



Integrating Tabu Search and MPOSH Heuristic for Solving a Multiple-Period Oil Station Replenishment Problem

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ABSTRACT

Multi-period oil station replenishment problem is one type of vehicle routing problem that has constraints such as number of truck, capacity of truck's compartments and capacity of tank space in each station. Generally, the objective of vehicle routing problem is to minimize the transportation cost. Solving the large problem to find the best solution is complex and difficult. Because, in the large problem, many conditions and parameters are calculated, then the computer calculation is time consuming. In this study, the Multi-Period Oil Station Replenishment Heuristic (MPOSH), and integration between MPOSH and Tabu Search called Tabu MPOSH are constructed for performance tests. The problems are investigated with varied sizes, such as: number of stations are 5, 10, 20, 50, and 75 stations, and the demand frequencies in each station are 5, 10, and 20 days, the trucks used in transportation are 2 to 38 trucks, and the demands are two values (maximum and minimum). The results show the hybrid between MPOSH and Tabu Search or Tabu MPOSH with number of run 350 cycles (iterations) yields the better solution than others. Observantly, setting the higher iterations will improve the solution results. The solved information shows number of days for delivery, number of trucks, and stations of trips in each day.

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1. Introduction

Oil demand is increased every year. Even though biogas/syngas have been widely used as alternative (Vasileiadis *et al.*, 2011), oil price is still continuously getting higher. Consequently, the oil companies try to reduce cost, they obviously developed the new oil formula such as adding some biomaterial. The one source of cost comes from transportation of oil products from oil supplier to oil retailers.

Conillier *et al.* (2007, 2008) discussed multi-period oil station replenishment problem (MPOSP) which composes of delivery of several petroleum products to a set of petrol stations over a given planning horizon. One must determine, for each day of the planning horizon, how much of each product should be delivered to each station, how to load these products into vehicle compartments, and how to plan vehicle routes. The objective is to maximize the total profit equal to the revenue, minus the sum of routing costs and of regular and overtime costs.

The MPOSP is a combinatorial and NP-hard problem (Santosa and Hardiansyah, 2010). The MPOSP can be mathematical formulated in form of ILP model. The small MPOSP can be solved by the exact optimal method such that simplex. For the large MPOSP cannot be solved, because it is consists of many conditions and scenarios of solution. Conillier *et al.* (2007) solved the oil station replenishment problem (single period) using exact algorithm, but not on the multi-period oil station replenishment problem (MPOSP). Conillier *et al.* (2008) solved MPOSP by a heuristic called MPSRH, their iterative heuristic was composed of several procedures and embeds the solution of a route packing problem.

Tabu search is one meta-heuristic method which is accepted that could jump from local optimum to finding the global optimum. Tabu or Taboo means forbid or no entry, then Tabu search is means that searching with forbiddance. This forbiddance helps to avoid searching in the last searching or cyclic.

This paper investigates the exact solution for MPOSP using LINGO and constructs a new heuristic call MPOSH based similar on procedure's MPSRH. Moreover, the hybrid between MPOSH and Tabu Search is extensively constructed and experimental tested. The structure of this paper is organized as follows. A MPOSP problem is reviewed in Section 2 and section 3,

the detail of heuristics, MPOSH and Tabu MPOSH, and saving time procedure are described in Section 4 to 6, the experimental results and discussion are shown in Section 7, and the conclusion is followed in Section 8.

2. The MPOSP Problem

The MPOSP problem is one kind of capacitated vehicle routing problem, but it has more constraints. The characteristic of MPOSP are as follow.

Let $G = (V,A)$ be a directed graph, where $V = \{1, \dots, n\}$ is the vertex set and $A = \{(i, j): i, j \in V, i \neq j\}$ is the arc set. Vertex 1 corresponds to the depot while the remaining vertices represent petrol stations. The travel time t_{ij} and the travel cost c_{ij} , are associated with arc (i, j) . An armada of m trucks is based at the petrol depot (Conillier *et al.* 2008). **Figure 1** shows the network of travel routes of truck from a petrol depot to petrol stations and back to the depot. Number of visited stations for each route is not greater than or equal to two petrol stations.

