Implementation of the Saving Matrix and Nearest Neighbor Methods in Planning Courier Route for Package Distribution in the Kudus Area

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ABSTRACT

The rapid growth of the courier service industry, triggered by the increasing public demand for fast delivery services, has made it necessary for the Post Office to optimize the distribution process to ensure timely package delivery. The selection of distribution routes is a factor in achieving efficiency and effectiveness of delivery. Currently, the Kudus Post Office serves 9 sub-districts with 129 villages, using 12 couriers to deliver goods. However, the distribution route pattern that has not been well planned, causes a mismatch in delivery time. Thus, this study focuses on the formation of a package distribution route pattern using the Saving Matrix and Nearest Neighbor Methods, in designing a planned courier route pattern. The purpose of this method is to find out the route with the minimum distance, so as to produce an optimal delivery route that can increase customer satisfaction through faster delivery services. The results of this study are the formation of 12 package distribution route patterns for each courier, with a total difference in distance between the savings matrix and nearest neighbor methods of 127.75 km.

1. INTRODUCTION

Online buying and selling in Indonesia is currently trending, this has triggered a surge in online shipping and transactions [4]. People currently rely on online platforms to share their needs. For people in the interior, e-commerce is a solution to reach purchases of goods from outside the region more easily [12]. The post office as a company engaged in the field of mail, package and financial services delivery services, has increasingly tight logistics business competition. This competition requires the Kudus Post Office to adapt more quickly. However, a number of obstacles such as limited infrastructure, human resources and inadequate technology are major obstacles in the Post Office's efforts to improve service quality and retain customers. Currently, customers have many choices regarding faster and more efficient shipping services. The Kudus Post Office needs to innovate to meet increasing customer expectations. One step that can be taken regarding faster shipping is the need to make improvements to the shipping route, so that goods can arrive on time to customers. By optimizing vehicle routes, the time used to serve consumers will be much more efficient and goods can arrive to consumers on time [1, 3].

In shipping goods, the post office has 12 couriers who are tasked with distributing goods to customer locations by dividing them based on the number of sub-districts. Meanwhile, the number of group members is formed based on the number of sub-districts in each sub-district handled by the company, with each sub-district handled by one to two couriers. These sub-districts include, Kota Sub-district (10 Districts), Dawe Sub-district (18 Districts), Gebog Sub-district (11 Districts), Jati Sub-district (14 Districts), Jekulo Sub-district (12 Districts), Kaliwungu Sub-district (15 Districts), Kota Sub-district (20 Districts), Mejobo Sub-district (11 Districts), Undaan Sub-district (16 Districts).

Based on customer demand, the Post Office offers three types of delivery services, namely express, express, and regular. Express services guarantee delivery within 1-2 business days. The increasing need for delivery of goods requires delivery service companies to continuously improve the quality of service in order to remain competitive. To maintain customer satisfaction, the company provides more services in delivering goods. Couriers are required to prioritize timeliness and ensure that goods reach the recipient's hands according to the time limit specified with the type of delivery service chosen by the sender [6]. Shipping costs will be more expensive when customers choose a fast delivery guarantee. This

causes a difference in courier working hours, which is 6 to 10 hours per day. The difference in working hours can be influenced by the number of deliveries, as well as the route chosen to be taken. However, the pattern of distribution routes that have not been well planned, causes a mismatch in delivery times [2]. Thus, the courier route is the main factor in delivery in this study. Because the faster and more efficient the delivery, the more it minimizes the time and cost of delivering goods. When delivery is carried out efficiently, it will benefit the company, because of customer loyalty to the performance of the post office.

From the above problems, it is necessary to determine the right courier route pattern planning. One of the methods used for route optimization is using the Saving Matrix [13]. The method can handle many practical constraints, mainly because it is capable of forming routes and ordering stops on routes simultaneously [14]. The objective of the savings method is to minimize the total distance traveled by all vehicles and indirectly minimize the number of vehicles needed to service all stops [11]. This method calculates the costs of each route and simultaneously calculates the savings obtained taking into account the restrictions imposed. As the algorithm finds the greatest savings and meets the restrictions, the delivery route is created [8]. Thus, this study focuses on the package delivery route using the Saving Matrix method, to then be combined with the Nearest Neighbor method. Research on determining distribution routes, minimizing distribution routes using the Saving Matrix and Nearest Neighbor methods has actually been done by many other researchers. However, there are several things that differentiate the current research from previous research, especially regarding the research object, additional methods used in the research, and the research results. So, the purpose of this study is to determine the number of route patterns needed for sending packages to the Kudus area, according to the delivery area of each courier, and to determine the total distance results in designing package distribution route patterns obtained after using the saving matrix and nearest neighbor methods.

2. METHODS

In this research, the author used 2 methods simultaneously, including Savings Matrix Method and Nearest Neighbor Method. Savings matrix and nearest neighbor are chosen because both provide fast, practical, and efficient solutions to distribution routing problems [7]. Savings matrix is superior in overall distance or cost savings, while nearest neighbor provides a feasible initial solution with very high speed. Their combination or complementary application can produce efficient routes for various distribution conditions.

a. Saving Matrix Method

Saving matrix is one of the heuristic techniques used to choose the route, time, or costs incurred in the implementation of shipping goods by choosing the route that must be taken so that it can save travel costs and transportation costs [15]. This method is a technique used in choosing the route of distributing goods to the destination by choosing the route that must be taken and the amount of remaining based on the ability of the transportation tool in arranging the route to produce an efficient route and optimal transportation costs [10]. The steps of the storage system technique are as follows:

1) Identifying the Distance Metrix

   The first step is to determine the distance between the warehouse to each consumer and the distance between other consumers. Where the distance requires assistance from the Google Maps application.

