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Optimizing Vehicle Routing Problem with Nearest Neighbour Method and Saving Matrix on PT XYZ

Eva Qistiana Amanatillah*, Egi Riswanda, Galuh Halintar, Rifqi Firozan, Yani Iriani
Department of Industrial Engineering, Widyatama University Bandung, West Java, Indonesia
*eva.qistiana@widyatama.ac.id

ABSTRACT

Transportation is part of supply chains that could contribute up to 40% of total logistics costs. Therefore, the company should have a proper transportation system. PT XYZ is one of the pharmaceutical industries that offer/serve distribution and logistics services in health and other sectors in Indonesia. The recent problem at PT XYZ lingers on the Vehicle Routing Problem (VRP) along with its limitation. PT XYZ often finds some difficulties when dealing with distribution process, specifically the frequent delay in delivering products to their customers due to the inaccuracy of route configuration, and this exact case causes an increased transportation cost. In November 2020, PT XYZ could spend an average transportation cost for Rp. 1.902.022 daily with eight distribution routes. This happened since the company's ineffectiveness in maximizing the route and the vehicle capacity. The aim of this study is to determine distribution route and proper vehicle capacity at PT XYZ and to calculate the total cost of transportation by using nearest neighbor method and saving matrix. The nearest neighbor matrix is a simple method using the nearest neighborhood concept, while the saving matrix method is one of the methods that uses matrix table economical distance and restriction regarding cargo capacity. Based on the result processed by using nearest neighbor method and saving matrix, the most appropriate method that resulted optimal route with the distance covered and maximum capacity was saving matrix method. The calculation that used nearest neighbor method resulted in six routes with total distance at 168 km, whilst the saving matrix yielded five routes with the total distance at 186 km. The calculation result of the total cost regarding distribution activities for the nearest neighbor was Rp. 1.396.145, whilst the saving matrix method was Rp. 1.181.601. The cost comprised of the sum of fixed costs with variable costs and the total distance that had been calculated by both methods. By using the nearest neighbor method and saving matrix, the company could save up to 27% and 38% respectively for each method.

Keywords
Distribution, route, vehicle routing problem, nearest neighbor method, saving matrix

Introduction

PT XYZ is a pharmaceutical company that provides distribution and logistics services in the health sector and other fields in Indonesia. In its activities, this company has problems with transportation. Transportation activities at PT XYZ are very much needed to distribute products. Products sent to distributors and retailers have many alternative choices. In November 2020, PT XYZ can spend an average of Rp. 1,902,022 per day. This is certainly a problem because companies will experience swelling in their transportation costs. The objective of solving transportation problems is to achieve maximum profit by minimizing total production costs.

Transportation in companies must have a strategy and planning. Calculations in transportation planning require data in the form of the distance to the destination along with the price. Strategic planning in transportation requires mathematical calculations which can then be searched for routes with optimal distances and costs. This problem is also known as the Vehicle Routing Problem (VRP).

One solution to the problem in the vehicle routing problem (VPR) is the Algorithm Nearest Neighbour. The method Nearest Neighbour starts with moving the vehicle from the one depot to the closest depot without exceeding the vehicle capacity, if it exceeds the vehicle capacity the vehicle will go to the initial depot and then start visiting the depot that has not been visited until this algorithm can be stopped (Mukhsinin et al., 2013). The purpose of using the Nearest Neighbour method is to solve the complex so that it can be overcome. According to Mohammed et al. (2017), the Nearest Neighbour method is stochastic, making this method better in making decisions.

Apart from the Nearest Neighbour method, the saving matrix method is also a solution to problems in transportation. For the use of the saving matrix method, the distribution line is determined based on vehicle capacity (Indrawati

et al., 2016). Distribution problems can be solved by using the saving matrix method, with this method the company can also save the cost of sending products to customers directly (Pattiasina et al., 2018).

This research is oriented towards solving the vehicle routing problem in PT. XYZ. Optimization in solving the problem of vehicle problems is needed so that the transportation and distribution activities of the PT XYZ company can minimize the total distribution costs in order to achieve maximum profits. This study is intended to compare the calculations to determine the closest route using the methods Nearest Neighbour and Saving Matrix.

Literature Review

Vehicle Routing Problem

Vehicle Routing Problem (VRP) is one of the most important problems in the logistics system, the Vehicle Routing Problem covers problems related to vehicle routes in making deliveries from one depot to a number of distribution centers. Zirour (2008) defines VRP as a problem of determining the optimal route of a vehicle in the distribution of goods or services from one or more depots to a number of agents in different locations.

According to Caceres-Cruz et al. (2014), there are four general objectives of VRP which are as follows:

a. Minimizing transportation costs, related to distance and fixed costs associated with vehicles.
b. Minimizing the number of vehicles needed to distribute products.
c. Minimizing penalties due to unsatisfactory service from agents.

Nearest Neighbour Method

The method Nearest Neighbour is a method used for route problem solving, problem solving is done by starting the starting point then searching for the nearest point (Hutasoit et al., 2014).

According to Madona and Irmansyah (2013) explained that the method Nearest Neighbour starts with selecting a path or route that has the minimum distance value each through the area, then selecting the next area considering that the area has not been visited and has the minimum value or distance.

