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Solving a Fixed Charge Transportation Problem using Excel Solver

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Abstract:

Traditionally the methods that were used in solving optimization problems followed the use of dummy column that would consequently end in balanced optimization problems from unbalanced ones. A zero cost would be set when using the dummy column method. This method is well used in the fuzzy and also the crisp environments. Otherwise, we get even better results when a maximum cost is involved for the rows of each respective dummy column. More modified methods have a higher efficiency as compared to the existing techniques just as studies have shown. Optimization problem, for instant transportation problem, is concerned with getting cost minimum for delivery from the origin to the required destination. For the paper, this will be achieved by the use of spreadsheet and the excel solver.

Keywords: Transportation problem, fixed charge, spreadsheet, excel solver

1 Introduction:

When dealing with optimization problems, for immediate transportation problems, the transportation cost should be directly proportional to commodity amount that will be transported. Nevertheless, when the distribution variable assumes a positive value, additionally, a fixed cost or the setup cost is used in the many real-world problems (Balinski, 1961). These are the problems that are called fixed charge transportation problems, and the difference between them being the non-linearity on the objective function. There is a fixed cost to an objective function related to every origin when being non-linear for each variable. Dantzig and Hirsch originally formulated the fixed charge TP (Dantzig, 1963). There was a technique presented by Balinski in 1961, and it provided a solution that is approximate for an optimization problems in transportation.

Many researchers have studied FCTP. L. A. Zadeh introduced the fuzzy notion for formalizing the concept of regardless in the membership of the class and connected to human knowledge representation (Zadeh, 1965). The concept was developed in order to solve and define the complex system from the uncertain sources or the imprecise sources mainly non-statistical. Many authors have studied Fuzzy TP. In this paper, the data required will include:

- The transportation unit cost of the various commodities from origin to destination.
- The quantity supplied at origin and destination's demand.

It is important to note that a destination can receive a commodity from various sources. Therefore modeling aims to come up with the most optimal solution; minimum transportation cost.

Optimization problems are problems that are real to the world especially in the fields of economics, business, mathematics, science, and engineering. In all the cases we come up with the optimal solutions which involve; minimizing travel distance, maximization of profits, and minimization of cost and so on. We, therefore, formulate a mathematical model to describe the problem. The model should consist of the following:

- Decision Variables; usually represented by X1, X2 in that format to show the unknown quantities.
- Objective function; which is a mathematical expression for the variables involved in decisions. For example, minimizing the cost function.
- Constraints; which are the limitations.

A spreadsheet model is an implementation of a mathematical optimization by the use of spreadsheet and the solver which is in-built. For a model with two variables, a graphical method can be engaged but it's a rare thing in the world to have a two variable case. Therefore, the need for this technique is considered when it comes to more than two variables as the existing methods are very tedious, and the method also caters for the poor in mathematics.

2 Procedure:

a) Organize the spreadsheet so that it is the model representation.
b) For each separate cell a decision variable is represented.
c) A formula is created for objective and constraints functions representation.
d) On completion of this modeling into the spreadsheet, the solver is engaged for solution generation. Here identification cells for decision variables, objective function, constraints and maximizing or minimizing is carried out.

3 Numerical example:

Let us take a case study for an electrical company that wants to ship power to satisfy four number of cities. It wants to minimize the cost of transportation as it satisfies all the cities. It has three power stations that can supply the following power in kWh: Station 1- 48 million, Station 2- 55 million and Station 3- 45 million. The power demand (millions) that each city requires in kWh: C.yt 1- 51, C.yt 2- 27, C.yt 3- 35 and C.yt 4- 35. We also have to note that the cost of transportation of one million kWh depends on the travel distance of the electric power. This can be tabulated as:

Table 1

From	C.yt 1	C.yt 2	To C.yt 3	C.yt 4	M kWh Supply
St1	$9	$7	$10	$8	48
St 2	$9	$13	$12	$7	55
St 3	$15	$9	$17	$8	45
M kWh Demand	51	27	35	35	

Solution:

We will begin by organizing our work in order then transferring the related work into a spreadsheet where we will see in put the formulas and come out with the most optimal solution.

The power is from each station, (i= 1, 2, and 3), to each city, (j=1, 2, 3, and 4) meaning:

Xij= produced kWh in a million at i and destined to j.

