Saving Matrix Application to Minimize Fuel Distribution Route Allocation

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**Abstract.** The irregular allocation of routes generated for each shift is a problem that exists in PT. Rewulu. This research allocates routes and distribution schedules and determines the capacity and number of effective and efficient tank trucks to profit the company. This research uses the savings matrix method, which is essentially a method to minimize distance, time, or cost by considering existing constraints. The calculation of the savings matrix method obtained fuel distribution in shift 1 has 30 routes, 2 has 28, and 3 is 25. Route 1 shift 1 includes refreshment stand, gas station 44,562.10 (A62), gas station 44,562.01 (A64), gas station 44,562.09 (A66), and return to refreshment stand with a total travel distance of 192 km with a required time of 6.4 hours with 64 liters of fuel, with a fuel cost of Rp 329,600.00. The calculation of the savings matrix method obtained fuel distribution in shift 1 has 30 routes, 2 has 28, and 3 is 25. Route 1 shift 1 includes refreshment stand, gas station 44,562.10 (A62), gas station 44,562.01 (A64), gas station 44,562.09 (A66), and return to refreshment stand with a total travel distance of 192 km with a required time of 6.4 hours with 64 liters of fuel, with a fuel cost of Rp 329,600.00.

# INTRODUCTION

When Increasingly sophisticated technology certainly impacts the development of a company, each company is required to improve all aspects so that the company's profits also increase. Routes are optimal if all channels can be consistent in different sales times and are not independent of profit allocation [1]. The parameters discussed are mileage, number of routes, and travel time [2]. One aspect that we should consider in achieving these goals is the distribution aspect. The proposed distribution determination can determine the route of the distribution channel achieved, the efficiency of time and distance, taking into account capacity and route [3]. Companies must determine specific routes that will serve specific customers and the order they will visit to minimize the total distance traveled [4]. Some companies do not currently have a fixed or standard distribution line. The distribution channels obtained only based on interviews or daily distribution are based solely on the order of the address list intended by the driver [3]. Errors in determining distribution channels and delays in product delivery may hinder the distribution of products from manufacturers to consumers, resulting in reduced or declining corporate profits and may also potentially cause harm to the company. Excellence in omnichannel distribution can achieve by expanding delivery mode, improving delivery speed, and service level [5]. One way to lower transportation costs is to streamline the distribution and use of existing modes of transportation. The growth of online purchasing services with direct delivery to customers makes distribution and transportation activities increasingly important. The cost component of this activity is increasing in the supply chain. Supply Chain Management (SCM) handles the management of all activities from upstream to downstream to provide goods or services to end customers [1], [4]–[9]. Routes decided by suppliers affect the profits of all members of the supply chain [1], [4], [6]–[11]. Vehicle route problems generally aim to design routes that minimise transport costs [1], [2], [12]–[16], [17]–[26], [3], [27], [28], [4], [5]. The efficiency of the distribution system can do by determining the distribution route to minimize the total mileage and the length of travel to optimize the use of capacity and the number of vehicles. This representation determines the batch and route of each vehicle in the distribution system and has three advantages.

First, each vector represents an actual delivery order, and this structure facilitates design for a simple and efficient environment. Second, given that decision-making about time exclude, this representation minimizes the relationship between production and distribution. Third, through the delivery time of each product, the start time (latest) to ship each work can be easily obtained [29]—some of the problems that exist in PT. Rewulu, among others, the high amount of fuel demand is not offset by optimal fueling system so that at certain times it experiences

buildup and emptiness. The study allocated routes and distribution schedules and determined the capacity and number of tank truck vehicles capable of minimizing mileage, length of travel, and transportation costs. Reducing the number of routes will reduce vehicle allocation costs and distribution transport costs [2]. With limited distance, efficiency will achieve at all costs [30]. Earliness on-demand delivery for various reasons such as storage costs or human resource allocation can lead to customer dissatisfaction to consider orders delivered before maturity time [17]. Produce optimal departure routes that are more than functional, and a new approach is developed for optimal design and allocation of departure routes [31]. Because different stakeholders may have other interests, so the allocation methods applied should be closely scrutinized [26]. Scheduling algorithms can be incorporated into the framework to resolve vehicle and crew issues and optimize resource allocation within a certain period [28].

# METHOD

Data processing begins by calculating the number of vehicles, cost, and distance for the initial distribution of products used as a comparison. The following calculation is done with the saving matrix method to get the results according to the pre-defined objectives. It can also be by calculating the proportional cost allocation used, based on each customer's distance to the depot or based on the product of each customer's request (load) and its reach to the depot [32]. The steps of data processing using the saving matrix method are as follows:

a. Identify the distance matrix from the refreshment stand to each gas station.

b. Calculate savings matrix by using formulas: Si,j = do,i + do,j – di,j.

c. Combine the two gas stations that produce the enormous savings and check if the two gas stations can be serviced by the exact vehicle or not.

d. Update the cells that have the enormous saving value and calculate the total delivery volume.

e. Sort consumers in routes formed with the nearest insert and nearest neighbor.

