บทความวิจัย

การเปรียบเทียบการจัดเส้นทางการเดินทางรถขายกับข้าว (รถพุ่มพวง) โดยประยุกต์ใช้ปัญหาการเดินทางของพนักงานขาย ด้วยวิธีเซฟวิ่งอัลกอริทึม วิธีเพื่อนบ้านใกล้ที่สุดและฟังก์ชันเอ็กเซลโซลเวอร์ กรณีศึกษา: พื้นที่ให้บริการ ตำบลหนองบัวศาลา อำเภอเมือง จังหวัดนครราชสีมา

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บทคัดย่อ

รถขายของชำ (รถพุ่มพวง) มีบทบาทในต่างจังหวัดของประเทศไทย โดยเฉพาะช่วงวิกฤตการณ์ไวรัสโควิด-19 ที่คนไทยส่วนใหญ่ต้องอยู่บ้าน อย่างไรก็ตาม การไม่วางแผนเส้นทางทำให้สิ้นเปลืองค่าใช้จ่ายและเวลา นอกจากนี้ การเร่งทำเวลาการให้บริการทำให้มีการขับรถย้อนศร ซึ่งผิดกฎจราจรและอาจเกิดอุบัติเหตุได้ งานวิจัยนี้มีวัตถุประสงค์เพื่อจัดเส้นทางการให้บริการรถพุ่มพวงโดยประยุกต์ใช้ปัญหาการเดินทางของพนักงานขาย โดยเปรียบเทียบวิธีเพื่อนบ้านใกล้ที่สุด วิธีเซฟวิ่งอัลกอริทึม และการใช้ฟังก์ชันเอ็กเซลโซลเวอร์ ในพื้นที่ตำบลหนองบัวศาลา จังหวัดนครราชสีมา ภายใต้ข้อจำกัด คือ 1) สามารถให้บริการครบทุกจุดบริการ 2) ไม่ละเมิดกฎจราจร และ 3) ระยะทางรวมหลังการจัดเส้นทางควรน้อยกว่าเดิม ข้อมูลเส้นทาง ระยะทาง จุดบริการ และพิกัด รวบรวมด้วย จีโอ แทร็คเกอร์ แอปพลิเคชัน มีจุดจอด 45 แห่ง (ระยะทางรวม 31.24 กิโลเมตร) โดยเริ่มต้นจากตลาดสดประปา ทั้งนี้ การใช้ฟังก์ชันเอ็กเซลโซลเวอร์แสดงระยะทางสั้นที่สุด ซึ่งระยะทางลดลงร้อยละ 18.85 ขณะที่ วิธีเพื่อนบ้านใกล้ที่สุด และวิธีเซฟวิ่งอัลกอริทึม (เริ่มจากตลาดสดประปา หรือตลาดสุรนคร) มีระยะทางเพิ่มขึ้น ร้อยละ 0.58 ร้อยละ 9.99 และ ร้อยละ 8.77 ตามลำดับ การวิจัยนี้สามารถประยุกต์การจัดเส้นทางรถที่มีลักษณะวิ่งวนเป็นรอบ (มิลค์ รัน) เช่น รถสองแถว หรือรถรับส่งพนักงาน เพื่อเพิ่มประสิทธิภาพการขนส่ง

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Research Article

Comparison of Vehicle-Routing for Grocery Car Service (Rod Phum-punag) by Applying the Travelling Salesman Problem with the Saving Algorithm, the Nearest Neighbor Algorithm, and the Microsoft Excel Solver: A Case Study of Service Area in Nong Bua Sala Subdistrict, Nakhon Ratchasima Province

