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The Reduction of Transportation Cost in Transportation Company by Evolutionary methods

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Abstract *- The objective of this research is to study and solve the problem of transportation route management by a heuristic method. From studying the working process before improvement, the transportation company works with random truck routes, which is compared to last month's route reference. The results show that the company's original work resulted in an average goods volume of only 21.69 cubic meters on a truck, with a total distance of 13,680 kilometers. This research has adopted the Nearest Neighbor Approach and Evolutionary functions in Excel Solver. From the routing results, it was found that Evolutionary methods provide better results than the closest neighbor methods. When compared to the original data of the company, the total distance after the adjustment has been reduced from 13,680 kilometers to a total distance of 10,468.12 kilometers. From the application of the heuristic method of truck routes, it was found that the area used on the trucks after the improvement was able to increase the average production volume from 21.69 cubic meters to 29.83 cubic meters.*

Keywords — *Heuristic method, Increase performance, Transportation Routing*

I. INTRODUCTION

The company was engaged in the logistics service business with a focus on building customer service satisfaction. The company was also engaged in the land transport service business. Studies of good transportation management contribute significantly to customer service satisfaction. In addition, the company received a maximum benefit for business operations. Therefore, the company analyzed transportation factors with good management and found that the company's current net volume transported per vehicle makes up 59.43 percent of the total volume of goods transported, which directly affects the company and the company's operating costs due to the diversity of products and unequal transport volume for customers.

In addition, work from multiple sections beginning with the product delivery process, the truck loading process, and the palette loading process have effects on current problems. The company in the current case study transported automobile products and parts. Transportation service providers should be able to meet customer needs on schedule with no damage to transported products and quality in order to create the most satisfaction for customers. Trucks were divided into 6-wheeled trucks and 10-wheeled trucks, with the mean transportation volume shown in Table I.

TABLE I: SUMMARY OF THE COMPANY'S TOTAL DISTANCE AND MEAN PRODUCT VOLUME

Truck	routes /day	routes/day (m^3/day)	average (m^3/truck)	Percentage by volume of loading
6 wheel	83	1,789.21	21.56	59.06
10 wheel	17	379.91	22.35	61.23
Total	100	2,169.12	21.69	59.43
Total distance		13,680 km		

II. NEAREST NEIGHBOR HEURISTIC METHOD

The Nearest Neighbor Heuristic Method is the division of groups to seek a route that uses the principle of trying to run to the closest point with the following selection steps:

Step 1 – Start from the desired starting point by beginning travel time at zero for every route.

Step 2 – Select the route with the shortest distance.

Step 3 – Select a point close to the destination in Step 2 to go to the closest point, not only the selected route.

Step 4 – Total travel distance from the old destination from Step 2 to the new destination from Step 3 is the total travel distance of that route.

Step 5 – Follow Steps 2 to 4 until every point has been selected and select the route with the lowest score.

Step 6 – If the distance is not appropriate, select a new route.

III. SOLVING LINEAR SCHEDULING PROBLEMS WITH EXCEL SOLVER

After creating a linear program model, the next step is processing models to seek the most appropriate solution. In practice, a selected software can be usedprocess results on this topic. Using Microsoft Excel Solver is recommended to process the linear program model. The Standard Excel Solver that comes with Microsoft Excel can be used with no more than 200 deciding variables and

100 limitations. The method for using Microsoft Excel Solver as a solver for linear program problems was demonstrated [1-3] as a linear programming calculation instrument that will help to optimize responses from limits or conditions. Solvers are add-ins for analyzing problems with the need for the best response or outcome. Normally, solvers cannot search for the best outcome because they will provide the best outcome within a certain scope or a specified time. However, in practice or from the view of decision-making, whether the outcome is the best outcome or not or the best outcome within a scope is not an important issue as long as the outcome, which enables better operation with the objective function, was obtained.

The following 3 methods were the best for determining results:

1. The Simplex LP method: it was used to solve linear models, including models that require certain cells or every cell for decision-making to be integers and/or binary numbers.