# RESULTS

PT. Rewulu has a distribution area of 178 gas stations. Table 1 lists gas stations supplied from Rewulu fuel terminals, daily average fuel demand data for gas stations, and distance data from each station's refreshment stand. The required data is as follows:

a. Data were filling sheed NGS.

b. Fueling time to tank car.

c. Some fleets are used.

d. Data Round Trip Hours (RTH)

e. Fuel Delivery Shift Data

From the determination of the order of the visit is obtained the schedule and delivery route are as follows:

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **The Gas Station** | **Order** | **Distance** |  | **The Gas Station** | **Order** | **Distance** |  | **The Gas Station** | **Order** | **Distance** |
| 4455516 | 8 | 2 |  | 4455609 | 24 | 23 |  | 4456121 | 24 | 48 |
| 4455714 | 8 | 5 |  | 4455709 | 8 | 24 |  | 4456105 | 8 | 50 |
| 4455207 | 40 | 5 |  | 4455204 | 24 | 25 |  | 4457425 | 8 | 51 |
| 4455506 | 8 | 11 |  | 4455517 | 8 | 26 |  | 4456118 | 8 | 58 |
| 4355218 | 16 | 15 |  | 4455713 | 24 | 27 |  | 4456103 | 8 | 55 |
| 4455711 | 16 | 15 |  | 4455708 | 8 | 27 |  | 4456206 | 8 | 63 |
| 4455528 | 8 | 16 |  | 4355715 | 8 | 25 |  | 4456504 | 8 | 61 |
| 4455103 | 8 | 16 |  | 4455534 | 8 | 25 |  | 4456216 | 16 | 68 |
| 4455530 | 8 | 17 |  | 4455507 | 16 | 28 |  | 4456202 | 16 | 69 |
| 4455111 | 8 | 17 |  | 4455702 | 8 | 29 |  | 4456212 | 8 | 59 |
| 4455118 | 8 | 18 |  | 4455512 | 8 | 25 |  | 4456204 | 16 | 68 |
| 4455523 | 8 | 18 |  | 4455525 | 40 | 31 |  | 4456213 | 16 | 73 |
| 4455209 | 8 | 18 |  | 4455501 | 16 | 31 |  | 4456203 | 8 | 74 |
| 4455707 | 8 | 18 |  | 4455521 | 8 | 32 |  | 4456208 | 8 | 75 |
| 4455509 | 8 | 19 |  | 4455533 | 8 | 26 |  | 4456205 | 8 | 80 |
| 4455502 | 8 | 20 |  | 4457416 | 8 | 37 |  | 4456207 | 8 | 83 |
| 4455505 | 16 | 20 |  | 4457401 | 8 | 37 |  | 4456210 | 8 | 81 |
| 4455803 | 16 | 20 |  | 4457411 | 8 | 43 |  | 4456214 | 24 | 86 |
| 4455602 | 16 | 21 |  | 4457419 | 8 | 35 |  | 4456201 | 16 | 83 |
| 4455508 | 8 | 21 |  | 4456104 | 40 | 48 |  | 4456211 | 16 | 91 |
| 4455217 | 16 | 22 |  | 4457404 | 8 | 46 |  | 4456209 | 8 | 96 |
| 4455110 | 8 | 22 |  | 4156101 | 16 | 52 |  | 4456215 | 8 | 77 |
| 4455518 | 16 | 23 |  |