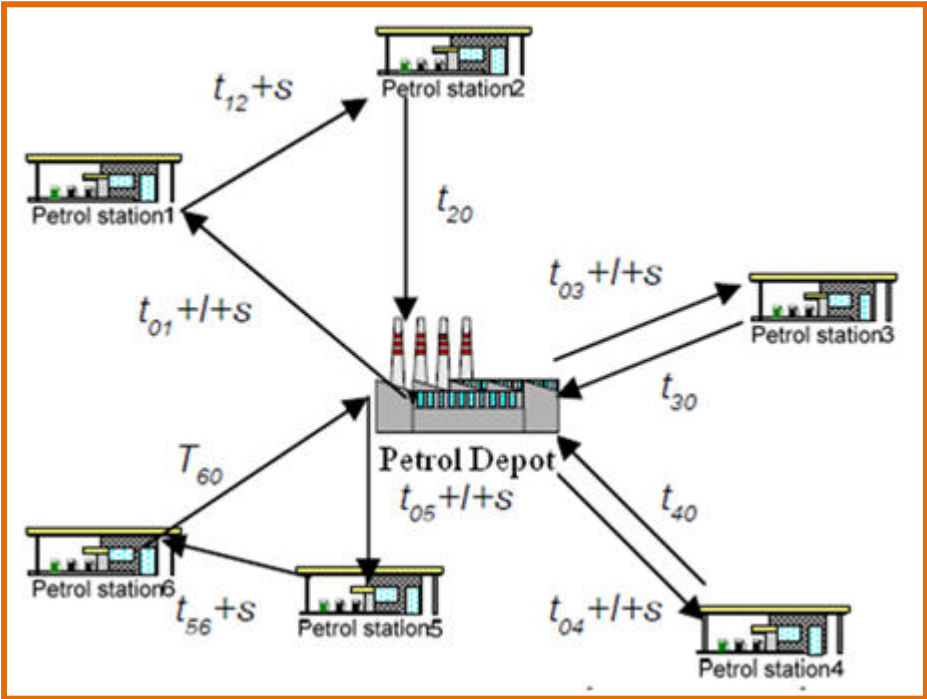


Figure 1: The travel routes of trucks from terminal or depot.

If m_{ip} denotes the underground tank capacity of product p at station i , S_{ipt} stands for the stock level of product p at station i at the start of period t . All trucks are assumed to travel of the

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same constant speed and have the identical fixed and variable cost. Each truck is subdivided into several partitions of different capacities. The stock levels decrease continuously during the day and delivery amounts should be a function of trucks arrival time at a station. The existence of safety stocks is assumed, so that it is feasible to deliver at any time during the day. When a truck delivers a product to a station, it completely empties the compartment containing that product. Any given truck compartment can be partially filled when the truck leaves a depot. The MPOSP contains a temporary and a spatial dimension. Since it is not necessary to visit each station during each period of the planning horizon, one must determine the ideal periods to visit stations, taking into account stock levels, fleet capacity, and routing efficiency.

This problem can, therefore, be viewed as an inventory routing problem with additional constraints induced by varying tank sizes and truck compartments. These decisions are optimized centrally by the distributor. In other words, the considered operating mode can be described as a push system. The number of stations on any given route is limited; this limit is equal to two. The two-stop limit per route is a common practice in North America (Cornillier *et al.*, 2008). It is explained by the fact that the most tank of a truck contains four to six compartments and each station typically orders two or three products, one of which often requires two compartments. Irrespective of the quantity delivered at each station, the service time is assumed to be constant and equal to stock level. Several routes can be assigned to the same vehicle in any given period. The normal duration of a working day is equal to H ; however, this duration can be extended to H' by using overtime. A regular labor wage rate applies until time H and an overtime rate applies between H and H' . We solve the problem on a planning horizon of T periods. Note that the same methodology could be applied on a rolling horizon basis. The MPOSP consists of determining many decision variables for each period t of the planning horizon such as:

- the set of stations to which deliveries should be made,
- the quantity of each product p to be delivered to each of these stations,
- the loading of these products into vehicle compartments,
- the feasible delivery routes to these stations,
- the assignment of routes to available trucks.