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Abstract

Grocery car servicing (Rod Phum-puang) plays a role in upcountry consumers in Thailand, especially in the Coronavirus disease (COVID-19) crisis when most Thai population have to stay home. However, Rod Phum-puang services confront a non-plan of vehicle routing problem, wasting both costs and time. Additionally, speeding up service time has resulted in driving against the flow of traffic that breaks the traffic rules, and may cause accidents. This research aimed to manage the vehicle routing of Rod Phum-puang service using the application of Travelling Salesman Problem (TSP). Rod Phum-puang service routing's solving methods were determined by the saving algorithm, the nearest neighbor algorithm, and the Microsoft Excel Solver in Nong Bua Sala Sub-district, using Nakhon Ratchasima Province as a case study. The scope of this research included: 1) providing service at all service stops, 2) compliance with traffic rules, and 3) less total distance after vehicle routing. The Geo-tracker Application collected the route information about distance, service stops, and location coordinates revealing 45 nodes with the total distance about 31.24 km starting from Prapa Fresh Market. Then, the Microsoft Excel Solver showed the shortest distance of the Rod Phum-puang service route, with the decrease at 18.85% compared to the original route. In contrast, the nearest neighbor algorithm, and the saving algorithm starting from Prapra Fresh Market or Suranakhon Market showed an increasing distance of about 0.58%, 9.99%, and 8.77%, respectively. These results can be applied to transportation works running around nodes (milk run) such as school buses or staff shuttle to increase transportation efficiency.

Keywords: Rod Phum-puang, Geo – Tracker Application, Nearest Neighbor Algorithm, Saving Algorithm, Microsoft Excel Solver

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1. Introduction

Rod Phum-puang is a grocery service car, a small business that provides inexpensive raw materials and food for low- and middle-income Thailand's population. Typically, Rod Phum-puang services are found in suburbs and local communities of Thailand. Rod Phum-puang have been increasing because the Thai population stayed at home after the Coronavirus disease (COVID-19) crisis to prevent COVID-19 transmission [1]. The service goal of Rod Phum-puang owners is to provide their services covering all target areas. Rod Phum-puang runs along a non-clearly transportation network route but focuses on serving in communities and villages. The service provides goods to customers, in several places resulting in more incomes. The problem of Rod Phum-puang services is not well-planed of vehicle route service, which wastes both costs and time. Moreover, car accidents could be occurred because of unplanned transportation route and service times. Transportation planning and vehicles routing are many long-studied transport and logistics problems to reduce transportation costs and reduce energy costs. Though, many factors, conditions, and limitations, such as pattern transportation, number of destinations, number of vehicles, transportable quantity, etc., impact vehicles' transportation planning and routing. So, vehicle routing problems are widely studied and have been developed continuously.

The Traveling Salesman Problem (TSP), one of the studies of computational intelligence and operations research problems [2], is applied to solve transportation planning and vehicle routing. The TSP, a mathematical problem, can be created as a mathematical programming problem [3]. The application of TSP can organize the vehicle routing at total efficiency as the shortest route, reducing transportation costs. The TSP inquires a single vehicle, which visits several customers before returning to the depot, minimizing total routing time or vehicle distance [4]. The problem solving of TSP is divided into three groups as exact algorithm, problem-based heuristics, and metaheuristic [5], [6]. The heuristics method is a method for finding answers that are relying on setting up specific rules. Nevertheless, answers may be not optimal; it's just the closest to the most suitable solution [6]. The application of problem-based heuristics is divided into two methods: saving heuristics and nearest neighbor heuristic. These methods are different in conditions of transport routing with pick-up and delivery. The concept of saving heuristics is the saving distance for linking two customers into the same route [7]. The nearest neighbor heuristic determines two nodes closest to each other and finds the node nearby the pair of nodes. This process is repeated until all the nodes which the last node returns to the starting node [8]. Additionally, the Microsoft Excel Solver as the open-source software is one method to prove the TSP [9]. Microsoft Excel Solver is the most accessible using for demonstrating these problems [9], and it is suitable for non-complicated problems. Generally, the saving algorithm, the nearest neighbor algorithm, and the Microsoft Excel Solver are widely applied to solve the TSP. These methods are easy to understand because of few factors to consider. For example, [10] used savings algorithm with TSP to optimize the vehicle route of an electric car tour in Chiangrai that decreased the traveling distance by