Saving Matrix Method

Matrix is one of the methods used to solve transportation problems with the aim of minimizing costs. The transportation problem, which is the vehicle routing problem (VRP), is in the form of determining the distribution route of a product from one depot to the depot by considering the maximum capacity of the vehicle used (Indrawati et al., 2016).

In addition to the Nearest Neighbour method, the saving matrix method is included as a heuristic method for determining the distribution route of a product (Sutoni & Apipudin, 2019). The purpose of implementing the saving matrix method is to allocate goods to delivery areas based on carrying capacity on the basis of the largest savings (Ikfan & Masudin, 2013).

The steps that must be done using the Saving Method are as follows:
1) Start with the initial solution with each customer being visited by one vehicle route.
2) Calculate the savings (savings) for each pair of customers $i \in C$ and $\in C \in C$ with the formula:

$$Sij = C0i + Cj0 - Cij$$

3) Sort the savings in a list descending (or from largest to smallest).
4) Find a feasible arc (i, yang) in the list of savings that satisfies:
a. Customer i and customer j are located on different routes.
b. Customer i and customer j are the first or last customers visited on the route concerned.
c. The total quantity of the route which includes customer i and customer j does not exceed the loading capacity of vehicle K.
d. Update the solution by adding arcs (i, j) and deleting arcs (0, i) and (j, 0).

5) Repeat step 2 so that neither bow meets the three conditions in step 2 or there is a final saving.

Methodology

This study uses a quantitative approach. The data obtained is divided into two, namely primary and secondary data. Primary data in this study were obtained through interviews with resource persons (company employees), data collected in the form of data regarding company profiles, customer data, vehicle types, vehicle capacity and number of vehicles used to distribute products to each distribution center and distance data from depot to each delivery location.

Secondary data in this study were obtained from other written data relating to research such as data on the number of product shipments to each distribution center every day, literature and other document data.

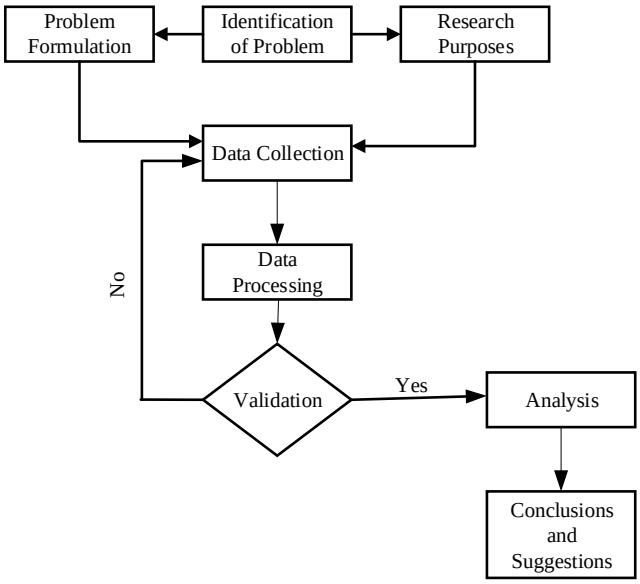

Figure 1. Flowchart research

1. Problem Identification
   The selection of the research location used was PT XYZ, while the problems identified were the ineffective route of the vehicles used in the transportation process which resulted in significant expenditure.
2. Problem Formulation
   After conducting a field study, the next step is to formulate the problem. The formulation of the problem of this study is the occurrence of large expenses due to an ineffective distribution system.
3. Research
   Objectives The research objective is the objective of conducting a study, in this case it is to determine the root of the problem of the vehicle routing problem (VPR), apply the use of the Nearest Neighbour method and the saving matrix method, and analyse the comparison of the two methods.
4. Literature Study
   A method used to collect data or sources related to the topic raised in a study. This research literature study is obtained from various sources such as journals, books and the internet.
5. Data Collection
   The next stage is data collection. At this stage the authors collect the data needed to solve this problem, namely data in the form of area names, distances, and other matters related to the distribution of goods at PT XYZ.
6. Data Processing Data
   Processing data using the Nearest Neighbour method and the Saving Matrix Method.
7. Analysis
   After processing the data, the author will analyse the results of the resulting data processing. Analysing is important for the continuation of the research that has been done by the author, the data that is generated in processing then the data will be checked whether the data is valid or not.
8. Conclusions and Suggestions
   The final step in the research is the conclusions and suggestions. Both of these are done after the researcher conducts analysis and interpretation, then the researcher makes general conclusions (generalizations).

Results and Discussion

Data collected is related to the distribution of products from the depot to each DC, consisting of several data including data on distribution systems, distribution area data, vehicle capacity, address *distribution center*, demand data, and variable cost data. transportation.