3. The MPOSP Mathematical Model

The problem can be formulated as a mixed integer programming model. The objective

function is minimizing transportation cost. This model could be solved optimally only in a small scale problem. The decision variables are defined as following (Conillier *et al.*, 2008).

Parameters are:

C = regular labor time cost per minute,

C' = overtime labor cost per minute,

c = travel cost per minute,

s_{ipt} = remaining oil stock of product p at station i period t ,

V_{ipt} = demand of oil product p at station i period t ,

q_{wk} = capacity of compartment w of truck k ,

m_{ip} = capacity of underground tank for product p at station i

T_{ij} = travel time from station i to station j , including loading time, l at the terminal and unloading time, S at station j

t_{ij} = travel time from station i to station j

Then, $T_{ij} = t_{ij} + l + s$ when $i = I$,

$T_{ij} = t_{ij} + s$ when $i, j \neq I$,

and $T_{ij} = t_{ij}$ when $j = I$.

h_{kt} = regular time for truck k at period t

h'_{kt} = overtime for truck k at period t

H = Maximum regular time

H' = Maximum regular and over time

x_{ipwvkt} = quantity of product p of station i loaded in compartment w of truck k within trip v at period t

The decision variables are:

$Z_{ijvkt} = \{1,0\}$ equal to 1 if truck k travels from station i (the terminal if $i = 0$) to station j (the terminal if $j = 0$) within trip v at period t ,

$Y_{ipwvkt} = \{1,0\}$ equal to 1 if and only if product p of station i is loaded in compartment w of truck k within trip v at period t .

The objective function objective function is formulated to minimize the total cost which can be decomposed into regular working time and overtime costs, and travel costs of trucks show in Eq. (1),

$$\text{Min} \sum_{(k,t)} (Ch_{kt} + C'h'_{kt}) + \sum_{(i,j,v,k,t)} c_{ij} T_{ij} Z_{ijvkt} \quad (1)$$

Subject to:

$$s_{pi,t+1} = s_{pit} - V_{pit} + \sum_{(w,k,t)} x_{ipwvkt} \quad \forall (i,p,t) \quad (2)$$

$$x_{ipwvkt} \leq q_{wk} Y_{ipwvkt} \quad \forall (i,p,w,v,k,t) \quad (3)$$

$$s_{ipt} + \sum_{(w,k,t)} x_{ipwvkt} \leq m_{ip} \quad \forall (i,p,t) \quad (4)$$

$$\sum_{(i,p)} y_{ipwvkt} \leq 1 \quad \forall (w,v,k,t) \quad (5)$$

$$\sum_i z_{ijvkt} \geq y_{ipwvkt} \quad \forall (j,p,w,v,k,t), j \neq 0 \quad (6)$$

$$\sum_i z_{ijvkt} = \sum_i z_{jivkt} \quad \forall (j,p,w,v,k,t) \quad (7)$$

$$\sum_j z_{1jvkt} \leq 1 \quad \forall (v,k,t) \quad (8)$$

$$z_{ijvkt} + z_{jivkt} \leq 1 \quad \forall (j,p,w,v,k,t), i,j \neq 0 \quad (9)$$

$$\sum_{(i,j)} z_{ijvkt} \leq 3 \quad \forall (v,k,t) \quad (10)$$

$$\sum_{(i,j,v)} T_{ij} z_{ijvkt} = h_{kt} + h'_{kt} \quad \forall (v,k,t) \quad (11)$$