2. The Generalized Reduced Gradient (GRG) Nonlinear method: it was used to solve linear models when objective cells (cells that show objective values) and enforced conditions are continuous and gradually changing functions of deciding cells.

3. The Evolutionary method: it was used to solve difficult problems requiring good results (as close to the best result as possible), including problems in which objective cells and/or enforced conditions are functions with non-constant values or values without gradual changes in model decision-making cells to determine the best possible answer for linear models when objective cell values are linear functions of decision-making cells. Meta-heuristic methods are currently used rather than the Excel Solver program to solve engineering problems such as ant colony optimization [4], migrating birds optimization algorithm [5], fish algorithm [6], artificial bee colony algorithm [7-8], firefly algorithm [9], grey wolf optimization [10], sine cosine optimization, thermal exchange optimization [11], biogeography-based optimization algorithm [12] and elevator kinematic optimization [13], etc.

From the aforementioned problems, the compilers had a concept to determine guidelines to modify transport routes by studying and analyzing the problem with a cause and effect diagram along with studying work processes to analyze the true cause of problems. The heuristic method was used to determine appropriate work orders and organizing transport routes to increase the mean volume carried in trucks, which will reduce operating costs and expenses. In the study, the following works used the aforementioned methods to solve problems:

Clarke G & Wright J. [14] proposed the Nearest Neighbor Algorithm and the Saving Algorithm, which considered route organization based on the needs of multiple customers and vehicle capacity in order to select the best route with one single exit point for delivering products.

Zheng Wang [15] studied vehicle routing problems with drones (VRDP) to augment vehicle routing. In addition to using vehicles, drones can be used to deliver goods to customers. The unique feature of vehicle routing problems with drones was that they could be used for traveling with delivery vehicles and fly from the parking space to deliver goods to customers and return to travel with other vehicles. Under conditions of flight limitations and load capacity, a mixed-integer programming model was presented, and a branch-and-price algorithm was developed. The outcome from experimenting with a randomly created sample in a real working environment showed the effectiveness of the aforementioned algorithm calculations, including analysis of the sensitivity of factors with effects on overall costs.

Annelieke C. Baller [16] applied the vehicle routing problem to vehicle route management by vehicle routing with partial outsourcing (VRPPO). Customers received services from the agency’s transportation unit or outsourced basic transportation or a combination between the agency’s transportation units and outsourced basic transportation with the objective of stabilizing costs and minimizing fluctuating costs created by the agency’s transportation unit and outsourced basic transportation.

According to José Ruiz-Meza [17], increases in supply chain transportation created a complex need to allocate transportation routes by considering different variables and environments. Vehicle routing problem (VRP) models were an effective instrument in solving low, medium, and high complexity transportation routing problems. Vehicle routing models were developed under conditions of strict timeframes, multiple warehouses, products, and different vehicles in order to have the shortest transportation distance. The aforementioned vehicle routing model was then applied to a case study of a company distributing bottled water and water packs by distributing products using product delivery schedules analyzed by a Pareto Diagram. Calculations were able to reduce the distance to 35.08 percent of the current route.

According to Edoardo Fadda [18], the objective of the traveling salesman problem (TSP) model with multiple random routes is Hamilton’s tour specifications with expectations of minimum costs. In networks with different routes between each node pair, this problem was proven to be estimable when route travel costs are free and spread evenly.

According to Stoilova and T Stoilov [19], the traveling salesman problem (TSP) was solved by the widely-used Excel program by determining numerical algorithms that yield the most appropriate result for solving problems. In the aforementioned study, a real transportation problem in Sofia was specified to show how to use Excel to solve the TSP problem, methods for writing the program on Excel worksheets, and using solvers to determine appropriate results.

Therefore, from the problems encountered, the compilers analyzed problems and problem-solving methods. Problem-solving steps consisted of dividing transportation time groups, organizing routes in transportation time groups, and providing a sufficient number of trucks for all routes. Problem-solving procedures will be shown in the next section.

