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Research Paper

Products Distribution from Suppliers to Retailers in Bandarlampung City (Case Study: Retailers location in Teluk Betung)

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Abstract
Traveling Salesman Problem(TSP) is a problem where a salesman visits cities, each city is connected, and there are weights to move between cities, thus forming a complete weighted graph. The objective of the TSP is to determine all city routes with the lowest total weight. Cheapest Insertion Heuristic (CIH), one of the algorithms to solve TSP. This algorithm provides different travel routes depending on the order of city elimination on the subtour in question. In this study, the CIH algorithm will be discussed to determine the shortest route for distribution of goods from suppliers to several retailers in the city of Bandarlampung, especially for 23 retailers whose locations in Teluk Betung sub-district. The result shows that the total distance travel from the supplier to the 23 retailers and then back to the supplier location is 34.84 km.

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1. INTRODUCTION

Distribution can be interpreted as a marketing activity that seeks to expedite and facilitate delivery of goods and services from producers to consumers, so that their use is in accordance with what is needed (type, quantity, price, place, and when needed). Distribution channel is a route or series of intermediaries, both managed by marketers and independent, in delivering products from producers to consumers [1]. One of the factors that greatly affects the distribution channel is the route of delivery of goods which must be efficient in saving costs and time. The distribution route of goods from suppliers can be formed with a graph, where the suppliers and retailers are represented by nodes or vertices, while the road that connects between two locations are represented by edges [2].

The Traveling Salesman Problem (TSP) is an optimization problem and has a wide search space and is said to be NP-hard, which means it cannot be solved in polynomial time [3, 4, 5]. The TSP is applied in many fields today. One of its applications is to determine the shortest route from a to its retailer. In simpler words, suppose we have n cities, then we can get $(n-1)!$ alternate route to cover all n cities. In TSP, we have to determine the sequence of routes from a number of cities that must be passed by the salesman where each city may only be passed once in his journey, and the trip must end at the city of departure where the salesman begins his journey. Salesmen must minimize expenses/distance that must be traveled for their journey [6].

The optimal solution to this TSP problem will greatly assist companies in the field of goods delivery to streamline the goods delivery process, both in terms of cost and time. In determining the shortest route there are many algorithms that can be used. Selection of the most optimal algorithm is one of the problems because each algorithm has its advantages and disadvantages. An algorithm is a sequence of steps (instructions) that are systematically organized to solve a problem [7]. To To determine the TSP, there are several algorithms that can be used, including Nearest Neighbor Heuristics, Particle Swarm Optimization (PSO), Brute and Force Method, Genetis Algorithms, Cheapest Insertion Heuristic (CIH) and others. Kurniawan et al. [8] solved the TSP using Particle Swarm Optimization (PSO) and Brute Force, utilizing data with up to 30 vertices. To solve the TSP, Violina [9] employed the Brute Force technique and Branch and Bound. Because it computes every possibility, the Brute and Force answer

Table 1. Distance of Five Cities

	A	B	C	D	E
A	0	1	3	5	2
B	1	0	2	4	3
C	3	2	0	3	2
D	5	4	3	0	5
E	2	3	2	5	0

Table 2. The Iteration of CIH for Five Cities

Iteration	Subtour	Total Weight	$\|E\| = n$?	Lines/Edges Candidates to be Selected	Calculation of Tour Length	New Subtour
0	A-B-C-A	6	No	A-B = 1		
				B-C = 2		
				C-A = 3		
1	A-B-C-A	6	No	A-E = 2	A-E = 6 - 3 (AC) + 2 + 2 (CE) = 7	A-B-C-E-A
				B-E = 3	B-E = 6 - 2 (BC) + 3 + 2 (CE) = 9	
				C-E = 2	C-E = 6 - 3 (CA) + 2 + 2 (AE) = 7	
2	A-B-C-E-A	7	No	A-D = 5	A-D = 7 - 2 (BC) + 5 + 5 (ED) = 15	
				B-D = 4	B-D = 7 - 2 (BC) + 4 + 3 (CD) = 12	
				C-D = 3	C-D = 7 - 2 (BC) + 3 + 4 (BD) = 12	A-B-C-D-E-A
				E-D = 5	E-D = 7 - 2 (EC) + 5 + 3 (CD) = 13	
3	A-B-C-D-E-A	12	Yes			

is always the best but takes a lengthy time. However, because Branch and Bound does not calculate every possibility, it finds the best answer faster. The Nearest Neighbour Heuristic used by [10, 11, 12, 13]. Doumi et al [14] solve the TSP using Genetic Algorithms. The Cheapest Insertion Heuristic is used for finding product distribution by [15, 16, 17], To illustrated the problem, 5 cities as simple example is used by [18]. For more survey about TSP can be found in [19, 20].