$$\sum_{(j,v,k,t)} z_{1jvkt} \geq 1 \quad \forall (j,v,k,t) \quad (12)$$

$$s_{pi1} = 0 \quad \forall (i,p) \quad (13)$$

$$z_{iivkt} = 0 \quad \forall (i,j,v,k,t) \quad (14)$$

$$\sum_{(p,w)} y_{ipwvkt} = 0 \quad \forall (i,p,w,v,k,t), p \neq w \quad (15)$$

$$0 \leq h_{kt} \leq H \quad \forall (k,t) \quad (16)$$

$$0 \leq h'_{kt} \leq H' - H \quad \forall (k,t) \quad (17)$$

$$z_{ijvkt} \in \{0,1\} \quad \forall (i,j,v,k,t) \quad (18)$$

$$y_{ipwvkt} \in \{0,1\} \quad \forall (j,p,w,v,k,t) \quad (19)$$

Eq. (2) ensures stock equilibrium between two consecutive periods. Eq. (3) specifies the quantity loaded does not exceed the allotted compartment capacity q_{wk} . A constraint (4) specifies stock level after a delivery should not exceed the tank capacity. Constraint(5) ensure that at most one product demand is assigned to a compartment. Constraint (6) a product quantity can be delivered to station j only if a truck travels from station i to station j . Eq. (7) specifies that the number of arrivals at a given station must be equal to the number of departure from this station. Constraint (8) imposes for each trip at most only one departure made from a depot. Constraint (9) eliminate round trips between two stations, and the number of visited stations is limited to three per trip including a depot by constraint(10). Eq. (11) decomposes for each truck the workload into regular working time and overtime. Eq. (12) enforces to transport product from terminal, quantities of oil at starting time is zero in Eq.(13), and eliminate travel in the same station (14). Eq.(15) each compartment has one type of product. Eq.(16) imposes a regular time limited to H hours (16) and a maximum overtime limited to $H' - H$ hours (17).

4. The MPOSP Heuristic

MPOSH consists of 2 parts, first is constructing the route of oil station without consider truck, and second is dividing the route for each truck. The location of oil stations is filled to system using coordinate x and y value. And the input data are: number of station(n), speed of truck(v), type of oil products(p), delivery time of each station($ddate$), travel cost per minute(c), regular labor cost per minute(C), overtime labor cost per minute(C'), regular working hours(H), end of working include overtime(H'), loading time time(l), unloading time(s), demand of oils at each period(Dpn), capacity of underground tank(mip), and amount of remaining oil product p at station i period t (spit), and travel route(o).

MPOSH procedure:

- 1) Euclidean calculate distance from station i to station j using:

$$d_{ij} = ((x_i - x_j)^2 + (y_i - y_j)^2)^{1/2}$$

- 2) Calculate travel time for each distance, $t_{ij} = d_{ij}/v$, and travel time between stations including loading and unloading time are;

$$T_{ij} = t_{ij} + l + s, \text{ when } i = 0 \text{ or } T_{0j} = t_{0j} + l + s$$

$$T_{ij} = t_{ij} + s, \text{ when } i \text{ and } j \neq 0 \text{ or } T_{ij} = t_{ij} + s$$

$$T_{ij} = t_{ij}, \text{ when } j = 0 \text{ or } T_{i0} = t_{i0}.$$

- 3) Determine the number of stations for each transportation route for each truck is less than or equal to 2 that is the same Eq.(10). The conditions of this step are:

- a. In case of travel time of route is over the end of time including overtime:

If $T_{0j} + T_{ij} + T_{i0} \leq H'$ then the number of visited stations for this route is 2, and set

$$TT_{ij} = T_{0j} + T_{ij} + T_{i0},$$

- b. In case of travel time of route is not within the end of time including overtime,

If $T_{0j} + T_{ij} + T_{i0} > H'$ then the number of visited stations for this route is only 1, and set $TT_{0j} = T_{0j} + T_{i0}$.

In case of number of visited stations equal to 2, calculate transportation pairs of route that are minimize travel time from station i to station j :

$$\text{Min: } TT_{ij} = T_{0j} + T_{ij} + T_{i0}, i \neq j, i \dots n, j \dots n$$

After matching pair of each route, set 1st route composes of station $i(1)$ and set station $j(1)$.

Calculate travel time of 1st route and add the new station pairs, the new must has minimum travelling, and consider the new pairs must be not selected the same stations selected before.

$$\text{Min: } TT_{ij} = T_{0j} + T_{ij} + T_{i0}; i \neq j, i_{(2)} \neq i_{(1)}, j_{(2)} \neq j_{(1)}, i_{(1)}$$

Do until all stations are selected, each route is set, the number of total route is increase, $O=O+1$.