IV. RESEARCH AND DATA COLLECTION METHODS

A. History of the Company in the Case Study

The company is a 3rd party logistics service provider accepting work related to logistics management by providing transportation services. Products were received from 78 factories that manufacture automobile parts, which were delivered to one automobile assembling factory located in an industrial estate in Rayong.

B. Transported Products

The transported products were various types of automobile parts packed in boxes and stacked on palettes to prevent products from mixing.

C. Studies of Problems in Various Areas

According to the findings of previous studies, routes were not sufficiently effective to make load volumes on trucks close to maximum load because employees organized transportation routes without appropriate organizing instruments. According to data from June 2019, a total of 100 routes were used per day with a total production volume of 2,169 cubic meters or a mean of 21.69 cubic meters per day. In addition, some routes were found to have transported only 11.65 cubic meters due to inappropriate routing, causing product volume to be less than half of a truck's capacity of 36.5 cubic meters. The aforementioned data was analyzed to determine the causes of problems. Trucks from the aforementioned company in the case study did not achieve maximum volume because the company in the case study did not have instruments for product acceptance planning. The company in the case study had limitations in the area of trucks from using 6-wheeled trucks and 10-wheeled trucks at equal ratios. Product volume for each work was not equal. In addition, products had heavyweight, preventing trucks from being loaded to maximum volume. In addition, mistakes were found in organizing products on trucks due to a lack of employees' supervision when trucks were loaded. Moreover, product delivery time specifications had to match customer notices, causing employees to be unable to reroute vehicles without referring to old routes, causing product pick-up schedules to be unsystematic and ineffective. When investigating into causes of routing problems, it was found that the studied company did not have transportation plans due to its lack of modifying routing processes and appropriate instruments for solving problems. Therefore, the product transports were not able to achieve maximum volume. With a high total distance, distance costs rose, and drivers did not have knowledge and understanding of transportation routes.

D. Product Delivery Process

When customers sent amounts of products and product delivery times, route designing began by using the number of products to design routes. Customers then tested and confirmed routes and truck types were prepared to deliver products as planned. Product delivery work was performed by the company's employees, who randomly organized transportation routes to be within the timeframe of 8 to 10 hours with a product volume not exceeding the truck's load of 36.5 cubic meters. The Milk Run transportation system was used with pick-up points divided into 78 points with 1 transportation point, a total of 79 points. The transportation point was Point 1, the automobile assembly factory. The next points were divided by customer code, as shown in Table II.

TABLE II: DATA ON 79 PRODUCT TRANSPORTATION AND PICK-UP POINTS

Node	customer-id	Node	customer-id	Node	customer-id
1	Plant	30	M157	59	S997
2	A044	31	M389	60	T002
3	A083	32	M547	61	T019
4	A142	33	M562	62	T025
5	A395	34	M583	63	T050
6	A397	35	M590	64	T055
7	A466	36	M664	65	T073
8	B007	37	M693	66	T074
9	B018	38	N029	67	T079
10	B022	39	N084	68	T095
11	C384	40	N100	69	T099
12	D184	41	N119	70	T220
13	D434	42	N358	71	T251
14	E171	43	N398	72	T349
15	F039	44	O020	73	T599
16	F177	45	O032	74	T664
17	G026	46	O034	75	T669
18	H166	47	O090	76	T694
19	H201	48	P175	77	U034
20	H202	49	P459	78	V127
21	I006	50	R219	79	V166
22	I186	51	S010	72	T349
23	I188	52	S030	73	T599
24	J035	53	S133	74	T664
25	J127	54	S327	75	T669
26	J168	55	S341	76	T694
27	K013	56	S473	77	U034
28	K247	57	S605	78	V127
29	K334	58	S776	79	V166

