



Travelling Salesman Problem in The Case of Refined Sugar Shipment From Distribution Centers For the beverage Industries

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ABSTRACT

Travelling Salesman Problem (TSP) is one of the route management models with a higher level of complexity than the shortest path problem (SPP). In the logistic context, the distribution of products can be in the form of resources such as trucks, ships, aircraft, and other transportation fleets that can be completed with different settlement models. In TSP, researchers look for the shortest route that crosses all cities the product will be sent to and will end up in the city that first sent the product. The distribution of refined sugar that occurs is a problem that is not following its designation, causing the proposed creation of a distribution center to streamline the distribution of refined sugar to a beverage company that is closest to the processing plant and its delivery with the same truck trailer. with more structured through the formulation of a linear program for TSP with asymmetrical distance matrix. So that resulting in minimizes the distance distribution of refined sugar by trucks in distributing its products by 74.28%.

1. INTRODUCTION

Traveling Salesman Problem (TSP) is a Graph Theory application and is part of Operations Research. TSP is considered as a special case of transportation problems, with supply (bi supply), and demand (aj demand), one for each i and every j. TSP can also be considered as a special case of the assignment problem with n workers will only be filled by one worker and n jobs are assumed to be n destination cities, and the optimum results of the assignment problem must form a circuit, meaning that these workers must visit n-1 cities and return to the city of origin [1]. While Wibisono (2018) Traveling salesman problem can be interpreted as a problem setting the route for one resource to visit all service points without repetition and return to the starting point with a minimum total or cost. TSP is a classic problem, which emerged since 1800, but this problem will continue to be an interesting object of study. If the researches can solve TSP problems that have n millions, then the processes of routing, shipping, and other problems will be more

efficient to do [2]. Traveling Salesman Problems with Pickup and Delivery look for the minimum cost path by taking before shipping. This is important in long-distance logistics on-demand, such as travel sharing and food delivery [3]. Efforts to solve the CSR program in finding optimal solutions in a more structured way can be achieved through the formulation of a linear program, simulating and solving the problem of traveling salesman problem to get the shortest travel route [4].

The presence of sugar in Indonesia is generally used in two categories, namely for direct consumption (household) and indirect consumption (food and beverage industry). Sugar in Indonesia consists of white crystal sugar and refined crystal sugar. The sugar used for direct consumption is white crystal sugar (GKP), while refined crystal sugar (GKR) is used for the needs of the food and beverage processing industry. Refined sugar is a sugar that is processed from raw sugar raw materials (raw sugar) which goes through a more rigorous distillation, filtering, and cleaning process [5]. Based on

the Classification of Industrial Business Fields (KLUI), of all these industries there are 18 types of industries that use refined sugar as one of the raw materials. This competition is not only between domestic sugar user industries but also with food/beverage industries abroad which have greater opportunities to enter the domestic market with a 5% import duty facility [6].

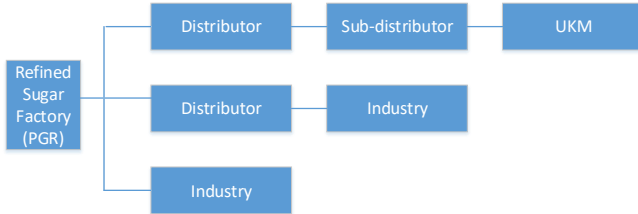


Figure 1. Refined Sugar Distribution Network

The distribution chain in refined sugar is as illustrated above, where raw materials originate from raw sugar importers and then are processed in refined sugar factories and distributed to industries and sub-distribution up to the final consumers of SMEs making food and beverages. The pattern of trade distribution illustrates the distribution chain of goods ranging from producers to consumers who have an important role in the community's economy, as a liaison between producers and consumers so that they can provide added value to the perpetrators. A good distribution chain can move an item from producer to the consumer at the lowest possible cost and can provide a fair share of the total price paid by consumers to all parties involved in it. (BPS 2016)[7]. A distribution warehouse is a warehouse where products from various suppliers are collected for delivery to each customer [8].

