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Transportation Cost Optimization of an Online Business Applying Vogel's Approximation Method

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ABSTRACT

Red Tech. BD, an online based business company intended to spread their business over whole Rajshahi District. As there is no cost for manufacturing the only factor that can maximize the profit is the product transportation cost. Determination of the optimum & reliable transportation medium was the first challenge. A suitable destination for distributing the products in the selected location has been chosen carefully on the basis of demand & minimum rent of warehouse. First, the mathematical model has been formed & then it has been solved by a program written in 'C' programming language. The program can show the result of the optimum amount of supply with the corresponding destination together in a single output. Verification of the program or 'code' has been done with the help of hand calculation. The company can determine the supply unit with destination to minimize the transportation cost before every shifting of products from warehouse to the destination.

***Keywords*:** Cost optimization, Transportation model, Vogel's approximation method, 'C' program

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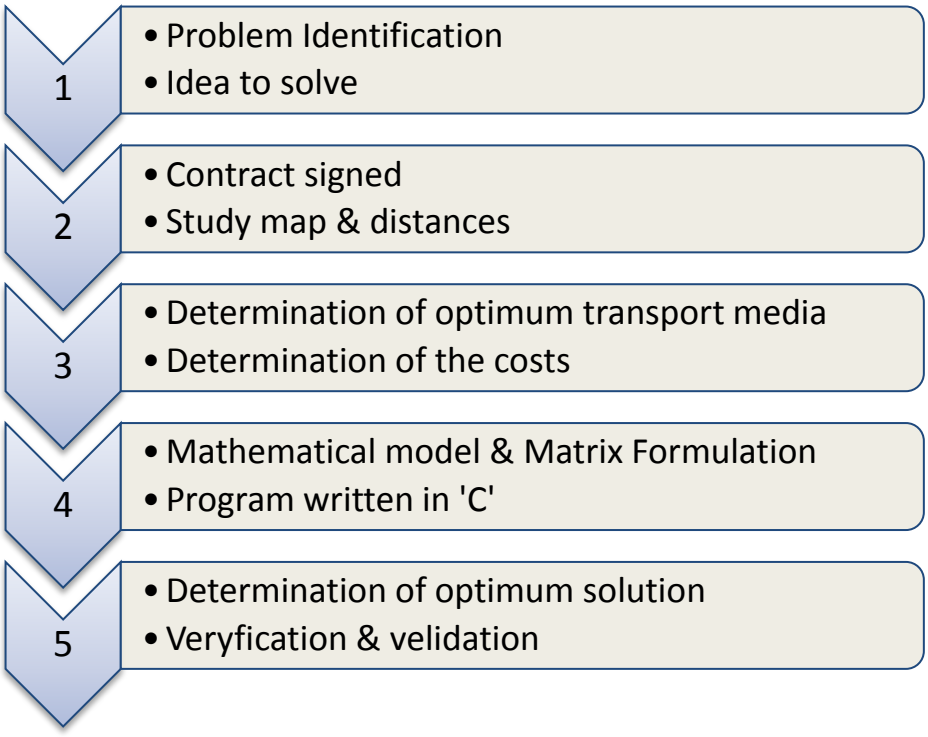
GRAPHICAL ABSTRACT



1. INTRODUCTION

A contract signed with the business owner to find the optimal ways & media to transport goods from the warehouses to several destinations at a minimum cost. The primary demand of different products has been forecasted by the company. It was not possible to send different products on different time at an optimum cost because it is really very costly to deliver single product in a particular transport. So, it was very necessary to fix a transportation media of minimum cost & maximum reliability. Then, destination points outside the 8 sub-districts have been chosen carefully on the basis of the transportation media availability & buying ability of people there. Distances of the destinations & warehouses have been measured by google map.

Vogel's approximation method is a very popular method to solve Transportation problem model under some assumptions. A 'C' programming language has been written in which is very fast and widely used in various platforms. At first, the program takes the number of warehouses and destinations as input from the user. From that information a cost matrix is formed which is also an input from the user. Then for each warehouse the supply limit and for each destination, the demand is specified. There is a sorting function which can identify the lowest penalty cost. After getting that point the demand is filled with respect to the supply limit. At the end of the program, the optimal way to transport products so that minimum cost can be achieved which is from which warehouse how many units of products need to deliver to a specified destination is printed out also the minimum cost is calculated and shown at the end.