List of Distribution Center

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Data collected by the author is in the form of location data distribution center PT XYZ. Table 1 is the data for the name of the area Distribution Center PT XYZ and Figure 2 is a map of the area distribution center that has been marked by the author, namely:

Table 1. Name of distribution center PT XYZ

CODE	DISTRIBUTION CENTER
1	CENGKARENG
2	GROGOL
3	PETAMBURAN
4	TAMAN SARI
5	KEBON JERUK
6	KALIDERES
7	PALMERAH
8	KEMBANGAN
9	JOGLO
10	MERUYA
11	SRENGSENG
12	KEMANGGISAN
13	KOTA BAMBU
14	KEDOYA
15	GLODOK
16	SEMANAN
17	JEMBATAN BESI
18	KALI ANYAR
19	KAPUK
20	RAWA BUAYA
21	TANJUNG DUREN

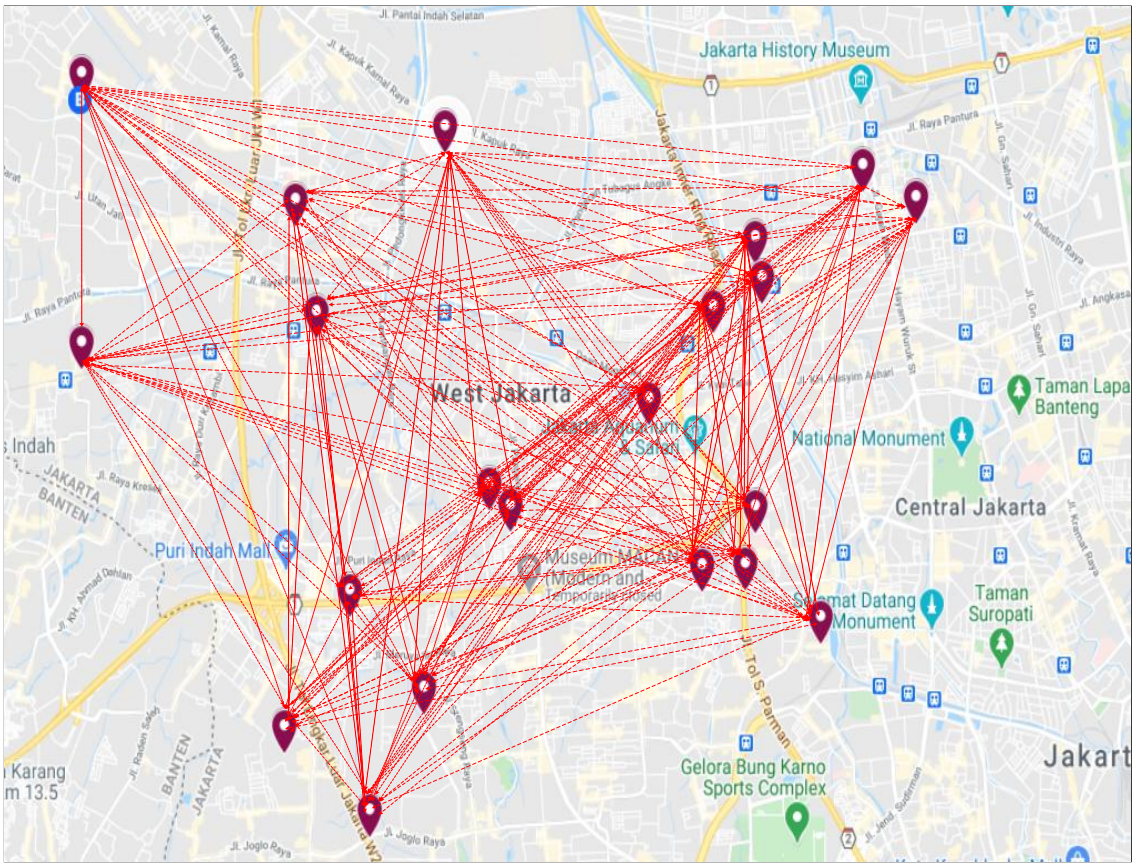

Figure 2. Map of area distribution center PT XYZ

Distance between Distribution Centers

Table 2 and 3 are distance data between distribution centers PT XYZ based on distance measurements that have been made using application Google Maps, namely:

Table 2. Distance between distribution centers

FROM		TO		DISTANCE (KM)
1	CENGKARENG	2	GROGOL	10,5
		3	PETAMBURAN	19,1
		4	TAMAN SARI	16,9
		5	KEBON JERUK	11,8
		6	KALIDERES	7,6
		7	PALMERAH	11,3
		8	KEMBANGAN	9,7
		9	JOGLO	11,5
		10	MERAYU	10,4
		11	SRENGSENG	11,4
		12	KEMANGGISAN	12,8
		13	KOTA BAMBU	12,9
		14	KEDOYA	10,1
		15	GLODOK	14,3
		16	SEMANAN	7,6
		17	JEMBATAN BESI	9,8
		18	KALI ANYAR	11,3
		19	KAPUK	5,8
		20	RAWA BUAYA	3,9
		21	TANJUNG DUREN	9,7
2	GROGOL	1	CENGKARENG	19,1
		3	PETAMBURAN	8,2
		4	TAMAN SARI	7,3
		5	KEBON JERUK	8,6
		6	KALIDERES	22,7
		7	PALMERAH	4,2
		8	KEMBANGAN	11,4
		9	JOGLO	14,8
		10	MERAYU	13,6
		11	SRENGSENG	10,4
		12	KEMANGGISAN	6,8
		13	KOTA BAMBU	5,9
		14	KEDOYA	5,8
		15	GLODOK	7,1
		16	SEMANAN	11
		17	JEMBATAN BESI	2,7
		18	KALI ANYAR	3,8
		19	KAPUK	5,7
		20	RAWA BUAYA	7
		21	TANJUNG DUREN	2,6
3	PETAMBURAN	1	CENGKARENG	19,1
		2	GROGOL	8,2
		4	TAMAN SARI	7,2
		5	KEBON JERUK	6,1
		6	KALIDERES	18,3
		7	PALMERAH	8,8
		8	KEMBANGAN	11,7
		9	JOGLO	12,9
		10	MERAYU	3,6
		11	SRENGSENG	10,5
		12	KEMANGGISAN	2,9
		13	KOTA BAMBU	3,9
		14	KEDOYA	9,1
		15	GLODOK	7,9
		16	SEMANAN	16,7
		17	JEMBATAN BESI	9,6
		18	KALI ANYAR	9,5
		19	KAPUK	13
		20	RAWA BUAYA	14,4
		21	TANJUNG DUREN	5,6
4	TAMAN SARI	1	CENGKARENG	16,9
		2	GROGOL	7,3
		3	PETAMBURAN	7,2
		5	KEBON JERUK	14
		6	KALIDERES	22
		7	PALMERAH	9,8
		8	KEMBANGAN	16,6
		9	JOGLO	19
		10	MERAYU	6,7
		11	SRENGSENG	15,3
		12	KEMANGGISAN	8,9
		13	KOTA BAMBU	7,6
		14	KEDOYA	12
		15	GLODOK	2,1
		16	SEMANAN	16,5
		17	JEMBATAN BESI	6,6
		18	KALI ANYAR	6,6
		19	KAPUK	10,8
		20	RAWA BUAYA	14,2
		21	TANJUNG DUREN	8,5
5	KEBON JERUK	1	CENGKARENG	11,6
		2	GROGOL	8
		3	PETAMBURAN	6,1
		4	TAMAN SARI	12,5
		6	KALIDERES	14,2
		7	PALMERAH	5,7
		8	KEMBANGAN	5,2
		9	JOGLO	8
		10	MERAYU	5,9
		11	SRENGSENG	5,1
		12	KEMANGGISAN	6
		13	KOTA BAMBU	7,2
		14	KEDOYA	1,1
		15	GLODOK	12,8
		16	SEMANAN	12,5
		17	JEMBATAN BESI	9,9
		18	KALI ANYAR	12,2
		19	KAPUK	9,1
		20	RAWA BUAYA	8,4
		21	TANJUNG DUREN	5,1
6	KALIDERES	1	CENGKARENG	7,6
		2	GROGOL	22,7
		3	PETAMBURAN	21,6
		4	TAMAN SARI	22
		5	KEBON JERUK	14,2
		7	PALMERAH	17,1
		8	KEMBANGAN	11,8
		9	JOGLO	12,2
		10	MERAYU	12,5
		11	SRENGSENG	13,5
		12	KEMANGGISAN	17,4
		13	KOTA BAMBU	16,4
		14	KEDOYA	11,5
		15	GLODOK	17,6
		16	SEMANAN	4,6
		17	JEMBATAN BESI	13,3
		18	KALI ANYAR	14,4
		19	KAPUK	9,3
		20	RAWA BUAYA	6,2
		21	TANJUNG DUREN	12,6