2) Identifying the Saving Matrix

   Saving Matrix is a procedure to calculate the load reserve that is divided and taken together which is obtained by combining two shipping lanes into one. This combination can occur if the total load of the two lanes does not exceed the truck's carrying capacity. The conditions for calculating the saving matrix are as follows:

   $S(x,y) = J(G,X) + J(G,y) – J(x,y)$. ……(a)

   Description:

S(x,y) : Combined distance savings of x and y into one.
J(G,x) : Distance from center to consumer x.
J(G,y) : Distance from center to consumer y.
J(x,y): Distance from consumer x to consumer y.

3) Identify Consumers to Vehicles and Routes Based on Location

Distance and cost savings can be achieved by finding two routes that can be combined on the condition that they do not exceed the carrying capacity. This method can be done continuously until no combination meets the requirements.

4) Sort Consumers into Known Routes

The route sorting method is as follows:

a) Farthest Insertion
This method involves gradually adding consumers to the travel route. Consumers who are added are those with the furthest travel distance. This process is repeated until all consumers are included in one route.
b) Nearest Insertion
This method starts with the closest consumer route from the starting location, then adds other consumers repeatedly until all consumers are included in one travel route.
c) Nearest Neighbor
This Nearest Neighbor algorithm will start the journey from the depot and then look for the closest point to visit first. Furthermore, the next point will be selected based on the closest distance from the last location visited, until all points are visited.

b. Nearest Neighbor Method

Nearest Neighbor is a calculation that starts the vehicle path from the distribution center (Movement Center) to the closest distance [11]. Furthermore, the vehicle will continue to move to another area that is closest to the previous distance, until all transportation destinations are reached. The Nearest Neighbor strategy is used to select the closest visit arrangement. So, it can be concluded that the Nearest Neighbor calculation is to choose the area closest to the warehouse and head to the next closest route [5]. In this way, the vehicle will continue to move towards the closest point, so that it is expected to reduce the distance that must be traveled. Starting by selecting the starting point (depot), then going to the next point and choosing a route based on the closest distance.

The Nearest Neighbor calculation generally uses the Euclidean Distance metric to measure the level of closeness between data. Euclidean Distance, which is the first common partition metric for numeric data [9], is characterized as follows:

$$d(x_i, x_j) = \sqrt{\sum_{r=1}^{n}(a_r\ (x_i) - a_r\ (x_j))}^{\,2} \quad \text{.....(b)}$$

Description:
$d\ (x_i, x_j)$ = $euclidean\ distance$
x_i = $record\ ke - i$
x_j = $record\ ke - j$
a_r = $data\ ke - r$
i, j =$1, 2, 3, 4, \ldots . n$

3. RESULTS AND DISCUSSION

a. Problem Description

Kudus Post Office faces stiff competition in delivery services, forcing them to adapt quickly despite being hampered by limited infrastructure, technology, and human resources. To meet increasing customer expectations, innovation is needed, especially in improving delivery routes so that goods arrive on time. With 12 couriers serving various sub-districts and offering three types of express, express, and regular services, route efficiency is key to reducing delivery time and

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costs. This study focuses on optimizing package delivery routes using the saving matrix method combined with the nearest neighbor method to improve customer service and loyalty.

b. Data Collection

In overcoming this delivery route problem, some data is needed to determine an efficient route so that it can minimize delivery time. The data used and needed is data on the number of couriers and sub-districts handled by the company, as well as data on the distance from the central post office to the customer (destination). Data on sub-districts and the number of couriers obtained from the operational section of the post office, while data on distance is obtained from Google Maps. The data includes data on the delivery location area held by the company based on sub-districts and villages, data on the distance to customers which is processed by using a distance matrix.

1) Courier Delivery Area Data

In the process of delivering packages to customers, couriers use motorbikes as vehicles. The delivery area covers 9 sub-districts and 129 villages, with 12 couriers responsible for delivery. The following is the courier and delivery area data:

Table 1. Courier Delivery Area Data

Courier Delivery Area					
No.	**Courier Name**	**Subdistrict**	**No.**	**Courier Name**	**Subdistrict**
1	Firman	Bae	**7**	Yoga	Jekulo
2	Hakim	Dawe	**8**	Roni	Kaliwungu
3	Adit		**9**	Feri	Kota
4	Riski	Gebog	**10**	Deni	
5	Alam		**11**	Denis	Mejobo
6	Antok	Jati	**12**	Alfin	Undaan

2) Distance Data

Distance data is done using Google Maps. Here are the steps to determine the distribution distance using the Google Maps application.

a) Determining the Starting Point and Destination Point

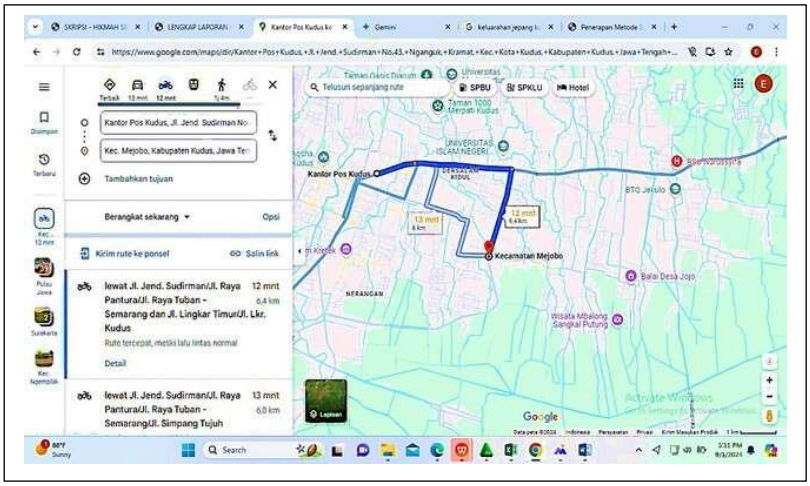

Figure 1. Determining the Starting Point and Destination Point in Google Maps

For example, to determine the distance from the depot (Pos) to the destination in Mejobo Subdistrict, Mejobo Village, you need to input the addresses of both locations into Google Maps. The depot is located at Jl. Jend. Sudirman No. 43, Nganguk, Kramat, Kudus City Subdistrict, Kudus Regency, Central Java 59311, while the destination village is located in Mejobo, Mejobo Subdistrict, Kudus Regency, Central Java.

