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Transportation Time Minimization: An Algorithmic Approach

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ABSTRACT

In this paper, a transportation algorithm is applied to determine the minimum transportation time. The algorithm determines the Initial Basic Feasible Solution (IBFS) of Transportation Problem (TP) to minimize time. Herein, the Distribution Indicators (DI) is calculated by the difference of the greatest time unit and the nearest-to-the-greatest time unit. Then the least entry of the Transportation Table (TT) along the highest DI is taken as the basic cell. The result with an elaborate illustration demonstrates that the method presented here is effective in minimizing the transportation time.

Keywords: Transportation problem, optimization

1. Introduction

Transportation model plays a vital role to ensure the efficient movement and in-time availability of raw materials and finished goods from sources to destinations. Transportation problem is a Linear Programming Problem (LPP) stemmed from a network structure consisting of a finite number of nodes and arcs attached to them [1]. The objective of the TP is to determine the shipping schedule that minimizes the total shipping cost while satisfying the demand and supply limit [2]. If we are able to minimize the transportation time, transportation cost comes down naturally. In literature, a good number of researches [4, 5, 6, 7, 8] are available regarding minimization of transportation cost. These research developments can be used to minimize the transportation time. Here we use a new transportation algorithm to find the IBFS of time minimization problem with equal constraints. We present the typical problem of a single product to be shifted from m origins (factories) to n destinations (warehouses/ sales centers) wherein $a_1, a_2, \ldots, a_m$ and $b_1, b_2, \ldots, b_n$ are the capacities of the origins and destinations respectively.

There is a constant t_{ij} called unit time is required to transport the items from the origin i to the destination j.

Several methods are available to determine the IBFS. The well-known methods are: Vogel's Approximation Method (VAM) [1], Balakrishnan's version of VAM [6], Shore's application of VAM [7], H.S. Kasana et al. Extremum Difference Method for Transportation [8] are appreciated for the initial basic feasible solution. In this paper we present a method which gives better IBFS than given by the methods just mentioned.

2. Algorithm of the Method Presented Herein

Step 1 Place the row and the column distribution indicators just after and below the supply and demand amount respectively within the first brackets, which are the difference of the greatest element and before-the-greatest element of each row and column of the TT. If there are two or more greatest elements in a row or column, difference is to be taken as zero.

Step 2 Identify the largest distribution indicator. Choose the smallest entry along the largest distribution indicator. If there are two or more smallest elements, choose any one of them arbitrarily.

Step 3 Allocate x_{ij} = min (a_i , b_j) on the left top of the smallest entry in the cell (i, j) of the TT.

Step 4 If $a_i < b_j$, leave the i-th row and readjust b_j as $b_j^{/} = b_j - a_i$.
If $a_i > b_j$, leave the j-th column and readjust a_i as $a_i^{/} = a_i - b_j$.
If $a_i = b_j$, then leave either i-th row or j-th column but not both.

Step 5 Repeat Steps1 to 4 until the rim requirement is satisfied.

3. Illustration

A company manufactures cement and it has three factories F_1, F_2 and F_3 whose weekly production capacities are 10, 15 and 5 thousand bags respectively. The company supplies cement to its three warehouses located at

W_1, W_2 and W_3 whose weekly demands are 10, 8 and 12 thousand bags respectively. The transportation time of shipment are given below in the TT:

Factory	Warehouse			Capacity
	W_1	W_2	W_3	
F_1	10	2	20	10
F_2	3	7	9	15
F_3	12	14	16	5
Demand	10	8	12	

We want to arrange the transportation of cement from factories to warehouse in minimum time.

Factory	Warehouse			Capacity	Row Distribution Indicators		
	W_1	W_2	W_3				
F_1	$^{2}10$	$^{8}2$	20	10	(10)	(10)	-
F_2	$^{8}3$	7	$^{7}9$	15	(2)	(6)	(6)
F_3	12	14	$^{5}16$	5	(2)	(4)	(4)
Demand	10	8	12				
Column Distribution	(2)	(7)	(4)				
	(2)	-	(4)				
	(9)	-	(7)				

Step 1 We calculate the distribution indicators and place them just after and below the supply and demand amount respectively within the first brackets which are (10), (2), (2); (2), (7), (4).

Step 2 Among them the largest distribution indicator is 10. We choose the smallest entry along 10 which is 2.

Step 3 Allocate x_{ij} = min $(10,8)$ =8 on the left top of the smallest entry 2 in the cell (1, 2) of the TT.

Step 4 Since $a_1 > b_2$, we leave the 2nd column and re-adjust a_1 as $a_1^{/} = a_1 - b_2 = 10 - 8 = 2$.

Step 5 We repeat Steps1 to 4 until the supply and demand limit are exhausted.

We see that the number of basic variables is 5(=3+3-1) and the set of basic cells do not contain a loop. Thus the solution obtained is a basic feasible solution and the initial basic feasible solution is

$$x_{11} = 2, x_{12} = 8, x_{21} = 8, x_{23} = 7, x_{33} = 5.$$

Therefore, in order to complete the shipment it takes time

$T_1 = \max\{t_{11}, t_{12}, t_{21}, t_{23}, t_{33}\} \Rightarrow T_1 = \max\{10, 2, 3, 9, 16\}$ = 16 units of time.

4. Optimality Test

Since $t_{13} = 20 > T_1$, the non-basic cell (1, 3) is crossed out.

Factory	Warehouse			Capacity
	W_1	W_2	W_3	
F_1	$^{2}10$	$^{8}2$	20	10
F_2	$^{8}3^{(-5)}$	7	$^{7}9^{(+5)}$	15
F_3	$12^{(+5)}$	14	$^{5}16^{(-5)}$	5
Demand	10	8	12	

We draw a loop originating from the cell (3, 3) using the cells (3, 1), (2, 1) and (2, 3); where (3, 1) is the entering cell shown in the left table.

Factory	Warehouse			Capacity
	W$_1$	W$_2$	W$_3$	
F$_1$	^{2}10	^{8}2	20 ////	10
F$_2$	^{3}3	7	^{12}9	15
F$_3$	^{5}12	14 ////	16 ////	5
Demand	10	8	12	

We subtract 5 units from the cells (3, 3) and (2, 1). Also we add these 5 units to the cells (3,1) and (2, 3) in order to adjust the demand and supply limit.

Since $t_{32} = 14 > T_2$ and $t_{33} = 16 > T_2$, the non-basic cells (3, 2) and (3, 3) are crossed out.

Now we cannot form any loop originating from the cell (3, 1). Thus the current solution $x_{11} = 2, x_{12} = 8, x_{21} = 3, x_{23} = 12, x_{31} = 5$ is optimum and the optimum shipment time is $\max\{10, 2, 3, 9, 12\} = 12$

5. Conclusions

The method presented and discussed above gives us an initial basic feasible solution of the transportation problem with equal constraints, in minimization of time. The method developed here ensures a solution which is very closer to the optimal solution. From the example, illustrated here by this method, we see that it takes less iteration to reach the optimum solution. Sometimes this method provides the optimal solution directly.

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