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Optimizing Last-Mile Delivery and Transportation Modes for the Tempe Supply Chain

Agung Prayudha Hidayat[1]✉,Sesar Husen Santosa[1,2], Ridwan Siskandar[1], Fadhil Rizqi Az Zahran[1], Dea Ananda[1], Khadijah Meutia Savanah[1], Siti Aisyah[1], Stevani Putri[1], Nalanaya[1]

[(1)]Industrial Management Study Program, College of Vocational Studies IPB University, Jl. Kumbang No.14, Bogor, 16610, Indonesia

[(2)]Computer Engineering Study Program, College of Vocational Studies IPB University, Jl. Kumbang No.14, Bogor, 16610, Indonesia

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✉ Corresponding author:
[agungprayudha@apps.ipb.ac.id]

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Abstract

Tempe supply chain is managing the distribution flow of production until it reaches consumers. The distribution flow must be arranged and managed effectively and efficiently to increase the company's productivity and minimize costs. Method is used in this research are Saving Matrix for optimizing route and Break Even Point (BEP) for evaluating the mode Transportation. The research results show that selected route to consumers is obtained via the G-C1-C2-C5-C6-C3-C4-G route with an optimal capacity of 1500 boxes. Meanwhile, an evaluation of the transportation modes owned shows that the company can leaseif the average delivery in one year is below 1000 boxes and has its own mode if deliveries are above 1000 boxes.

1. INTRODUCTION

Tempe is a cultural heritage of the Indonesian people which is currently also popular in the world. Tempeh is a traditional food in Indonesia made from the fermentation of the fungus Rhizopus sp, soybean raw materials. Tempe has a delicious taste at a relatively cheap price, even though it is cheap and has a simple shape, it turns out that tempeh has special qualities from a nutritional perspective, ideal for diet food, low in saturated fat and cholesterol free, rich in minerals and vitamins (Handajani, 2001; Romulo & Surya, 2021).

One of the things that can become an obstacle in the tempe supply chain is managing the distribution flow of production until it reaches consumers. The distribution flow must be arranged and managed effectively and efficiently to increase the company's productivity and minimize costs. To overcome this, this can be done by identifying the product distribution network until it reaches consumers (Min et al., 2019; Wieland, 2021). Last-mile delivery is a distribution network design where in delivering goods, the distributor or retailer does not use a third party delivery service, but instead sends them directly from door to door. So that it can optimize routes and number of transportation modes (Boysen et al., 2021; Galkin et al., 2019; Jazemi et al., 2023; Shuaibu et al., 2025)

One of the business units operating in the field of processed foods made from tempe in Indonesia is under the auspices of the Indonesian Tofu Tempe Producers Cooperative (KOPTI) which has implemented the

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concepts of Good Hygienic Practices (GHP) and Good Manufacturing Practices (GMP). However, in this case distribution is still a problem that occurs in this business unit where an intense number of deliveries are sent every day to several consumer locations through the distribution center using refrigerated box cars. The aim of this research is to optimize the tempe distribution route from producers directly to consumers using a last mile delivery approach and optimizing existing transportation modes using a break even point approach.

2. METHODS

The method used in this research to optimize route distribution uses the Saving Matrix approach. Apart from that, optimization of the transportation modes used uses a break even point model approach. Saving Matrix can be used as problem solving to optimize the costs of distributing goods (Damayanti et al., 2020; Prayudha Hidayat et al., 2021). The stages in using the saving matrix method are as follows :

a) Determining distance matrix

The distance matrix is determined by identifying the allocation to each consumer visited. This distance data can be obtained using Google Maps or the speedometer on the vehicle. The distance matrix used is as follows:

Table 1. Distance Matrix

	Vo	Vi	Vj	Vn
Vo	0			
Vi	Coi	0		
Vj	Coj		0	
Vn	Con	Cin	Cjn	0

b) Determining Saving Matrix

Savings are made by combining delivery over the distance between the two consumers which is assumed to be S (x, y) and returning to the depot. The saving matrix table that can be used is as follows:

Table 2. Saving Matrix

	Vo	Vi	Vj	Vn
Vo	-			
Vi	Sii	-		
Vj	Sij	Sij	-	
Vn	Sin	Cin	Sjn	-

c) Combine consumers into vehicle routes The number of consumer needs is adjusted to the capacity of existing vehicles. If demand exceeds vehicle capacity, it is allocated to other vehicle capacity

d) Determining consumer orders

Determining consumer orders can be done in 2 ways, namely farthest insert method, nearest insert method, nearest neighbor method, greedy method, and sweep method. The Nearest Neighbor method is used in this research by selecting an algorithm based on the number of consumer orders that is closest to the vehicle capacity for visitation and so on until all consumers can be visited.