FROM		TO		DISTANCE (KM)
7	PALMERAH	1	CENGKARENG	14,9
		2	GROGOL	4,2
		3	PETAMBURAN	8,8
		4	TAMAN SARI	9,8
		5	KEBON JERUK	5,7
		6	KALIDERES	17,1
		8	KEMBANGAN	14
		9	JOGLO	21,8
		10	MERAYU	8,8
		11	SRENGSENG	11,7
		12	KEMANGGISAN	3,3
		13	KOTA BAMBU	1,7
		14	KEDOYA	13,3
		15	GLODOK	13,8
		16	SEMANAN	22,7
		17	JEMBATAN BESI	15
		18	KALI ANYAR	15,2
		19	KAPUK	19
		20	RAWA BUAYA	19,6
		21	TANJUNG DUREN	10,8
8	KEMBANGAN	1	CENGKARENG	9,7
		2	GROGOL	10,8
		3	PETAMBURAN	11,7
		4	TAMAN SARI	15,2
		5	KEBON JERUK	5,2
		6	KALIDERES	11,8
		7	PALMERAH	14
		9	JOGLO	4,6
		10	MERAYU	3,2
		11	SRENGSENG	3,4
		12	KEMANGGISAN	8,4
		13	KOTA BAMBU	10,1
		14	KEDOYA	4,8
		15	GLODOK	15,7
		16	SEMANAN	9,4
		17	JEMBATAN BESI	13,4
		18	KALI ANYAR	14,4
		19	KAPUK	17,5
		20	RAWA BUAYA	5,2
		21	TANJUNG DUREN	8
9	JOGLO	1	CENGKARENG	11,5
		2	GROGOL	15,3
		3	PETAMBURAN	12,9
		4	TAMAN SARI	17,6
		5	KEBON JERUK	7,2
		6	KALIDERES	12,2
		7	PALMERAH	21,8
		8	KEMBANGAN	4,6
		10	MERAYU	6,2
		11	SRENGSENG	7,3
		12	KEMANGGISAN	13,9
		13	KOTA BAMBU	16,4
		14	KEDOYA	10,4
		15	GLODOK	19,1
		16	SEMANAN	15,7
		17	JEMBATAN BESI	17,1
		18	KALI ANYAR	18,2
		19	KAPUK	17,2
		20	RAWA BUAYA	13,6
		21	TANJUNG DUREN	14,7
10	MERUYA	1	CENGKARENG	10,9
		2	GROGOL	10,4
		3	PETAMBURAN	11,9
		4	TAMAN SARI	14,8
		5	KEBON JERUK	5,9
		6	KALIDERES	12,5
		7	PALMERAH	8,8
		8	KEMBANGAN	3,2
		9	JOGLO	6,2
		11	SRENGSENG	4,1
		12	KEMANGGISAN	9,6
		13	KOTA BAMBU	10,9
		14	KEDOYA	5,7
		15	GLODOK	21,5
		16	SEMANAN	11,4
		17	JEMBATAN BESI	19,5
		18	KALI ANYAR	20,6
		19	KAPUK	12,1
		20	RAWA BUAYA	8
		21	TANJUNG DUREN	8,8
11	SRENGSENG	1	CENGKARENG	11,4
		2	GROGOL	9,5
		3	PETAMBURAN	10,5
		4	TAMAN SARI	13,9
		5	KEBON JERUK	5,1
		6	KALIDERES	13,5
		7	PALMERAH	11,7
		8	KEMBANGAN	3,4
		9	JOGLO	5,5
		10	MERAYU	4,1
		12	KEMANGGISAN	7,6
		13	KOTA BAMBU	8,7
		14	KEDOYA	4,2
		15	GLODOK	14,4
		16	SEMANAN	12,6
		17	JEMBATAN BESI	10,3
		18	KALI ANYAR	11,4
		19	KAPUK	10,3
		20	RAWA BUAYA	8,4
		21	TANJUNG DUREN	7,9
12	KEMANGGISAN	1	CENGKARENG	15,1
		2	GROGOL	7,1
		3	PETAMBURAN	7.1
		4	TAMAN SARI	8,9
		5	KEBON JERUK	3,2
		6	KALIDERES	17,4
		7	PALMERAH	3,3
		8	KEMBANGAN	8,4
		9	JOGLO	13,9
		10	MERAYU	9,6
		11	SRENGSENG	7,6
		13	KOTA BAMBU	5,2
		14	KEDOYA	6,3
		15	GLODOK	10,9
		16	SEMANAN	15,5
		17	JEMBATAN BESI	7,4
		18	KALI ANYAR	7,8
		19	KAPUK	12
		20	RAWA BUAYA	10,5
		21	TANJUNG DUREN	5,1

Table 3. Distance between distribution centers part 2

Characteristics of Products Distributed

FROM		TO		DISTANCE (KM)
13	KOTA BAMBU	1	CENGKARENG	16,7
		2	GROGOL	5,9
		3	PETAMBURAN	3,9
		4	TAMAN SARI	7,6
		5	KEBON JERUK	7,2
		6	KALIDERES	16,4
		7	PALMERAH	1,7
		8	KEMBANGAN	10,1
		9	JOGLO	16,4
		10	MERAYU	10,9
		11	SRENGSENG	8,7
		12	KEMANGGISAN	5,2
		14	KEDOYA	7,7
		15	GLODOK	7,3
		16	SEMANAN	14,2
		17	JEMBATAN BESI	5,4
		18	KALI ANYAR	6,5
		19	KAPUK	10,5
		20	RAWA BUAYA	10,1
		21	TANJUNG DUREN	3,1
14	KEDOYA	1	CENGKARENG	10,1
		2	GROGOL	6,6
		3	PETAMBURAN	9,1
		4	TAMAN SARI	13,8
		5	KEBON JERUK	1,9
		6	KALIDERES	11,5
		7	PALMERAH	13,3
		8	KEMBANGAN	4,8
		9	JOGLO	10,4
		10	MERAYU	5,7
		11	SRENGSENG	4,2
		12	KEMANGGISAN	6,3
		13	KOTA BAMBU	7,7
		15	GLODOK	12,5
		16	SEMANAN	12,3
		17	JEMBATAN BESI	11,1
		18	KALI ANYAR	12,1
		19	KAPUK	7,9
		20	RAWA BUAYA	6,6
		21	TANJUNG DUREN	4,5
15	GLODOK	1	CENGKARENG	14,5
		2	GROGOL	7,2
		3	PETAMBURAN	7,9
		4	TAMAN SARI	2,1
		5	KEBON JERUK	12,8
		6	KALIDERES	17,6
		7	PALMERAH	13,8
		8	KEMBANGAN	15,7
		9	JOGLO	19,1
		10	MERAYU	21,5
		11	SRENGSENG	14,4
		12	KEMANGGISAN	10,9
		13	KOTA BAMBU	7,3
		14	KEDOYA	12,5
		16	SEMANAN	14,9
		17	JEMBATAN BESI	5,3
		18	KALI ANYAR	3,2
		19	KAPUK	9,2
		20	RAWA BUAYA	10,8
		21	TANJUNG DUREN	7,1
16	SEMANAN	1	CENGKARENG	7,6
		2	GROGOL	11,8
		3	PETAMBURAN	16,7
		4	TAMAN SARI	16,5
		5	KEBON JERUK	12,5
		6	KALIDERES	4,6
		7	PALMERAH	22,7
		8	KEMBANGAN	9,4
		9	JOGLO	15,7
		10	MERAYU	11,4
		11	SRENGSENG	12,6
		12	KEMANGGISAN	15,5
		13	KOTA BAMBU	14,2
		14	KEDOYA	12,3
		15	GLODOK	14,9
		17	JEMBATAN BESI	13,4
		18	KALI ANYAR	14,5
		19	KAPUK	9,4
		20	RAWA BUAYA	5
		21	TANJUNG DUREN	12,8
17	JEMBATAN BESI	1	CENGKARENG	16,6
		2	GROGOL	2,7
		3	PETAMBURAN	8,6
		4	TAMAN SARI	6,6
		5	KEBON JERUK	8,7
		6	KALIDERES	13,3
		7	PALMERAH	15
		8	KEMBANGAN	13,4
		9	JOGLO	17,1
		10	MERAYU	19,5
		11	SRENGSENG	10,3
		12	KEMANGGISAN	7,4
		13	KOTA BAMBU	5,4
		14	KEDOYA	11,1
		15	GLODOK	5,3
		16	SEMANAN	13,4
		18	KALI ANYAR	1,1
		19	KAPUK	6,1
		20	RAWA BUAYA	10,5
		21	TANJUNG DUREN	3,5

