



RESEARCH ARTICLE

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INTEGRATION MODEL OF SAVING MATRIX AND NEAREST NEIGHBOR METHODS FOR OPTIMIZING DISTRIBUTION OF PRODUCTION RESULTS OF BAWEAN GRESIK SMES – EAST JAVA, INDONESIA

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ABSTRACT

Since 2018, the Gresik Regency Government has made serious efforts to facilitate various businesses for the Bawean community, including providing capital assistance, equipment, training, and marketing support. According to 2022 data from the Gresik Regency Government, there are 52 small and seven medium-sized SMEs in Bawean. This UKM can absorb approximately 620 non-formal workers, which is essential for empowering the Bawean community. The problem in this research is that transportation costs for delivering SME products remain too high because they are not optimized for factors such as distance, transportation capacity, and time, and more than 30-35% of sales proceeds are used to finance distribution. The method used to solve this problem is to integrate the saving matrix and nearest-neighbor methods, thereby achieving distance, time, and cost savings while considering existing constraints to increase the income of Bawean SMEs. After designing the distribution route using the nearest-neighbor method, delivery costs are calculated based on the resulting route. By using the selected proposed method, a distribution cost of Rp. 93,696,850 from the original Rp. 158,400,000 and a total distance traveled of 13,448.9 km from the original 24,303.6 km. By using the nearest-neighbor method, companies can save on the distribution costs of Rp. 64,703,150, or 40.85% less than the existing distribution costs, and saves 10,854.7 km in distribution mileage, or 44.66% shorter than the total existing mileage..



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I. INTRODUCTION

Bawean Island is part of Gresik Regency, located in the outermost part of the island, separated by a strait or waters from other regions. The potential of the Bawean region is actually immense, but has not been optimally managed [1]. This potential includes fertile areas for agriculture, especially for fruit crops. In the north of Bawean, there is the potential for unpolluted ponds, making it suitable for cultivating milkfish, crabs, and shrimp, and seafood is also quite good. In 2017, Bawean Island had a population of 63,894, but more than 30% of the population had migrated outside the area because it was challenging to earn a living there [2]. This resulted in Bawean being a disadvantaged region. However, since the Gresik Regency Government empowered SMEs, the unemployment rate has decreased, community income has increased, and contributions to the regional budget have increased [3]. Bawean SMEs are primarily engaged in processing fish and marine products, namely 64% of them, including smoked fish, salted fish, otak-otak, presto fish, spiced fish, fish crackers, petis, and shrimp paste [4]. In comparison, around 36% are engaged in the craft and souvenir sector, including bags, belts, hats, and various other crafts made from marine products [5]. However, the largest consumers of Bawean SMEs are from outside Bawean, such as Surabaya, Malang, Gresik, Tuban, and Pasuruan. Bawean SMEs have not been able to deliver their products to customers efficiently and effectively, resulting in very high distribution costs, even reaching 35%, resulting in suboptimal profits [6].

However, the largest consumers of Bawean SMEs are from outside Bawean, such as Surabaya, Malang, Gresik, Tuban, and Pasuruan. Bawean SMEs have not been able to deliver their products to customers efficiently and effectively, resulting in very high distribution costs, even reaching 35%, resulting in suboptimal profits [6]. The delivery of these SMEs' products is certainly not as efficient as that of large companies, so it is necessary to consider storage capacity, delivery time, delivery distance, and transportation mode [7]. This transportation problem is better known as VRP (Vehicle Routing Problem). VRP concerns determining routes in problems involving multiple vehicles with a given capacity in the distribution process [8]. There are four objectives of VRP: (a) minimizing transportation costs related to distance and fixed vehicle costs [9]; (b) minimizing the number of vehicles needed for distribution, thus reducing the number of drivers [10]; (c) Balancing routes related to time and vehicle capacity [10]; (d) minimizing the risk of dissatisfaction due to late delivery [11]. This research aims to develop an optimal delivery model for Bawean SME products to all consumers by integrating the saving matrix and nearest-neighbor methods.

