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Determining Routes of Drinking Water Depot Distribution Refill Using the Saving Matrix Method Study Depot RO Supardi

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Abstract
In the Refill Drinking Water Depot business, of course, it is very important to distribute refilled water to every consumer, design optimal distribution to save time, transportation costs, as well as effective and efficient distribution channels, AMIU RO Supardi is one of the SMEs engaged in the Water Sector. Drinking Refills, the problem faced by this Ro depot is the needs of consumers and the absence of distribution channels. The purpose of this study is to analyze the optimum distribution route using the saving matrix method. After doing research using the Saving Matrix method, the number of distribution routes can be reduced from 16 routes to 11 routes. The original mileage of 113.76 km can be reduced to 40.21 kilometers, which means the distance can be shortened/saving 65% or about 73.55 kilometers. Decreasing routes results in lower shipping costs. Initial cost Rp. 163,800, down to Rp. 125,025. Thus, there is a saving in the delivery of refilled drinking water of Rp. 38,755 or about 24%. The novelty of this research lies in its tailored application of a classical optimization method to a specific and practical problem in drinking water depot distribution, potentially yielding new insights, practical solutions, and broader implications for both the industry and the academic field

Keywords: Saving matrix, Distribution, Transportation, milkrun

INTRODUCTION

Distribution is the main marketing activity for a company because it is to support consumer needs and make one of the bases for consumers to determine producers or when agents determine how quickly and precisely producers distribute a particular product, according to Sofjan Assuari distribution is an institution that delivers products, consisting of goods or services from producers to consumers (Sofjan Assauri, 2008).

Refillable Drinking Water Depot is an industrial business that uses the raw water treatment stage into drinking water that is marketed directly to consumers. In essence, the water treatment stage at the drinking water depot is filtration (filtration) and disinfection. According to (Athena, 2004) The filtration stage which is interpreted in addition to separating suspended contaminants also decomposes a mixture in the form of colloids including microorganisms from the water, while disinfection is interpreted to kill microorganisms that were not filtered in the previous stage.

In the Refillable Drinking Water Depot business, it is certainly very important to distribute refillable water to each consumer, carry out optimal distribution planning to save time, transportation costs and effective and efficient distribution routes.

Supardi RO (Reverse Osmosis) water depot is a type of MSME that operates in the refillable drinking water depot sector located in Sindangkarya Village, Kutawaluya district, Karawang regency, RO Supardi has distributed its refill water using the direct shipment method of distributing directly from the depot to consumers without passing through warehouses and others and the milk run method

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to every village in Sindagkarya village, Sindangmulya, and Kalangsurya and so far are still focusing on expanding their distribution reach.

While the Saving Matrix Method is a well-established technique in vehicle routing problems, its application specifically to the distribution routes of drinking water depots might be underexplored. Existing literature might lack detailed studies focusing on the unique characteristics and challenges of water distribution, such as fluctuating demand and strict delivery schedules

The delivery process carried out by the AMIU RO Depot is also fairly inefficient, because the depot has to go to consumers and collect every gallon to be filled, so it can be said to be inefficient, because there are often delays in delivery and additional overtime to each employee in making deliveries. Similar previous research has also been conducted by (Anggraeni &; Rusindiyanto, 2020) conducting a study entitled Analysis of Route Determination of Organic Fertilizer Products using the saving matrix method at PT. XYZ Surabaya, the results of the research are by using the saving matrix method there is a distance savings of 34.19% and a percentage of cost savings of up to 31.68%.

Based on the existing problems, it is necessary to conduct research to observe the problem of route scheduling, using the saving matrix method so that it is expected to determine the optimal distribution route that can speed up delivery and obtain effective distribution routes and efficient transportation costs in distributing.

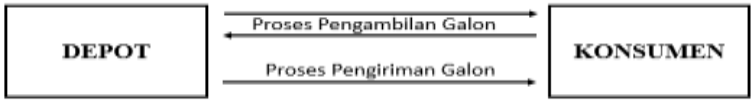

Figure 1 AMIU RO Supardi Distribution Activities
Source: Secondary Data/RO Supardi Data

RESEARCH METHOD

The type of research used is the Qualitative type, which is a research step that obtains descriptive data in the form of written expressions or direct speech from people and behavior that can be researched so said the opinion of Bogdan and Guba in (Suharsaputra, 2012). The initial step of research is to make observations to identify the problems faced and literature studies by conducting an overview to support the information needed in the research.