On the basis of demand forecasting, the optimum solution can be determined without any effort by means of this program. Verification of the program was done by solving the mathematical model manually or by hand calculation given in books [1-3]. A Renowned online business of Bangladesh named 'Red Tech. BD' had an existing business of selling products in only Rajshahi Shadar thana (sub-district). Their head office is in Dhaka, Gulshan-Badda link road. The company decided to spread the business over whole Rajshahi District.

The products are bought from China/Taiwan mainly, orders are taken online & distributed via local transports. There is no additional cost except the transportation cost. So, profit can be maximized by minimizing the transportation cost only. In order to distribute the products easily to the customer living in the remote areas or far from Rajshahi Shadar it might be very costly to send the products to the customers. Extra times, extra costs etc. might be required due to unavailability of transportation. This might harm the reputation of the business & customer satisfaction level might be very low. So, by taking rent a destination points or building new destination points in the heart of corresponding thana & sifting the products on the basis of demand forecasting weekly it would be very reliable [4]. It had made the possible on-time delivery of available local transport. Sometimes, the customer's house within a walking distance from the destination point.

Sub-districts around Rajshahi district are connected by bus service which is very cheap. This bus service also acts as a courier service to transport goods. It only cost 1.90 BDT per Kilometer for the one-unit product. Red Tech BD isn't interested to buy their own transportation media such as a covered van or any kind of vehicle. Because, it has a maintenance cost, driver cost etc. which would cost a certain extra amount in every month. In local transports, people don't carry heavy goods or luggage usually. So, the lockers remain empty usually. The products can be easily carried by local buses with a very low cost.

Kuhn, H. W., & Baumol, W. J. (1962) used 'Vogel's Approximation method' to solve transportation model [5]. SHORE, H. H. (1970) termed the 'Vogel Approximation Method (VAM)' as a short-cut approach to solving the transportation problem [6]. Mathirajan, M., & Meenakshi, B. (2004) presented a variant of 'Vogel's approximation method' to determine an efficient solution for large-sized transportation problems in the industries, the military etc. [7]. Gomah, T. I. G. E. M., & Samy, I. (2009) used the object-oriented model to solve different Transportation problems [8]. Hakim, M. (2012) used 'Vogel's Approximation method' to find a feasible solution of a transportation problem [9]. Das, U. K., Babu, M. A., Khan, A. R., Helal, M. A., & Uddin, M. S. (2014) stated that "Vogel's Approximation Method (VAM) is the more efficient algorithm to solve the transportation problem" [10]. Sergey V. Ivanov, Anastasia A. Lantseva (2017) used historical data in transportation planning [11]. Rizk M. Rizk-Allah, Aboul Ella Hassanien, Mohamed Elhoseny (2018) developed a new compromise algorithm for multi-objective transportation problem (MO-TP) inspired by Zimmermann's fuzzy programming and the neutrosophic set terminology [12].

2. MATERIALS AND METHODS

2. 1. Determination of Optimum Transport Media:

If Red Tech BD buys a new transportation such as a covered van, Cargo then it has a cost which will be an initial investment with a large amount. It will be required servicing after a certain period which is an additional cost.