II. THEORETICAL REFERENCE

II.1 SAVING MATRIX

The Saving Matrix Method is a heuristic method used to solve the Vehicle Routing Problem (VRP) with the primary goal of minimizing total travel distance, travel time, or distribution costs [12]. This method was first introduced by Clarke and Wright (1964) and remains one of the most popular approaches due to its simplicity, speed, minimal computational requirements, and the ability to provide near-optimal solutions for many real-world situations [13]. Simply put, the saving matrix is used to determine which pairs of customers are appropriate to combine into a single route, resulting in the greatest savings. The Saving Matrix calculates the distance savings if two customers, for example, i and j , are included in the same route, rather than being visited separately [14]. The core formula for the Saving Matrix is:

$$S_{ij} = d_{i0} + d_{0j} - d_{ij} \quad (1)$$

Where:

S_{ij} = savings value if node i is merged with node j
 d_{i0} = distance from depot to customer i
 d_{0j} = distance from depot to customer j
 d_{ij} = distance between customers i and j

If merging customers i and j reduces travel distance, then the S value will be large. The larger the S value, the more "profitable" it is to merge the nodes.

Key Steps in the Saving Matrix

a. Step 1: Route Initialization

Each customer is considered a separate route:

Route 1: Depot $\rightarrow$ 1 $\rightarrow$ Depot

Route 2: Depot $\rightarrow$ 2 $\rightarrow$ Depot, and so on.

b. Step 2: Calculate the savings matrix

For each pair of customers i and j ($i \neq j$), calculate the values as in equation (1).

The result is a table/matrix S , with dimensions of $n \times n$.

c. Step 3: Sort the S values from largest to smallest

The combination with the largest S value is considered first (because it yields the greatest savings).

d. Step 4: Merge routes based on S values Merging is permitted if:

- Node i is at the end of one route
- Node j is at the end of another route
- Vehicle capacity is not violated If the conditions are met, then:
- Routes i and j are merged into a single route
- If not met, proceed to the next S value.

e. Step 5: Repeat until no more merges are found

After all S values have been tested, the final remaining route is the optimization result.

Types of saving matrices [9]:

1. Parallel saving algorithm

Combines multiple routes in parallel according to the highest S value.

2. Sequential saving algorithm

Develops one route at a time until it can no longer be combined, then moves on to the next route.

The advantages of saving matrices include [12], [14]:

1. Simple and easy to use, so it doesn't require complex computation
2. Fast, so it's suitable for cases with many customers (good scalability)

3. Produces routes that are more optimal than manual routes
4. Significantly reduces travel distance and distribution costs
5. Flexible because it can be easily combined with other methods (NN, GA, Tabu Search, etc.)
6. Practical for real-world applications such as logistics, couriers, LPG distribution, and waste collection

Disadvantages of the Saving Matrix [12], [14]:

1. Results are not always optimal, especially for complex VRPs (time window, multi-depot, multi-vehicle)
2. Highly dependent on the order in which the largest savings are combined—sensitive to small changes
3. Does not consider field dynamics (traffic density, road conditions, time)
4. Not suitable for routes that require strict constraints, such as time limits or scheduled deliveries
5. If the distance between nodes is asymmetric, the results can be less accurate

II.2 NEAREST NEIGHBOR

Nearest Neighbor (NN) is a heuristic method used to select the next point in a process based on the shortest distance from the current position [15]. This method is particularly popular in two fields: Distribution Route Optimization (VRP/TSP) and Data Classification (KNN). Although the applications differ, the basic principle remains the same: select the closest neighbor as the next step. Nearest Neighbor in the Vehicle Routing Problem (VRP) is used in logistics routes, package delivery, transportation, waste collection, and so on. Nearest Neighbor works by starting at the depot, selecting the closest customer from the current location, transferring to that customer, and repeating until all customers have been visited and returned to the depot [16]. This method is often combined with the Saving Matrix to improve route performance.

The advantages of the Nearest Neighbor method include [17], [18]:

1. Very fast and simple.
2. Easy to apply to large datasets.
3. Suitable as a starting point or basic route builder.
4. Best combined when used with the Saving Matrix.

Disadvantages of the Nearest Neighbor method [17], [18]:

1. Often trapped in local solutions
2. Can produce routes much longer than the optimum
3. Does not consider the global perspective (short-term choices can be detrimental in the long run)

Besides routing, the Nearest Neighbor concept is used in K-Nearest Neighbor (KNN), a classification/regression algorithm that determines labels based on the nearest neighbors. The basic principle is that each new data point is classified based on the k closest data points in the dataset. Distance is calculated using specific metrics such as Euclidean, Manhattan, Minkowski, Cosine Distance, and Chebyshev. General Formula for Euclidean Distance.

$$(x, y) = \sqrt{\sum_{i=1}^n (x_i - y_i)^2} \quad (2)$$

III. MATERIALS AND METHODS

Several stages of research were carried out with the following steps:

1. Preliminary Stage
 - a. Field Study. The field study conducted in this research is an observational activity to identify and reveal existing facts in greater depth.
 - b. Literature Study. The purpose of this literature study is to gather information to support the research being conducted.
 - c. Problem Identification. To identify and understand the problem, the initial step is to identify the issues encountered by SMEs in the Bawean Region, Gresik Regency.
 - d. Problem Formulation. After identifying the problem, the next step is to formulate a problem.
 - e. Determining Research Objectives. Determining objectives is intended to allow researchers to focus on the problem being studied, so that the research can be conducted systematically and without deviating from it.