A distribution centre is a place that is used as a storage/warehouse and used as a source of meeting the needs of small traders in an area so that the selling price of products in the market becomes more competitive. In developing a distribution centre, warehouse location greatly influences distribution costs, the right location can minimize transportation costs [9]. It also needs to pay attention to the class of roads leading to the distribution centre especially if you are going to use container trucks to supply or distribute. A warehouse as a distribution centre (distribution centre) is used as a place for collecting and storing goods or products temporarily from a location (for example a factory) and then sent to several destination locations when needed. With a distribution centre, shipping costs will be cheaper than if shipping is done directly from the original location to several destination locations.

Transportation costs depend on the vehicle used in transportation from the sugar factory and the transportation of various types of sugar products through the distribution centre to refined sugar user companies. Because transportation resources are small, controlling all available facilities is important. Modern industrial distributors must be simultaneously reliable, flexible, and cost-conscious. Integrated decision making is needed to achieve the product distribution paradigm [8]. This study

aims to find the best route using the Traveling Salesman Problem (TSP). And get the minimum distance in distributing refined sugar to beverage companies around X province, which is closest to the distribution centre.

This research discusses the problem of Traveling Salesman Problem (TSP) for the distribution of refined sugar products that have been sent by processing companies to distribution centres so that it becomes the beginning of the distribution route arrangement to the ten beverage companies which have the closest distance to the company. Modes of transportation that will send refined sugar in the form of trucks with a large capacity. Where the contents of the truck must be balanced loading, so there is no build-up on one side of the truck. For the efficiency of the distance, the truck can only send to one point to the beverage company and the truck looks for the minimum distance to visit each or the whole beverage company that will be sent refined sugar, and after completion, the truck can return to the distribution centre and so on.

2. RESEARCH METHOD

2.1 Linear program formulation for TSP

Efforts to solve the TSP problem to find optimal solutions in a more structured way can be reached through linear program formulation, which can find optimal solutions more quickly. Linear program formulation for TSP based [10] written in the equation below is general and applies to symmetrical distance matrices ($c_{ij} = c_{ji}$). The variables used in the equation are as follows:

- N : the set of all points (nodes) in the problem
- N : |N| number of points in the problem
- C_{ij} : the cost of traveling from point i to point j, the bias is expressed in terms of distance
- X_{ij} : Binary decision variable that has a value of 1 if the segment ij is selected as a solution or value 0 if the segment ij is not selected
- \mathcal{S} : all possible subsets of N

$$\min \sum_{i=1}^N \sum_{j=1}^N c_{ij} x_{ij} \quad \text{--- (1)}$$

$$\text{st. } \sum_{i=1}^N x_{ij} = 1 \quad \forall j \quad \text{--- (2)}$$

$$\sum_{j=1}^N x_{ij} = 1 \quad \forall i \quad \text{--- (3)}$$

$$\sum_{i \in \mathcal{S}} \sum_{j \in \mathcal{S}} x_{ij} \leq |\mathcal{S}| - 1 \quad \forall \mathcal{S} \subset \mathcal{N}, |\mathcal{S}| \geq 2 \quad \text{--- (4)}$$

$$x_{ij} \in \{0,1\} \quad \forall i, j \quad \text{--- (5)}$$

In the formulation above the objective function is to minimize the total distance and limits on the regulated boundary, there can only be one shipment to one point while the other restriction can only be a departure from one predetermined point. In other words, it is a general requirement in TSPs that one point can only be passed once. The next limitation describes imaginary products

carried by trucks on their way or distribution around all service points. While the last boundary conditions indicate the nature of the decision variable whose value will be sought.

3. RESULT AND DISCUSSION

PT. XYZ is a high-quality white sugar refiner in Indonesia, known locally as double refined sugar, its products are made from high-quality raw sugar sourced from all over the world and its refining process complies with ISO 9001/2000 and ISO 22000/2005 international standards. Easy access in shipping because the position of the processing plant is very strategic to ensure the movement of products to be more efficient throughout industrial companies that in need.

Following is the distance matrix data that is displayed from the distribution centre after refined sugar is sent from the PT.XYZ processing plant.