Fixed cost per unit ($);

$F_{11}= 9$; $F_{12}= 7$; $F_{13}= 10$; $F_{14}= 8$

$F_{21}= 9$; $F_{22}= 13$; $F_{23}= 12$; $F_{24}= 7$

$F_{31}= 15$; $F_{32}= 9$; $F_{33}= 17$; $F_{34}= 8$

The decision variables for the total cost to cater for supply can therefore be written as:

$9X._{11} + 7X._{12} + 10X._{13} + 8X._{14}$ from St. 1

$9X._{21} + 13X._{22} + 12X._{23} + 7X._{24}$ from St. 2

$15X._{31} + 9X._{32} + 17X._{33} + 8X._{34}$ from St. 3

The constraints that are facing the company is that, the supply from each station cannot surpass its capacity and the power demanded by the cities cannot go below the peak demand levels. This can be represented mathematically as follows:

Constraints of S:

$X_{11} + X_{13} + X_{12} + X_{14} \leq 48$ from St. one

$X_{21} + X_{23} + X_{22} + X_{24} \leq 55$ from St. two

$X_{31} + X_{33} + X_{32} + X_{34} \leq 45$ from St. three

Constraints of D:

$X_{11} + X_{21} + X_{31} \geq 51$ -C.yt 1

$X_{12} + X_{22} + X_{32} \geq 27$ -C.yt 2

$X_{13} + X_{23} + X_{33} \geq 35$ -C.yt 3

$X_{14} + X_{24} + X_{34} \geq 35$ for C.yt 4

Constraint for against Negativity:

$X._{ij} \geq 0$ (i= 1, 2, 3 and j= 1, 2, 3, 4)

With this we can develop a program that is linear for the electric power company and then incorporate the solver to get the required supply from the various stations to cater for the demands of the cities.

LP Formulation:

Min z= $9X_{11} + 7X_{12} + 10X_{13} + 8X_{14} + 9X_{21} + 13X_{22} + 12X_{23} + 7X_{24} + 15X_{31} + 9X_{32} + 17X_{33} + 8X_{34}$

In which $X_{11} + X_{13} + X_{12} + X_{14} \leq 48$

$X_{21} + X_{23} + X_{22} + X_{24} \leq 55$

$X_{31} + X_{33} + X_{32} + X_{34} \leq 45$

Which are supply constraints and below is constraints for demand;

$X_{11} + X_{31} + X_{21} \geq 51$

$X_{12} + X_{32} + X_{22} \geq 27$

$X_{13} + X_{33} + X_{23} \geq 35$

$X_{14} + X_{34} + X_{24} \geq 35$

And a constraint for against negativity;

$X_{.ij} \geq 0$ (with j= 1, 2, 3, 4 and i= 1, 2, 3)

Analysis and Results:

In analysis and results, we simply follow the spreadsheet and solver procedure. The data is organized in order on a spreadsheet.

Cost per Unit					
	City 1	City 2	City 3	City 4	Supply
Station 1	$ 9	$ 7	$ 10	$ 8	48
Station 2	$ 9	$ 13	$ 12	$ 7	55
Station 3	$ 15	$ 9	$ 17	$ 8	45
Demand	51	27	35	35	

Figure 1: Model Representation

Then we input formulas on the modified model representation (Ragsdale, 2011).

Volume						
	City 1	City 2	City 3	City 4	Station Supply	Supply
Station 1					0	48
Station 2					0	55
Station 3					0	45
City Demand	0	0	0	0		
Demand	51	27	35	35		
Transportation Cost	0					

Figure 2: Model Representation with Incorporated Formulas

The solver and the constraints are engaged. Formulas for the constraints are put into the solver's dialog box so as a solution which is viable and optimal can be achieved.