2. Stage of Data Collection

The data collection method used in this research is direct observation at the company under study.

- a. Interviews. A method for obtaining data or information by asking questions directly to individuals knowledgeable about the research object.
- b. Observation. Direct observation or review at the research site, namely the Bawean SME in Gresik Regency, by observing the existing system, observing the distribution process flow, and determining costs regarding expedition service rental fees and other expenses required for distribution activities.
- c. Documentation. Studying company documents containing data on the number of products distributed, the location of the company's branches, and the load capacity of the truck fleet.

- d. Documentation. Studying company documents containing data on the number of products distributed, the location of the company's branches, and the load capacity of the truck fleet.
- e. Discussion. Exchanging opinions with experts, in this case, management with expertise in specific fields related to vehicle routing problems, the costs incurred in the distribution process, and the costs of all activities in Gresik Regency.

3. Stage of Data Processing

The data processing stages of the saving matrix method are as follows:

- a. Identifying and determining the type of vehicle routing problem occurring in the field.
- b. Identifying and determining the distance matrix from the SME location to the Bawean SME marketing area, as well as the distance matrix between the destinations within the Bawean SME marketing area.
- c. Identifying and calculating the saving matrix.
- d. Allocating vehicles and routes to the Bawean SME marketing area destinations.
- e. Sorting the destination routes based on the results of the Bawean SME marketing area destinations. In this study, the procedure for sorting the company branches within the established routes used the nearest-neighbor method.
- f. Calculating the total distance traveled. After obtaining the optimal route, the total distance traveled for apple juice distribution was calculated based on the procedure that yielded the smallest total distance between nearest neighbors.
- g. Comparison of distribution costs. After comparing the smallest total distance traveled between the routes using the nearest-neighbor method, the route with the most optimal distance was selected.

4. Stage of Analysis and Discussion

In the analysis of apple juice distribution optimization, the saving matrix and nearest-neighbor methods were used to determine the optimal delivery route and costs.

5. Conclusion

Researchers draw conclusions related to the formulation of the problem they wish to achieve, while suggestions are input related to the research being conducted.

IV. RESULTS AND DISCUSSIONS

IV.1 DATA DISCUSSION 1

Assume that one SME in Bawean currently has one distribution center in Bawean, Gresik Regency, and five Distribution Centers (DCs) spread throughout East Java Province.

Table 1: Distance Saving Matrix Data.

	A	B	C	D	E
A	0				
B	116	0			
C	97,5	152	0		
D	534	103	95,5	0	
E	52	0	56,5	54	0

Source: Authors, (2026).

Based on Table 1, it is known that branch pair A–D has the highest distance-saving matrix of 534 km, branch pair B–C has the second- highest distance-saving matrix of 152 km, and branch pair C–D has the third-highest distance-saving matrix of 95.5 km. Based on the results of the saving matrix, branches A, C, and D can be grouped into a single distribution route. On this route, a rearrangement is carried out using the nearest-neighbor method, starting from the warehouse. There are three branches to target, and each has a known distance from the warehouse. The distance of each branch is:

Warehouse Distance → A = 288 km Warehouse Distance → C = 134.5 km Warehouse Distance → D = 317 km

Branch C is the closest to the warehouse, so it will be the first branch visited. Next, find the next branch to see based on the nearest distance from branch C as the end point.

Warehouse distance → C → A = 335 km Warehouse distance → C → D = 356 km

Since the closest distance produced is 335 km, the next one to be visited is branch A, so the route obtained using the nearest neighbor method is Warehouse → C → A → D. After obtaining the distance matrices from the warehouse to each company branch and between company branches, the next step is to compile a savings matrix. The distance-saving matrix is obtained using formula (2). For example, to find the savings between the SRBY and MJKT branches, the Warehouse → SRBY distance matrix, the Warehouse → MJKT distance matrix, and the SRBY → MJKT distance matrix are required.