- 4) Check the demand of each oil product in those selected travel routes on each day

For $f \dots p, i_{(o)}n, j_{(o)} \dots n, \text{ and } o \dots O, a \dots ddate$

$$Z_{f(i_o)a} = D_{fi(o)a} + D_{fj(o)a}$$

- 5) Check the remaining stock for each station plus demand in each station. It should not more than capacity of underground tank in each station that is the same as Eq.(4).

$$S_{fi(o)a-1} + d_{fi(o)a} < V_{fi(o)}$$

$$S_{fj(o)a-1} + d_{fj(o)a} < V_{fj(o)}$$

- 6) Check the order quantities of customer for each route;

- a. In case of products f total amount of Z liters' on date a is not over the capacity of compartment ($Z_{foa} < s_f$), then update the remaining stock of product f on each station (i_o, j_o) of travel route o on date a ;

$$Stock_{fi(o)a} = Stock_{fi(o)a-1} + D_{fi(o)a}$$

$$Stock_{fj(o)a} = Stock_{fj(o)a-1} + D_{fj(o)a}$$

- b. In case of product f total amount of Z liter's on date a is over the capacity of compartment ($Z_{foa} > s_f$), keep the last demand of date a into unfinished account. In case of no travel between stations set travel time of that route equal to zeroes.

$$Stock_{fi(o)a} = 0 \text{ station 'i'}$$

$$Stock_{fj(o)a} = 0 \text{ station 'j'}$$

$$TT_{oa} = TT_o$$

- 7) Check amount of current date is equal to the delivery date or not? (a & $ddate$);

If $a < ddate$, find out some amount of demand on date $a+1$ include the delivery on date a .

$$(Z_{foa} = Z_{foa} + Z_{foa+1}), \text{ and } a = a+1$$

Then, go back to step 5)

If $a > ddate$, go to step 7).

- 8) Check amount of total route(o) are meet all stations, if not add $o=o+1$ and go back to step 5),
- 9) Assign the routes for trucks by considering the truck that has minimum travel time should be selected for the next route.

$$vc_{ka} = TT_{oa}; k \dots u, o \dots O, a \dots ddate$$

$$\text{Min: } vc_{ka}$$

$$vc_{ka} = TT_{(o)a} + TT_{(o+1)a}$$

- 10) Calculate and show the associated costs;

In the case of travel time is over regular time, working cost, wc , is included overtime cost:

$$vc_{ka} > H;$$

$$\text{Working Cost} = (H \times RTcost) + ((vc_{ka} - H) \times OTcost)$$

In the case of travel time is less than regular time(minute):

$$vc_{ka} \leq H;$$

$$\text{Working Cost} = (vc_{ka} \times RTcost)$$

Transportation cost, tc , is labor cost multiply by travel time(minute):

$$\text{Transportation Cost} = vc_{ka} \times TRANcost$$

Total cost is working cost plus transportation cost.

$$\text{Total Cost} = \text{Working Cost} + \text{Transportation Cost}$$

5. Tabu MPOSP Heuristic

The same input data such as, number of station(n), station coordinate locations (x,y), speed of truck(v), type of oil products(p), delivery time of each station($ddate$), travel cost per minute(c), regular labor cost per minute($TRANcost$), overtime labor cost per minute($OTcost$), regular working hours(H), end of working include overtime(H'), loading time time(l), unloading time(s), demand of oils at each period(D_{pn}), capacity of underground tank(m_{ip}), and amount of remaining oil product p at station i period t (S_{pit}), and travel route(o).

Variables used in Tabu search are;

$Rtubu$ = maximum pairs of station that can be keep in tabu list

$Stabu$ = the total station pairs selected to tabu list in each iteration.

$Ftubu$ = checker to count the number of station pairs that are limited.