about 9.075% (550 m). [11] designed the traveling route in Ayutthaya province by comparing three methods: 1) Sorting and ordering by tourist spots popularity, 2) Greedy Algorithm, and 3) Travelling Salesman Problem. So, the minimum traveling cost and quickest shortest distance were about 45.95 km in 90 min. [12] compare methods between the nearest neighbor heuristics and the saving algorithm with TSP to reduce the petrol cost and determine the quantity of a car accessory company Surin province. The result showed that the transportation cost was 20,647.38 baht using the nearest neighbor heuristics and 21,099.70 baht using saving algorithm with TSP. Moreover, [13] used the Microsoft Excel Solver to solve a vehicle routing problem of drinking water delivery. The distance decreased by about 59.97%, or 4,138.56 baht of reduction cost. As, [14] planned the transportation for the Elderly to the hospital, which was called Home to Hospital Transport Planning by using ArcGIS program (Network Analysis function) to measure distance and HandyGPS application to identify each elderly. The result indicated that this plan decreased 65.64% of the distance. Additionally, the nearest neighbor algorithm and saving algorithm were applied to improve the transportation route of ready-to-drink dairy products. The distance decreased about 29.63% using the nearest neighbor algorithm and increased by approximately 51.65% using the saving algorithm [15]. In managing routes transportation using the saving algorithm and the nearest neighbor algorithm, the total distance decreased about 57.95% and 66.89%, respectively [16]. [3] Compared the results of the TSP in various methods to obtain the shortest or least costly circular route of 32 cities in Slovakia (995 km). The results showed that Excel (precise method), GAMS software (precise method), Excel (metaheuristic method), the nearest neighbor (heuristic method), and the most profitable neighbor (heuristic method) were about 865, 865, 865, 995, and 907 km, respectively.

This research was due to the service of Rod Phum-puang, which drove against the flow of traffic for rapid convenience in meeting customers. This occurrence could risk an accident and break the law. The objective of this research was the management of Rod Phum-puang service with limitations as 1) to might service in all service stops 2) not breaking traffic rules, and 3) total distance after management should be smaller than before. Rod Phum-puang service is no other factor to consider, such as time windows or vehicle capacity. So, the saving algorithm, the nearest neighbor algorithm, and the Microsoft Excel Solver are suitable to solve the Rod Phum-puang service vehicle-routing.

Thus, this research aimed to evaluate the vehicle route of the Rod Phum-puang in Nong Bua Sala Sub-district, using Nakhon Ratchasima province as a case study by applying TSP through saving algorithm, the nearest neighbor algorithm, and the Microsoft Excel Solver methods. Finally, the results are compared, and the best solution method is suggested.

2. Materials and Methods

2.1 Area

The service of a Rod Phum-puang in Nong Bua Sala Sub-district, Nakhon Ratchasima, was chosen as shown in Figure 1. Nong Bua Sala covers area of 32,434 m^2 with population of 20,457 people (~10 villages or 11,667 families).

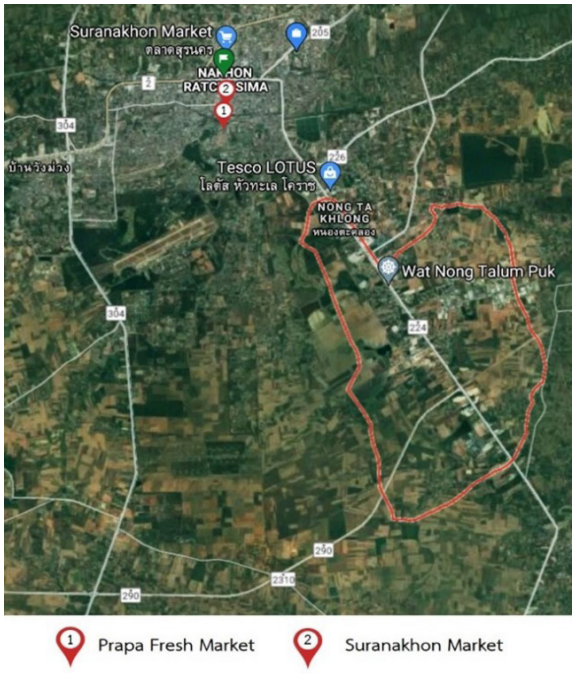

Figure 1 Nong Bua Sala Sub-district area.