E. Product Organization on Trucks and Palettes

In the process of organizing products on the company's trucks, products were organized by drivers who received instruction on the number and characteristics. Product organization was designed as a model for organizing products on trucks. Products were loaded on trucks by forklifts from manufacturing companies, and employees of manufacturing companies always loaded products on trucks. In addition, when unloading products at the customer's company, forklifts from the customer's company had to be used by drivers from the customer's company. However, drivers had to follow up and see whether products were delivered to the customer and if products were damaged. Before returning to the company, drivers had to have the customer's company sign to confirm that the customer received all products with no defects. When opening and closing containers, seal check forms were at container locks, and drivers had to record every seal use. In the final step of delivery, drivers had to record time on the control sheet at 4 times consisting of the time of arrival, the time when product loading-unloading begins, the time when product loading-unloading ends, and the time of departure specified by the customer. Transportation management had to be in the period specified by the customer to meet customer needs. Product placement on palettes had packaging and adjustment to make product surfaces even in order to be able to stack products. Each palette held separate types of products without mixing different types of products on a palette.

The compilers used the heuristic theory to organize vehicle routes in order to determine appropriate routes and increase opportunities for heavier product loads. Operations began from dividing times for delivering products by organizing products in the order of the earliest due date. Transportation routes were then organized by the Nearest Neighbor Approach and the Evolutionary Approach to compare old transportation data and data after adjustments.

V. OPERATION

In organizing work, two methods were used, consisting of First Come First Serve by organizing work which arrived first to be done first and Earliest Due Date by selecting steps to deliver work with the earliest due date. Delivery times were divided into 8 times, with 4 times in the morning and 4 times at night. Transportation was prohibited from exceeding specified times. The 8 transportation times were shown in Table III.

TABLE III: TABLE OF DELIVERY TIMES

Day	Period 1	Period 2	Period 3	Period 4
time	8.00 - 10.00	10.00 - 12.00	13.00 - 15.00	15.00 - 17.00
Night	**Period 5**	**Period 6**	**Period 7**	**Period 8**
time	20.00 - 22.00	22.00 - 00.00	01.00 - 03.00	03.00 - 05.00

Transportation was planned by using the Nearest Neighbor Approach. In the company's transportation, routing plan data was used to study problems and seek solutions. Routes had characteristics of instructing vehicles to collect products from several companies in nearby areas to use truck volume at full efficiency. When volumes were close to filling truckloads and the next product order cannot be picked up, route rounds were cut, as shown in Fig. 1.

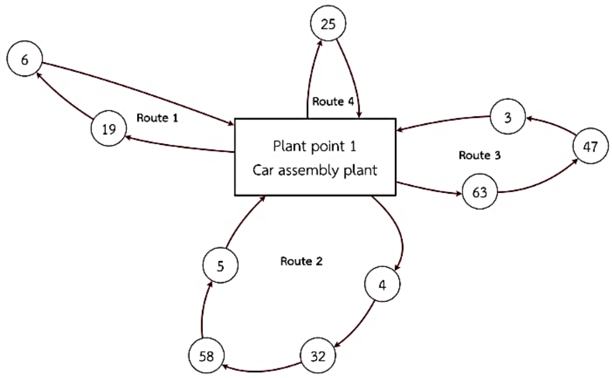

Fig. 1: Transport Routing with Specified Cargo Volumes

The compilers used a heuristic theory and the Nearest Neighbor Approach to prioritize product collection from various companies in order to create the shortest distance in picking up products, beginning with by collection of products from nearby companies. The beginning and the ending points were Point 1, the position of the automobile assembling factory. The table of distances between points was shown in Table 4.

TABLE IV: DATA ON DISTANCES FOR EACH CUSTOMER CODE

Customer	1	2	3	4	5	...	79
id	Plant	A044	A083	A142	A395	…	V166
Plant	0	142	43	22	40	...	37
A044	142	0	130	123	125	...	123
A083	43	130	0	24	8	...	10
A142	22	123	24	0	19	...	22
A395	40	125	8	19	0	...	16
A397	39	127	7	20	6	...	9
A466	6	137	38	17	35	...	36
B007	41	143	24	48	16	...	34
B018	40	127	6	22	4	...	14
B022	112	109	126	115	133	...	128
...	...	...	...	...	...	...	...
V166	37	123	10	22	16	...	0

The total number of transports during each time period came to 74 rounds per day before data were summarized by adding total distance traveled by trucks and determining mean product volume on trucks. Trucks had a full load of 36.5 cubic meters. The results were summarized by using 6-wheeled trucks and 10-wheeled trucks for 74 rounds per day with a mean product volume of 29.07 cubic meters and a total distance of 10,625.81 kilometers. The number of rounds was shown in Table V.