b) Determining the Selected Distance

After the destination address is entered, several route options will appear from Google Maps, complete with the total time and distance to be traveled. Route selection requires consideration, such as choosing a shorter distance and paying attention to the road conditions that will be passed. For example, for a trip from the Central Post Office to Mejobo Subdistric, a route with a distance of 6 km is chosen.

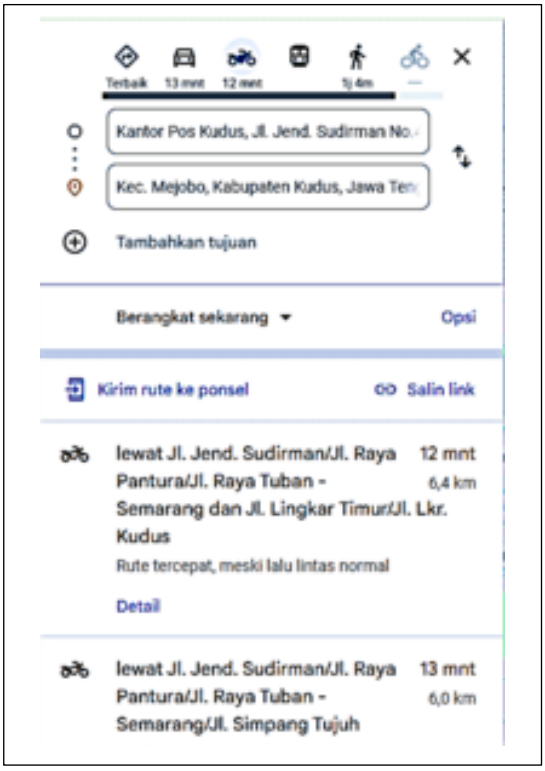

Figure 2. Determining the Starting Point and Destination Point in Google Maps

c) Inputting selected distances into the Distance Matrix

After all the distances from the center point (Pos) to the destination location (Sub-district) are known, the data needs to be entered into the distance matrix table. This matrix is used in calculating the savings matrix and nearest neighbor methods to determine the most efficient courier route pattern in sending goods to customers. Below are the results of the distance matrix per sub-district and sub-district handled by the company.

		Pos	Kec. Bae									
			A	B	C	D	E	F	G	H	I	J
POS PUSAT	Pos	0										
Kel. Bacin	A	3,2	0									
Kel. Bae	B	5	3,6	0								
Kel. Dersalam	C	3,3	2,2	5	0							
Kel. Gondangmanis	D	6,6	3,5	2,5	4,1	0						
Kel. Karangbener	E	6,3	3,3	5	2,5	3	0					
Kel. Ngembalrejo	F	4,4	4,5	6,3	2,1	4,2	2,5	0				
Kel. Panjang	G	3,6	2,1	2,4	3,8	4	4,9	6,3	0			
Kel. Pedawang	H	2,5	1,2	4,2	1,1	4,6	3,5	3,8	3,0	0		
Kel. Peganjaran	I	4,4	2,9	2,8	4,6	4,8	5,7	7,1	1,9	3,6	0	
Kel. Purworejo	J	4,2	2,1	1,8	4,4	3,3	4,7	6,0	0,8	3,4	3	0

Figure 3. Bae Subdistrict Distance Matrix Results

		Pos	Kec. Jati												
			AN	AO	AP	AQ	AR	AS	AT	AU	AV	AW	AX	AY	AZ	BA
POS PUSAT	Pos	0														
Kel. Getaspejaten	AN	2,8	0													
Kel. Jati Kulon	AO	4,2	2	0												
Kel. Jati Wetan	AP	6	3,4	3,3	0											
Kel. Jepangpakis	AQ	3,2	3,8	4,9	7,1	0										
Kel. Jetiskapuan	AR	5,1	2,5	2,4	2,4	4,4	0									
Kel. Loram Kulon	AS	3,4	1,5	2,6	4,8	2,9	2,5	0								
Kel. Loram Wetan	AT	4,1	2,4	3,5	5	2,1	3,3	0,85	0							
Kel. Megawon	AU	3,7	5,6	6,8	8,7	2,5	7,1	4,6	4	0						
Kel. Ngembal Kulon	AV	4,7	7	10,6	10,7	4,6	9,6	6,5	5,9	2,4	0					
Kel. Pasuruhan Kidul	AW	6,3	5,2	2,3	3,6	8,1	4,3	5,7	6,4	10	12,5	0				
Kel. Pasuruhan Lor	AX	5,8	3,7	1,7	3,1	6,5	3,8	4,3	5,1	8,4	12	1,6	0			
Kel. Ploso	AY	3,2	1,3	1,5	4,2	4,1	3,3	2,9	3,7	5,2	7,8	3,8	3,2	0		
Kel. Tanjungkarang	AZ	7	4,4	4,3	3,2	4,4	2,3	3,2	2,9	7	8,4	6,8	5,7	5,2	0	
Kel. Tumpangkrasak	BA	3	6,5	7,6	11,1	3,4	9,5	5,4	4,8	1,2	3,1	9,9	9,3	5,6	8,8	0

Figure 4. Jati Subdistrict Distance Matrix Results

Figure 3 is the result of the distance matrix of Bae sub-district, from the center point (Pos), to each sub-district consisting of 10 sub-districts. Figure 4, is the result of the distance matrix of Jati sub-district, from the center point (Pos), to each sub-district consisting of 14 sub-districts.