2.2 Data collection

The route information of Rod Phum-puang service as distance, parking stop, and location coordinates was collected by Geo Tracker – GPS tracker application in the latitude and longitude information. The data entry was demonstrated using some partial input data as shown in Figure 2. This application collects the real-time physical location of roaming users' devices to obtain the geographical location of the managed mobile device. Route tracking of a Rod Phum-puang was collected for seven days (5–11 August 2020, from 02.00–12.00 am), resulting in 45 services stops on average (Figure 3).

2.3 Data Analysis process

2.3.1 Saving Algorithm method

	A	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV	AW
1	Node	32	33	34	35	36	37	38	39	40	41	42	43	44	45	
4	1	14.40	14.40	14.10	14.20	13.10	11.70	11.70	11.90	11.50	11.30	13.10	11.40	11.20	11.10	
5	2	15.35	15.21	15.54	15.42	15.14	13.69	13.67	13.96	13.55	13.33	15.04	13.31	13.09	13.02	
6	3	1.80	1.60	2.50	1.90	1.60	0.84	0.95	1.10	1.10	1.20	1.50	2.00	2.00	2.00	
28	25	2.90	2.90	2.60	2.70	3.10	1.10	1.10	1.30	1.40	1.40	3.80	4.30	4.30	4.30	
29	26	2.70	2.70	2.40	2.50	2.80	1.10	1.10	1.10	1.30	1.50	2.30	2.80	2.80	2.80	
30	27	2.80	2.90	2.60	2.60	3.00	1.50	1.50	1.50	1.60	1.80	3.80	4.20	4.30	4.20	
31	28	1.19	1.05	1.39	1.26	0.99	1.50	1.60	1.60	1.70	1.90	3.70	4.10	4.10	4.10	
32	29	1.36	1.23	1.56	1.43	1.15	1.30	1.40	1.30	1.40	1.70	2.70	3.20	4.50	3.20	
33	30	0.23	0.30	0.30	0.17	0.19	2.30	2.40	2.20	2.40	2.60	4.10	4.60	4.60	4.60	
34	31	0.20	0.16	0.40	0.24	0.45	2.40	2.40	2.30	2.40	2.60	3.52	4.60	4.70	4.60	
35	32	0.00	0.13	0.30	0.16	0.40	2.30	2.40	2.20	2.40	2.60	4.10	4.60	4.60	4.60	
36	33	0.13	0.00	0.30	0.25	0.50	2.40	2.40	2.30	2.40	2.60	3.51	4.60	4.60	4.60	
37	34	0.30	0.35	0.00	0.14	0.50	2.10	2.10	1.90	2.10	2.30	3.80	4.30	4.30	4.30	
38	35	0.16	0.25	0.14	0.00	0.35	2.20	2.20	2.00	2.20	2.40	3.90	4.40	4.40	4.40	
39	36	0.40	0.50	0.50	0.35	0.00	2.50	2.50	2.40	2.50	2.70	3.42	4.70	4.80	4.70	
40	37	2.30	2.40	2.10	2.20	2.50	0.00	0.22	0.60	0.30	0.36	3.10	3.60	3.60	3.60	
41	38	2.40	2.40	2.10	2.20	2.50	0.22	0.00	0.35	0.12	0.35	3.10	3.60	3.60	3.60	
42	39	2.20	2.30	1.90	2.00	2.40	0.55	0.35	0.00	0.40	0.65	3.40	3.80	3.90	3.80	
43	40	2.40	2.40	2.10	2.20	2.50	0.30	0.12	0.40	0.00	0.22	3.00	3.40	3.50	3.40	
44	41	2.60	2.60	2.30	2.40	2.70	0.36	0.35	0.65	0.22	0.00	2.70	3.20	3.20	3.20	
45	42	5.70	4.49	5.40	5.50	4.42	2.90	2.90	3.20	2.80	2.60	0.00	1.00	1.20	1.20	
46	43	4.90	5.00	4.70	4.80	5.10	2.10	2.00	2.50	1.90	1.70	0.90	0.00	0.22	0.28	
47	44	4.50	4.60	4.30	4.40	5.60	1.80	1.80	2.10	1.70	1.50	1.20	0.22	0.00	0.06	
48	45	4.50	4.60	4.30	4.30	5.60	1.80	1.80	2.10	1.70	1.40	1.20	0.28	0.06	0.00	
51	SA 1 node	39	10	8	37	38	40	41	24	25	42	43	44	45	3	1
52	distance (km)	=@INDEX($D$4:$AV$48,AI51,AJ51)				0.12	0.22	1.30	0.16	3.80	1.00	0.22	0.06	1.70	12.20	46.56
54	SA 2 node	39	10	8	37	38	40	41	24	25	42	43	44	45	3	2
55	distance (km)	=@INDEX($D$4:$AV$48,AI54,AJ54)				0.12	0.22	1.30	0.16	3.80	1.00	0.22	0.06	1.70	13.00	46.98
57	NN node	18	17	34	35	32	33	31	30	36	42	43	44	45	3	1
58	distance (km)	=@INDEX($D$4:$AV$48,AI57,AJ57)				0.13	0.16	0.29	0.19	3.42	1.00	0.22	0.06	1.70	12.20	43.62
60	MSE node	40	41	37	8	7	6	5	4	22	23	42	43	44	45	2
61	distance (km)	=@INDEX($D$4:$AV$48,AI60,AJ60)				0.07	0.08	0.10	0.09	0.11	1.96	1.00	0.22	0.06	11.30	36.65