TABLE V: DATA ON ROUTES BY THE NEAREST NEIGHBOR APPROACH METHOD

Transportation route		
Period	**Route**	**Distance (km)**
1	1-38-1	20
2	1-60-1	22
3	1-60-70-28-1	40
4	1-48-1	34
5	1-48-12-66-35-77-31-1	89

Transportation route		
Period	**Route**	**Distance (km)**
6	1-47-22-36-1	79
7	1-68-36-1	78
8	1-64-26-44-1	77.532
9	1-6-78-54-63-50-5-44-39-1	101.289
10	1-31-62-16-19-1	305
11	1-10-25-1	382
12	1-40-1	600
13	1-70-48-1	37
14	1-15-1	56
15	1-22-1	76
16	1-22-74-64-26-63-1	92.532
17	1-9-50-21-1	88
18	1-62-58-39-1	117
19	1-39-66-41-19-1	285
20	1-25-40-61-1	693
21	1-38-1	20
22	1-60-1	22
23	1-60-48-1	37
24	1-48-1	34
25	1-59-65-77-1	76
26	1-22-36-1	78
27	1-36-74-51-67-21-27-1	98
28	1-31-52-55-72-8-62-1	117
29	1-62-41-10-1	345
30	1-7-23-60-29-28-43-75-1	48
31	1-20-71-38-45-1	35
32	1-48-1	34
33	1-48-37-4-59-15-1	69
34	1-33-15-73-5-1	96
35	1-11-66-1	81
36	1-42-77-35-31-52-14-18-58-1	92.138
37	1-68-46-24-74-36-1	80.09
38	1-22-1	76
39	1-22-51-69-1	86.62
40	1-64-49-63-54-9-67-21-3-55-39-1	96.81
41	1-17-58-27-72-1	90
42	1-62-39-76-1	249
43	1-13-2-32-10-25-1	530.33
44	1-25-1	392
45	1-38-23-1	27
46	1-60-1	22
47	1-60-48-1	37
48	1-48-73-44-1	83
49	1-22-36-1	78
50	1-36-44-64-1	84.532
51	1-31-54-62-1	109
52	1-62-19-10-1	325
53	1-10-25-1	382
54	1-60-45-55-1	66
55	1-45-57-48-1	42
56	1-33-15-51-64-74-46-1	103.402
57	1-11-66-14-58-1	88.231
58	1-22	76
59	1-34-8-62-67-39-58-19-1	266
60	1-25-1	392
61	1-60-1	22
62	1-60-48-1	37
63	1-48-4	45
64	1-59-65-56-77-31-6-1	86.62
65	1-47-22-36-1	79
66	1-36-46-51-50-21-1	99
67	1-62-52-78-2-1	339
68	1-2-40-1	608
69	1-48-1	34
70	1-48-35-79-77-58-1	93
71	1-68-7-4-22-51	93
72	1-5-9-50-27-1	93
73	1-62-30-39-66-1	120
74	1-6-63-225-53-1	543

In planning transportation by the Evolutionary Method, studies of the problem found the transportation routing problem to be a non-polynomial-hard (NP-Hard) problem with various responses. When the size and number of problems increased, time spent on solving problems increased correspondingly. Therefore, the Evolutionary Method was selected to solve problems by organizing pick-up routes beginning from the automobile assembly factory and picking up parts from customers. After loading products close to vehicles' full load volume, vehicles returned to the automobile assembling factory. The steps consisted of selecting solvers in Microsoft Excel and using the Evolutionary Method. The outcome from transportation at each time was a total of 73 rounds per day. Data were then summarized by combining total distance traveled by trucks and determining mean product volume on trucks. In total, 73 rounds were made by trucks per day with a mean product volume of 29.83 cubic meters and a total distance of 10,468.12 kilometers, as shown in Table VI.