In this study we use the Cheapest Insertion Heuristic(CIH) to determine the shortest route from The supplier in Tanjung Bintang to twenty three (23) retailers in Teluk Betung District, Bandarlampung City.

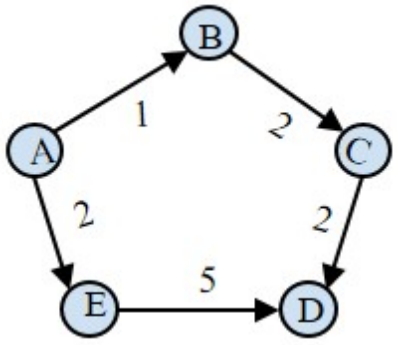

Figure 1. The TSP of Five Cities

2. METHODS

2.1 The Cheapest Insertion Heuristics (CIH)

The CIH starts by making a tour from of two nearest point or nodes. In our method, we do make changes by making tour of three nearest nodes. The following is the steps of CIH:

Step 1: The search begins by determining the 3 points that have the shortest distance and adding up the distance between the 3 points (total weight).

Table 3. The Information of Locations of The Supplier (X) and Retailers (X to W)

Node	Retailer	Location
A	Retailer 1	Wolter Monginsidi Rd. No.159 K, Pengajaran, North Teluk Betung District, Bandarlampung, Lampung 35215
B	Retailer 2	Wolter Monginsidi Rd., Gulak Galik, North Teluk Betung District, Bandarlampung, Lampung 35213
C	Retailer 3	Gedong Pakuon, South Teluk Betung District, Bandarlampung, Lampung 35211
D	Retailer 4	Citra Garden Rd. Block CW7 No.008, Negeri Olok Gading, West Telung Betung District, Bandarlampung, Lampung 35223
E	Retailer 5	Negeri Olok Gading, West Telung Betung District, Bandarlampung, Lampung 35223
F	Retailer 6	Kh. Hasyim Ashari Rd. No.44, Gedong Pakuon, South Teluk Betung District, Bandarlampung, Lampung 35224
G	Retailer 7	Ikan Tenggiri Rd., Pesawahan, South Teluk Betung District, Bandarlampung, Lampung 35221
H	Retailer 8	Wolter Monginsidi Rd, Talang, South Teluk Betung District, Bandarlampung, Lampung 35221
I	Retailer 9	Patimura Rd. No.131, South Teluk Betung District, Kota Bandarlampung, Lampung
J	Retailer 10	Wolter Monginsidi Rd. No.L 009, Gotong Royong, South Teluk Betung District, Bandarlampung, Lampung 35211
K	Retailer 11	Wolter Monginsidi, Pengajaran, South Teluk Betung District, Bandarlampung, Lampung 35213
L	Retailer 12	KH. Ahmad Dahlan Rd. No.156, Kupang Teba, North Teluk Betung District, Bandarlampung, Lampung 35212
M	Retailer 13	Salim Batubara Rd., Kupang Teba, North Teluk Betung District, Bandarlampung, Lampung 35212
N	Retailer 14	Gulak Galik, North Teluk Betung District, Bandarlampung, Lampung 35225
O	Retailer 15	Gulak Galik, North Teluk Betung District, Bandarlampung, Lampung 35212
P	Retailer 16	Dr. Cipto Mangunkusumo Rd. No.40, Sumur Batu, North Teluk Betung District, Bandarlampung, Lampung 35212
Q	Retailer 17	Dokter Susilo Rd.No.56, Pahoman, North Teluk Betung District, Bandarlampung, Lampung 35212
R	Retailer 18	Pahoman, North Teluk Betung District, Bandarlampung, Lampung 35228
S	Retailer 19	Gatot Subroto Rd., Pecoh Raya, South Teluk Betung District, Bandarlampung, Lampung 35226
T	Retailer 20	Ikan Kakap Rd. No.41, Pesawahan, South Teluk Betung District, Bandarlampung, Lampung 35221
U	Retailer 21	Laks. Malahayati Rd, South Teluk Betung District, Bandarlampung, Lampung 35221
V	Retailer 22	Banten Rd. No.26, Bakung, West Teluk Betung District, Bandarlampung, Lampung 35223
W	Retailer 23	Laksamana R.E.Martadinata Rd., Pesawahan, South Teluk Betung District, Bandarlampung, Lampung
X	Supplier	Tembesu Rd. No.8, Campang Raya, Sukabumi District, Bandarlampung, Lampung 35244

