Experiment: 06

Date: 20.04.2022

Title: Transportation Problem Solution with Excel Solver.

Question:

1. Cars are shipped from three distribution centers to five dealers. The shipping cost is based on the mileage between the sources and the destinations and is independent of whether the truck makes the trip with partial or full loads. The following Table summarizes the mileage between the distribution centers and the dealers together with the monthly supply and demand figures given in *number* of cars. A full truckload includes 18 cars. The transportation cost per truck mile is $25. Formulate the associated transportation model.

Dealer

	1	2	3	4	5	Supply
Center 1	100	150	200	140	35	400
Center 2	50	70	60	65	80	200
Center 3	40	90	100	150	130	150
Demand	100	200	150	160	140	

2. Construct an Excel Solver model and determine the optimum solution. [Mention each step involved in the model building]

Answer:

1. **Formulate the associated Transportation Problem:**

The Cost Matrix is:

To / From	Dealer					Supply
	1	2	3	4	5	
Center 1	**2500**	**3750**	**5000**	**3500**	**875**	**23**
Center 2	**1250**	**1750**	**1500**	**1625**	**2000**	**12**
Center 3	**1000**	**2250**	**2500**	**3750**	**3250**	**9**
Demand	**6**	**12**	**9**	**9**	**8**	$\sum a_i = \sum b_j = 44$

Mathematical Model of a Transportation Problem :

Let,

x_{ij} = **The amount of goods transportat from i – th origin to j – th destination**

C_{ij} = **The cost to transport unit amount of goods from i – th origin to j – th destination**

a_i = **The Supply amount at i – th origin ,** $i = 1, 2, 3, \ldots \ldots \ldots \ldots, m$

b_j = **The Demand amount at j – th destination ,** $j = 1, 2, 3, \ldots \ldots \ldots \ldots, n$

Then the mathematical model for a Transportation Problem is given by:

Find x_{ij} so as to,

$$Minimize\ Z = \sum_{i=1}^{m} \sum_{j=1}^{n} C_{ij} x_{ij}$$

Subject To,

$$\sum_{j=1}^{n} x_{ij} = a_i \ , \quad i = 1, 2, 3, \ldots \ldots \ldots \ldots \ldots, m \quad (Supply\ Constraint)$$

$$\sum_{i=1}^{m} x_{ij} = b_j \ , \quad j = 1, 2, 3, \ldots \ldots \ldots \ldots \ldots, n \quad (Demand\ Constraint)$$

$$x_{ij} \geq 0 \ , \quad \forall\ i, j$$

2. Transportation Problem Solution with Excel Solver:

In Excel Solver, the spreadsheet is the input and output medium for the Transportation problem. We use the following steps to formulate the following model in Excel:

Transportation model:

To / From	Dealer					Supply
	1	2	3	4	5	
Center 1	2500	3750	5000	3500	875	23
Center 2	1250	1750	1500	1625	2000	12
Center 3	1000	2250	2500	3750	3250	9
Demand	6	12	9	9	8	$\sum a_i = \sum b_j = 44$

Step 1:

- In the first step, create the transportation table in an Excel spreadsheet. The table should contain origins, destinations, cost per unit from each supply center to demand center, the supply capacity at each origin, and the demand of each center. This is shown in the Excel matrix indicated by cells **L4:S9**.

Step 2:

- Check whether the problem is balanced or not by comparing the total supply and the total demand. If total demand is more than the total supply then add a dummy origin (i.e., a row in the cost matrix) with the cost values as zero. Similarly, if the total supply is more than the total demand then add a dummy destination (i.e., a column in the cost matrix) with the cost values as zero.

Step 3:

- At the bottom of this transportation matrix, a linear model is constructed with decision variables (**Cell: M13:Q15**), objective function (**Cell: M19**) and both supply and demand constraints (**Cell: S13:S15** and **M17:Q17**, resp.). This is shown in cells **L12:S19**.