TABLE VI: DATA ON ROUTES BY THE EVOLUTIONARY METHOD

Transportation route		
Period	**Route**	**Distance (km)**
1	1-10-25-1	382
2	1-60-1	22
3	1-38-1	20
4	1-60-70-28-1	40
5	1-62-47-22-1	91
6	1-36-1	76
7	1-19-40-12-77-35-16-36-1	692
8	1-48-1	34
9	1-68-44-26-44-1	83
10	1-64-44-5-54-1	81.532
11	1-48-12-66-31-1	83
12	1-6-78-50-63-39-31-1	93
13	1-70-48-1	37
14	1-15-21-1	89
15	1-40-61-25-19-1	437
16	1-19-41-66-58-1	283
17	1-62-22-1	89
18	1-64-26-63-58-21-39-1	98.532
19	1-22-1	76
20	1-39-63-50-9-50-9-74-1	95
21	1-55-31-52-27-72-21-67-51-1	58
22	1-38-48-1	38

Transportation route		
Period	**Route**	**Distance (km)**
23	1-51-74-36-1	83
24	1-22-62-8-41-1	154
25	1-48-59-1	54
26	1-77-65-10-60-1	280
27	1-60-1	22
28	1-7-33-62-22-1	96
29	1-38-45-60-29-15-1	77
30	1-20-71-20-71-23-1	23
31	1-55-39-72-67-52-1	98
32	1-59-76-2-32-25-1	461.333
33	1-48-1	34
34	1-48-28-75-43-37-4-1	50.555
35	1-62-58-39-1	117
36	1-39-66-41-19-1	285
37	1-25-40-61-1	693
38	1-38-1	20
39	1-60-1	22
40	1-60-48-1	37
41	1-48-1	34
42	1-59-65-77-1	76
43	1-22-36-1	78
44	1-36-74-51-67-21-27-1	98
45	1-31-52-55-72-8-62-1	117
46	1-62-41-10-1	345
47	1-7-23-60-29-28-43-75-1	48
48	1-20-71-38-45-1	35
49	1-48-1	34
50	1-44-36-1	85
51	1-48-57-45-25-1	406
52	1-55-39-66-1	54
53	1-60-33-67-11-1	56
54	1-15-34-1	84
55	1-25-19-66-14-58-1	465.231
56	1-62-8-1	84
57	1-22-1	76
58	1-46-74-51-64-58-1	96.402
59	1-48-4-1	45
60	1-4-59-2-40-1	614
61	1-62-47-22-1	91
62	1-60-1	22
63	1-40-65-77-56-31	626.62
64	1-6-52-78-21-50-1	90
65	1-60-36-1	78
66	1-36-46-51-1	84
67	1-48-1	34
68	1-25-53-32-66-1	522
69	1-62-22-68-74-5-1	105
70	1-77-79-35-66-58-1	94
71	1-48-5-9-1	86
72	1-50-39-30-27-1	96
73	1-58-1	84

VI. RESULTS

In conducting research and implementations to modify work, the Evolutionary Method yielded better outcomes than the Nearest Neighbor Approach with lower outcomes in total distance and higher mean product volume carried on vehicles. Performance from both methods was shown in Table VII.