Table 4. The Distance Between Locations (in Km)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
A	0	0.29	0.75	2.7	3.1	2.2	2.2	1.4	2.6	1	1.1	3	2.4	1.6	0.85	2.5	2.7	2.9	3.3	3.3	2.5	3.6	2.8	11
B	0.29	0	0.6	2.5	2.9	2	2.2	1.1	2.2	1.3	1.4	2.7	2.1	1.7	0.85	2	3	3.2	3.5	2.4	2.2	3.4	2.5	11
C	0.75	0.6	0	2	2.3	1.3	2	1.4	2.6	1.8	1.9	2.9	2.3	2	1.4	2.5	3.4	3.7	4	2.2	1.7	2.4	2	11
D	2.7	2.5	2	0	0.35	1.2	2	1.9	3.5	3.8	3.9	4.1	3.5	3.1	3.3	4.4	5.4	5.7	6	2.3	1.5	1.4	1.7	12
E	3.1	2.9	2.3	0.35	0	1.6	2.4	2.3	3.9	4.1	4.2	4.4	4.4	3.5	3.7	6	5.8	6	6.4	2.7	1.9	1.8	2.1	13
F	2.2	2	1.3	1.2	1.6	0	0.8	1.4	3	3.2	3.3	3.5	3	2.6	2.8	4.2	4.1	4.2	4.4	1.1	0.27	1.6	0.6	11
G	2.2	2.2	2	2	2.4	0.8	0	0.85	2.2	3.3	3.4	2.8	2.2	1.8	2.8	3.5	3.3	3.5	3.7	0.3	0.5	1.7	0.4	10
H	1.4	1.1	1.4	1.9	2.3	1.4	0.85	0	2	2.4	2.5	2.5	1.9	1.5	2	3	3.7	3.9	4.2	1.3	1.3	2.8	1.30	11
I	2.6	2.2	2.6	3.5	3.9	3	2.2	2	0	3.8	3.6	1.1	1.3	1.3	1.7	2.4	3.1	2.7	2.9	0.95	1.8	2.9	1.7	9.7
J	1	1.3	1.8	3.8	4.1	3.2	3.3	2.4	3.8	0	0.11	3.8	3.2	2.5	1.9	2.7	2.8	3.1	3.4	4.5	0.11	4.6	3.8	10
K	1.1	1.4	1.9	3.9	4.2	3.3	3.4	2.5	3.6	0.11	0	3.7	3.1	2.4	2	2.5	2.5	2.7	3	4.6	3.6	4.7	3.9	9.9
L	3	2.7	2.9	4.1	4.4	3.5	2.8	2.5	1.1	3.8	3.7	0	0.55	1.3	2.1	1.2	1.4	1.5	1.7	1.6	2.4	3.8	2.4	8.1
M	2.4	2.1	2.3	3.5	4.4	3	2.2	1.9	1.3	3.2	3.1	0.55	0	0.75	1.5	1.7	1.9	2.1	2.3	1.8	2.6	4.1	2.5	8.7
N	1.6	1.7	2	3.1	3.5	2.6	1.8	1.5	1.3	2.5	2.4	1.3	0.75	0	0.75	1.4	2.1	2.3	2.7	2	2.5	3.7	2.4	10
O	0.85	0.85	1.4	3.3	3.7	2.8	2.8	2	1.7	1.9	2	2.1	1.5	0.75	0	1.2	1.8	2	2.3	2.7	3.1	4.2	3.3	9.6
P	2.5	2	2.5	4.4	6	4.2	3.5	3	2.4	2.7	2.5	1.2	1.7	1.4	1.2	0	2	2.2	2.4	2.8	3.6	5	3.5	8.8
Q	2.7	3	3.4	5.4	5.8	4.1	3.3	3.7	3.1	2.8	2.5	1.4	1.9	2.1	1.8	2	0	0.26	0.55	3	3.8	5.2	3.7	8.2
R	2.9	3.2	3.7	5.7	6	4.2	3.5	3.9	2.7	3.1	2.7	1.5	2.1	2.3	2.1	2.2	0.26	0	0.7	3.2	4	5.4	3.9	7.1
S	3.3	3.5	4	6	6.4	4.4	3.7	4.2	2.9	3.4	3	1.7	2.3	2.7	2.3	2.4	0.55	0.7	0	3.4	4.2	5.6	4.1	6.4
T	3.3	2.4	2.2	2.3	2.7	1.1	0.3	1.3	0.95	4.5	4.6	1.6	1.8	2	2.7	2.8	3	3.2	3.4	0	0.8	0.9	0.7	10
U	2.5	2.2	1.7	1.5	1.9	0.27	0.5	1.3	1.8	0.11	3.6	2.4	2.6	2.5	3.1	3.6	3.8	4	4.2	0.8	0	1.3	0.4	11
V	3.6	3.4	2.4	1.4	1.8	1.6	1.7	2.8	2.9	4.6	4.7	3.8	4.1	3.7	4.2	5	5.2	5.4	5.6	0.9	1.3	0	1.3	12
W	2.8	2.5	2	1.7	2.1	0.6	0.4	1.30	1.7	3.8	3.9	2.4	2.5	2.4	3.3	3.5	3.7	3.9	4.1	0.7	0.4	1.3	0	11
X	11	11	11	12	13	11	10	11	9.7	10	9.9	8.1	8.7	10	9.6	8.8	8.2	7.1	6.4	10	11	12	11	0

