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A00 TRANSPORTATION PROBLEM WITH OBJECTIVES TO MINIMIZE TOTAL COST AND DURATION OF TRANSPORTATION BY USING INTEGER PROGRAMMING APPROACH

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Abstract: A transportation problem with twin objectives of minimizing the cost as well as the distance traveled – has been studied. The twin objectives are merged as one with the proper measure to minimize on the whole. This problem has been reduced to an Integer programming problem and the same is solved to get the optimum solution. An example is presented with the real-life data to demonstrate the application of the method.

KeyWords: Transportation cost, Optimization and Integer Programming.

1. INTRODUCTION

In today's competitive environment for business, organizations strive for optimizing the cost and well as the time to ship the product from their Factories to various Market Places for sales purpose. Efforts have been directed towards the careful utilization of the available demand and the supply capabilities. The problem of minimizing the total cost of transportation has been studied since long and it is familiar. In the recent past many researchers have studied about this Transportation Model, like Hammer [3,4], Garifinkel and Rao [2], Szware [9], Bhatia, Puri [1], Ramakrishnan [6], Sharma and Swarup [8], Seshan and Tikekar [7] and Satya Prakash [10]. The objective of this paper is to merge the twin objectives into one with the proper measure to minimize on the whole. This problem has been reduced to a Integer programming problem and the same is solved to get the optimum solution.

The rest of the paper is organized as follows: In section-2, the notations and assumptions are stated. Section –3 contains with the general structure of the present transportation structure and its mathematical model has also been constructed. In section-4, the solution procedure is explained. Section-5 deals with the conclusion of the outcome of the Integer Model. A numerical example is dealt in section-6. Finally, the overall conclusion is made.

2. NOTATIONS AND ASSUMPTIONS

Notations:

i : number of factories located in different places, i = 1,2,..,m
j : number of market places located in different places, j = 1,2,..,n
m,n : finite positive integers
d_{ij} : distance in kilometers between the ith factory and the jth market place

t_{ij} : unit cost of transportation from the ith factory and the jth market place
m_{ij} : cost per kilometer between the ith factory and the jth factory
$k_{ij} = t_{ij} / d_{ij}$; for all , i = 1,2,..,m and j = 1,2,..,n.
S_i : supply capability from the ith factory
D_j : demand capability from the jth market
X_{ij} : number of units to be transported from the ith factory to the jth market

Assumptions

- The values of d_{ij}'s, t_{ij}'s, S_i's and D_j's are known and fixed constant for all i = 1,2,..,m and j = 1,2,..,n
- The total supply should be equal to the total demand. i.e., $\sum_{j=1}^{n} D_j = \sum_{i=1}^{m} S_i$

2. STRUCTURE OF THE TRANSPORTATION PROBLEM

Ramakrishnan [6] studied about the time minimizing transportation problem. He has given a new approach, but that approach is not giving the best optimum solution. A new table can be created by merging the distance to be traveled and the unit cost of transportation such a way to give the unit transportation cost of moving the product per kilometer. The same can be computed using the relation

$$\mathbf{k_{ij} = t_{ij} / d_{ij}};\ \text{for all , i = 1,2,..,m and j = 1,2,..,n.}$$

Market / Factory	**M1**	**M2**	**….**	**…**	**Mn**	**Supply**
F1	t_{11} d_{11}	t_{12} d_{12}			t_{1n} d_{1n}	S_1
F2	t_{21} d_{21}	t_{22} d_{22}			t_{2n} d_{2n}	S_2
…..	….	….	….	…	….	…
…..	….	….	…..	…	….	…
Fm	t_{m1} d_{m1}	t_{m2} d_{m2}			t_{mn} d_{mn}	S_m
Demand	D_1	D_2	…	….	D_n	$\sum_{j=1}^{n} D_j = \sum_{i=1}^{m} S_i$

The restructured table can be given as

Market / **Factory**	**M_1**	**M_2**	**….**	**…**	**M_n**	**Supply**
F_1	k_{11}	k_{12}			k_{1n}	S_1
F_2	k_{21}	k_{22}			k_{2n}	S_2
…..	….	….	….	…	….	…
…..	….	….	…..	…	….	…
F_m	k_{m1}	k_{m2}			k_{mn}	S_m
Demand	D_1	D_2	…	….	D_n	$\sum_{j=1}^{n} Dj = \sum_{i=1}^{m} Si$

The value of k_{ij} is proportionate to the value of d_{ij} for all i = 1,2,..,m and j = 1,2,..,n. The low value of k_{ij} value implies that distance is too long. In order to get the optimum solution for the given Transportation Problem, it is sufficient to solve the above problem with maximization objective. To fine the optimum solution to this Mathematical Model we have used the Integer Programming Application.