		Pos	Kec. Dawe (Kurir 1)								
			K	L	M	N	O	P	Q	R	S
POS PUSAT	Pos	0									
Kel. Cendono	K	7,8	0								
Kel. Colo	L	19,7	12,8	0							
Kel. Cranggang	M	17,9	8,9	7,6	0						
Kel. Dukuhwaringin	N	20,2	13,7	4,1	4,7	0					
Kel. Glagah Kulon	O	19,5	12,9	7,8	4,0	3,7	0				
Kel. Japan	P	20,4	13,8	4,3	8,2	2,2	4,3	0			
Kel. Kajar	Q	16,0	9,5	4,1	7,4	4,6	8,4	4,8	0		
Kel. Kandangmas	R	14,5	7,9	10,8	3,9	7,0	5,1	9,4	9,6	0	
Kel. Kluwukan	S	19,3	12,7	4,9	3,7	3,5	7,2	4,6	3,7	7,7	0

		Pos	Kec. Dawe (Kurir 2)								
			T	U	V	W	X	Y	Z	AA	AB
POS PUSAT	Pos	0									
Kel. Cendono	T	12,0	0								
Kel. Colo	U	10,1	4,4	0							
Kel. Cranggang	V	11,4	4,5	6,8	0						
Kel. Dukuhwaringin	W	12,4	5,9	8,4	1,6	0					
Kel. Glagah Kulon	X	13,8	5,8	3,7	8,2	9,8	0				
Kel. Japan	Y	9,9	3,9	5,8	3,0	2,9	7,2	0			
Kel. Kajar	Z	14,9	8,8	10,8	4,7	4,7	12,2	5,3	0		
Kel. Kandangmas	AA	19,7	7,8	9,3	10,2	11,6	7,1	11,7	14,6	0	
Kel. Kluwukan	AB	16,7	9,7	12,1	5,8	7,0	13,5	7,6	4,7	15,6	0

Figure 5. Dawe Subdistrict Distance Matrix Results (a) Courier 1 (b) Courier 2

Figure 5 is the result of the distance matrix of Dawe sub-district, from the center point (Pos), to each district consisting of 18 districts.

		Pos	Kec. Gebog (Kurir 1)				
			AC	AD	AE	AF	AG
POS PUSAT	Pos	0					
Kel. Besito	AC	7,3	0				
Kel. Getasrabi	AD	9,4	5,8	0			
Kel. Gondosari	AE	11,2	4,2	8,5	0		
Kel. Gribig	AF	9,4	4,3	4,8	7	0	
Kel. Jurang	AG	9,4	2,3	7,8	2,1	6,3	0

		Pos	Kec. Gebog (Kurir 2)					
			AH	AI	AJ	AK	AL	AM
POS PUSAT	Pos	0						
Kel. Karangmalang	AH	6,9	0					
Kel. Kedungsari	AI	12,4	6,6	0				
Kel. Klumpit	AJ	6,8	3,1	7,9	0			
Kel. Menawan	AK	16,1	10,3	4,7	12,6	0		
Kel. Padurenan	AL	8,8	2,7	5,5	2,9	9,8	0	
Kel. Rahtawu	AM	21,7	16,1	11,6	18,5	11,3	17,4	0

Figure 6. Gebog Subdistrict Distance Matrix Results (a) Courier 1 (b) Courier 2

Figure 6 is the result of the distance matrix of Dawe sub-district, from the center point (Pos), to each district consisting of 18 districts

		Pos	Kec Jekulo											
			BB	BC	BD	BE	BF	BG	BH	BI	BJ	BK	BL	BM
POS PUSAT	Pos	0												
Kel. Bulung Kulon	BB	13,6	0											
Kel. Bulungcangkring	BC	12,4	4	0										
Kel. Gondoharum	BD	20	13,3	15,7	0									
Kel. Hadipolo	BE	7,3	7,7	6,4	14,1	0								
Kel. Honggosoco	BF	9,6	11,2	10	17,6	3,5	0							
Kel. Jekulo	BG	8,4	5,3	4	11,7	2,4	8,4	0						
Kel. Klaling	BH	13,4	8,8	9	6	6,8	6	5	0					
Kel. Pladen	BI	10,7	4,2	5,3	10,5	4,7	8,7	2,3	4,6	0				
Kel. Sadang	BJ	11,9	6,3	3	16,6	6,3	9,9	5	10	6,2	0			
Kel. Sidomulyo	BK	13,9	3	5,3	10,4	6,8	10,4	4,4	7,5	2,8	7,6	0		
Kel. Tanjungrejo	BL	12,2	11,2	9,9	16,4	4,9	4,1	5,9	7,9	7,1	9,8	9,4	0	
Kel. Terban	BM	12,8	6,4	8,3	11	6,7	8,4	4,3	3,6	3,1	9,2	5,1	7,6	0