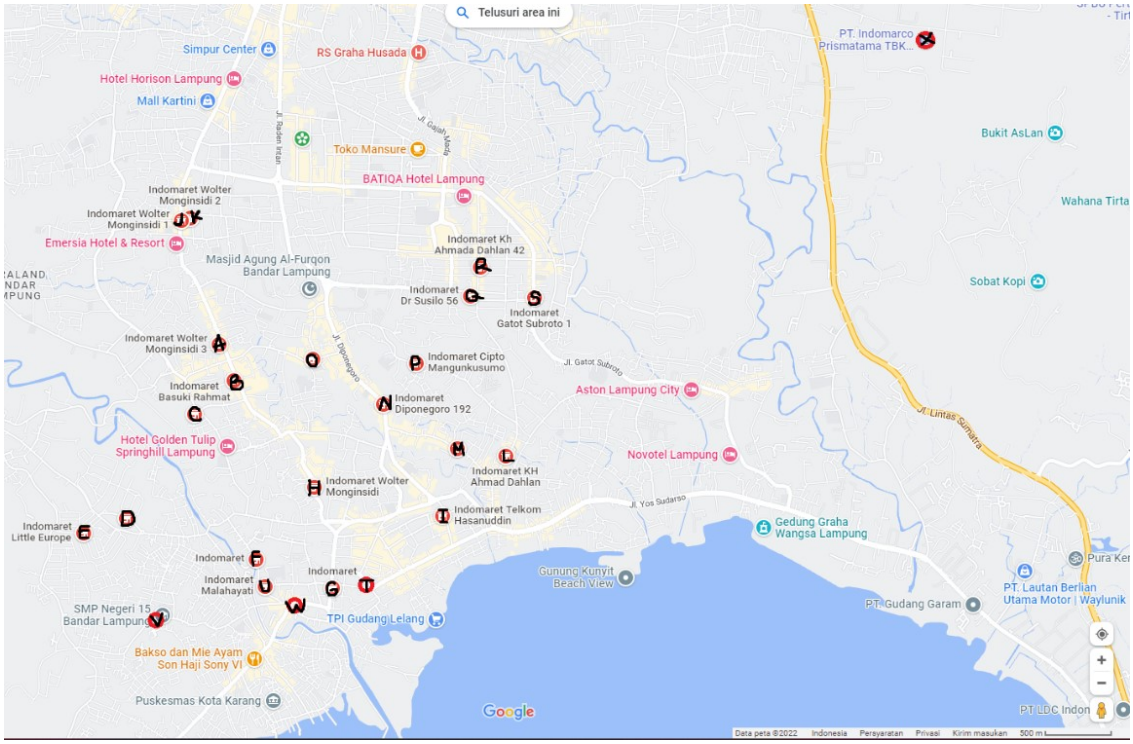

Figure 2. The Map of Supplier (X) and its 23 Retailers (A - W)