Data Collection

Initial Route Data of Distribution

The distribution route that is currently running when making a delivery, can be seen in the table below with the distance traveled and costs incurred:

Table 1. Deliveries made by AIMU RO Supardi Depot

Route	Purpose	Charge	Route Order	Total distance (meters)	Armada
1	J	29	Depot - J -Depot - J - Depot	19600	Roda 3
2	G - F - D	7	Depot – G – D – F - Depot – G – D - F - Depot	19980	Roda 3
3	C - E	15	Depot - C - E – Depot - C - E - Depot	10220	Roda 3
4	L	5	Depot – L – Depot – L – Depot	4560	Roda 2
5	H	15	Depot – H – Depot – H - Depot	5960	Roda 3

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6	K	30	Depot – K – Depot – K Depot	7600	Roda 3
7	I	4	Depot – I – Depot – I -Depot	1520	Roda 2
8	B	18	Depot – B – Depot – B - Depot	5520	Roda 3
9	B	18	Depot – B – Depot – B - Depot	5520	Roda 3
10	A	6	Depot – A – Depot – A Depot	1520	Roda 2
11	A	6	Depot – A – Depot – A Depot	1520	Roda 2
12	A	6	Depot – A – Depot – A Depot	1520	Roda 2
13	A	6	Depot – A – Depot – A Depot	1520	Roda 2
14	A	6	Depot – A – Depot – A Depot	1520	Roda 2
15	L	5	Depot – L – Depot – L – Depot	4560	Roda 2
16	I	4	Depot – I – Depot – I – Depot	1520	Roda 2
			Total Distance	113760	

Source: Secondary Data/Supardi RO Data

Information :

Depot	: Depot AMIU Supardi				
A	: Babakan Loa	E	: Kobak Bali	I	: Kobak Jiman
B	: Babakan kukun	F	: Sunyar	J	: Ciwelut
C	: Cikiuntul	G	: Rawa bebek	K	: Gambasari
D	: Garunggung	H	: Rawa Bambu	L	: Tamiang

From the data above, it can be seen that, there is waste and ineffectiveness because there are unscheduled deliveries, this can be suppressed by scheduling distribution in order to save delivery time and save mileage on each delivery line. With a limited fleet, this saving matrix can provide solutions in overcoming existing problems by shipping and scheduling shipments by combining routes in one millk run delivery.

Travel Mileage

The following is known the distance traveled by each consumer to the depot and from consumers:

Table 2. Distance of Consumers in Each Village to the Depot (Meters)

	Depot	A	B	C	D	E	F	G	H	I	J	K	L
Depot	0												
A	380	0											
B	1380	1000	0										
C	2510	2130	1150	0									
D	3870	3500	2500	1790	0								
E	2030	1650	650	570	1860	0							
F	2740	2360	1360	1280	1300	710	0						
G	2920	2550	1900	1800	1900	1300	600	0					
H	1490	1110	600	1760	3360	1260	2060	1480	0				
I	380	360	1370	2440	4570	1990	2700	2920	1480	0			

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	Depot	A	B	C	D	E	F	G	H	I	J	K	L
J	4900	4500	3500	2800	950	2850	2300	2990	4360	4870	0		
K	1900	1720	2770	3920	5270	3420	4130	4270	2830	1490	6270	0	
L	1140	760	260	1400	2760	900	1620	1810	350	1180	3760	2540	0

Source: Supardi depot delivery data

There are often inefficient delivery times and frequent and no delivery schedules, problems that occur in the distribution of RO Supardi with increasing consumer interest and the absence of scheduling distribution channels that make delivery lines sometimes random, resulting in a waste of time in delivery. After conducting field observations and literature studies, the author is interested in researching the problem of route scheduling by conducting research using the saving matrix method, it is expected to know the optimal route and delivery schedule so as to speed up delivery.