		Pos	Kec Kaliwungu													
			BN	BO	BP	BQ	BR	BS	BT	BU	BV	BW	BX	BY	BZ	CA	CB
POS PUSAT	Pos	0															
Kel. Bakalankrapyak	BN	2,6	0														
Kel. Banget	BO	9,7	7,8	0													
Kel. Blimbing Kidul	BP	10,8	8,9	1,9	0												
Kel. Gamong	BQ	9,3	7,4	2,5	2,8	0											
Kel. Garung Kidul	BR	6,9	5	4,3	5,3	4,8	0										
Kel. Garung Lor	BS	4,9	3	5,1	6,1	5,7	2,5	0									
Kel. Kaliwungu	BT	7,1	5,2	2,7	3,7	2,2	2,9	2,4	0								
Kel. Karangampel	BU	5,6	3,7	5,8	6,8	5,3	4	2,2	3,1	0							
Kel. Kedungdowo	BV	8	6,1	1,7	2,7	2,5	2,7	3,4	1,3	4,4	0						
Kel. Mijen	BW	4,9	5	3,5	4,6	3,1	2,7	2,2	0,85	1,8	2,1	0					
Kel. Papringan	BX	10,7	8,8	5,3	5,4	3,3	7,2	6	3,6	6,7	4,9	4,5	0				
Kel. Prambatan Kidul	BY	3,8	2,7	7,6	8,7	6,8	3	2,4	4,6	3,1	6	4,4	8,1	0			
Kel. Prambatan Lor	BZ	5	3	6,3	7,4	6,2	2,1	1,8	4	2,5	4,7	3,8	7,5	1,5	0		
Kel. Setrokalangan	CA	8,8	6,9	3,7	4,7	4,2	2,3	4,2	3	6,1	2	3,9	6,5	5,6	4,7	0	
Kel. Sidorekso	CB	10,2	8,3	3,1	3,2	1,4	6,1	5,6	3,2	6,3	4,5	4	1,9	7,7	6,7	6,2	0

Figure 7. Jekulo Subdistrict Distance Matrix Results **Figure 8.** Kaliwungu Distance Matrix Results

Figure 7 is the result of the distance matrix of Jekulo sub-district, from the center point (Pos), to each district consisting of 12 districts. Figure 8, is the result of the distance matrix of Kaliwungu sub-district, from the center point (Pos), to each district consisting of 15 districts.

		Pos	Kec. Kota (Kurir 1)											
			CC	CD	CE	CF	CG	CH	CI	CJ	CK	CL	CM	CN
POS PUSAT	Pos	0												
Kel. Barongan	CC	0,9	0											
Kel. Burikan	CD	1	0,6	0										
Kel. Damaran	CE	3	2,9	3,4	0									
Kel. Demaan	CF	1,2	1,5	2	1,6	0								
Kel. Demangan	CG	2,3	2,6	3,4	1,7	1,5	0							
Kel. Glantengan	CH	0,9	0,4	0,9	2,1	1,1	2,3	0						
Kel. Janggalan	CI	2,5	2,8	3,3	1,1	1,3	0,65	2,4	0					
Kel. Kaliputu	CJ	1,8	0,95	0,85	3	2,3	3,4	1,2	3,6	0				
Kel. Kauman	CK	2,1	2,4	2,9	0,8	1,1	0,8	2,1	0,6	3,3	0			
Kel. Krandon	CL	2,3	2,2	2,7	1	1,8	1,8	2,3	1,8	2,5	1,1	0		
Kel. Langgardalem	CM	1,6	1,9	2,4	0,8	1,1	1,3	1,6	1,1	2,8	0,6	1,1	0	
Kel. Nganguk	CN	0,5	0,6	0,6	2,8	1,6	2,4	1	2,5	1,5	2,3	3	2,3	0

		Pos	Kec. Kota (Kurir 2)									
			CO	CP	CQ	CR	CS	CT	CU	CV	CW	CX
POS PUSAT	Pos	0										
Kel. Rendeng	CO	1,3	0									
Kel. Singocandi	CP	2,6	2,8	0								
Kel. Kramat	CQ	0,6	1,8	3,6	0							
Kel. Kajeksan	CR	1,4	2,8	1,4	2,2	0						
Kel. Kerjasan	CS	1,9	3,4	2,2	2,4	0,95	0					
Kel. Panjunan	CT	2	3,5	3	2,1	1,8	2	0				
Kel. Purwosari	CU	3,2	4,8	3,4	3,1	2,2	1,3	2,1	0			
Kel. Sunggingan	CV	2,3	3,7	3,3	2,6	2	1,4	1,1	1,3	0		
Kel. Wergu Kulon	CW	1,4	2,6	3,4	1,1	2,2	2,5	2,2	3,4	2,5	0	
Kel. Wergu Wetan	CX	1,5	2,2	3,8	1,2	2,7	3,1	2,5	3,7	2,9	0,6	0

Figure 9. Kota Subdistrict Distance Matrix Results (a) Courier 1 (b) Courier

Figure 9 is the result of the distance matrix of Kota sub-district, from the center point (Pos), to each district consisting of 22 districts.

		Pos	Kec. Mejobo										
			CY	CZ	DA	DB	DC	DD	DE	DF	DG	DH	DI
POS PUSAT	Pos	0											
Kel. Golantepus	CY	8	0										
Kel. Gulang	CZ	10	6,1	0									
Kel. Hadiwarno	DA	8,8	1,9	8,8	0								
Kel. Jepang	DB	6,9	3,5	4,9	4,8	0							
Kel. Jojo	DC	17	10,4	15,5	8,2	11,4	0						
Kel. Kesambi	DD	11,7	4,8	8,2	3,9	4,8	3,5	0					
Kel. Kirig	DE	10	3,9	6,7	5,2	3,5	8,2	4,4	0				
Kel. Mejobo	DF	6,4	3	5,1	4,3	2	11	5,3	4	0			
Kel. Payaman	DG	10,1	6,1	4	7,3	3,2	10,3	6,5	5,2	3,7	0		
Kel. Temulus	DH	13,1	6,3	9,4	6,9	6,2	8,3	4,5	4,4	6,7	7,9	0	
Kel. Tenggeles	DI	6,8	2,5	10,2	2,5	7,1	10,7	5,4	6,6	5,1	8,8	8,4	0

