5	4,78	0,25	0,5	5,53
O – A – J – O	112	1,87	0,25	0,5	2,62
Total		17,84			21,84

Based on Table 7 and 8, there is a decrease in distribution time from 39,74 hours to 21,84 hours. It can be concluded the repair route provides efficiency of distribution time 17,9 hours or 45,04%.

Delivery Schedule

The delivery schedule is arranged based on the working time of the driver and conductor and considers the number of vehicles.

Table 9

Delivery Schedule of Initial Route

Initial Route	Distribution Time (Hour)	Used Vehicle	Delivery Schedule
O – A – O	1,62	Vehicle 1	Day 1
O – B – O	6,64	Vehicle 2	
O – C – O	6,67	Vehicle 3	
O – D – O	2,84	Vehicle 4	
O – E – O	5,17	Vehicle 1	Day 2
O – F – O	2,62	Vehicle 2	
O – G – O	2,59	Vehicle 3	
O – H – O	2,54	Vehicle 4	
O – I – O	1,7	Vehicle 1	Day 3
O – J – O	1,65	Vehicle 2	
O – K – O	2,52	Vehicle 3	
O – L – O	3,18	Vehicle 4	

Table 10

Delivery Schedule of Repair Route

Repair Route	Distribution Time (Hour)	Used Vehicle	Delivery Schedule
O – B – C – I – O	7,89	Vehicle 1	Day 1
O – H – L – D – G – K – O	5,80	Vehicle 2	
O – E – F – O	5,53	Vehicle 3	
O – A – J – O	2,62	Vehicle 4	

Based on table 9 and 10, the delivery process can be finished in one day compared to three days from initial route.

Vehicle Operating Cost

Vehicle Operating Cost are calculated based on fixed costs and variable costs. The composition of fixed costs is explained in table 11.

Table 11

Composition of Fixed Costs

Depreciation	Purchase Price	Selling Price	Service Life (Year)	Depreciation / Year	Depreciation/ Day
	Rp400.000.000	Rp250.000.000	5	Rp30.000.000	Rp82.191,78
Salary	Driver Salary / Month	Driver Salary / Day	Conductor Salary / Month	Conductor Salary / Day	Total Salary / Day
	Rp2.302.797	Rp115.139,85	Rp2.302.797	Rp115.139,85	Rp230.279,70
Tax and Administration	Tax/ Year	SWDKLLJ / Year	Administration / Year	Total Tax/ Year	Total Tax/ Day
	Rp6.500.000,00	Rp143.000,00	Rp50.000,00	Rp6.693.000,00	Rp18.336,99

The composition of Variable Costs is explained in table 12

Table 12

Composition of Variable Costs

Fuel	Price / Litre	Ratio	Price / Km
	Rp6.450	1 : 4,5	Rp1.433
Tires (6 Tires)	Tires Price	Replacement Time (Km)	Price / Km
	Rp1.230.000	40.000	Rp185
Services and Oil	Price	Service and Oil replacement Time (Km)	Price / Km
	Rp750.000,00	10.000	Rp75,00

Table 13

Variable Operating Costs of initial route

No	Amount of Delivery Day	Initial Route	Distance (Km)	Vehicle	Fix Cost	Variabel Cost	Table Money / Delivery	Total
1	1	O – A – O	67	Vehicle 1	Rp330.808,47	Rp113.420	Rp150.000	Rp594.228,30
2	1	O – B – O	368	Vehicle 2	Rp330.808,47	Rp622.963	Rp150.000	Rp1.103.771,13
3	1	O – C – O	370	Vehicle 3	Rp330.808,47	Rp626.348	Rp150.000	Rp1.107.156,80
4	1	O – D – O	140,4	Vehicle 4	Rp330.808,47	Rp237.674	Rp150.000	Rp718.482,27
5	1	O – E – O	280	Vehicle 1	Rp330.808,47	Rp473.993	Rp150.000	Rp954.801,80
6	1	O – F – O	126,8	Vehicle 2	Rp330.808,47	Rp214.651	Rp150.000	Rp695.459,73
7	1	O – G – O	125,4	Vehicle 3	Rp330.808,47	Rp212.281	Rp150.000	Rp693.089,77
8	1	O – H – O	122	Vehicle 4	Rp330.808,47	Rp206.526	Rp150.000	Rp687.334,13
9	1	O – I – O	71,6	Vehicle 1	Rp330.808,47	Rp121.207	Rp150.000	Rp602.015,33
10	1	O – J – O	68,8	Vehicle 2	Rp330.808,47	Rp116.467	Rp150.000	Rp597.275,40
11	1	O – K – O	120,8	Vehicle 3	Rp330.808,47	Rp204.494	Rp150.000	Rp685.302,73
12	1	O – L – O	160,6	Vehicle 4	Rp330.808,47	Rp271.869	Rp150.000	Rp752.677,50
				Total				Rp9.191.594,91

Table 14

Variable Operating Costs of Repair Route

No	Amount of Delivery Day	Initial Route	Distance (Km)	Vehicle	Fix Cost	Variabel Cost	Table Money / Delivery	Total
1	1	O – B – C – I – O	413,4	Vehicle 1	Rp330.808,47	Rp699.817	Rp150.000	Rp1.180.625,77
2	1	O – H – L – D – G – K – O	257,5	Vehicle 2	Rp330.808,47	Rp435.905	Rp150.000	Rp916.713,05
3	1	O – E – F – O	286,5	Vehicle 3	Rp330.808,47	Rp484.997	Rp150.000	Rp965.805,22
4	1	O – A – J – O	112	Vehicle 4	Rp330.808,47	Rp189.597	Rp150.000	Rp670.405,80
Total								Rp3.733.549,84

The efficiency of vehicle operating costs is calculated by comparing the vehicle operational costs of initial route with the vehicle operational cost of repair route.