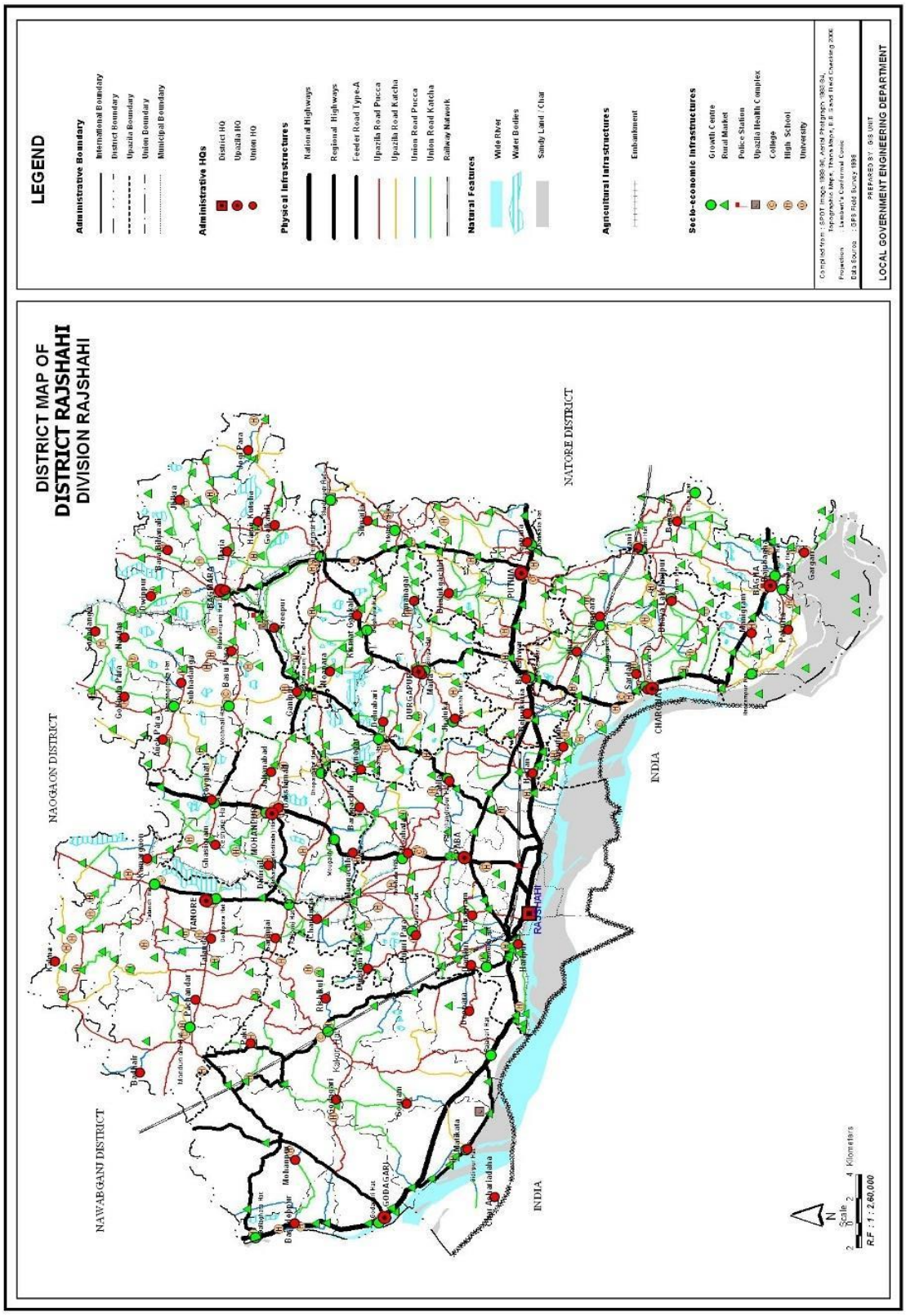


Figure 1. Road map of Rajshahi district.

A driver will need to appoint. But, only one transportation media cannot cover the whole district. Because an online business has a certain time limit to deliver the ordered product. So, one transportation cannot cover all the destinations. The total cost of buying new transport & maintenance can't be overcome by an online business because benefit per unit is not more than 200 BDT ($2.5). There is no additional cost without transportation cost. So, to maximize the net profit in new business a reliable system of minimizing the transportation cost is a must. Rail is available but in most sub-districts, it is not available & also the security of the products is very low.

The most reliable & cheapest media for internal sub-district is the local bus. The product safety is enough & cost is very low. By contracting with a local bus, the products can be distributed from the particular destination at a certain time & at a constant cost. The roadmap in the following figure [11] shows the national highways, regional highways, feeder road type-A, Upazila (sub-district) road pucca, Upazilla road katcha are covered by the local buses.