Figure 10. Mejobo Subdistrict Distance Matrix Results

		Pos	Kec. Undaan					
			DJ	DK	DL	DM	DN	DO
POS PUSAT	Pos	0						
Kel. Karangrowo	DJ	13,6	0					
Kel. Larikrejo	DK	12,8	3,6	0				
Kel. Ngemplak	DL	9,1	3,6	5,3	0			
Kel. Undaan Lor	DM	11,3	7	3,4	5,6	0		
Kel. Undaan Tengah	DN	14,4	6,1	2,5	3	3	0	
Kel. Wates	DO	9,4	5	3,4	5,6	5,6	5,9	0

Figure 11. Undaan Subdistrict Distance Matrix Results

Figure 10 is the result of the distance matrix of Mejobo sub-district, from the center point (Pos), to each district consisting of 11 districts. Figure 11, is the result of the distance matrix of Undaan sub-district, from the center point (Pos), to each district consisting of 6 districts.

c. Data Processing Using Savings Matrix

For example, to find out the savings matrix in Bae Subdistrict, from Bacin Village (starting point) to Bae Village, the distance matrix value of the Central Post Office (Pos) → Bacin Village (A), distance matrix value from Central Post Office (Pos) → Bae Village (B), and distance matrix value from Bacin Village (A) → Bae Village (B).

1) Distance matrix Pos → A (Pusat, x) = 3,2 km
2) Distance matrix Pos → B (Pusat, y) = 5 km
3) Distance matrix A → B (x, y) = 3,6 km

Once the distance matrix is known, calculations are carried out using the formula (a):

$S\ (x, y)$ = Dist (Center, x) + Dist (Center, y) – Dist (x, y)
$S(A, B)$ = 3,2 km + 5 km – 3,6 km
$\boldsymbol{S(A, B)}$ **= 4,6 km**

By carrying out the steps above, a distance savings matrix will be obtained between Bacin Village and Bae Village in Bae Subdistrict. The results of the savings matrix between villages for Bae Subdistrict are presented in Figure 12 below.

		Kec. Bae									
		A	B	C	D	E	F	G	H	I	J
Kel. Bacin	A	0									
Kel. Bae	B	4,6	0								
Kel. Dersalam	C	4,3	3,3	0							
Kel. Gondangmanis	D	6,3	9,1	5,8	0						
Kel. Karangbener	E	6,2	6,3	7,1	9,9	0					
Kel. Ngembalrejo	F	3,1	3,1	5,6	6,8	8,2	0				
Kel. Panjang	G	4,7	6,2	3,1	6,2	5	1,70	0			
Kel. Pedawang	H	4,5	3,3	4,7	4,5	5,3	3,10	3,10	0		
Kel. Peganjaran	I	4,7	6,6	3,1	6,2	5	1,70	6,10	3,30	0	
Kel. Purworejo	J	5,3	7,4	3,1	7,5	5,8	2,60	7,05	3,30	5,6	0

Figure 12. Bae Subdistrict Savings Matrix Results

This savings matrix is useful for determining routes based on the largest savings matrix that is prioritized to the smallest savings matrix. Furthermore, the route compilation process starts from the sub-district that has the largest distance savings. The following are the steps to compile a distribution route in Bae District using the saving matrix method:

	Kec. BAE									
	A	B	C	D	E	F	G	H	I	J
A	0									
B	4,6	0								
C	4,3	3,3	0							
D	6,3	9,1	5,8	0						
E	6,2	6,3	7,1	9,9	0					
F	3,1	3,1	5,6	6,8	8,2	0				
G	4,7	6,2	3,1	6,2	5	1,70	0			
H	4,5	3,3	4,7	4,5	5,3	3,10	3,10	0		
I	4,7	6,6	3,1	6,2	5	1,70	6,10	3,30	0	
J	5,3	7,4	3,1	7,5	5,8	2,60	7,05	3,30	5,6	0

Figure 13. Iteration I Saving Matrix Bae Subdistrict

a) Iteration 1: Selecting the largest saving matrix value in the savings matrix, namely between Gondangmanis Village (D) and Karangbener Village (E) of 9.9 km. These two villages will be included in one distribution route. So the route that is currently formed is Pos – D – E.
b) Selecting the next largest saving matrix value in the savings matrix, namely between Bae Village (B) and Gondangmanis Village (D) of 9.1 km. Therefore, the route that is currently formed, namely Pos – D – E – B.

	Kec. BAE									
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
A	0									
B	4,6	0								
C	4,3	3,3	0							
D	6,3	9,1	5,8	0						
E	6,2	6,3	7,1	9,9	0					
F	3,1	3,1	5,6	6,8	8,2	0				
G	4,7	6,2	3,1	6,2	5	1,70	0			
H	4,5	3,3	4,7	4,5	5,3	3,10	3,10	0		
I	4,7	6,6	3,1	6,2	5	1,70	6,10	3,30	0	
J	5,3	7,4	3,1	7,5	5,8	2,60	7,05	3,30	5,6	0

Figure 14. Iteration 2 Saving Matrix Bae Subdistrict

c) By following the steps above, the route and total distance formed from the saving matrix method for Bae sub-district are obtained, namely:
   1) Route : **Pos - D - E - B - F - G - J - C - H - A - I – Pos**
   2) Total distance : **42 km**

   The route pattern that is formed will then be used for the next stage with the nearest neighbor method. The results of the route pattern along with the total distance for each sub-district formed using the saving matrix method are presented in table 2.