Table 15

Composition of Variable Costs

	Initial Route	Repair Route
Distance (Km)	2021,4	1069,4
Total Cost	Rp9.191.594,91	Rp3.733.549,84

Based on table 15, there is a decrease in vehicle operational costs from Rp 9.191.594,91 to Rp 3.733.549,84. It can be concluded the repair route provides efficiency of vehicle operational costs Rp 5.458.045,07 or 59,38%.

Conclusion

This study concludes that the initial condition of the DOC delivery transportation route at PT Berdikari (Persero) has a total distribution distance of 12 cities/districts of 2021,4 km. After using the saving matrix method, alternative routes are obtained, there are (O – B – C – I – O), (O – H – L – D – G – K – O), (O – E – F – O), and (O – A – J – O). This route provides a total distribution distance of 1069.4 km, the total distance saved for all routes is 952 km. The distribution process using the repair route takes a total of 21,84 hours, resulting in an efficiency of 17,9 hours compared to the initial route, which is 39,74 hours. In the distribution process, the distance savings are 47.1% and travel time is 52.95%. The total vehicle operating costs incurred by PT Berdikari (Persero) in the existing condition is Rp.9.191.594,91 and after using the saving matrix method, it is Rp.3.733.549,84. Total savings of vehicle operating costs are Rp. 5.458.045,07 or 59,38%. The results obtained indicate that the route created using the saving matrix method produces a route and DOC shipping costs that are more minimum and more optimal.

References

1. Ubud, S. and M. Nanere. *THE ROLE OF SUPPLY CHAIN FLEXIBILITY AND ITS ANTECEDENT VARIABLE IN INCREASING COMPETITIVE ADVANTAGE OF MANUFACTURING INDUSTRIES IN EAST JAVA*.
2. LaLonde, B.J. and T.L. Pohlen, *Issues in supply chain costing.* The International Journal of Logistics Management, 1996. **7**(1): p. 1-12 DOI: https://doi.org/10.1108/09574099610805395.
3. Chopra, S., P. Meindl, and D.V. Kalra, *Supply chain management: Strategy, planning, and operation.* Vol. 232. 2013: Pearson Boston, MA.
4. Nalaka, S. and H. Diunugala, *Factors Associating with Social Media related Crime Victimization: Evidence from the Undergraduates at a Public University in Sri Lanka.* International Journal of Cyber Criminology, 2020. **14**(1): p. 174-184.
5. Ikfan, N. and I. Masudin, *Determining the Shortest Transportation Route to Minimize Costs Using the Saving Matrix Method.* Scientific Journal of Industrial Engineering, 2013. **12**(2): p. 165-178.
6. Alhadar, A., *Analysis of road performance in an effort to overcome traffic congestion at signalized intersections in Palu City.* SMARTek, 2011. **9**(4).
7. Dantzig, G.B. and J.H. Ramser, *The truck dispatching problem.* Management science, 1959. **6**(1): p. 80-91 DOI: https://doi.org/10.1287/mnsc.6.1.80.

8. Fisher, M.L. and R. Jaikumar, *A generalized assignment heuristic for vehicle routing.* Networks, 1981. **11**(2): p. 109-124 DOI: https://doi.org/10.1002/net.3230110205.
9. Sarmiento, A.M. and R. Nagi, *A review of integrated analysis of production-distribution systems.* IIE transactions, 1999. **31**(11): p. 1061-1074 DOI: https://doi.org/10.1080/07408179908969907.
10. Supriyadi, S., K. Mawardi, and A. Nalhadi. *Cost Minimization in Determining Beverage Product Distribution Routes Using the Savings Matrix Method*.
11. Laporte, G., *What you should know about the vehicle routing problem.* Naval Research Logistics (NRL), 2007. **54**(8): p. 811-819 DOI: https://doi.org/10.1002/nav.20261.
12. Toth, P. and D. Vigo, *Exact solution of the vehicle routing problem*, in *Fleet management and logistics*. 1998, Springer. p. 1-31 DOI: https://doi.org/10.1007/978-1-4615-5755-5_1.
13. Nodeland, B. and R. Morris, *The Impact of Low Self-control on Past and Future Cyber Offending.* International Journal of Cyber Criminology, 2020. **14**(1): p. 106-120.
14. Suparjo, S., *Metode Saving Matrix Sebagai Alternatif Efisiensi Biaya Distribusi (Studi Empirik Pada Perusahaan Angkutan Kayu Gelondongan Di Jawa Tengah).* Media Ekonomi Dan Manajemen, 2017. **32**(2) DOI: https://doi.org/10.24856/mem.v32i2.513.
15. Sudarjah, G.M. and M. Ridwan, *ANALYSIS OF FINANCIAL AND ECONOMIC FEASIBILITY OF CITY TRANSPORT CONVERSION TOWARDS BANDUNG TRANS METRO BUS.* Journal of Economic Empowerment Strategy (JEES), 2021. **4**(1): p. 7-13.
16. Wolsey, L.A. and G.L. Nemhauser, *Integer and combinatorial optimization*. Vol. 55. 1999: John Wiley & Sons.
17. Nzeakor, O.F., B.N. Nwokeoma, and P.-J. Ezeh, *Pattern of cybercrime awareness in Imo state, Nigeria: An empirical assessment.* International Journal of Cyber Criminology, 2020. **14**(1): p. 283-299.