FROM		TO		DISTANCE (KM)
18	KALI ANYAR	1	CENGKARENG	11,3
		2	GROGOL	2,9
		3	PETAMBURAN	9
		4	TAMAN SARI	6,6
		5	KEBON JERUK	12,2
		6	KALIDERES	14,4
		7	PALMERAH	15,2
		8	KEMBANGAN	14,4
		9	JOGLO	18,2
		10	MERAYU	20,6
		11	SRENGSENG	11,4
		12	KEMANGGISAN	7,8
		13	KOTA BAMBU	6,5
		14	KEDOYA	12,1
		15	GLODOK	3,2
		16	SEMANAN	14,5
		17	JEMBATAN BESI	1,1
		19	KAPUK	8,2
		20	RAWA BUAYA	11
		21	TANJUNG DUREN	4,1
19	KAPUK	1	CENGKARENG	4,3
		2	GROGOL	6,2
		3	PETAMBURAN	14,3
		4	TAMAN SARI	10,8
		5	KEBON JERUK	9,1
		6	KALIDERES	9,3
		7	PALMERAH	19
		8	KEMBANGAN	17,5
		9	JOGLO	17,2
		10	MERAYU	12,1
		11	SRENGSENG	10,3
		12	KEMANGGISAN	12
		13	KOTA BAMBU	10,5
		14	KEDOYA	7,9
		15	GLODOK	9,2
		16	SEMANAN	9,4
		17	JEMBATAN BESI	6,1
		18	KALI ANYAR	8,2
		20	RAWA BUAYA	7,2
		21	TANJUNG DUREN	7,4
20	RAWA BUAYA	1	CENGKARENG	4,7
		2	GROGOL	8,2
		3	PETAMBURAN	12,6
		4	TAMAN SARI	14,2
		5	KEBON JERUK	8,4
		6	KALIDERES	6,2
		7	PALMERAH	19,6
		8	KEMBANGAN	5,2
		9	JOGLO	13,6
		10	MERAYU	8
		11	SRENGSENG	8,4
		12	KEMANGGISAN	10,5
		13	KOTA BAMBU	10,1
		14	KEDOYA	6,6
		15	GLODOK	10,8
		16	SEMANAN	5
		17	JEMBATAN BESI	10,5
		18	KALI ANYAR	11
		19	KAPUK	7,2
		21	TANJUNG DUREN	9,8
21	TANJUNG DUREN	1	CENGKARENG	9,4
		2	GROGOL	2,6
		3	PETAMBURAN	5,6
		4	TAMAN SARI	8,5
		5	KEBON JERUK	5,1
		6	KALIDERES	12,6
		7	PALMERAH	10,8
		8	KEMBANGAN	8
		9	JOGLO	14,7
		10	MERAYU	8,8
		11	SRENGSENG	7,9
		12	KEMANGGISAN	5,1
		13	KOTA BAMBU	3,1
		14	KEDOYA	4,5
		15	GLODOK	7,1
		16	SEMANAN	12,8
		17	JEMBATAN BESI	3,5
		18	KALI ANYAR	4,1
		19	KAPUK	7,4
		20	RAWA BUAYA	9,8

Products distributed by PT XYZ are medicines in tablet form. The following product details are obtained, namely:

One sheet: 4 items
One carton: 30 kg, 64 boxes
One box: 25 sheets, 200 grams

Transportation Costs

Delivery of goods certainly requires costs in the form of transportation costs. Transportation costs consist of fixed costs and variable costs.

Fixed Cost

Costs Fixed costs are costs incurred by the company in a constant state or generally do not change even though there is an increase or decrease in the number of goods or services produced. In this study, which includes fixed costs, namely the cost for the vehicle driver.

For each delivery, each vehicle truck is delivered by the driver. Daily wages and overtime pay for drivers are included in the total fixed costs which are included in distribution costs in this study. The overtime pay applies to a multiple of two hours, if it is less than that time it is not considered.