No.	Subdistrict	Route SM	Total Distance (km)
1	Mejobo	Pos - DC - DD - DH - DA - CZ - DG - CY - DB - DE - DF - DI - Pos	73,7
2	Undaan	Pos - DK - DN - DJ - DO - DL - DM - Pos	48,9
3	Kota	Pos - CE - CI - CK - CF - CJ - CL - CM - CC - CH - CD - CN - CG - Pos	20,2
		Pos - CU - CV - CS - CQ - CW - CR - CX - CO - CP - CT - Pos	24,3
4	Kaliwungu	Pos - BO - BP - BQ - CB - BV - CA - BT - BX - BR - BS - BU - BW - BY - BZ - BN - Pos	54,1
5	Jekulo	Pos - BD - BH - BB - BK - BM - BC - BJ - BF - BL - BG - BI - BE - Pos	88,4
6	Jati	Pos - AW - AX - AP - AZ - AR - AO - AS - AT - AY - BA - AU - AV - AQ - AN - Pos	46,5
7	Gebog	Pos - AE - AG - AD - AF - AC - Pos	37,5
		Pos - AK - AM - AI - AH - AJ - AL - Pos	60,4
8	Dawe	Pos - N - P - L - S - M - O - R - K - Q - Pos	77,8
		Pos - Z - AB - X - AA - W - V - U - Y - T - Pos	81,9
9	Bae	Pos - D - E - B - F - G - J - C - H - A - I - Pos	42

Table 2. Route Results and Total Distance for each Subdistrict Using Saving Matrix (SM)

d. Data Processing Using Nearest Neighbor

After obtaining the results of the saving matrix method, the next step is to compile a route using the nearest neighbor method. The purpose of implementing the nearest neighbor method is to compile a route from the saving matrix by determining the destination point based on the closest distance from the last point at the destination at that time. After seeing the results of the proximity to the distance of the destination point, the total distance will be shorter than the results when using the saving matrix method.

For example, for Bae District, the route generated from the savings matrix method is Pos - D - E - B - F - G - J - C - H - A - I - Pos. This route is then rearranged using the nearest neighbor method

starting from the depot (Pos). There are ten sub-districts that are the destinations, and the distance from the depot to each sub-district is known, as seen in Figure 4.3 above. The distance of each sub-district is as follows:

- Distance: Pos → D = 6,6 km
- Distance: Pos → E = 6,3 km
- Distance: Pos → B = 5 km
- Distance: Pos → F = 4,4 km
- Distance: Pos → G = 3,6 km
- Distance: Pos → J = 4,2 km
- Distance: Pos → C = 3,3 km
- Distance: Pos → H = 2,5 km
- Distance: Pos → A = 3,2 km
- Distance: Pos → I = 4,4 km

Pedawang Village (H) is the closest to the depot (Post), so it is the first destination to be visited. After that, the next village to be visited is selected based on the closest distance from Pedawang Village (H) as the next travel point.

- Distance: Pos → H → D = 7,1 km
- Distance: Pos → H → E = 6 km
- Distance: Pos → H → B = 6,7 km
- Distance: Pos → H → F = 6,3 km
- Distance: Pos → H → G = 5,5 km
- Distance: Pos → H → J = 5,9 km
- Distance: Pos → H → C = 3,6 km
- Distance: Pos → H → A = 3,7 km
- Distance: Pos → H → I = 6,1 km

Since the closest distance obtained is 3.6 km, the next destination is Dersalem Village (C), so the route becomes Post – H – C. And so on until all points in Bae District enter one series of distribution route patterns. Thus, the nearest neighbor results for the route pattern in Bae District, namely:

- Route : Pos - H - C - F - E - D - B - J - G - I - A - Pos
- Total distance : 23 km

By applying the steps above, all routes formed through the saving matrix method for package delivery in each sub-district are reprocessed using the nearest neighbor method, and the results are presented in table 3 below:

Table 3. Route Results and Total Distance for each Subdistrict Using Nearest Neighbor (NN)

No.	Subdistrict	Route NN	Total Distance (km)
1	Mejobo	Pos - DF - DB - DG - CZ - CY - DA - DI - DD - DC - DE - DH - Pos	60.7
2	Undaan	Pos - DL - DN - DK - DM - DO - DJ - Pos	42.2
3	Kota	Pos - CN - CC - CH - CD - CJ - CF - CK - CI - CG - CM - CE - CL - Pos	13.3
		Pos - CQ - CW - CX - CO - CP - CR - CS - CU - CV - Pos	14.55
4	Kaliwungu	Pos - BN - BY - BZ - BS - BU - BW - BT - BV - BO - BP - BQ - CB - BX - CA - BR - Pos	40.15
5	Jekulo	Pos - BE - BG - BI - BK - BB - BC - BJ - BM - BH - BD - BL - BF - Pos	73.7
6	Jati	Pos - AN - AY - AO - AX - AW - AP - AR - AZ - AT - AS - AQ - AU - BA - AV - Pos	35.35
7	Gebog	Pos - AC - AG - AE - AF - AD - Pos	32.9
		Pos - AJ - AL - AH - AI - AK - AM - Pos	56.7
8	Dawe	Pos - K - R - M - S - N - P - L - Q - O - Pos	65.3
		Pos - Y - W - V - T - U - X - AA - Z - AB - Pos	70.1
9	Bae	Pos - H - C - F - E - D - B - J - G - I - A - Pos	23

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e. Discussion

Table 4. Total Distance Difference Between Savings Matrix and Nearest Neighbor

No.	Subdistrict	Total Distance (km)		Total Distance Difference (km)
		Saving Matrik	***Nearest Neighnor***	
1	Bae	42	23	19
2	Dawe	77,8	65,3	12,5
		81,9	70,1	11,8
3	Gebog	37,5	32,9	4,6
		60,4	56,7	3,7
4	Jati	46,45	35,35	11,1
5	Jekulo	88,4	73,7	14,7
6	Kaliwungu	54,1	40,15	13,95
7	Kota	20,2	13,3	6,9
		24,3	14,5	9,8
8	Mejobo	73,7	60,7	13
9	Undaan	48,9	42,2	6,7
Total Difference (km)				127,75

Based on the problems faced by the company, and based on the calculation results in the previous sub-chapter using the saving matrix method, this study contributes by showing the delivery routes that must be passed first. for each sub-district handled by each courier. After processing using the saving matrix method, the resulting route group will be continued with the nearest neighbor method. This method functions to sort distribution routes and find a more optimal distance from the route results using the saving matrix method. With the nearest neighbor method, distribution routes are analyzed based on distance, thus enabling the achievement of optimal travel distance.