Table 1. Data Matrix Distance of refined sugar delivery from the distribution centre to the beverage industry

	PT.1	PT.2	PT.3	PT.4	PT.5	PT.6	PT.7	PT.8	PT.9	PT.10
PT.1	0	14	12	1	11	12	19	4	20	16
PT.2	14	0	9	2	13	15	17	5	2	19
PT.3	12	9	0	6	2	15	14	11	3	19
PT.4	1	2	6	0	9	13	2	2	19	2
PT.5	11	13	2	9	0	7	18	9	4	6
PT.6	12	15	15	13	7	0	4	4	20	7
PT.7	19	17	14	2	18	4	0	15	1	8
PT.8	4	5	11	2	9	4	15	0	11	17
PT.9	20	2	3	19	4	20	1	11	0	20
PT.10	16	19	19	2	6	7	8	17	20	0

The results obtained based on the Excel Solver are as follows: The optimal distance of the truck sending refined sugar from the distribution centre to each beverage company is 27 units of distance, where the initial distance that the truck does in sending refined sugar products is 105 units of distance, the following is Excel Solver results with iteration 20 times and a permutation rate of 7.5%, and an integer tolerance value of 1%.

Result: Solver cannot improve the current solution. All Constraints are satisfied.

Solver Engine
 Engine: Evolutionary
 Solution Time: 51.453 Seconds.
 Iterations: 0 Subproblems: 85201

Solver Options
 Max Time Unlimited, Iterations 20, Precision 0.000001, Use Automatic Scaling
 Convergence 0.0001, Population Size 100, Random Seed 0, Mutation Rate 0.075, Time w/o Improve 30 sec, Require Bounds
 Max Subproblems Unlimited, Max Integer Sols Unlimited, Integer Tolerance 1%, Assume NonNegative

Objective Cell (Min)

Cell	Name	Original Value	Final Value
\$N\$12	Cost	105	27

Figure 2. Excel Solver Answer Results

The route for distributing refined sugar formed by obtaining a minimum total distance is a truck starting from PT.7 which will be considered as a distribution centre and then will continue the journey to PT.9 then to PT.8 then to PT.6 and so on. The portrayal of the route can be seen in the following table.

Table 2. The optimal route and distance distribution of refined sugar

	PT.1	PT.2	PT.3	PT.4	PT.5	PT.6	PT.7	PT.8	PT.9	PT.10
PT.1			0							
PT.2					2					
PT.3										6
PT.4				2						
PT.5		2								
PT.6									2	
PT.7							1			
PT.8						4				
PT.9								4		
PT.10	4									

By the results of the solver below, in this case, the distribution and distance for PT.2 send refined sugar to PT.5 or vice versa due to the use of symmetrical material in the formulation written earlier. Or Truck from PT. 8 will send refined sugar to PT. 6 and will continue to PT. 9 and from PT. 9 will end at PT. 8.

Table 3. Results of Population Report Distribution of Refined Sugar with a 10x10 Matrix

Cell	Name	Best Value	Mean Value	Standard Deviation	Maximum Value	Minimum Value
SMS2	PT.1 PT	3	4.02	3.452359755	10	1
SMS3	PT.2 PT	5	5.65	1.844319699	10	4
SMS4	PT.3 PT	10	6.91	2.81085558	10	3
SMS5	PT.4 PT	4	6.66	1.747841382	10	1
SMS6	PT.5 PT	2	6.02	2.597512407	9	2
SMS7	PT.6 PT	9	6.21	2.543738599	9	1
SMS8	PT.7 PT	7	6.31	1.481842969	8	2
SMS9	PT.8 PT	6	6.38	3.106786316	10	2
SMS10	PT.9 PT	8	5.71	2.046406064	10	2
SMS11	PT.10 PT	1	1.13	0.799684281	7	1

4. CONCLUSION

Routing for a single source or distribution centre to visit all service points of a sign of repetition and return to the original point in the Traveling Salesman. The problem in this research case resulted in a total minimization of the distance of 27 units of distance. Which was solved by using the help of Excel Solver with iteration 20 times and a permutation rate of 7.5%, and an integer tolerance value of 1%. So that resulting in minimizes the distance distribution of refined sugar by trucks in distributing its products by 74.28%.

Suggestions for further research are to integrate Traveling Salesman Problem (TSP) with Genetic algorithm (GA) so that the formulation of bias problems is more complex with wider city distance data.

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