Daily Wage: Rp. 172,000
Overtime pay: Rp. 49.711

Variable Cost

In this study, the variable cost of transportation is calculated from the cost of fuel used by the truck to distribute to the distribution center, namely:

Type of vehicle: Mitsubishi Colt Diesel FE71
Capacity: 2.3 tons or 2300 grams.
Fuel Price: Rp. 9400 / liter
Average Fuel Consumption: 24 liters / day
Cost per km: Rp. 391,67

Nearest Neighbour method

This following are steps for the method Nearest Neighbour.

a. Determine the Distributor Center. PT XYZ distributor center is located in Cengkareng City, in its completion Cengkareng City is marked with number 1.
b. After the distribution center is known, the next process is to look at the distribution center which has the shortest distance. Every time you reach a distribution center, this algorithm will choose the distribution center next that has not been visited and has the minimum distance after that. Table 4 is the optimal route that the author has obtained using the method Nearest Neighbour, namely:

Table 4. Optimal route of distribution center PT XYZ with Nearest Neighbour method

NO.	ROUTE	VEHICLE CAPACITY (KG)	DISTANCE (KM)
1	1,20,16,6,1	180	21,1
2	1,19,1	2300	10,1
3	1,8,10,11,14,5,1	2040	34,7
4	1,21,2,17,18,15,4,3,12,17,1	2190	49,7
5	1,9,1	540	23
6	1,13,1	2300	29,6
TOTAL		9550	168,2

Based on Table 4, the optimal route for product distribution at PT XYZ is divided into five routes, with a total distance of 168.2 km.

Next is calculating the total cost. The total cost for this distribution activity consists of the sum of fixed costs with variable costs. The total distance calculated by *Nearest Neighbour* method will then be multiplied by the variable cost of transportation. The assumption used by the author is that each route has a different car and all operating vehicles have overtime pay.

= (168.2 x 391.67) + (6 x 221,711)
= IDR. 1,330,266 + Rp. 65,878.89
= Rp. 1.396.145

Saving Matrix Method

Saving matrix

Distance between distribution center obtained in point 4.2 is then processed by calculating the largest savings matrix using the formula as described in point 2.3. Table 5 is the savings matrix that the author has calculated, namely:

Table 5. Savings Matrix

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FROM		SAVING MATRIX																					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
CODE	DISTRIBUTION CENTER	CENGKARENG	GROGOL	PETAMBURAN	TAMAN SARI	KEBON JERUK	KALIDERES	PALMERAH	KEMBANGAN	JOGLO	MERUYA	SRENGSENG	KEMANGISA	KOTA BAM	KEDOYA	GLODOK	SEMANAN	JEMBATAN	KALI AN	KAPUK	RAWA BUA	TANJUNG DUR	DEMAND
1	CENGKARENG																						
2	GROGOL			21,4	18	14,1	-4,6	21,2	9,4	6,7	11	12,4	18,5	21,3	14	17,8	6,3	24,4	18,9	8,6	7	17,3	30
3	PETAMBURAN				26,7	24,6	5,1	25,2	17,1	17,7	18,1	20	27,1	31,9	20,1	25,7	10	27,1	21,4	9,1	11,2	22,9	720
4	TAMAN SARI					13,9	0,4	19,9	9,3	8,7	10,9	12,3	21	23,9	11,1	27,2	5,9	24,8	19,5	8,3	5,3	15,7	120
5	KEBON JERUK						5	20,8	16,1	15,9	16,6	17,9	23,5	21,1	19,8	13,3	6,7	19,5	10,7	6,8	7,9	15,9	60
6	KALIDERES							5,4	5,5	6,9	6	5,5	5,3	7,9	6,2	4,5	10,6	10,9	4,5	2,6	6,1	4,4	60
7	PALMERAH								10,6	4,6	17	14,6	26,7	29,9	11,7	15,6	-0,2	16,5	11	0,2	0	13,5	390
8	KEMBANGAN									16,6	17,4	17,7	16,4	16,3	15	8,5	7,9	12,9	6,6	-3,5	9,2	11,1	480
9	JOGLO										16,2	15,6	12,7	11,8	11,2	6,9	3,4	11	4,6	-1,4	2,6	6,2	540
10	MERUYA											18,2	16,4	16,7	15,3	3,9	7,1	8	1,6	3,1	7,6	11,5	30
11	SRENGSENG												18,9	19,4	17,3	11,5	6,4	17,7	11,3	5,4	7,7	12,9	210
12	KEMANGGISAN													26,6	18,9	18,7	7,2	24,3	18,6	7,4	9,3	19,4	30
13	KOTA BAMBU														19,1	23,9	10,1	27,9	21,5	10,5	11,3	23	2580
14	KEDOYA															12,1	5,4	15,6	9,3	6,5	8,2	15	1260
15	GLODOK																7,2	25,8	22,6	9,6	8,4	16,8	120
16	SEMANAN																	10,8	4,4	2,5	7,3	4,2	60
17	JEMBATAN BESI																		26,8	14,8	10,8	22,5	60
18	KALI ANYAR																			7,4	5	16,6	30
19	KAPUK																				1,8	6,3	5940
20	RAWA BUAYA																					4,3	60
21	TANJUNG DUREN																						690

Iteration

After obtaining the savings matrix table, the next step is to search for the best route by iterating based on the order of the largest savings matrix values as shown in Table 6, with a note that the vehicle has a maximum limit of 2300 kg in its transportation activities.