Equivalent Integer Programming Model:

$$\textit{Maximize} \quad Z = \sum_{j=1}^{n} \sum_{i=1}^{m} k_{ij} * X_{ij}$$

Subject to the Constraints

$$\sum_{j=1}^{n} X_{ij} = S_i; \qquad \text{for all} \quad i = 1,2,\ldots,m$$

$$\sum_{i=1}^{m} X_{ij} = D_j; \qquad \text{for all} \quad j = 1,2,\ldots,m$$

$$Xij \geq 0 \ \text{ and Integers}$$

4. SOLUTION PROCEDURE

Depending on the formulated model, packages are available for solving Integer Programming Models. Examples of these are Linear Interactive and Discrete Optimizer [LINDO], General Integer and non-Linear Optimizer [GINO], Optimizer Software Library [OSL] and TORA. Results of the models will yield implementable solution.

5. NUMERICAL EXAMPLE

Market Factory	M_1	M_2	M_3	Supply
F_1	$t_{11} = 10$ $d_{11} = 5$	$t_{12} = 18$ $d_{12} = 6$	$t_{13} = 8$ $d_{13} = 4$	$S_1 = 25$
F_2	$t_{21} = 8$ $d_{21} = 2$	$t_{22} = 20$ $d_{22} = 5$	$t_{23} = 15$ $d_{23} = 6$	$S_1 = 25$
F_3	$t_{31} = 4$ $d_{31} = 2$	$t_{32} = 12$ $d_{32} = 7$	$t_{33} = 14$ $d_{33} = 5$	$S_1 = 25$
Demand	$D_1 = 20$	$D_2 = 25$	$D_3 = 30$	75

Restructured table can be present as

Market Factory	M_1	M_2	M_3	Supply
F_1	2	3	2	$S_1 = 25$
F_2	4	4	2.5	$S_1 = 25$
F_3	2	1.71	2.8	$S_1 = 25$
Demand	$D_1 = 20$	$D_2 = 25$	$D_3 = 30$	75

The optimum solution for the Transportation model is provided by solving directly using the Tora Package.

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INPUT GRID - TRANSPORTATION

		D1	D2	D3	Supply
	S/D Name				
S1		2.00	3.00	2.00	25
S2		4.00	4.00	2.50	25
S3		2.00	1.71	2.80	25
Demand		20	25	30	

TRANSPORTATION MODEL OUTPUT SUMMARY

Title:
Final Iteration No.: 2
Objective Value (minimum cost) =155.25

Next Iteration | All Iterations | Write to Printer

From	To	Amt Shipped	Obj Coeff	Obj Contrib
S1:	D1:	20	2.00	40.00
S1:	D2:	0	3.00	0.00
S1:	D3:	5	2.00	10.00
S2:	D3:	25	2.50	62.50
S3:	D2:	25	1.71	42.75

Hence the optimum allocation is
F1 to M1 20 units; F1 to M3 5 units; F2 to M3 25 units; F3 to M2 25 units

Optimum time for cost shipping is 915 Rupees.
Optimum distance travelled for total shipping is 290 kms.

Alternatively the same problem can be converted into an Integer Programming model and the same can be solved.

Hence the optimum allocation is
F1 to M1 20 units; F1 to M3 5 units; F2 to M3 25 units; F3 to M2 25 units

Optimum time for cost shipping is 915 Rupees.
Optimum distance travelled for total shipping is 290 kms.

INPUT GRID - INTEGER PROGRAMMING

	x1	x2	x3	x4	x5	x6	x7	x8	x9	Enter <, >, or =	R.H.S.
Var. Name											
Minimize	2.00	3.00	2.00	4.00	4.00	2.50	2.00	1.71	2.80		
Constr 1	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	=	25.00
Constr 2	0.00	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00	=	25.00
Constr 3	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	=	25.00
Constr 4	1.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	=	20.00
Constr 5	0.00	1.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00	=	25.00
Constr 6	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	1.00	=	30.00
Lower Bound	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Upper Bound	infinity	infinity	infinity	infinity	infinity	infinity	infinity	infinity	infinity		
Unrestr'd (y/n)?	n	n	n	n	n	n	n	n	n		
Integer (y/n)?	y	y	y	y	y	y	y	y	y		

Title:
(Current) Best Objective Value (Min) =155.25
Found at Iteration 1
Optimality verified at Iteration 2

FEASIBLE SOLUTIONS (in improved order)

Subproblem	ObjVal, z	x1	x2	x3	x4	x5	x6	x7	x8	x9
1	155.25	20	0	5	0	0	25	0	25	0

B&B Search completed

6. CONCLUSION

Based on the final optimum solution, one can decide easily, the number of units to be transported from various factories to various market places. The decision that we have arrived at this juncture is taking care regarding distance traveled and the cost of transportation. In the next section, an example to demonstrate the utility of the Mathematical Programming approach is presented.

7. REFERENCE:

[1]. Operations Research – An Introduction, Dr P. Mariappan, Pearson India Limited, 2013.
[2]. Operations Research – An Introduction, Hamdy A Taha, Fourth Edition, Tata MgCraw Hill, 2008.