Warehouse distance matrix → SRBY = 148 km Warehouse distance matrix → MJKT = 142 km SRBY distance matrix → MJKT = 84 km

Once the distance matrices for the related points are known, calculations are carried out.

$$- S(x, y) = \text{Dist}(\text{Center}, x) + \text{Dist}(\text{Center}, y) - \text{Dist}(x, y)$$

$$- S(\text{SRBY}, \text{MJKT}) = 148 \text{ km} + 142 \text{ km} - 84 \text{ km}$$

$$- S(\text{SRBY}, \text{MJKT}) = 206 \text{ km}$$

The following are the steps in preparing distribution routes in the first week of June 2024 using the saving matrix method. Selecting the most significant saving matrix value in the saving matrix, namely between the JEPR and KUDS destination points of 809. These two destination points will be included in a single distribution route because the fleet capacity is sufficient to deliver both.

The current route is JEPR – KUDS, with the number of products shipped as follows:

$$\text{JEPR Shipping} + \text{KUDS Shipping} = 1,975 \text{ kg} + 1,858 \text{ kg} = 3,840 \text{ kg}$$

Selecting the next largest saving matrix value in the saving matrix is between the SMRG and JEPR branches of 681. The SMRG branch has a total demand of 1,589 kg, so it can be combined with route one because the fleet capacity is still sufficient. Therefore, the route currently formed is JEPR – KUDS – SMRG, with the number of products shipped as follows:

$$- \text{JEPR Shipping} + \text{KUDS Shipping} + \text{SMRG Shipping}$$

$$1,971 \text{ kg} + 1,856 \text{ kg} + 1,591 \text{ kg} = 5,417 \text{ kg}$$

The largest saving achieved is 517. This saving was achieved between the JOGY and JEPR branches. If these branches were combined into route 1, the fleet capacity would not be sufficient. Therefore, the JOGY branch will be included in the second route. The subsequent route was formed: JOGY – SOLO – NGW, with the number of products shipped as follows:

$$- \text{JOGY Shipping} + \text{SOLO Shipping} + \text{NGW Shipping} = 2,165 + 2,264 + 1,178 = 5,607 \text{ kg}$$

Following the steps above, 55 iterations of the saving matrix and 12 routes were obtained. The following iterations and routes were generated for the distribution of products produced by Bawean SMEs in June, July, and August 2024.

Table 2: Iteration of the Order of Saving Values from Largest to Smallest.

Iteration	Branch Pair	Saving Value	Iteration	Branch Pair	Saving Value
1	JEPR - KUDS	708,9	29	KEDR - NGW	153,2
2	SMRG - JEPR	630,8	30	TLNG - SMRG	152
3	SMRG - KUDS	613,4	31	KEDR - SOLO	146,2
4	JOGY - JEPR	517	32	KEDR - JOGY	146,2
5	SOLO - JEPR	510	33	MJKT - NGW	132,8
6	JOGY - SMRG	506	34	KEDR - SMRG	131,2
7	JOGY - KUDS	505	35	MJKT - JOGY	127,8
8	SOLO - JOGY	500,5	36	MJKT - SOLO	126,8
9	SOLO - KUDS	496	37	MJKT - SMRG	108,8
10	SOLO - SMRG	466	38	SRBY - NGW	100,9
11	MJKT - TLNG	419	39	NGW - JEPR	99,8
12	NGW - KUDS	405	40	SRBY - JOGY	98,9
13	NGW - JOGY	360	41	SRBY - SOLO	97,9
14	NGW - SOLO	359	42	MJKT - KEDR	94,1
15	NGW - SMRG	353	43	JBER - JEPR	92
16	TLNG - JEPR	218	44	JBER - KUDS	92
17	KEDR - JEPR	207,2	45	SRBY - JBER	91,9
18	TLNG - JOGY	206	46	SRBY - SMRG	79,9
19	TLNG - KUDS	205	47	SRBY - TLNG	71,9
20	MJKT - JEPR	198,8	48	SRBY - KEDR	69,1
21	MJKT - KUDS	198,8	49	JBER - TLNG	64
22	KEDR - KUDS	188,2	50	MJKT - JBER	53,8
23	SRBY - JEPR	183,9	51	JBER - KEDR	12,2
24	SRBY - KUDS	183,9	52	JBER - JOGY	7
25	TLNG - SOLO	178	53	JBER - SOLO	5
26	TLNG - NGW	158	54	JBER - SMRG	0
27	KEDR - TLNG	157,7	55	JBER - KEDR	12,2
28	SRBY - MJKT	157,1			

Source: Authors, (2026).