Fleet data used

Type and capacity of fleet used in RO Supardi delivery

Table 3. Armada RO Supardi

Transportasi Pendistribusian	Kapasitas per Pengiriman	Jumlah	Bahan Bakar
Motor Roda Tiga	34	2	Bbm Premium
Sepeda Motor Roda Dua	6	3	Bbm Premium

Sources: observational data

Distribution Cost Data

The cost of making deliveries is calculated from fuel oil (BBM) and also variable costs that are not fixed such as if the delivery time is too late resulting in additional operational costs for employees.

Table 4. AMIU RO Supardi Depot Shipping Cost

Rute	Jenis biaya	Harga	Qty	Jumlah
1	Bahan bakar Pertalite	Rp. 7650 /liter		
2	Biaya Makan	Rp. 12.000 / orang	5 Orang	Rp. 60.000
3	Bahan Bakar untuk Motor Roda 3 (3 Liter)	Rp. 22.950 / Armada	2 Armada	Rp 45.900
4	Bahan Bakar untuk Motor Roda 2 (2 Liter)	Rp. 15.300 / Armada	3 Armada	Rp. 45.900
5	Biaya tambahan (lembur)	Rp. 12.000	1 Orang	Rp. 12.000
	Total			Rp. 163.800

Source: AMIU RO Supardi Depot Cost Data

RESULTS AND DISCUSSION

Calculating the Distance from the Depot to each consumer

The initial process in doing this saving matrix method is to find out the distance of each consumer and depot using google maps to identify the distance between each consumer and depot as follows:

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TABLE 5. CONSUMER DISTANCE

	Depot	A	B	C	D	E	F	G	H	I	J	K	L
Depot	0												
A	380	0											
B	1380	1000	0										
C	2510	2130	1150	0									
D	3870	3500	2500	1790	0								
E	2030	1650	650	570	1860	0							
F	2740	2360	1360	1280	1300	710	0						
G	2920	2550	1900	1800	1900	1300	600	0					
H	1490	1110	600	1760	3360	1260	2060	1480	0				
I	380	360	1370	2440	4570	1990	2700	2920	1480	0			
J	4900	4500	3500	2800	950	2850	2300	2990	4360	4870	0		
K	1900	1720	2770	3920	5270	3420	4130	4270	2830	1490	6270	0	
L	1140	760	260	1400	2760	900	1620	1810	350	1180	3760	2540	0

Source: Processed data

Identify the Saving Matrix

The second stage is to identify the saving matrix with the formula: S (x,y) = J(G,x) + J(G,y) – J(x,y), for example Saving (a,b) = Distance(depot,a) + Distance(depot,b)-distance(a,b) then Saving (a, b) = Distance (depot,a) +(depot, b) – Distance (a , b)=S(a,b)=(380)+(1380)-(1000)=760, concluded Saving matrix the distance between a and b is 760 meters. So it is produced as follows from the results of several savings matrix calculations for merging shipping routes.

Tabel 6. Tabel Saving Matrix

	A	B	C	D	E	F	G	H	I	J	K	L
A	0											
B	760	0										
C	760	2740	0									
D	750	2750	4590	0								
E	760	2760	3970	4040	0							
F	760	2760	3970	5310	4060	0						
G	750	2400	3630	4890	3650	5060	0					
H	760	2270	2240	2000	2260	2170	2930	0				
I	400	390	450	-320	420	420	380	390	0			
J	780	2780	4610	7820	4080	5340	4830	2030	410	0		
K	560	510	490	500	510	510	550	560	790	530	0	
L	760	2260	2250	2250	2270	2260	2250	2280	340	2280	500	0

Source: Processed data

Based on the results of the matrix calculation, the largest value of this savings is D and J, namely Ciwelut and Sunyar, this is because the distance between Ciwelut and Depot is the longest distance, therefore by shipping the same route with Sunyar so that savings can be made in shipping.

And the distance that is disadvantaged if combined in shipping is routes I and J, Kobak jiman and Ciwelut because these distances are very different paths, it is not recommended for 1 shipping route.