$Iteration$ = number of iterations

1) Initialize

Generate the initial population of rout, S_0 , by previous MPOSH procedure. ($Count = 0$)

Such as:

$$S_0 = i(1)j(1) . i(2)j(2) . i(3)j(3)$$

$$= 13-24-56$$

It means:

Route 1 = pair of station 1 and station 3

Route 2 = pair of station 2 and station 4

Route 3 = pair of station 5 and station 6

2) Set the initial population is the best of station pair, ($S_{best} = S_0$)

Calculate the fitness C_0 and set it equal to $Cost_{best}$

3) Add the station pair set to tabu list(a), and update the total station pairs selected to tabu list, $a = ftabu + stabu$

Example, if $stabu = 1$

$$tabu[a][1] = station 1$$

$$tabu[a][2] = station 3$$

4) Construct the neighborhood of station pair

($S_{neighbor}$) that are not assigned in tabu list, and then find the best neighborhood of pair of station.

($S_{neighbor_best}$) using the saving time procedure (as shown further section).

5) Update the tabu list under condition ($a < Rtabu$)

In case of ($a < Rtabu$)

Set $Ftabu = a$ and back to step 3,

In case of ($a \geq Rtabu$)

Reset the tabu list except the last station pair, and set it to 1st station pair in *tabu list*.

$$Ftabu = 1$$

6) Compare the fitness of the best neighborhood and the cost best, ($f(S_{neighbor_best})$ and (C_{best}).

If ($f(S_{neighbor_best}) > (C_{best})$), go to step 7

If ($f(S_{neighbor_best}) < (C_{best})$).

$$C_{best} = f(S_{neighbor_best})$$

$$S_0 = S_{neighbor}$$

7) Increase number of iteration, $Count = Count + 1$, Check number of iteration \geq maximum iteration.

If number iteration $<$ maximum iteration go to step 3.

If number iteration = maximum iteration, generate the solution files “best_solution1.txt”, and “best_solution2.txt”

6. The Saving Time Procedure

In saving time procedure, the steps are the same as MPOSH but only step 3 is changed.

At step 3), in case of 2 stations are selected, we assign the station pair that has maximum saving time to be a departure, the calculate as:

$$Max S_{ij} = (T_{j0} + T_{0j}) + (T_{i0} + T_{0i}) - (T_{0j} + T_{ij} + T_{i0}) = T_{j0} - T_{ij} + T_{0i}$$

After matching pair of each route, set 1st route composes of station $i(1)$ and set station $j(1)$.

Calculate travel time $TT_o = T_{0j} + T_{ij} + T_{i0}$ or I^{st} route and add the new station pairs, the new must has maximum saving time, and consider the new pairs must be not selected the same stations selected before.

$$Max S_{ij} = (T_{j0} + T_{0j}) + (T_{i0} + T_{0i}) - (T_{0j} + T_{ij} + T_{i0}) = T_{j0} - T_{ij} + T_{0i};$$

$$i \neq j, i_{(2)} \neq i_{(1)}, j_{(2)} \neq j_{(1)}, i_{(2)}$$

Do until all stations are selected, each route is set, the number of total route is increase, $O = O + 1$.

7. Experimental results and discussion

The algorithms are coded in Borland C++5.02 and test run on PC 1.6 GHz., RAM 1 GB., and Virtual Memory is 10 GB. The problem instances are generated as similar as actual real case possible (**Table 1**). The product type is consists of 4 products, Diesel, Gasohol-91, Gasohol-95, and Benzin-91. The numbers of the replenishment station are 5, 10, 20, 50, and 75 stations. For each station, the underground tanks capacities are randomly generated in ranges. The daily demand sales are randomly generated in ranges. Depot coordinate is fixed as (100km,100km) for all instances, while replenishment stations coordinates are randomly uniform distribution in a (300km, 300km). Then, distances are Euclidean calculated. The truck type is

only one type which consists of four compartments according to petro-oil products and each compartment is limited capacity. The velocity of each truck is the same of 60 km/hr.

Moreover, the related data used for all instances are as following; Labor cost in regular time is 1 baht /minute, labor cost in overtime is 2 baht/minute, and travel cost is 1 baht /minute. At depot, loading time is 30 minutes. At replenishment stations, unloading time is 45 minutes. The regular time is 8 hours and the maximum time include over time is 12 hours.

Table 1: Problem instances.