The Break even point model can be used to optimize a break even point to obtain decision support information for company management through cost optimization (Kurmangaliyeva et al., 2021). The relevant costs for achieving a break-even point are fixed costs and variable costs (Ricardianto, 2019). The stages in using Break Even Point are as follows (Angsoka & Aliludin, 2020):

a) BEP Unit

Profit = $SP_X - VC_X - TFC$ (1)

Where:
X = Amout of Units Produced
TFC = Total Fixed Cost
SP = Sales price/unit
VC = Variable Cost

Contribution Margin Per Unit (x) = (SP – VC) (x) (2)

b) BEP Profit

$$\frac{Profit+TFC}{Contribution\ Margin\ per\ Unit} \quad (3)$$

3. RESULT AND DISCUSSION

The process of determining the optimal distribution route for a Tempe customer, the steps required are a series of detailed and strategic processes. These steps can be described as follows:

a) Distance Matrix

In the process of creating a distance matrix, information is needed regarding the coordinates of the warehouse location and the location of the customer to be addressed. These coordinates are usually obtained using a platform such as Google Maps, where the addresses of the Tempe company and the target customer are entered to determine the location accurately. After the coordinates have been obtained, the next step is to calculate the distance between the warehouse and each customer, forming a distance matrix that presents information about the distance from the warehouse to each customer's destination in detail.

Table 3. Warehouse Distance and Customer Matrix

	Warehouse	C1	C2	C3	C4	C5	C6
C1	17	0,0					
C2	20	3	0,0				
C3	74,4	60,3	65	0,0			
C4	74,6	60,5	65,3	0,18	0,0		
C5	80	51	40,2	39,8	39,5	0,0	
C6	61,7	49,7	52,4	20,5	20,7	10,2	0,0

b) Saving Matrix

After the distance matrix is created, the next step is the formation of a saving matrix, which involves the process of adding and subtracting the differences between the existing distances. This is done to calculate the potential distance reduction that can be achieved by choosing the optimal route.

Table 4. Saving Customer Matrix

	C1	C2	C3	C4	C5	C6
C1	0,0					
C2	34	0,0				
C3	31,1	29,4	0,0			
C4	31,1	29,3	148,8	0,0		
C5	46	59,8	114,6	115,1	0,0	
C6	29	29,3	115,6	115,6	131,5	0,0

As an illustrative example, the process of calculating the savings matrix between two customers, namely customer 1 and customer 2, can be explained in detail as follows:

S12 = Distance (Warehouse,x) + Distance (Warehouse,y) – Distance (x,y)
= 17 + 20 – 3
= 34 km

c) Vehicle Allocation

The next step is to organize vehicle groups based on the saving matrix, by ordering them from largest to smallest value. This vehicle allocation process has the main objective of minimizing the number of trips by combining several customers into one route. The calculation results obtained from this process will be the basis for determining optimal distribution routes, which effectively reduce costs and increase operational efficiency.

Route 1
G - C3 - C4 - G = 300 + 150 = 450 boxes
Route 2
G - C5 - C6 - G = 350 + 200 = 550 boxes
Route 3
G - C1 - C2 - G = 300 + 200 = 500 boxes

The initial route obtained from the merging results is as follows:
G – C3 – C4 – C5 – C6 – C1 – C2 – G

d) Nearest Neighbor Method

The next step involves the identification process using the nearest neighbor method, where we add customers who are the closest to the previous customer and the warehouse that is the final destination. This process aims to establish optimal distribution routes by considering the shortest distance between distribution points and customers, thereby minimizing delivery time and costs. An illustration of the nearest neighbor method can be seen as follows:

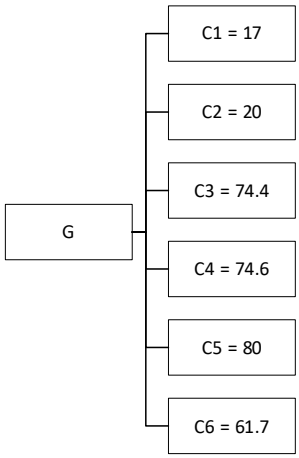

Fig.1. First Stage of Determination Nearest G

Based on the image above, the closest customer is selected based on the smallest value. The smallest value that appears is 17 on C1. So, C1 was chosen as the closest customer to the Gudang. Next, is to determine the closest customer from C1.

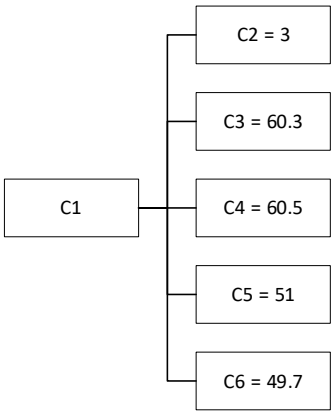

Fig.2. Second Stage of Determination Nearest C1

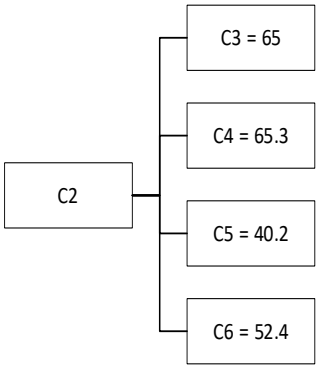

Fig.3. Third Stage of Determination Nearest C2

Based on the image above, the closest customer is selected based on the smallest value. The smallest value that appears is 40.2 on C5. Thus, C5 was chosen as the closest customer to C2. Next, is to determine the closest customer from C5.