After obtaining all iterations in the saving matrix, all point pairs obtained are allocated to distribution route groups. The resulting route groups and the number of shipments for the distribution of products produced by Bawean SMEs in June, July, and August 2024 are shown.

Table 3: Distribution Routes for Bawean SME Products First Week of June 2024.

No.	Route	Number of Shipments
1.	JEPR – KUDS – SMRG	5.466 kg
2.	JOGY – SOLO – NGW	5.657 kg
3.	SRBY – MJKT – JBER	5.707 kg
4.	KEDR – TLNG	4.452 kg

Source: Authors, (2026).

Table 4: Distribution Routes for Bawean SME Products June 2024, Second Week.

No.	Route	Number of Shipments
1.	SOLO – SMRG – JOGY	5.993 kg
2.	KEDR – TLNG – NGW	5.240 kg
3.	SRBY – MJKT – JBER	5.836 kg

Source: Authors, (2026).

Table 5: Distribution Routes for Bawean SME Products Third Week of June 2024.

No.	Route	Number of Shipments
1.	SOLO – SMRG – JOGY	5.985 kg
2.	KEDR – TLNG – NGW	5.353 kg
3.	SRBY – MJKT – JBER	5.947 kg

Source: Authors, (2026).

Table 6: Distribution Routes for Bawean SME Products Fourth Week of June 2024.

No.	Route	Number of Shipments
1.	JEPR – KUDS – SMRG	5.871 kg
2.	JOGY – SOLO – NGW	5.995 kg
3.	SRBY – MJKT – JBER	5.971 kg
4.	KEDR – TLNG	4.392 kg

Source: Authors, (2026).

IV.2 DATA DISCUSSION II

Data Processing Using the Nearest Neighbor Method

The SMRG delivery destination is closest to the warehouse, so it becomes the first destination to be visited. The next destination is then selected based on the nearest distance from the SMRG delivery destination to the final destination.

$$\begin{aligned} \text{Distance from Warehouse} \rightarrow \text{SMRG} \rightarrow \text{JEPR} &= 459.2 \\ \text{km Distance from Warehouse} \rightarrow \text{SMRG} \rightarrow \text{KUDS} &= \\ &434.6 \text{ km} \end{aligned}$$

The total distribution distance for this route using the existing method is 1,122 km. Therefore, the distance saving achieved on this delivery route using the nearest neighbor method is:

$$\begin{aligned} &\text{- Total Distance Using the Existing Method – Total Distance Using the Nearest Neighbor Method} \\ &1,122 \text{ km} - 476 \text{ km} = 646 \text{ km} \end{aligned}$$

Table 7: Comparison of Distribution Routes for Bawean SME Products Using the Existing and Nearest Neighbor Methods, First Week of June 2024.

No	Existing Method	Distance	Nearest Neighbor	Distance	Saving
	Route		Route		
1.	Warehouse → JEPR, Warehouse → KUDS, Warehouse → SMRG	1.073	Warehouse → SMRG → KUDS → JEPR	425,7	647,3
2.	Warehouse → JOGY, Warehouse → SOLO, Warehouse → NGW	754	Warehouse → NGW → SOLO → JOGY	328,5	425,5
3.	Warehouse → SRBY, Warehouse → MJKT, Warehouse → JBER	389	Warehouse → MJKT → SRBY → JBER	331	58
4.	Warehouse → KEDR, Warehouse → TLNG	201,2	Warehouse → KEDR → TLNG	122,7	79,5

Source: Authors, (2026).

Table 8: Comparison of Distribution Routes for Bawean SME Products Using the Existing and Nearest Neighbor Methods, Week Two of June 2024.

No.	Existing Method	Distance	Nearest Neighbor	Distance	Saving
	Route		Route		
1.	Warehouse → SOLO, Warehouse → SMRG, Warehouse → JOGY	890	Warehouse → SOLO → JOGY → SMRG	451,1	438,9
2.	Warehouse → KEDR, Warehouse → TLNG, Warehouse → NGW	385,2	Warehouse → KEDR → TLNG → NGW	269,7	115,5
3.	Warehouse → SRBY, Warehouse	389	MJKT, Warehouse → JBER Warehouse → MJKT → SRBY → JBER	331	58

Source: Authors, (2026).

Table 9: Comparison of Distribution Routes for Bawean SME Products Using the Existing and Nearest Neighbor Methods, Third Week of June 2024.