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The next step is to facilitate route determination, a saving matrix saving matrix ranking order is made from the largest to the smallest based on the calculations in Table 6, explained the order for savings if the merger is carried out, by merging routes can be seen as a reference in determining the combination of routes that have been defined:

Table 7. Order of savings

Peringkat	Nilai	Peringkat	Nilai	Peringkat	Nilai	Peringkat	Nilai	Peringkat	Nilai
1.	7820	**15.**	3630	**29.**	2260	**43.**	760	**57.**	450
2.	5340	**16.**	2930	**30.**	2250	**44.**	760	**58.**	420
3.	5310	**17.**	2780	**31.**	2250	**45.**	750	**59.**	420
4.	5060	**18**	2760	**32.**	2250	**46.**	750	**60.**	410
5.	4890	**19.**	2760	**33.**	2240	**47.**	560	**61.**	400
6.	4830	**20.**	2750	**34.**	2170	**48.**	560	**62.**	390
7.	4610	**21.**	2740	**35.**	2030	**49.**	550	**63.**	390
8.	4590	**22.**	2400	**36.**	2000	**50.**	530	**64.**	380
9.	4080	**23.**	2280	**37.**	790	**51.**	510	**65.**	340
10.	4060	**24.**	2280	**38.**	780	**52.**	510	**66.**	-320
11.	4040	**25.**	2270	**39.**	760	**53.**	510		
12.	3970	**26.**	2270	**40.**	760	**54.**	500		
13.	3970	**27.**	2260	**41.**	760	**55.**	500		
14	3650	**28.**	2260	**42.**	760	**56**	490		

Source: Processed data

Determination of Depot Delivery and Shipping Experience

It is necessary to know consumer delivery data, which will then be carried out delivery scheduling and allocation of shipments according to vehicle capacity and the most optimal savings if combined in one delivery route.

The benefits of scheduling filling before delivery to consumers are in order to adjust the portion of delivery, there is no waste of time, along with the last 7 days delivery data carried out by the AMIU RO Supardi depot, this data as forecasting calculation data for delivery on the next day, it can be recapitulated in the delivery table as follows:

Table 8. AMIU RO Supardi Depot shipping table

	1	2	3	4	5	6	7
A	32	28	27	28	30	30	29
B	40	35	33	36	36	33	39
C	13	14	13	15	14	15	15
D	8	7	7	6	8	7	7
E	17	18	17	20	18	18	20
F	15	15	14	13	15	14	13
G	7	5	7	6	7	6	7
H	15	17	15	15	16	15	15
I	10	7	8	7	7	8	8
J	27	30	30	28	27	30	30
K	29	31	33	27	32	31	31
L	5	7	5	5	6	5	5

Source: Processed data

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To do scheduling, it is necessary to do Forecasting (Forecasting), so that when the delivery will be made it can be precise and in accordance with what is predicted. Because in the delivery and patterns contained in the delivery every day make deliveries that are not much different from the previous day, it is assumed that the forecasted data is close to historical past data, then the Time Series Analysis forecasting method is used, this method is closely related to the past method which is then calculated to get data results which then get calculation results for the future.

Table 9. Next period delivery forecasting

Konsumen	Hasil Peramalan (Galon)	Konsumen	Hasil Peramalan (Galon)	Konsumen	Hasil Peramalan (Galon)
A	29	**E**	19	**I**	8
B	36	**F**	14	**J**	28
C	15	**G**	7	**K**	31
D	7	**H**	15	**L**	5

Sources: Processed Data

Sort Routes identified as optimal

The next step is to sort the routes that have been defined, which is then determined which route is the most optimal, by iterating the distance to each delivery location. In sequencing adjusted to the capacity of the shipping fleet owned.

Table 10. Route Sorting Iteration

Rute	Tujuan	Muatan Gabungan	Urutan Rute	Total Jarak (Meter)
1	G – D – F - B	34 (7 + 7 + 14 + 6)	Depot - D - F - G - B - Depot	9050
			Depot - D - F - B - G - Depot	11350
			Depot - D - B - F - G - Depot	11250
			Depot - D - B - G - F - Depot	11610
			Depot - D - G - B - F - Depot	11770
			Depot - D - G - F - B - Depot	9110
			Depot - F - B - G - D - Depot	11770
			Depot - F - B - D - G - Depot	11420
			Depot - F - D - B - G - Depot	11360
			Depot - F - D - G - B - Depot	9220
			Depot - F - G - D - B - Depot	9120
			Depot - F - G - B - D - Depot	11610