Remark: SA 1: Saving algorithm (starting from Prapa fresh market), SA 2: Saving algorithm (starting from Suranakhon market), NN: Nearest neighbor, and MSE: Microsoft Excel Solver

Distance of each node Target cell (Result)

Figure 2 Data entry of route information and formula in an Excel spreadsheet for data analysis.

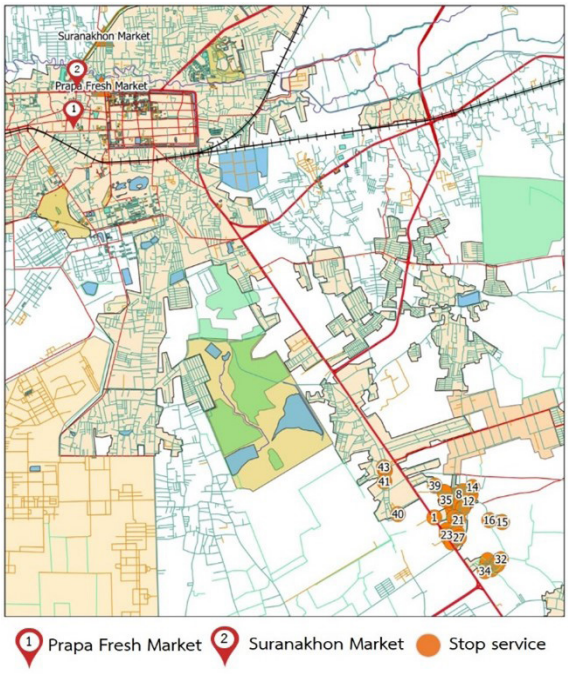

Figure 3 Location coordinates of services stops.

2.3.1.1 The depot of Rod Phum-puang service, Prapa fresh market (node 1), or Surana-khon market (node 2) as shown in Figure 3.

The application of the saving algorithm to calculate the distance had to be the depot as the market for buying the goods. Then, it showed the two markets (node 1 and node 2) that the saving algorithm compared the total distance from different depots.

2.3.1.2 Calculating the economical transportation distance (S_{ij}), which is the economy between i and j as Equation (1) [17].

$$S_{ij} = d_{0i} + d_{0j} - d_{ij} \quad (1)$$

where S_{ij}: the saving value from node i (staring node) to node j (next node), d_{0i}: the distance between the depot (market) to node i (stop service no. i), d_{0j}: the distance of the depot (market) to node j (stop service no. j), and d_{ij}: the distance between the node i (service stop no. i) to node j (service stop no. j).