TABLE VII: SUMMARY OF THE NUMBER OF TRUCKS AND MEAN PRODUCT VOLUME

Evolutionary Method				
Truck	route/day	Product volumn (m^3)	Average (m^3)	Percentage by volume of loading
6 wheel and 10 wheel	73	2,169.12	29.83	8172.
Total distance (km)	10,468.12 km			
Nearest Neighbor Approach Method				
Truck	route/day	Product volumn (m^3)	Average (m^3)	Percentage by volume of loading
6 wheel and 10 wheel	74	2,169.12	29.07	79.65
Total distance (km)	10,625.81 km			

Product pick-ups were divided based on truck drivers' working hours into two periods consisting of the morning period and the night period. This began by using outcomes from the Excel Solver for each of 8 times consisting of 4 times in the morning and 4 times in the night time. In dividing rounds for picking up products to deliver to the automobile assembling factory, the compilers divided times by matching pairs in the morning and at night. Times in picking up products were matched between the 1st time and the 5th time, the 2nd time and the 6th time, the 3rd time and the 7th time and the 4th time and the 8th time beginning by pairing products that have the most transportation time with products that have the less transportation time. In this place, products which used the most time used 8 to 10 hours. This was repeated with every pair. After matching product pick-up and delivery time pairs, a small volume of products with low time requirements and products requiring more than 10 hours were divided and added to rounds which used less time with consideration given to existing pick-up and delivery times for work in the aforementioned routes. Products requiring more than 10 hours were organized as one round per day. After all vehicle rounds were divided, this study obtained the number of trucks needed to pick-up and deliver products at 37 trucks, which was lower than the old number by one truck. Information on each vehicle's route was shown in Table VIII.

TABLE VIII: SUMMARY OF ROUTE ORGANIZATION

Truck No.	Day time: period 1	Day time: period 2	Nighttime	Time (hr.)
1	1-10-25-1		1-23-10-25-1	15.15
2	1-6-78-50-63-39-31-1		1-19-31-1	10.33
3	1-48-12-66-31-1		1-48-73-36-1	9.01
4	1-64-44-5-54-1		1-54-64-44-1	8.49
5	1-62-47-22-1		1-62-22-36-1	8.18

Truck No.	Day time: period 1	Day time: period 2	Nighttime	Time (hr.)
6	1-68-44-26-1		1-44-36-1	7.47
7	1-60-70-28-1	1-7-33-62-22-1	1-60-1	10.39
8	1-36-1	1-15-73-68-1	1-38-1	9.52
9	1-40-61-25-19-1		1-25-19-66-14-58-1	18.17
10	1-19-41-66-58-1		1-48-57-45-25-1	15.18
11	1-64-26-63-58-21-39-1	1-48-1	1-46-74-51-64-58-1	12.13
12	1-39-63-50-9-50-74-1		1-60-33-67-11-1	9.14
13	1-15-21-1		1-15-34-1	7.30
14	1-62-22-1		1-62-8-1	7.30
15	1-22-1		1-55-39-66-1	6.58
16	1-70-48-1		1-22-1	6.15
17	1-77-65-10-60-1		1-6-52-78-21-50-1	11.38
18	1-55-31-52-27-72-21-67-51-1		1-62-47-22-1	9.33
19	1-22-62-8-41-1		1-36-46-51-1	9.19
20	1-51-74-36-1		1-60-36-1	7.42
21	1-48-59-1		1-48-4-1	6.35
22	1-38-48-1		1-60-1	5.46
23	1-59-76-2-32-25-1		1-25-53-32-66-1	17.18
24	1-31-55-3-66-42-77-58-18-14-1		1-62-22-68-74-5-1	11.17
25	1-69-5-63-49-54-9-17-1		1-77-79-35-66-58-1	10.18
26	1-68-36-24-46-74-51-61-1		1-50-39-30-27-1	9.58
27	1-55-39-72-67-52-1		1-58-1	9.17
28	1-38-45-60-29-15-1		1-48-5-9-1	8.43
29	1-48-28-75-43-37-4-1		1-48-1	7.24
30	1-60-1	1-20-71-20-71-23-1		6.35
31	1-38-1	1-60-1	1-40-65-77-56-31	15.02
32	1-48-1	1-35-66-1		5.51
33	1-22-1			3.17

In the performance, the compilers modified routes by prioritizing from 8 transportation times using the Earliest Due Date method and the First Come First Serve method in the process of loading products on trucks. The Nearest Neighbor Approach and the Evolutionary Method were then used to organize vehicle routes. According to Table 7, with a summary of performance, the Evolutionary Method can be seen to have better outcomes than the Nearest Neighbor Approach. Therefore, the Evolutionary Method was selected to modify the work processes of the company in organizing vehicle routes, resulting in higher average product volume, as shown in Fig. 2.