2. 2. Destination point & cost determination

The distance between each warehouse and destinations have been measured using google maps. For the sake of simplicity, the names of the sub-districts are represented by numerical numbers.

Table 1. Destinations Identifier for ease of calculation

Destinations Identifier	**Identifier**
Destinations	
Destination 1	1
Destination 2	2
Destination 3	3
Destination 4	4
Godagari	5
Tanore	6
Mohanpur	7
Durgapur	8
Bagmara	9
Puthia	10
Charghat	11
Bagha	12

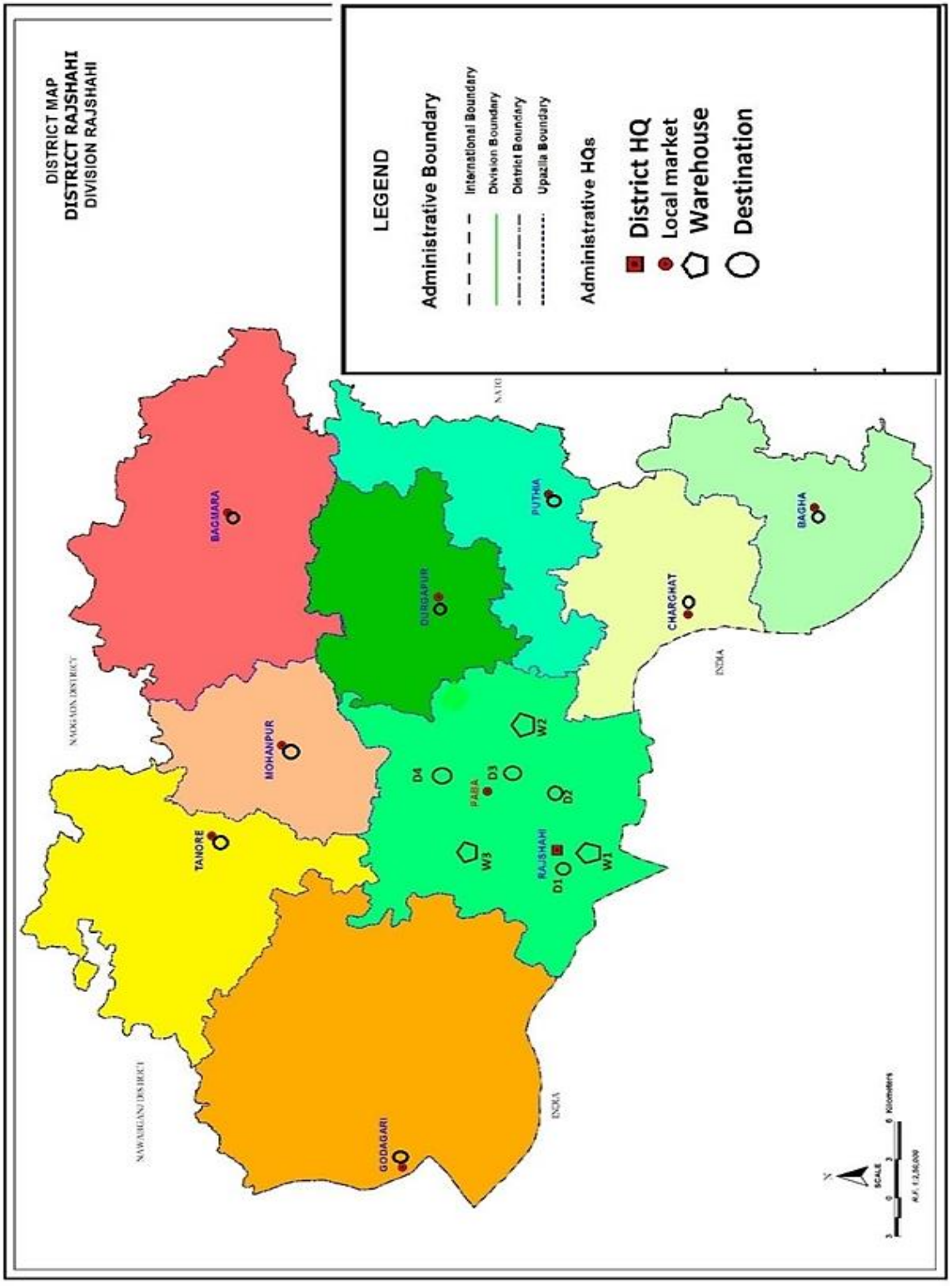


Figure 2. Existing & planned Warehouses & Destinations in whole Rajshahi district.