**TABLE 1.** List of gas stations along with request data and distance from the refreshment stand

**TABLE 2.** Results of the Nearest Insert Shift Method

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Route With Nearest Insert Method** | | | | | | | **Order** | **Round Trip Distance** |
|
| Route 1 | Refreshment stand | 4456210 | 4456201 | | 4456209 | Refreshment stand | 32 KL | 192 |
| Route 2 | Refreshment stand | 4456214 | | | | Refreshment stand | 24KL | 172 |
| Route 3 | Refreshment stand | 4456205 | 4456207 | | 4456211 | Refreshment stand | 32 KL | 184 |
| Route 4 | Refreshment stand | 4456204 | | 4456215 | | Refreshment stand | 24 KL | 154 |
| Route 5 | Refreshment stand | 4456213 | 4456208 | | 4456203 | Refreshment stand | 32 KL | 156,5 |
| Route 6 | Refreshment stand | 4456216 | | | | Refreshment stand | 16 KL | 136 |
| Route 7 | Refreshment stand | 4456212 | 4456206 | | 4456202 | Refreshment stand | 32 KL | 148,2 |
| Route 8 | Refreshment stand | 4156101 | | 4456103 | | Refreshment stand | 24 KL | 110,7 |
| Route 9 | Refreshment stand | 4456121 | | | | Refreshment stand | 24 KL | 96 |
| Route 10 | Refreshment stand | 4456104 | | | | Refreshment stand | 32 KL | 96 |
| Route 11 | Refreshment stand | 4456104 | 4456105 | 4456118 | 4456504 | Refreshment stand | 32 KL | 130 |
| Route 12 | Refreshment stand | 4457419 | | 4457425 | | Refreshment stand | 16 KL | 94,2 |
| Route 13 | Refreshment stand | 4457416 | 4457401 | 4457404 | 4457411 | Refreshment stand | 32 KL | 90,1 |
| Route 14 | Refreshment stand | 4455525 | | | | Refreshment stand | 32 KL | 62 |
| Route 15 | Refreshment stand | 4455533 | 4455501 | | 4455525 | Refreshment stand | 32 KL | 69,4 |
| Route 16 | Refreshment stand | 4455713 | | | | Refreshment stand | 24 KL | 54 |
| Route 17 | Refreshment stand | 4455609 | | | | Refreshment stand | 24 KL | 46 |
| Route 18 | Refreshment stand | 4455534 | 4455708 | 4455702 | 4455521 | Refreshment stand | 32 KL | 69,5 |
| Route 19 | Refreshment stand | 4455512 | | 4455507 | | Refreshment stand | 24 KL | 57,1 |
| Route 20 | Refreshment stand | 4455508 | 4455518 | | 4455517 | Refreshment stand | 32 KL | 52 |
| Route 21 | Refreshment stand | 4455803 | 4455709 | | 4355715 | Refreshment stand | 32 KL | 58,4 |
| Route 22 | Refreshment stand | 4455204 | | | | Refreshment stand | 24 KL | 50 |
| Route 23 | Refreshment stand | 4455209 | 4455505 | | 4455509 | Refreshment stand | 32 KL | 42 |
| Route 24 | Refreshment stand | 4455217 | | 4455110 | | Refreshment stand | 24 KL | 53 |
| Route 25 | Refreshment stand | 4455714 | | 4455602 | | Refreshment stand | 24 KL | 42 |
| Route 26 | Refreshment stand | 4355218 | 4455502 | | 4455523 | Refreshment stand | 32 KL | 47 |
| Route 27 | Refreshment stand | 4455711 | 4455103 | | 4455118 | Refreshment stand | 32 KL | 37,1 |
| Route 28 | Refreshment stand | 4455516 | 4455207 | 4455111 | 4455707 | Refreshment stand | 32 KL | 53,4 |
| Route 29 | Refreshment stand | 4455207 | | | | Refreshment stand | 32 KL | 10 |
| Route 30 | Refreshment stand | 4455506 | 4455528 | | 4455530 | Refreshment stand | 24 KL | 43,6 |

Results of Nearest Neighbor Shift Method 1:

Route 1: Refreshment stand – the gas station 4456210 – the gas station 4456201- the gas station 4456209 – Refreshment stand = 192 Km.

Route 2: Refreshment stand - the gas station 4456214 – Refreshment stand = 172 Km.

Route 3: Refreshment stand - the gas station 4456205 – the gas station 4456207- the gas station 4456211 – Refreshment stand = 184 Km.

Route 4: Refreshment stand - the gas station 4456204 – the gas station 4456215 – Refreshment stand = 154 Km.

Route 5: Refreshment stand - the gas station 4456213 – the gas station 4456208 - the gas station 4456203 – Refreshment stand = 156.5 Km.

Route 6: Refreshment stand - the gas station 4456216 – Refreshment stand = 136 Km.

Route 7: Refreshment stand - the gas station 4456212 – the gas station 4456206 - the gas station 4456202 – Refreshment stand = 148.2 Km.

Route 8: Refreshment stand - the gas station 4156101 – the gas station 4456103 – Refreshment stand = 110.7 Km.

Route 9: Refreshment stand - the gas station 4456121 – Refreshment stand = 96 Km.

Route 10: Refreshment stand - the gas station 4456104 – Refreshment stand = 96 Km.

Route 11: Refreshment stand - the gas station 4456104 – the gas station 4456105- the gas station 4456118 – the gas station 4456504 - Refreshment stand = 130 Km.