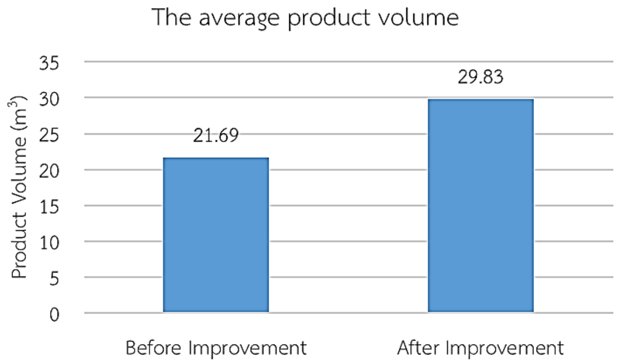

Fig.2: Chart Comparing Volume of Work Before and After Modification

The chart comparing product volume showed the application of the routing process by the Evolutionary method in the Excel Solver caused mean product volume transported on routes after modification to increase by 81.72 cubic meters from 59.43 cubic meters. More cargo space was used when compared to mean product volume from old routes. A chart comparing the total distance between before and after modifications were then prepared, as shown in Fig. 3.

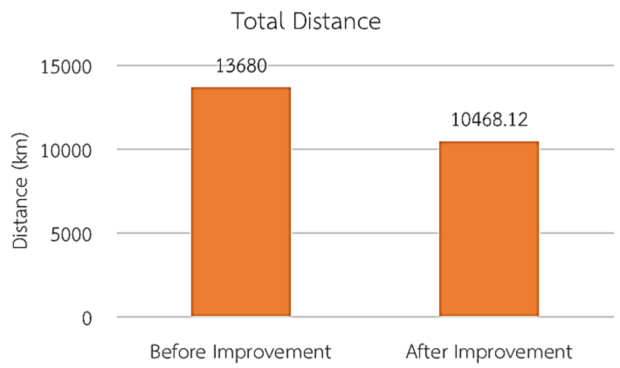

Fig. 3: Chart Comparing Total Distance Before and After Modification

According to the comparison of outcomes from calculating the total distance and average volume of products transported by the evolutionary method and the nearest neighbor approach, the evolutionary method was found to have better outcomes. When outcomes were compared to the company's old route information, the total distance in transporting was reduced from 13,680 kilometers to 10,468.12 kilometers, and the mean volume of products transported increased from 21.69 cubic meters to 29.83 cubic meters. In addition, the number of transports was reduced by 1 vehicle, indicating the application of routing by the evolutionary method enhanced transportation efficiency with better outcomes in the area of distance than old routing methods.

VII. CONCLUSION

Data collection on vehicle routing problems, work processes, and steps were carried out in this research in order to analyze the transportation problems. From the data analysis, the research was interested in solving only the problem of failure to achieve maximum packing volume and reorganize routes by using appropriate instruments. Guidelines were also studied to solve the aforementioned problem, and heuristic theories were adapted by using the Nearest Neighbor Approach and the Evolutionary Functions in Excel Solver to deliver the best outcomes from both methods. The findings showed the evolutionary method to have better outcomes, and outcomes from this method were used. Thus, it can be concluded that heuristic theories can be used to route vehicles and increase the use of space on trucks with total product volume increased by 22.29 percent or from 21.69 cubic meters to 29.83 cubic meters. Comparisons were made between old routes and routes after modification by measuring total distance, resulting in a reduction of the total distance from 13,680 kilometers to 10,468.12 kilometers. After problem-solving, the distance was reduced by 23.48 percent.

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