2.3.1.3 Sorting the S_{ij} values from the smallest to the largest value and connecting the stop service between i and j nodes, which the highest S_{ij} values to create a vehicle route, the distance was created the route until the vehicle route of Rod Phum-puang service ultimately.

2.3.1.4 The analysis of the shortest distance was specific in cell $D52$ (starting from Prapa fresh market) as Equation (2) and cell D55 (starting from Prapa fresh market) as Equation (3) in Figure 2.

$$D52 = INDEX(\$D\$4:\$AV\$48,AI51,AJ51) \quad (2)$$

$$D55 = INDEX(\$D\$4:\$AV\$48,AI54,AJ54) \quad (3)$$

2.3.2 Nearest neighbor algorithm method

2.3.2.1 Prapa fresh market was chosen as the depot because it was the nearest selling nodes (service stops).

2.3.2.2 Matching node i and node j by first considering the distance between the shortest nodes as a pair of nodes.

2.3.2.3 Repeating the matching process by finding the nearest node until the last node.

2.3.2.4 Calculating the total distance as an Equation (4).

$$d = \sum_{i=1}^{N} d_i \quad (4)$$

where d: the total distance, N: the number of nodes, and d_i: the nearest neighbor algorithm distance for node i.

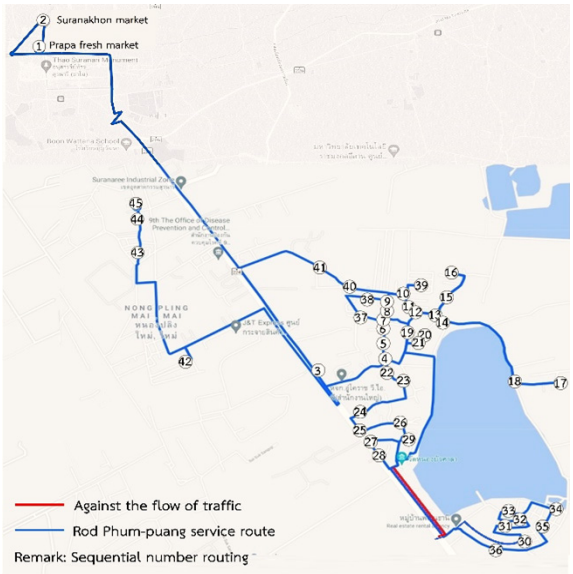

Figure 4 The original route.

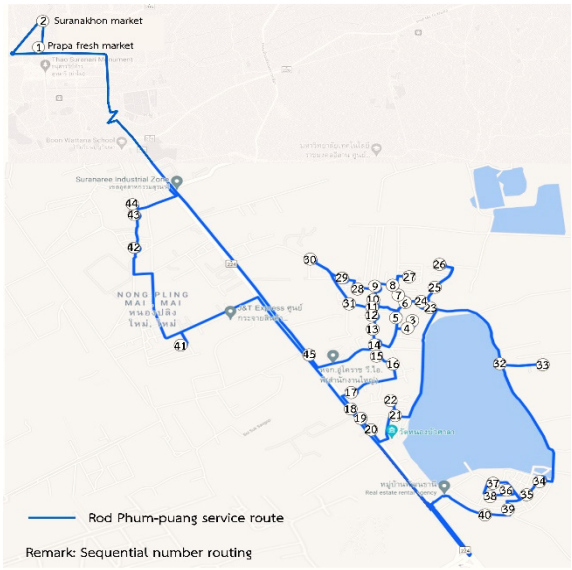

Figure 5 Routing of the nearest neighbor algorithm.

2.3.2.3 The analysis of the shortest distance was specific in cell *D58* as Equation (5) in Figure 2.

$$D58 = INDEX(\$D\$4:\$AV\$48,AI57,AJ57) \quad (5)$$

2.3.3 Microsoft Excel Solver method

2.3.3.1 Preparing route information by creating a sheet of Microsoft Excel (Microsoft Excel 2016, Windows 10). Row i and column j consisted of the distance between each service stop as node 1: Prapa fresh market, node 2: Suranakhon market, node 3: service stop no. 1, ..., node 45: final service stop (end node) (Figure 3).