Route 12: Refreshment stand - the gas station 4457419 – the gas station 4457425 – Refreshment stand = 94.2 Km.

Route 13: Refreshment stand - the gas station 4457416 – the gas station 4457401- the gas station 4457404– the gas station 4457411 - Refreshment stand = 90.1 Km.

Route 14: Refreshment stand - the gas station 4455525– Refreshment stand = 62 Km.

Route 15: Refreshment stand - the gas station 4455533– the gas station 4455501 - the gas station 4455525 – Refreshment stand = 69.4 Km.

Route 16: Refreshment stand - the gas station 4455713 – Refreshment stand = 54 Km.

Route 17: Refreshment stand - the gas station 4455609 – Refreshment stand = 46 Km.

Route 18: Refreshment stand - the gas station 4455534 – the gas station 4455708- the gas station 4455702 – the gas station 4455521 - Refreshment stand = 69.5 Km.

Route 19: Refreshment stand - the gas station 4455512 – the gas station 4455507 – Refreshment stand = 57.1 Km.

Route 20: Refreshment stand - the gas station 4455508 – the gas station 4455518- the gas station 4455517- Refreshment stand = 52 Km.

Route 21: Refreshment stand - the gas station 4455803 – the gas station 4455709- the gas station 4355715- Refreshment stand = 58.4 Km.

Route 22: Refreshment stand - the gas station 4455204– Refreshment stand = 50 Km.

Route 23: Refreshment stand - the gas station 4455209 – the gas station 4455505- the gas station 4455509- Refreshment stand = 42 Km.

Route 24: Refreshment stand - the gas station 4455217 – the gas station 4455217 – Refreshment stand = 53 Km.

Route 25: Refreshment stand - the gas station 4455714 – the gas station 4455714 – Refreshment stand = 42 Km.

Route 26: Refreshment stand - the gas station 4355218 – the gas station 4455502- the gas station 4455523- Refreshment stand = 47 Km.

Route 27: Refreshment stand - the gas station 4455711 – the gas station 4455103- the gas station 4455118- Refreshment stand = 37.1 Km.

Route 28: Refreshment stand - the gas station 4455516 – the gas station 4455207- the gas station 4455111– the gas station 4455707 - Refreshment stand = 53.4 Km.

Route 29: Refreshment stand - the gas station 4455207– Refreshment stand = 10 Km.

Route 30: Refreshment stand - the gas station 4455506 – the gas station 4455528- the gas station 4455530- Refreshment stand = 43.6 Km.

Determination and scheduling of fuel distribution routes with this saving matrix method only for shift 1. The distance matrix is a matrix that states the distance between locations to be visited in the distribution process. Distance Matrix:

Dist (A,B) = √((Xa-Xb)\_2 + (Ya-Yb)^2 ) (1)

In addition, it can use the google—map application.

The next step is to identify the saving matrix. Two or more routers are combined; two destinations can be combined into one route to minimize the distance traveled with the saving matrix. The value of savings uses the following formula:

2J(G,1) + 2J(G,2) - [J(G,1) + J(1,2) + J(G,2)]

= J(G,1) + J(G,2) - J(1,2) (2)

This formula can be generalized to assume that distance (x, y) = distance (y, x). Then we get the following procedure:

S(x, y) = J(G, x) + J(G, y) – J(x, y). (3)

S (x, y) is the distance saving (saving) obtained by combining route x and y.

The next step is to calculate the travel time required in 1 fuel delivery route. To calculate the travel time, then use the formula as follows :

W = j/k+wb+wt+wp (4)

w : time wb : unloading time

j : distance wt : waiting time

k : speed wp : charging time

Then the example of the calculation is as follows :

W = 192/50+0,75+1.5+0.3 = 6.39 jam

Furthermore, calculate the cost of fuel used in distributing energy in one trip route. The fuel used by haulers in distributing power is bio solar/B30 type, a mixture of pure diesel 70% and Fame 30%, with the price per liter is Rp 5.150. In calculating the cost of such fuel by using the following formula:

Cost = L x Rp 5.150 (5)

L: Number of Liters used in distributing one travel route. Then the example of the calculation is as follows: Cost=64 x Rp 5.150 = Rp 329.600

# CONCLUSION

Shift 1 has 30 routes, shift two as many as 28 ways, and shift three as many as 25 routes. With this, it can conclude that there has been a decrease in travel routes than before. The allocation of travel routes on route one shift 1 includes refreshment stand, gas station 44.562.10 (A62), gas station 44.562.01 (A64), gas station 44.562.09 (A6 6), and return to refreshment stand with a total return distance of 192 Km with a travel time of 6.4 hours with fuel spend of 64 liters with a fuel cost of Rp 329.600.00.

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