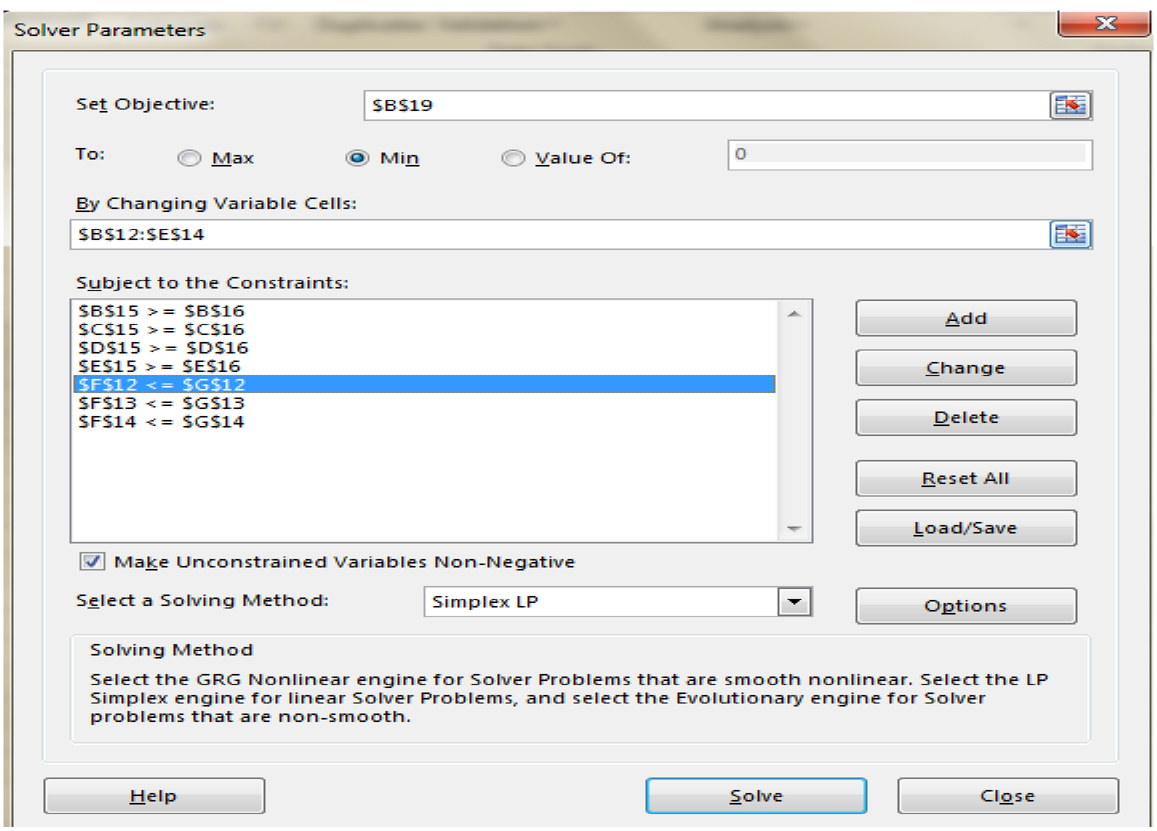

Figure 3: Excel Solver Parameter

Then the solve button is pressed and the solver tells whether a solution has been found or not. If not, there must have been an error in either appropriate input of information or the formulas. In my case the solution was achieved and it as shown below.

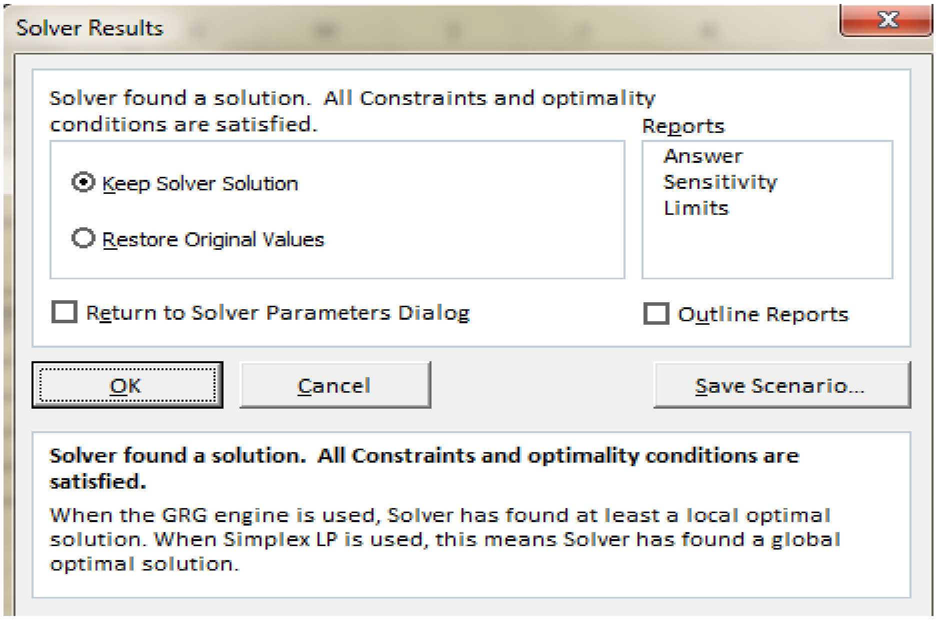

Figure 4: Results Dialog Box

On pressing ok button, we finally get the solver's optimal solution of the supply of power (Walkenbach, 2007).

Volume						
	City 1	City 2	City 3	City 4	Station Supply	Supply
Station 1	0	13	35	0	48	48
Station 2	51	0	0	4	55	55
Station 3	0	14	0	31	45	45
City Demand	51	27	35	35		
Demand	51	27	35	35		
Transportation Cost	1302					

Figure 5: Excel Solver Solution

This result can be represented graphically. We can see that the best way for station 1 is to supply the shown quantities to city three and two, station 2 providing the amounts shown to city one and four and station 3 to supply the amounts given to city two and four. This will yield a transportation cost of $1302.

Therefore, z= 1302, X_{12}= 13, X_{13}= 35, X_{21}= 51, X_{24}= 4, X_{32}= 14, X_{34}= 31. This is the optimal solution achieved by the use of spreadsheet and the excel solver. The method is certainly accurate if all the information is put appropriately into the commands.

Conclusion:

It is evident that many optimization problems can be tackled by the use of Excel Solver. Also, it is way not complex as compared to the complex solution methods that are existing and follow the algorithms form. For the students who are not that good in mathematics can still engage in this course. Excel Solver has largely been used to solve the many optimization problems that are affecting the world in like all majors. It is quite straight forward and can solve many if not all optimization problems. Its use can be seen in industries, businesses, and in economics and so on.

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