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			Depot - G - F - B - D - Depot	11250
			Depot - G - F - D - B - Depot	8700
			Depot - G - B - D - F - Depot	11360
			Depot - G - B - F - D - Depot	11350
			Depot - G - D - B - F - Depot	11420
			Depot - G - D - F - B - Depot	8860
			Depot - B - D - F - G - Depot	11250
			Depot - B - D - G - F - Depot	9120
			Depot - B - G - D - F - Depot	9220
			Depot - B - G - F - D - Depot	9050
			Depot - B - F - G - D - Depot	9110
			Depot - B - F - D - G - Depot	8860
2	C - E	34	Depot - C - E – Depot	5110
		(15+ 19)	Depot – E – C – Depot	5110
3	L - F - H	34	Depot - H - F - L - Depot	6310
		(5 + 14 + 15)	Depot - F - H - L - Depot	6290
			Depot - F - L - H - Depot	6200
			Depot - L - F - H - Depot	6310
			Depot - L - H - F - Depot	6290
			Depot - H - F - L - Depot	6310
4	K - I	34	Depot - K - I – Depot	3770
		(30 + 4)	Depot - I- K – Depot	3770
5	J - A	32	Depot - J - A -Depot	9780
		(29 + 3)	Depot - A - J -Depot	9780
6	I - A	6	Depot - I - A -Depot	1120
		(4 + 2)	Depot - A - I -Depot	1120
7	B	30	Depot - B – Depot	2760
8	A	6	Depot - A – Depot	760
9	A	6	Depot - A – Depot	760
10	A	6	Depot - A – Depot	760
11	A	6	Depot - A – Depot	760

Sources: Processed Data

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After sorting routes and iterations and comparing which order is the most optimal, the optimal haulage route can be obtained on each combined route. Then after that set the most optimal route, namely:

Table 11. Optimal route sequence

Rute	Tujuan	Muatan Gabungan	Urutan Rute	Total Jarak (Meter)	Armada	Metode Pengiman
1	G – D – F – B	34	Depot - B - F - D - G – Depot	8860	Motor Roda 3	Milk Run
2	H – L – F	34	Depot - L - H - F - Depot	6290	Motor Roda 3	Milk Run
3	K – I	34	Depot – K – I – Depot	3250	Motor Roda 3	Milk Run
4	C – E	34	Depot - C - E - Depot	5110	Motor Roda 3	Milk Run
5	J – A	32	Depot - J - A -Depot	9780	Motor Roda 3	Milk Run
6	A – I	6	Depot - I - A -Depot	1120	Motor Roda 2	Direct Shipment
7	B	30	Depot – B – Depot	2760	Motor Roda 3	Direct Shipment
8	A	6	Depot – A – Depot	760	Motor Roda 2	Direct Shipment
9	A	6	Depot – A – Depot	760	Motor Roda 2	Direct Shipment
10	A	6	Depot – A – Depot	760	Motor Roda 2	Direct Shipment
11	A	6	Depot – B – Depot	760	Motor Roda 2	Direct Shipment
		228		40210		

Sources: Processed Data

Information :

Depot	: Depot AMIU Supardi				
A	: Babakan Loa	E	: Kobak Bali	I	: Kobak Jiman
B	: Babakan kukun	F	: Sunyar	J	: Ciwelut
C	: Cikiuntul	G	: Rawa bebek	K	: Gambasari
D	: Garunggung	H	: Rawa Bambu	L	: Tamiang

In the table above, it is explained that there will be a fleet that makes deliveries in 2 shipments and because routes K and I exceed the capacity of the means of transportation, shipments are made using 2-wheeled motors using the direct shipment method, which makes direct deliveries to consumers with routes that have been defined with the resulting mileage is 40210 Meters or 40.21 Km, with 11 Delivery routes.