Table 5. The Iteration of CIH for Five Cities

Iteration	Subtour	Total Weight	$\|E\| = n$?	Lines/Edges Candidates to be Selected	Calculation	New Subtour
0	T-G-U-T	1,6	No	T-G = 0.3	0.3 + 0.5 + 0.8 = 1.6	
				G-U = 0.5		
				U-T = 0.8		
1	T-G-U-T	1,6	No	G-F = 0.8	G-F = 1.6 − 0.5 + 0.8 + 0.27 (FU) = 2.17	T-G-F-U-T
				T-V = 0.9	T-V = 1.6 − 0.8 + 0.9 + 1.3 (VU) = 3	
				U-J = 0.11	U-J = 1.6 − 0.8 + 0.11 + 4.5 (TG) = 5.41	
2	T-G-F-U-T	2,17	No	G-W = 0.4	G-W = 2.17 − 0.8 + 0.4 + 0.6 (FW) = 2.37	T-G-W-F-U-T
				F-W = 0.6	F-W = 2.17 − 0.8 + 0.6 + 0.4 (WU) = 2.37	
				U-W = 0.4	U-W = 2.17 − 0.8 + 0.4 + 0.8 (TW) = 2.87	
				T-W = 0.7	T-W = 2.17 − 0.8 + 0.7 + 0.4 (GW) = 2.47	
3	T-G-W-F-U-T	2,37	No	T-V = 0.9	T-V = 2.37 − 0.8 + 0.9 + 1.3 (VU) = 3.77	T-G-W-F-U-V-T
				G-H = 0.85	G-H = 2.37 − 0.4 + 0.85 + 1.3 (WH) = 4.12	
				W-V = 1.3	W-V = 2.37 − 0.6 + 1.3 + 1.6 (FV) = 4.67	
				F-D = 1.2	F-D = 2.37 − 0.6 + 1.2 + 1.7 (WD) = 4.67	
				U-J = 0.11	U-J = 2.37 − 0.8 + 0,11 + 4.5(TJ) = 6.18	

Step 2: Find the candidate lines/edges to be selected to be merged in the new tour.

Step 3: Calculate each candidate lines that has been selected, using the formula: total weight − line weight to be removed + line weight to be added + line weight connecting the removed point and the added point.

Step 4 : Find the smallest value weight of the candidate lines that has been calculated.

Step 5 : Create new tour with the selected line. Repeat the steps above until all points are on the tour.

To illustrate the CIH method, suppose there are 5 cities depicted in Figure 1. Table 1gives information about the distances of five cities.

To simplify the steps of CIH, the result of that example is put in Table 2. Table 2 displays the iterations, temporary tour, the weight of the tour, the removed and added edges, and the final tour obtained for the example given

Table 2 displays the iterations, temporary tour, the weight of the tour, the removed and added edges, and the final tour obtained for the example given. For thisexample, the total distance of TSP is 12 with the tour is A-B-C-D-E-A.

2.2 The Data

Table 3 shows the information about the locations of the supplier (X) and the 23 retailers (A to W). Note that not all retailers on that area are taken into account. Two or more retailers whose distance are very. In this case study, it is assumed that a vehicle used to distribute these goods uses a large box truck capable of supplying 23 retailers in one go.

3. RESULTS AND DISCUSSION

Implemented the CIH into the data on Table 4, we get the result that simplify on Table 5. Table 5 shows the first three iteration in detail. Due to the space limitation, the process calculation is removed in Table 6 and replaced by Adding line/Edge to simplify the table.