No.	Existing Method	Distance	Nearest Neighbor	Distance	Saving
	Route		Route		
1.	Warehouse → SOLO, Warehouse → SMRG, Warehouse → JOGY	890	Warehouse → SOLO → JOGY → SMRG	451,1	438,9
2.	Warehouse → KEDR, Warehouse → TLNG, Warehouse → NGW	385,2	Warehouse → KEDR → TLNG → NGW	269,7	115,5
3.	Warehouse → SRBY, Warehouse → MJKT, Warehouse → JBER	389	Warehouse → MJKT → SRBY → JBER	331	58

Source: Authors, (2026).

Table 10: Comparison of Distribution Routes for Bawean SME Products Using the Existing and Nearest Neighbor Methods, Week 4 of June 2024.

No.	Existing Method	Distance	Nearest Neighbor	Distance	Saving
	Route		Route		
1.	Warehouse → JEPR, Warehouse → KUDS, Warehouse → SMRG	1.072	Warehouse → SMRG → KUDS → JEPR	425,7	646,3
2.	Warehouse → JOGY, Warehouse → SOLO, Warehouse → NGW	753	Warehouse → NGW → SOLO → JOGY	328,5	424,5
3.	Warehouse → SRBY, Warehouse → MJKT, Warehouse → JBER	389	Warehouse → MJKT → SRBY → JBER	331	58
4.	Warehouse → KEDR, Warehouse → TLNG	200,2	Warehouse → KEDR → TLNG	121,7	78,5

Source: Authors, (2026).

IV.3 SHIPPING COST ANALYSIS

After determining the optimal route using the nearest-neighbor method, shipping costs are calculated and compared with those of the proposed method. The following are the steps in determining shipping costs. Determine the route to be analyzed. For example, consider the JEPR – KUDS – SMRG route for the first week of June. The breakdown of existing shipping costs on this route is as follows:

- Warehouse Shipping Cost → JEPR = Rp. 1,900,000
- Warehouse Shipping Cost → KUDS = Rp. 1,700,000
- Warehouse Shipping Cost → SMRG = Rp. 1,900,000

Therefore, the total existing shipping costs for the JEPR – KUDS – SMRG route are:

$$- \text{Rp. } 1,900,000 + \text{Rp. } 1,700,000 + \text{Rp. } 1,900,000 = \text{Rp. } 5,500,000$$

Next, determine the shipping cost using the proposed route method. The resulting route using the nearest-neighbor method is: warehouse

$$\rightarrow \text{SMRG} \rightarrow \text{KUDS} \rightarrow \text{JEPR.}$$

The shipping cost breakdown for this route is as follows:

$$- \text{Warehouse Delivery Cost} \rightarrow \text{SMRG} = \text{IDR } 1,900,000$$

Furthermore, to determine delivery costs from SMRG → KUDS and KUDS → JEPR, the average cost per kilometer of the longest route to be visited is used. The longest route to be visited is Warehouse → JEPR, with a distance of 396 km and a cost of Rp. 1,900,000. Therefore, the average cost per kilometer is Rp. 4,800. The average cost per kilometer will serve as a reference to determine costs based on the distances between SMRG → KUDS and KUDS → JEPR.

The distance between SMRG → KUDS is 62.6 km, while the distance between KUDS → JEPR is 41.1 km. Using the above calculation, the results are as follows:

- SMRG Shipping Cost → KUDS = Rp. 300,500
- KUDS Shipping Cost → JEPR = Rp. 197,500

Therefore, the total shipping cost for the warehouse → SMRG → KUDS → JEPR route obtained using the nearest neighbor method is:

$$- \text{Rp. } 1,800,000 + \text{Rp. } 400,500 + \text{Rp. } 187,500 = \text{Rp. } 2,298,000$$

Next, a comparison is made between existing shipping costs and those using the proposed method to determine the savings. The calculation of the resulting shipping cost saving is as follows:

$$- \text{Rp. } 5,400,000 - \text{Rp. } 2,498,000 = \text{Rp. } 2,902,000$$

IV.4 DELIVERY TIME ANALYSIS

After optimal routes are obtained using the nearest neighbor method, the next step is to calculate the delivery time for each route. The following are the steps in determining delivery time. Determine the route to be analyzed. For example, consider the warehouse → KUDS → JEPR route for delivery in August 2024. The distribution process is assumed to run smoothly without any problems, with an average delivery fleet speed of 50 km/h. The delivery time details for this route are as follows:

$$\begin{aligned} \text{Warehouse} \rightarrow \text{KUDS Delivery Time} &= 8 \text{ hours} \\ \text{KUDS} \rightarrow \text{JEPR Delivery Time} &= 50 \text{ minutes} \end{aligned}$$