2.3.3.2 The depot and end node were set as the same because the Microsoft Excel Solver method applied the TSP. Then, TSP concept is run all nodes with the shortest distance. In Rod Phum-puang, the seller did not return to the depot (market) after the sale ended. The depot and end node were Prapa fresh market (node 45).

2.3.3.3 The Microsoft Excel Solver (evolutionary algorithm) analyzed the shortest distance in cell *D61* as Equation (6) (Figure 2).

$$D61 = INDEX(\$D\$4:\$AV\$48,AI60,AJ60) \quad (6)$$

3. Results

The Rod Phum-puang service in Nong Bua Sala Subdistrict managed the vehicle route by TSP through different solving methods. The original, nearest neighbor algorithm, saving algorithm (starting from Prapa fresh market), Microsoft Excel Solver, and saving algorithm (starting from Suranakhon market) methods showed their distances in Figures 4–8, respectively. The distance of Rod Phum-puang service between the original and different methods was exhibited in Table 1.

The TSP condition requires the same node of starting and ending nodes. As a result, the distance between the starting node to the end node in different

Figure 6 Routing of the Saving algorithm (starting from Prapa fresh market).

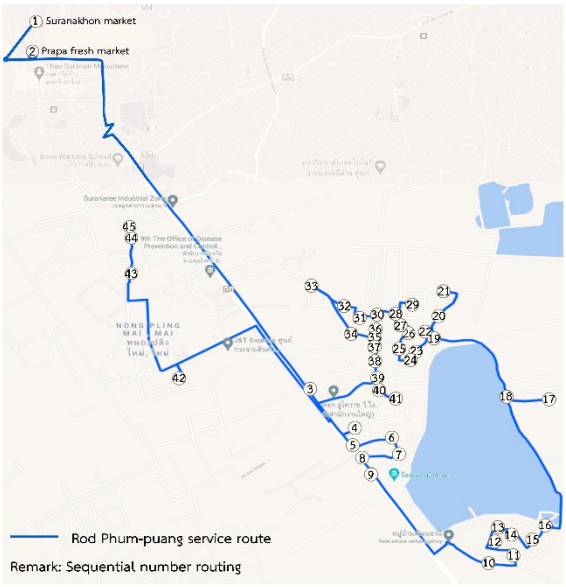

Figure 7 Routing of Microsoft Excel Solver.

methods as the saving algorithm (starting from Prapa fresh market or Suranakhon market), the nearest neighbor algorithm, and Microsoft Excel Solver was about 12.20, 13.00, 12.20, and 11.30 km, resulting

Figure 8 Routing of the Saving algorithm (starting from Suranakhon market).

in the total distance as 34.36, 33.98, 31.42, and 23.35 km, respectively.

In comparison, the original route of the Rod Phum-puang service was about 31.24 km (Table 1).

The application of TSP through the Microsoft Excel Solver indicated the shortest distance of the Rod Phum-puang service route, decreasing by 18.85% compared to the original route. In contrast, the other methods as the saving algorithm (starting from Prapra fresh market or Suranakhon market) and the nearest neighbor algorithm, showed an increase of about 9.99%, 8.77%, and 0.58% of the original route, respectively. Then, this study showed that implementing TSP through the Microsoft Excel Solver to organize the Rod Phum-puang service route was a suitable routing method. In other words, it is the most appropriate method compared to other methods.

Table 1 The comparison of the distance of Rod Phum-puang service in different solving methods