Step 4:

- Objective function is to minimize the total transportation cost. A formula for computing the objective function value is created in a cell. Cell **M19** would give the final value of minimized cost.
  For its calculation, a formula has to be created one can use **SUMPRODUCT** function available in the excel spreadsheet as the following :
  Cell M19: =SUMPRODUCT(M13:Q15,M5:Q7)

Step 5:

- Formula for computing the **total supply** from different origins are formulated in **Cell S13:S15**.

  The formulas are as follows:
  Cell S13:=SUM(M13:Q13),
  Cell S14:=SUM(M14:Q14),
  Cell S15:=SUM(M15:Q15)

Step 6:

- Formula for computing the **total inflow** at different destinations are formulated in **Cell M17:Q17**.

  The formulas are as follows:
  Cell M17:=SUM(M13:M15),
  Cell N17:=SUM(N13:N15),
  Cell O17: =SUM(O13:O15),
  Cell P17:=SUM(P13:P15),
  Cell Q17:=SUM(Q13:Q15)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1					Transportation Problem										Cost Matrix					
2					Problem Data										Problem Data					
3					Dealer										Dealer					
4			D1	D2	D3	D4	D5		Supply				D1	D2	D3	D4	D5		Supply	
5		Center 1	100	150	200	140	35		400			Center 1	2500	3750	5000	3500	875		23	
6		Center 2	50	70	60	65	80		200			Center 2	1250	1750	1500	1625	2000		12	
7		Center 3	40	90	100	150	130		150			Center 3	1000	2250	2500	3750	3250		9	
8																				
9		Demand	100	200	150	160	140					Demand	6	12	9	9	8		44	
10																				
11															Solution					
12													D1	D2	D3	D4	D5		Supply	
13												Center 1							0	
14												Center 2							0	
15												Center 3							0	
16																				
17												Demand	0	0	0	0	0			
18																				
19												Objective	0							
20																				

In Microsoft Excel, after entering entire Transportation Problem data in the worksheet, the following steps would lead to a solution:

Step 1:

- Select **Data** menu in the toolbar.

Step 2:

- In Data menu, select **Solver** application.

Step 3:

- Open Solver application. In Solver parameters dialog box Enter **$M$19** in set target cell. Select purpose of **min** (depending on the type of the objective and for transportation problem objective function type is always min). Enter **$M$13:$Q$15** in by changing cell box. To enter constraint equations, click on **Add** button.

Step 4:

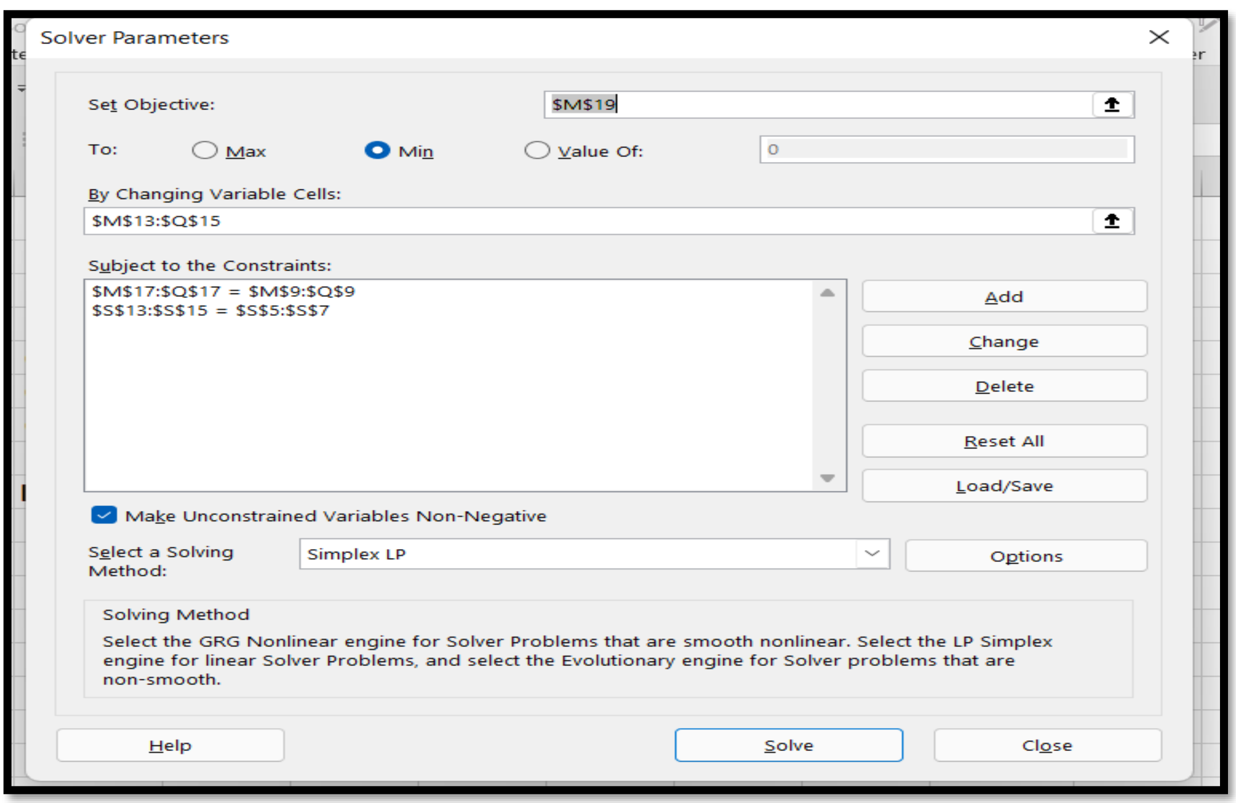
- When the **Add** constraint dialog box opens, it would have three boxes: first, cell reference; second, inequalities of ≤ and lastly, constraint box. For supply constraints, enter **$S$13:$S$15** in cell reference box; enter inequality of = and **$S$5:$S$7** in the constraint box. Then click on Add to add demand constraints in the similar process. After entering all constraints, click **OK**.

Step 5:

- Now choose Options. Select Assume Non-Negative and Assume Linear Model (in **MS Excel 2007**). In **Excel 2010** onwards, select Make Unconstraint Variables Non-negative and select Simplex LP from the dropdown menu of Select a Solving Method. Click **OK**.

Step 6:

- When Solver parameters dialog box appear, click on **Solve**.



Step 7.:

- Finally, when final solution appears on the worksheet, select Keep Solver Solution and click **OK**.

Output:

Transportation Problem

Problem Data

	Dealer					
	D1	D2	D3	D4	D5	Supply
Center 1	100	150	200	140	35	400
Center 2	50	70	60	65	80	200
Center 3	40	90	100	150	130	150
Demand	100	200	150	160	140	

Cost Matrix

Problem Data

	Dealer					
	D1	D2	D3	D4	D5	Supply
Center 1	2500	3750	5000	3500	875	23
Center 2	1250	1750	1500	1625	2000	12
Center 3	1000	2250	2500	3750	3250	9
Demand	6	12	9	9	8	44

Solution

	D1	D2	D3	D4	D5	Supply
Center 1	6	0	0	9	8	23
Center 2	0	3	9	0	0	12
Center 3	0	9	0	0	0	9
Demand	6	12	9	9	8	
Objective	92500					

Conclusion:

The obtained optimal solution of the transportation problem with the optimal cost is given by:

$$\begin{aligned} x_{11} &= 6 \\ x_{14} &= 9 \\ x_{15} &= 8 \\ x_{22} &= 3 \\ x_{23} &= 9 \\ x_{32} &= 9 \end{aligned}$$

Optimal Cost $= (6 \times 2500) + (9 \times 3500) + (8 \times 875) \quad + (3 \times 1750)$
$+(9 \times 1500) + (9 \times 2250) = 9250$