Therefore, the total delivery time for the Warehouse → KUDS → JEPR route is currently as follows:

$$\begin{aligned} \text{Warehouse} \rightarrow \text{KUDS Delivery Time} + \text{KUDS} \rightarrow \text{JEPR Delivery} \\ \text{Time } 8 \text{ hours} + 50 \text{ minutes} &= 8 \text{ hours } 50 \text{ minutes} \end{aligned}$$

By following the steps above, the delivery time is calculated for all optimal delivery routes generated using the nearest-neighbor method.

Table 11: Total Delivery Time of Optimal Nearest Neighbor Route.

No.	Route with Nearest Neighbor	Total Delivery Time
1.	Warehouse → KUDS → JEPR	9 hours 50 minutes
2.	Warehouse → SOLO → JOGY	8 hours 25 minutes
3.	Warehouse → NGW → SMRG	8 hours 10 minutes
4.	Warehouse → TLNG → NGW	7 hours 10 minutes
5.	Warehouse → KEDR → TLNG	3 hours 55 minutes
6.	Warehouse → MJKT → SRBY	3 hours 40 minutes
7.	Warehouse → SMRG → KUDS → JEPR	11 hours 35 minutes
8.	Warehouse → NGW → SOLO → JOGY	8 hours 25 minutes
9.	Warehouse → SOLO → JOGY → SMRG	11 hours 35 minutes
10.	Warehouse → KEDR → TLNG → NGW	7 hours 20 minutes
11.	Warehouse → MJKT → SRBY → JBER	8 hours 15 minutes
12.	Warehouse → TLNG → NGW → SMRG	10 hours 35 minutes

Source: Authors, (2026).

Next, add the time required to unload the cargo from the delivery fleet at each distribution destination branch. This activity has an estimated processing time of 30 minutes at each destination branch. Therefore, the total delivery time for the Warehouse → KUDS → JEPR route is as follows:

$$\begin{aligned} \text{Delivery Time Warehouse} \rightarrow \text{KUDS} \rightarrow \text{JEPR} + 2 \times (\text{Unloading} \\ \text{Time}) \text{ } 8 \text{ hours } 50 \text{ minutes} + 2 \times (30 \text{ minutes}) \\ 8 \text{ hours } 50 \text{ minutes} + 60 \text{ minutes} &= 9 \text{ hours } 50 \text{ minutes} \end{aligned}$$

Based on Table 11, the fastest delivery time is the warehouse → MJKT → SRBY route, at 3 hours and 40 minutes. Meanwhile, the longest delivery time is the warehouse → SOLO → JOGY → SMRG route, at 11 hours and 35 minutes.

IV.5 DISCUSSION

Distribution is a crucial factor in any business because it affects the profits of SMEs in Bawean, Gresik, and surrounding areas. During the daily distribution process, several SMEs in the Bawean, Gresik Regency, utilize delivery services. Product orders are placed through the marketing department, which then forwards them to the inter-area sales department, which is directly connected to the warehousing department of SMEs in the Bawean region, which produces various crafts and processed foods using the make-to-stock method. Once the inventory in the warehouse meets demand, shipments are made. The process of collecting orders and processing craft and processed food products is complete, and the products are then sent to several distribution areas within a specified timeframe. Currently, several SMEs in the Bawean region of Gresik Regency use a single delivery fleet for each branch. This is considered ineffective and inefficient due to the underutilization of fleet capacity.

By combining multiple branch destinations into a single delivery and scheduling deliveries a week in advance, companies can save on shipping costs. Using the saving matrix method, 12 optimal distribution route groups were generated based on their saving matrix. Of the 12 routes generated, several branch points are always included in the same route group. These branch points are the JEPR branch with the KUDS branch and the SRBY branch with the MJKT branch. These branch points can be grouped into several delivery destination clusters. The JEPR-KUDS branch is Cluster 1, and the SRBY-MJKT branch is Cluster 2.

Table 12: Distribution Route Groups Based on the Saving Matrix Method.

No.	Route Group
1.	JEPR – KUDS
2.	JOGY – SOLO
3.	SMRG – NGW
4.	TLNG – NGW
5.	KEDR – TLNG
6.	SRBY – MJKT
7.	JEPR – KUDS – SMRG
8.	JOGY – SOLO – NGW
9.	SOLO – SMRG – JOGY
10.	KEDR – TLNG – NGW
11.	SRBY – MJKT – JBER
12.	SMRG – NGW – TLNG

Source: Authors, (2026).