Method	Connecting the Stop Service Number	Distance (km)			Percentage
		End to Depot	TSP Application	Absolute Value	
Original route (Starting from Prapra fresh market)	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45	-	-	31.24	-
Saving algorithm (Starting from Prapra fresh market)	1, 2, 34, 35, 32, 33, 31, 30, 36, 18, 17, 15, 16, 14, 13, 6, 19, 21, 22, 23, 26, 29, 27, 28, 20, 4, 5, 7, 9, 11, 12, 39, 10, 8, 37, 38, 40, 41, 24, 25, 42, 43, 44, 45, 3, 1	12.20 (Node 3 to 1)	46.56	34.36	Increased 9.99%
Saving algorithm (Starting from Suranakhon market)	2, 1, 34, 35, 32, 33, 31, 30, 36, 18, 17, 15, 16, 14, 13, 6, 19, 21, 22, 23, 26, 29, 27, 28, 20, 4, 5, 7, 9, 11, 12, 39, 10, 8, 37, 38, 40, 41, 24, 25, 42, 43, 44, 45, 3, 2	13.00 (Node 3 to 2)	46.98	33.98	Increased 8.77%
Nearest neighbor algorithm (Starting from Prapra fresh market)	1, 2, 20, 21, 19, 12, 11, 10, 39, 9, 8, 7, 6, 5, 4, 13, 14, 15, 16, 39, 38, 37, 40, 41, 22, 23, 24, 25, 27, 28, 29, 26, 18, 17, 34, 35, 32, 33, 31, 30, 36, 42, 43, 44, 45, 3, 1	12.20 (Node 3 to 1)	43.62	31.42	Increased 0.58%
Microsoft Excel Solver (Starting from Suranakhon market)	2, 1, 3, 24, 25, 26, 29, 27, 28, 36, 30, 31, 33, 32, 35, 34, 17, 18, 14, 15, 16, 13, 20, 21, 19, 12, 11, 10, 39, 9, 38, 40, 41, 37, 8, 7, 6, 5, 4, 22, 23, 42, 43, 44, 45, 2	11.30 (Node 45 to 2)	36.65	25.35	Decreased 18.85%

Remark: Rod Phum-puang service was simulated the situation that it had to run back to fill goods at the market on the same day. As a matter of fact, Rod Phum-puang finished its service at the last stop each day, and it returned to the depot (market) the next day. So, the actual distance of Rod Phum-puang service (depot to end node) calculated from the total distance minus the distance at the end node ran back to the depot.

4. Discussion and Conclusions

The TSP states that the salesman must visit several cities starting from the office center, travel through each town exactly once, and return to the center [18]. TSP solving can be managed in different ways as the nearest neighbor algorithm, the saving algorithm, or Microsoft Excel Solver. Then, the application of solving methods in this research could summarize as follows: the saving algorithm was suitable for routing with multiple parameters, such as time windows, vehicle capacity, etc. On the other hand, it was more complicated for calculating the saving value, and recommended route might not be viable in practice. This method showed longer distances than other methods. The nearest neighbor algorithm was more manageable, practical, and suitable for Rod Phum-puang service routing. However, it was confused with routing, especially nodes with similar distances. Moreover, it required longer calculation times for processing with a lot of nodes. The Microsoft Excel Solver showed the most reliability than other methods and orderly routing. It spent a lot of time processing with many nodes as well as the nearest neighbor algorithm. From the

relevant results (routing and distance) and primary applicability analyses, the Microsoft Excel Solver to organize the Rod Phum-puang service route was an appropriate method for vehicle routing in this study. Hence, the open-source software, the Microsoft Excel Solver, is one of the most accessible solver tools for the TSP suitable for non-complicated problems [9].

Though the shortest distance may be the best quantitative results, this may not be economically the best method because the service in long distances may increase the chances of selling more products. The price of grocery products is relatively low, affecting transportation as transportation is an essential factor [19]. Thus, increasing the likelihood of meeting customers creates an opportunity to sell products, but one should be aware of the transportation price considering this business. It is a good thing to choose a service stop where Rod Phum-puang can sell many products. Because the average logistics cost per item reduces when the increasing of delivery size [19].

This research showed that the factor affected the vehicle routing of the Rod Phum-puang service in Nong Bua Sala Subdistrict, Nakhon Ratchasima Province, were service stops and the distance between service stops. This result can be applied to transportation works running around nodes (Milk run) such as minibus, school bus, staff shuttle, etc. Nevertheless, other factors such as the number of customers, sales volume, and sales possible at each service stop should be considered in the vehicle routing of the Rod Phum-puang services. With these conditions, this research should continuously study the optimal route of Rod Phum-puang service for complete analysis using the Goal programming in the future. Goal programming is a model for analyzing problems with multiple, incompatible objectives [20].

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