Distribution Cost Calculation for Saving Matrix

After calculating and scheduling distribution routes using the saving matrix, as its function is that the saving matrix is also an alternative in making cost savings, after scheduling, of course, there are changes in delivery time and optimization in making deliveries, as well as optimal in terms of costs, here are the details of shipping costs that must be incurred by the Supardi RO Depot after determining the scheduling route:

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Table 12. Distribution Cost Savings

Rute	Jenis biaya	Harga	Qty	Jumlah
1	Bahan bakar Pertalite	Rp. 7650 /liter		
2	Biaya Makan	Rp. 12.000 / orang	5 Orang	Rp. 60.000
3	Bahan Bakar untuk Motor Roda 3 (2 Liter)	Rp. 15.300 / Armada	2 Armada	Rp30.600
4	Bahan Bakar untuk Motor Roda 2 (1,5 Liter)	Rp. 11.475/ Armada	3 Armada	Rp. 34.425
	Total			Rp. 125.025

Source : AMIU RO Supardi Depot Cost Data

Comparison of Location Distance and Shipping Cost from Supardi RO Depot with Distance and Shipping Cost Saving Matrix Method

Provides a comparison of the distance and shipping costs from the Supardi RO Depot with the distance and distribution costs of the saving matrix method. The following is the result of comparing the distance and shipping costs pre and post using the saving matrix method.

Table 13. Comparison of Total Distance of Initial Route and Method

Total Jarak (Km)		Efisiensi Jarak (Km)	% Penghematan
Depot/Jarak Awal	Metode Saving Matrix		Jarak (%)
113,76 Km	40,21 Km	73,55 Km	65%

Savings analysis The table above explains how the depot delivery route carried out before the delivery route improvement can be seen and compared that by scheduling and determining the route can minimize the delivery distance to each consumer from the total distance before scheduling which is 113,760 Meters or 113.76 Km with the distance after determining the route which is 40,210 Meters or 40.21 Km, and the total savings are 73550 Meters or 73.55 Km or 65% of the initial distribution route.

Table 14. Comparison of Total Cost and Cost Savings Percentage

Total Biaya (Rp)		Efisiensi Biaya (Rp)	% Penghematan
Depot/Biaya Awal	Metode Saving Matrix		Biaya (%)
Rp. 163.800	Rp. 125.025	Rp. 38.775	24%

Based on the table above, after determining the scheduling route, there was a savings from the beginning before the establishment of the delivery and scheduling route of Rp. 163,800 and after scheduling the distribution of Rp. 125,025, there was a 24% cost savings.

CONCLUSIONS

The results showed that the effectiveness of delivery can be measured through several indicators, including delivery routes, mileage, and distribution costs. RO Supardi Refillable Drinking Water Depot managed to optimize its operations by determining 11 more efficient distribution route routes, reducing mileage from 113.76 Km to 40.21 Km, and saving shipping costs by 24%. The saving matrix method applied provides quite effective results, resulting in significant savings and estimating

sustainable savings in the future. Delivery routes determined after saving matrix analysis and iterations include the use of a fleet of 34-gallon loads for routes 1-4 and 30 gallons for route 7, as well as a fleet of two-wheelers with loads of 6 gallons for routes 6, 8, 9, 10, and 11, all of which are designed to optimize delivery efficiency. This research offers a comprehensive approach to optimizing drinking water distribution routes using the Saving Matrix Method. It provides practical solutions that enhance efficiency, reduce costs, improve service quality, and support sustainable business practices. These contributions make a significant impact on the fields of logistics, supply chain management, and sustainable business, offering a valuable framework for other industries facing similar distribution challenges.

LIMITATIONS AND FUTURE WORKS

Referring to the results of the research and conclusions that have been carried out, to develop the research, the researcher concluded several suggestions to several parties (1) For the AMIU (Refillable Drinking Water) RO Supardi Depot to compete in the depot business in addition to water quality, of course, the distribution process is very important in making deliveries, route determination and calculations must be considered so that the delivery can be made on time to the hands of consumers, By determining distribution channels using the saving matrix method by paying attention to existing distance problems, so that delivery can be carried out optimally. (2) For further research using the saving matrix method, it can minimize distance, can cover a wider area in conducting research so that the savings and distance traveled can result in higher savings and get maximum benefits and improvements. (3). For academics, the author hopes that with the research conducted, the author can increase knowledge and experience about the problem of Vehicle Routing, the problem of distribution path routes, one of which is by using the saving matrix method.

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