After processing with the saving matrix method, the obtained route groups will be further processed using the nearest neighbor method. This method is used to sort distribution routes and find the most optimal distribution distance from each route group that has been previously determined using the saving matrix method. The use of the nearest neighbor method allows for the achievement of optimal distribution distance, because the distribution route is analyzed first based on its distance. Table 4 will show the difference in the comparison of total distance when using the saving matrix method and the nearest neighbor method.

Based on table 4, it is known that the results of the total distance difference when using the saving matrix method alone, and after being reprocessed using the nearest neighbor method, have a difference in results of 127.75 km. Thus, it can be said that the nearest neighbor method will produce optimal distribution distance

4. CONCLUSION

Based on the results of the research, after designing a route for distributing packages by couriers to the Kudus area using the Saving Matrix method and the Nearest Neighbor method, it can be concluded that:

1. Based on the results of data processing, 12 route patterns were obtained for 12 couriers. With one sub-district handled by one to two couriers, with each courier having one route pattern.
2. The total distance generated from the route pattern when using the saving matrix method is 655.65 km. While the total distance generated from the nearest neighbor method is 527.9 km. The total difference in distance between the two methods is 127.75 km.

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REFERENCES

Aprilliani, K. D. (2021). Penentuan Rute Baru Distribusi Spare Part Di Pt. Bosowa Berlian Motor Dengan Menggunakan Metode Saving Matrix (Doctoral Dissertation, Universitas Hasanuddin).

Dwiyatno, S., Farhan, M. A., Pahmi, A. M., & Pinileh, G. A. (2021). Menentukan Rute Pengiriman Paket Terbaik Menggunakan Metode Topsis. Jsii (Jurnal Sistem Informasi), 137-140.

Fauzy, F. F. (2023). Analisis Penerapan Prosedur Pegiriman Special Cargo Pada Pt Angkasa Pura Logistik Kantor Cabang Surakarta (Doctoral Dissertation, Universitas Diponegoro Fauzy, F. F. (2023). Analisis Penerapan Prosedur Pegiriman Special Cargo Pada Pt Angkasa Pura Logistik Kantor Cabang Surakarta (Doctoral Dissertation, Universitas Diponegoro).

Lathifah, A., & Sekarningtyas, H. A Simulated Annealing Heuristics for Delivery Time Equality of the Couriers in an Expedition Company.

Lathifah, A., & Sekarningtyas, H. (2019). Optimization Of The Equal Courier Workload With Determination Of Schedule And Distribution Assignment Of Goods Using Heuristic Methods. The 3rd Icmst-Sttal, 2019, 35.

Martono, S., & Warnars, H. L. H. S. (2020). Penentuan Rute Pengiriman Barang Dengan Metode Nearest Neighbor.

Noviwiyocha, R., Matondang, A. R., & Hidayati, J. (2023). Application of Saving Matrix Approach for Minimize Distribution Cost and Route Optimization: A Literature Review. Jurnal Sistem Teknik Industri, 25(2), 206-217.

Olivares-Benítez, E., Sánchez-Partida, D., & Morales, S. O. C. (2018). ILS metaheuristic to solve the periodic vehicle routing problem. International Journal of Combinatorial Optimization Problems and Informatics, 9(3), 55.

Permatasari, D. A., & Lukmandono, L. (2024). Implementasi Metode Saving Matrix Dan Nearest Neighbor Untuk Meningkatkan Efektivitas Dan Efisiensi Rute. Industri Inovatif: Jurnal Teknik Industri, 14(1), 101-106.

Rahmi, F. (2023). Optimalisasi Rute Pengangkutan Sampah Dengan Penerapan Metode Saving Matrix Di Kota Tapaktuan (Doctoral Dissertation, Uin Ar-Raniry).

Rizwanullah, M., & Nilofer, M. (2018). Optimization of Vehicle Routine Problem of Using Saving Matrix Approach. Optimization, 8(7).

Sekarningtyas, H., Faza, I., & Kafidzin, R. (2023). Penentuan Jumlah Dan Rute Kendaraan Untuk Distribusi Tabung Oksigen (O_2) Wilayah Jawa Timur Dengan Algoritma Clarke and Wright Savings pada Pt Gcs. Juremi: Jurnal Riset Ekonomi, 3(2), 219-226.

Sekarningtyas, H. (2019). Optimasi Pemerataan Beban Kerja Kurir Dengan Penentuan Jadwal Dan Penugasan Pendistribusian Barang Menggunakan Metode Heuristik (Doctoral Dissertation, Universitas Internasional Semen Indonesia).

Suyitno, H., Rosyida, I., & Juni, D. (2020). Pengoptimalan rute distribusi produk menggunakan metode saving matrix dan nearest insertion2) 2020. UNNES Journal of Mathematics, 9(2), 2020.

Wulandari, R. T., & Azis, A. M. (2022). The Saving Matrix Method for Improving Distribution Efficiency. *Jurnal Manajemen Indonesia*, *22*(2), 217-226.