After being processed with the saving matrix method, the resulting route groups are further processed using the nearest-neighbor method. This method is used to sort distribution routes and to obtain the optimal distribution distance for each route group previously determined using the saving matrix method. The nearest-neighbor method produces optimal distribution distances because distribution routes are first analyzed by distance. Table 13 shows the results of sorting distribution routes using the nearest neighbor method.

Table 13: Results of Processing Distribution Routes Using the Nearest Neighbor Method.

No.	Nearest Neighbor Route
1.	Warehouse → KUDS → JEPR
2.	Warehouse → SOLO → JOGY
3.	Warehouse → NGW → SMRG
4.	Warehouse → TLNG → NGW
5.	Warehouse → KEDR → TLNG
6.	Warehouse → MJKT → SRBY
7.	Warehouse → SMRG → KUDS → JEPR
8.	Warehouse → NGW → SOLO → JOGY
9.	Warehouse → SOLO → JOGY → SMRG
10.	Warehouse → KEDR → TLNG → NGW
11.	Warehouse → MJKT → SRBY → JBER
12.	Warehouse → TLNG → NGW → SMRG

Source: Authors, (2026).

After processing using both methods, the resulting savings were compared to determine which method produced the most significant distance savings. Based on calculations, the nearest-neighbor method resulted in a distance savings of 10,854.7 km. Resulted in a distance saving of 6,874.5 km. The nearest-neighbor method produced a more optimal distance because the resulting distribution route was to the closest point from the distribution's starting point, and so on. Therefore, the distribution route chosen to compare shipping costs with the existing method was the nearest-neighbor method. After obtaining the optimal route using the nearest-neighbor method, shipping costs for crafts and food products were calculated based on the route. Shipping costs using the nearest neighbor method will be lower because the resulting distance is shorter than the existing distribution distance. This is because the company's costs are limited to the delivery fleet service. The company's delivery fleet service uses the fleet's mileage as a benchmark for its shipping costs. This means that the shorter the distance traveled by the delivery truck fleet, the lower the shipping costs charged to SMEs in the Bawean area of Gresik Regency.

Table 14: Results of Calculations Using the Existing Method and Processing Using the Saving Matrix and Nearest Neighbor Methods.

	Existing Methods	Saving Matrix and Nearest Neighbor Methods
Total od Distance	24.303,8 km	13.457,9 km
Number of Routes	11	4 - 5
Total Shipping Cost	Rp. 158.460.000	Rp. 93.672.850

Source: Authors, (2026).

Based on Table 14, the results of processing using the saving matrix and nearest-neighbor methods for compiling distribution routes yield a shorter total distance and lower shipping costs than the existing method.

After processing using the saving matrix and nearest-neighbor methods, the total distance traveled is 10,854.7 km shorter, or 44.66% lower than the initial distance, and the total shipping costs are Rp 64,703,150 lower, or 40.85% lower than the initial total.

V. CONCLUSIONS

Based on the results of the research that has been conducted, the conclusions that can be drawn include:

1. Routes that resulted in distance saving using the saving matrix method include JEPR – KUDS with a saving value of 708.9 km, SMRG – JEPR with a saving value of 630.8 km, SMRG – KUDS with a saving value of 613.4 km, and JOGY – JEPR with a saving value of 517 km.
2. Previously, the company had 11 distribution routes. After conducting research using the nearest neighbor method, four to five distribution routes were identified per week, depending on the number of requests. This research resulted in 12 route groups with the minimum total distance traveled and distribution costs. Distribution costs were reduced because SMEs in the Bawean region of Gresik Regency used delivery services that set pricing based on the fleet's mileage.
3. After designing the distribution routes using the nearest-neighbor method, delivery costs were calculated based on the resulting routes. Using the selected proposed method, distribution costs were reduced to Rp 93,696,850, down from the original Rp 1,000,000: 158,400,000, and the total distance was reduced to 13,448.9 km from the original 24,303.6 km. By using the nearest- neighbor method, the company can save on the distribution costs of Rp. 64,703,150, or 40.85% smaller than the existing distribution costs, and save a distribution distance of 10,854.7 km, or 44.66% shorter than the total existing distance.

VI. AUTHOR'S CONTRIBUTION

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Investigation: Rony Prabowo and Lutfia Bamatraf.

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