Product	Daily demand sale (Liters)		Underground tank Capacity (Liters)		Compartment Capacity (Liters)
	Max.	Min.	Max.	Min.	
Diesel	800	500	5000	3000	1600
Gasohol-91	700	400	3500	2000	1400
Gasohol-95	600	300	3000	2000	1200
Benzin91	400	200	2500	1500	800

The parameters used in tabu search are; $rtabu$ (maximum number of station pairs that are able to keep in tabu list) is equal to haft of station total ($n/2$), $stabu$ (number of station pairs that are selected into tabu list in each iteration is equal to haft of station total ($n/2$), number of generation is 350, and initialize $ftabu = 0$.

Table 2: Result comparison between LINGO and MPOSH.

Instances	n.station	Period (days)	n. truck	LINGO		MPOSH		Deviation (%)
				Cost	CPU (s)	Cost	CPU (s)	
1	3	3	3	2074	1	2074	0.062	0
2	3	4	3	2872	6	3404	0.063	18.52
3	4	3	4	3016	6	3016	0.062	0
4	4	4	4	4524	150	4524	0.072	0
5	5	3	5	NA	>12000	3691	0.087	0

$n. station$ is total number of stations, $n. truck$ is total number of trucks.

$Cost$ is the total cost, and $CPU (s)$ is CPU time in second.

Performance test results

The performance MPOSH was checked, for small problem size, by comparison with Lingo 11.0 package (Table 2). The most of results show that the optimal trips are the same costs in both results from MPOSH and Lingo 11.0 exempt 2nd instance. These data confirm the accuracy of MPOSH. The deviations of performance in percentage are obtained from Eq. (20).

$$Deviation = \frac{(New-Old)}{old} \times 100 \quad (20)$$

For the large size of problem, the numerical experiments are randomly generated 21 tests

instances with maximum 75 stations 20 days of period. The results of numerical experiments and the comparison between MPOSH and Tabu-MPOSH are shown in Table 3. Results confirm that the hybrid Tabu-MPOSH outperforms the MPOSH in cost but it requires more CPU times.

Table 3: Result comparison between MPOSH and Tabu MPOSH.

Instances	n.station	Period (days)	n. truck	MPOSH		Tabu MPOSH		Deviation (%)
				Cost	CPU (s)	Cost	CPU (s)	
1	5	5	2	7,382	0.08	7,118	4.17	-3.58
2			3	7,076	0.06	6,948	4.09	-1.81
3		10	2	16,947	0.06	16,241	4.34	-4.17
4			3	16,182	0.08	15,816	4.69	-2.26
5		20	2	35,402	0.09	34,036	5.27	-3.86
6			3	33,872	0.09	33,186	5.41	-2.03
7	10	5	6	20,150	0.08	19,366	6.16	-3.89
8		10	6	46,433	0.09	44,669	7.03	-3.8
9		20	6	96,808	0.11	93,084	8.45	-3.85
10	20	5	10	36,834	0.11	36,834	10.70	0
11			11	36,422	0.11	36,422	10.77	0
12		10	10	83,946	0.14	83,408	12.59	-0.64
13			11	82,916	0.13	82,916	12.42	0
14		20	10	176,031	0.19	175,588	15.77	-0.25
15			11	173,971	0.19	173,971	15.70	0
16	50	5	25	93304	0.16	88460	26.20	-5.19
17		10	25	209904	0.24	199337	31.05	-5.03
18		20	25	443194	0.28	420487	38.28	-5.12
19	38	5	38	140994	0.24	137688	41.48	-2.34
20		10	38	317807	0.33	310001	46.34	-2.46
21		20	38	659507	0.36	654221	55.42	-0.8

n. station is total number of stations, *n. truck* is total number of trucks
Cost is the total cost, and *CPU* (s) is CPU time in second

8. Conclusion

This work involved development of two heuristics, MPOSH and Tabu-MPOSH for solving the multi-period replenishment stations problem. These heuristics are composed of several complex procedures, for simply understanding, they mainly contain only route construction and truck loading procedures. The heuristics were tested on randomly generated numerical data based real life data. For small size of problem, the results show our heuristics is acceptable in performance. The experiments were extensive tested for the large size of problem and compared with each other. The results confirm that the hybrid Tabu-MPOSH is more efficient than MPOSH. This study shows the alternative algorithm to improve the heuristic and could be extensive used for all heuristics.

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