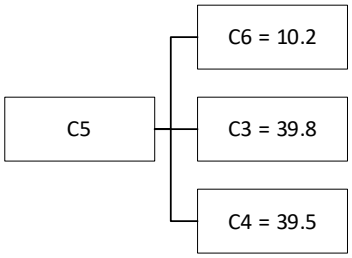

Fig.4. Fourth Stage of Determination Nearest C5

Based on the image above, the closest customer is selected based on the smallest value. The smallest value that appears is 10.2 on C6. Thus, C6 was chosen as the closest customer to C5.

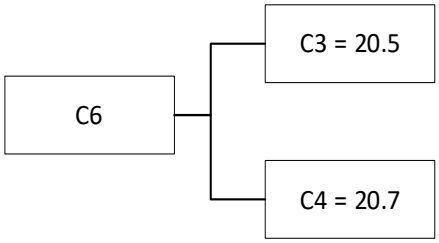

Fig.5. Fifth Stage of Determination Nearest C6

Furthermore, is to determine the closest customer from C6. Based on the image above, the closest customer is selected based on the smallest value. The smallest value that appears is 20.5 on C3. Thus, C3 was chosen as the closest customer to C6 and C4 became the last customer on this travel route. Therefore, a feasible route for distributing tempe company products is as follows:

G-C1-C2-C5-C6-C3-C4-G = 1,500 boxes.

In the context of the Tempe company's product distribution, after determining the optimal travel route based on the closest customer, the next step is to calculate the Break Even Point (BEP) value of the unit to determine the point at which the company's independent expenditure will be the same as the company's expenditure when renting. There is some information needed to calculate the Break Even Point (BEP) unit value, including the following:

a) CDD Truck Prices : Rp524.000.000,-
b) Truck's Depreciation : 8 years
c) Depreciation Cost : Rp 65.500.000,-/year
d) Maintenance Cost : Rp7.985.000,-/year

e) Truck Leased Cost : Rp8.050.000,-/year

Based on the information above, the unit BEP calculation can be done as follows:
BEP Unit :
Private = Leased
Fc + Vc (x) = Fc + Vc (x)
65.500.000 + 7.985.000x = 0 + 8.050.000x
65.500.000 = 65.500x
x = 1.000 Boxes

After getting a unit Break Even Point (BEP) value of 1,000 units, the next step is to illustrate the BEP through graphs to visualize the point at which it becomes balanced in the context of a comparison between the use of private and leased CDD trucks.

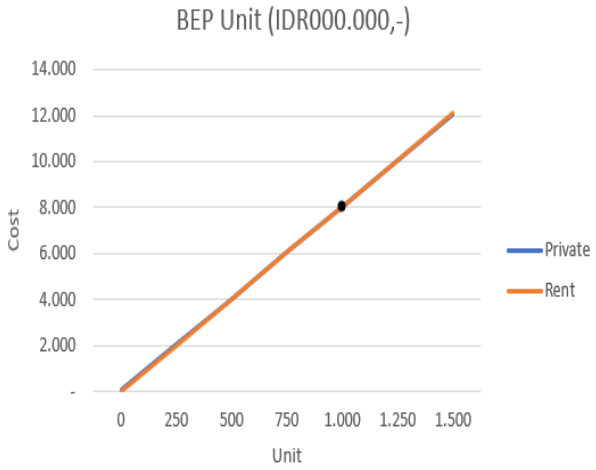

Fig.6. BEP Unit Analysis

Based on the graph that has been created, it is found that a Break Even Point (BEP) value of 1,000 boxes will result in costs of IDR 8,050,000,000, - both when using a CDD truck privately and through leased. From this graph, it can be seen that the decision that can be taken is to lease a CDD truck before reaching the BEP point (⩽1,000 boxes), and after reaching the BEP (⩾1,000 boxes), the company can switch to using the private CDD truck it owns.

4. CONCLUSION

Optimizing the route for sending tempe to consumers is obtained via the G-C1-C2-C5-C6-C3-C4-G route with an optimal capacity of 1500 boxes. Apart from that, with the existing capacity, an evaluation of the transportation modes owned shows that the company can rent if the average delivery in one year is below 1000 boxes and has its own mode if deliveries are above 1000 boxes.

5. ACKNOWLEDGMENTS

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