Table 6. Sequence of Savings Matrix Value

NO.	(i,	j)	VALUE	DEMAND
1	3	13	31,9	3300
2	7	13	29,9	2970
3	13	17	27,9	2640
4	4	15	27,2	240
5	3	12	27,1	750
6	3	17	27,1	780
7	17	18	26,8	90
8	3	4	26,7	840
9	7	12	26,7	420
10	12	13	26,6	2610
11	15	17	25,8	180
12	3	15	25,7	840
13	3	7	25,2	1110

And so on until the 190th savings matrix

Iteration 1
Capacity 1 ➔ 3 ➔ 13
720 + 2580 = 3300 (Decline because over capacity)
Iteration 2
Capacity 1 ➔ 7 ➔ 13
390 + 2580 = 2970 (Decline because over capacity)
Iteration 3
Capacity 1 ➔ 13 ➔ 17
2970 + 60 = 2640 (Decline because over capacity)
Iteration 4
Capacity 1 ➔ 4 ➔ 15
120 + 120 = 240 (Approve)
Iteration 5
Capacity 1 ➔ 3 ➔ 4 ➔ 12 ➔ 15
720 + 120 + 30 + 120 = 990 (Approve)

This iteration calculation is carried out until the most optimal route is obtained that is in accordance with the vehicle's carrying capacity. The results obtained are:

Table 7. Optimal routes for distribution center PT XYZ with Saving Matrix method

NO.	ROUTE	VEHICLE CAPACITY (KG)	DISTANCE (KM)
1	1,4,15,3,5,7,12,17,18,1	2250	61,8
2	1,10,8,11,14,2,21,1	2010	39,8
3	1,6,9,16,20,1	720	45,2
4	1,13,1	2300	29,6
5	1,19,1	2300	10,1
TOTAL		9580	186,5

For the calculation of the total cost, the assumptions used by the author are that each route has a different car and each operating vehicle has an overtime pay.

Total Distribution Cost = *Total variable Cost* + *Total Fixed Cost*
= (186.5 x 391.67) + (5 x 221,711)
= Rp. 1,108,555 + Rp. 73,046
= Rp. 1,181,601

Comparison of the Results of the Nearest Neighbour Method with the Saving Matrix

After the two methods were carried out, the total cost for the Nearest Neighbour method was Rp. 1,396,145 with a total distance of 168.2 km. While the calculation using Saving matrix method obtained the optimum distance data of 186.5 km with a total cost of Rp. 1,181,601.

The saving matrix method has a total distance that is more than using the Nearest Neighbour method. This is because the cost of fixed costs in the Nearest Neighbour method has a higher value than the saving matrix method. The calculation of total costs is influenced by fixed costs and variable costs. The assumption used by the authors is that each route has a different car and each operating vehicle has an overtime pay. Because the Nearest Neighbour method has more routes than the saving matrix method, the expenditure made by this method is also greater.

Table 8. Percentage before and after using both methods

NO.	METHOD	NUMBER OF VEHICLE (UNIT)	DISTANCE (KM)	COST	PERCENTAGE
1	Before Using Method	8	200	Rp1.902.022	100%
2	Nearest Neighbour Method	6	168,2	Rp 1.396.145	73%
3	Saving Matrix Method	5	186,5	Rp 1.181.601	62%

After doing the calculations that have been done on both methods, the comparison results obtained from the Nearest Neighbour method and the saving matrix method which previously cost Rp.1,902,022, then after obtaining a fee of Rp.1,396,145 for the Nearest Neighbour method and for the method of saving matrix Rp. 1,181,601. With the costs that have been obtained, it can be concluded that from the two methods that the saving matrix method can obtain savings of 38% from the initial cost, so the saving matrix method can be used by XYZ Company to make distributions.

Conclusion

Conclusion

PT XYZ is a pharmaceutical company that produces various kinds of pharmaceutical goods and medical equipment. In addition, PT XYZ also acts as an agent and distributor of chemical raw materials for the pharmaceutical, cosmetic and food industries. PT XYZ has more than 21areas *Distribution Center*. Based on the results of data collection and processing that has been done, we can see that processing data is divided into two, namely primary and secondary data.

The results of data processing using the *Nearest Neighbour Method* show that the optimal route for product distribution at PT XYZ is divided into five routes, with a total distance of 168.2 km. Based on the results of calculations using the *Nearest Neighbour Method*, we can see that this method obtains total cost data of Rp. 1,396,145. Calculations using Saving matrix method obtained the optimum distance data of 186.5 with a total cost of Rp. 1,181,601.

Based on the data above, we are able to know that in one delivery process the distance is 186.2 km. the total distance travelled will affect the total cost to be generated. The calculation results show that the total cost for this distribution activity is Rp. 1,181,601. This cost consists of the sum of fixed costs with variable costs and the total distance that has been calculated by the saving matrix method.

Suggestions

Suggestions obtained are:

1. For further research, it is recommended to compare the results before and after using *Nearest Neighbour method* and saving matrix method.
2. For further research, it is hoped that there will be verification of the research results whether they are in accordance with the *real system* or not.

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