Table 6. The All Iterations of CIH

Iteration	Subtour	Total Weight	$\|E\| = n$?	Added Line/ Edge	Discarded line	Total Weight after Addition	New Subtour
1	T-G-U-T	1.6	No	GF (0,8) FU (0,27)	G-U	2.17	T-G-F-U-T
2	T-G-F-U-T	2.17	No.	GW (0,4)FW (0,6)	G-F	2.37	T-G-W-F-U-T
3	T-G-W-F-U-T	2.37	No	TV (0,9) VU (1,3)	T-U	3.77	T-G-W-F-U-V-T
4	T-G-W-F-U-V-T	3.77	No	VD (1,4) DU (1,3)	U-V	5.37	T-G-W-F-U-D-V-T
5	T-G-W-F-U-D-V-T	5.37	No	VE (1,8) ED (0,35)	D-V	6.12	T-G-W-F-U-D-E-V-T
6	T-G-W-F-U-D-E-V-T	6.12	No	UH (1,3) DH (1,9)	U-D	7.82	T-G-W-F-U-H-D-E-V-T
7	T-G-W-F-U-H-D-E-V-T	7.82	No	DC(2)HC(1.4)	H-D	9.32	T-G-W-F-U-H-C-D-E-V-T
8	T-G-W-F-U-H-C-D-E-V-T	9.32	No	HB (1,1) BC (0,6)	H-C	9.62	T-G-W-F-U-H-B-C-D-E-V-T
9	T-G-W-F-U-H-B-C-D-E-V-T	9.62	No	BA (0,29)HA (1,4)	H-B	10.21	T-G-W-F-U-H-A-B-C-D-E-V-T
10	T-G-W-F-U-H-A-B-C-D-E-V-T	10.21	No	AO (0,85) HO (2)	H-A	11.66	T-G-W-F-U-H-O-A-B-C-D-E-V-T
11	T-G-W-F-U-H-O-A-B-C-D-E-V-T	11.66	No	HN (1,5) ON (0,75)	H-O	11.91	T-G-W-F-U-H-N-O-A-B-C-D-E-V-T
12	T-G-W-F-U-H-N-O-A-B-C-D-E-V-T	11.91	No	HM (1,9) MN (0,75)	H-N	13.06	T-G-W-F-U-H-M-N-O-A-B-C-D-E-V-T
13	T-G-W-F-U-H-M-N-O-A-B-C-D-E-V-T	13.06	No	ML (0,55) HL (2,5)	H-M	14.21	T-G-W-F-U-H-L-M-N-O-A-B-C-D-E-V-T
14	T-G-W-F-U-H-L-M-N-O-A-B-C-D-E-V-T	14.21	No	LI (1,1) HI (2)	H-L	14.81	T-G-W-F-U-H-I-L-M-N-O-A-B-C-D-E-V-T
15	T-G-W-F-U-H-I-L-M-N-O-A-B-C-D-E-V-T	14.81	No	UJ (0,11) JH (2,4)	U-H	16.02	T-G-W-F-U-J-H-I-L-M-N-O-A-B-C-D-E-V-T
16	T-G-W-F-U-J-H-I-L-M-N-O-A-B-C-D-E-V-T	16.02	No	HK (2,5) JK(0,11)	H-J	16.23	T-G-W-F-U-J-K-H-I-L-M-N-O-A-B-C-D-E-V-T
17	T-G-W-F-U-J-K-H-I-L-M-N-O-A-B-C-D-E-V-T	16.23	No	NP (1,4) OP (1,2)	N-O	18.08	T-G-W-F-U-J-K-H-I-L-M-N-P-O-A-B-C-D-E-V-T
18	T-G-W-F-U-J-K-H-I-L-M-N-P-O-A-B-C-D-E-V-T	18.08	No	OQ (1,8) PQ (2,2)	O-P	20.88	T-G-W-F-U-J-K-H-I-L-M-N-P-Q-O-A-B-C-D-E-V-T
19	T-G-W-F-U-J-K-H-I-L-M-N-P-Q-O-A-B-C-D-E-V-T	20.88	No	QR (0,26) PR (2,2)	P-Q	21.14	T-G-W-F-U-J-K-H-I-L-M-N-P-R-Q-O-A-B-C-D-E-V-T
20	T-G-W-F-U-J-K-H-I-L-M-N-P-R-Q-O-A-B-C-D-E-V-T	21.14	No	PS (2,4) SR (0,7)	P-R	22.04	T-G-W-F-U-J-K-H-I-L-M-N-P-S-R-Q-O-A-B-C-D-E-V-T
21	T-G-W-F-U-J-K-H-I-L-M-N-P-S-R-Q-O-A-B-C-D-E-V-T	22.04	No	PX (8,8) SX (6,4)	P-S	34.84	T-G-W-F-U-J-K-H-I-L-M-N-P-X-S-R-Q-O-A-B-C-D-E-V-T
22	T-G-W-F-U-J-K-H-I-L-M-N-P-X-S-R-Q-O-A-B-C-D-E-V-T	34.84	Yes				X-S-R-Q-O-A-B-C-D-E-V-T-G-W-F-U-J-K-H-I-L-M-N-P-X

4. CONCLUSIONS

Based on the Results and Discussion above, we can conclude that the best tour gained using the CIH method is from the supplier to 23 retails in sub-district Teluk Betung, Bandarlampung City is from Supplier → Retailer 19 → Retailer 18 → Retailer 17 → Retailer 15 → Retailer 1 → Retailer 2 → Retailer 3 → Retailer 4 → Retailer 5 → Retailer 22 → Retailer 20 → Retailer 7 → Retailer 23 → Retailer 6 → Retailer 21 → Retailer 10 → Retailer 11 → Retailer 8 → Retailer 9 → Retailer 12 → Retailer 13 → Retailer 14 → Retailer 16 → Supplier with the total distance travel is 34.84 km.

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