The following map [12] represents the warehouses & Destinations in different subdistricts. In Rajshahi Shadar the existing warehouses & destinations are also added to the planned destinations in different sub-districts.

The distances from each warehouse to each planned destination are represented as a matrix in the following table.

Table 2. Distance Matrix

Warehouse	Destinations											
D / W	1	2	3	4	5	6	7	8	9	10	11	12
W_1	2	7	9	11	35	38	35	31	50	33	28	46
W_2	13	8	6	7	38	37	31	19	45	28	26	44
W_3	10	10	9	8	33	30	28	36	46	32	31	47

The transportation cost inside Rajshahi is very low compared to the cost outside Rajshahi city. The cost matrix for the destination outside of Rajshahi city is presented below. The values are rounded to nearest integer.

Table 3. Per unit cost of transporting (Outside Rajshahi city)

Warehouse	Destination							
	5	6	7	8	9	10	11	12
W_1	38	42	38	34	55	36	31	51
W_2	41	40	34	21	49	31	29	48
W3	35	33	31	40	51	35	34	52

The cost of transportation of all destinations including existing destinations in Rajshahi Shadar has been included to minimize the total transportation cost.

2. 3. Mathematical Model & Matrix Formulation:

The objective function for cost minimization:

$$\text{Minimize: } Z = \sum_{a=1}^{m} \sum_{b=1}^{n} C_{ab} \; Q_{ab}$$

Subjected to

$$\sum_{b=1}^{n} \text{Qab} \leq S_a \; ; a = 1,2, \ldots\ldots\ldots\ldots, m$$

$$\sum_{a=1}^{m} \text{Qab} \geq D_b \; ; b = 1,2, \ldots\ldots\ldots\ldots, n$$

where:

a = 1,2,……, m is the set of warehouses

b = 1,2,.,……, n is the set of destinations

Q_{ab} = the quantity transported from a to b.

C_{ab} = Per unit cost for transporting from a to b.

S_a = Supply limit of the a-th warehouse

D_b = Demand at the b-th destination

Assumptions:

1. The transportation cost will remain constant.
2. The location of the planned destinations will not be changed.
3. The supply & demand will always equal.
4. In order to solve a transportation problem with 'Vogel's approximation method' a matrix containing all warehouses, destinations, demands, supply & transportation cost from all warehouses to all destinations is to be constructed first.

Table 4. Matrix for Vogel's approximation method

Warehouse	Destination												Supply
	1	2	3	4	5	6	7	8	9	10	11	12	
W_1	1	8	10	12	38	42	38	34	55	36	31	51	150
W_2	5	8	11	5	41	40	34	21	49	31	29	48	173
W3	6	9	12	5	35	33	31	40	51	35	34	52	125
Demand	20	20	50	60	30	39	40	37	37	41	38	36	∑ supply = ∑ demand = 448

2. 4. Solution

The algorithm that follows the 'C' program for solving the Vogel's Approximation Method is presented below:

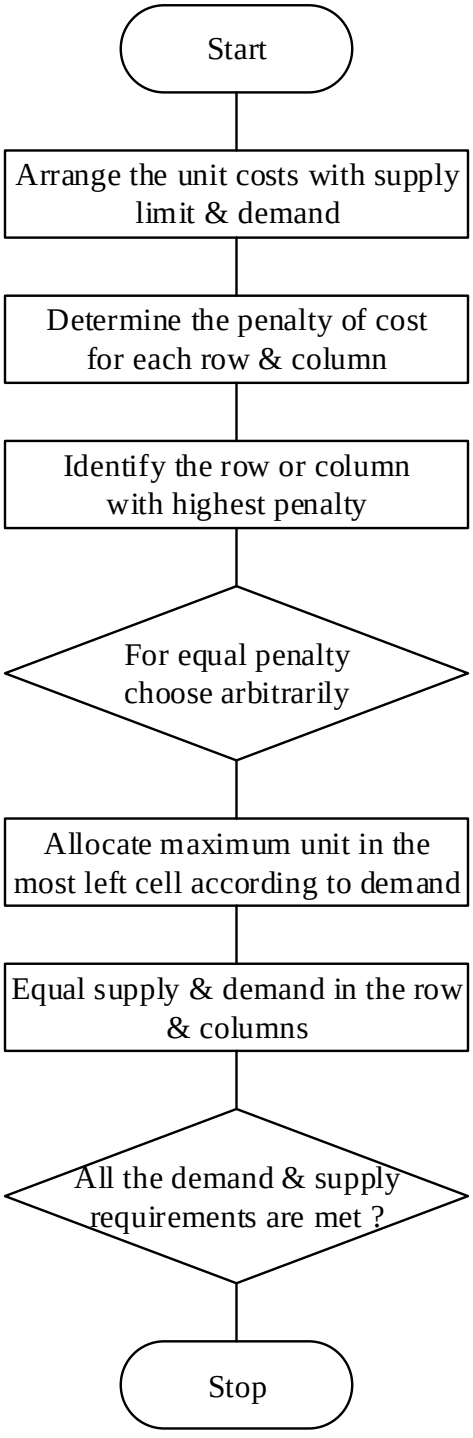


Figure 3. Algorithm to solve 'Vogel's approximation method' by 'C' Program

3. RESULT / EXPERIMENTAL

3. 1. Result from 'C' program

```
 This program solves transportation problem by
    Vogel's approximation method
        #####written by Deb#####

Enter the number of warehouse and Location:3
 12

Enter the cost:
1 8 10 12 38 42 38 34 55 36 31 51
5 8 11 5 41 40 34 21 49 31 29 48
6 9 12 5 35 33 31 40 51 35 34 52

Enter the demand:20 20 50 60 30 39 40 37 37 41 38 36

Enter the supply:150 173 125
```

Figure 4. Different inputs in the 'C' program

```
supply 37 units from warehouse 2 to destination 8

supply 20 units from warehouse 1 to destination 1

supply 39 units from warehouse 3 to destination 6

supply 60 units from warehouse 3 to destination 4

supply 41 units from warehouse 2 to destination 10

supply 20 units from warehouse 2 to destination 2

supply 50 units from warehouse 1 to destination 3

supply 38 units from warehouse 1 to destination 11

supply 40 units from warehouse 2 to destination 7

supply 26 units from warehouse 3 to destination 5

supply 4 units from warehouse 1 to destination 5

supply 35 units from warehouse 2 to destination 9

supply 2 units from warehouse 1 to destination 9

supply 36 units from warehouse 1 to destination 12


 Total minimized cost : 11576
press any number to continue
```

Figure 5. Optimum solution of cost minimization

When the program is run a window appears & asks to input required data at a sequence. Total number of warehouses, total number of destinations, all the costs, the demands & the supply have to be input carefully in the program window.

After completing all the inputs, the program solves the Transportation model by 'Vogel's approximation method'. From which warehouse to which destination including the amount of product & the total cost of transportation, all required solutions are gained at a time from a single program.

From the data of demand & supply provided by **Red Tech BD**, the minimum cost of transporting products from 3 warehouses to entire Rajshahi district is only 11576 BDT ($139.61).

3. 2. Verification & Validation:

Table 5. Manual solve of 'Vogel's approximation method'

Warehouse	Destination												Supply
	1	2	3	4	5	6	7	8	9	10	11	12	
W_1	1 **20**	8	10 **50**	12	38 **4**	42	38	34	55 **2**	36	31 **38**	51 **36**	150
W_2	5	8 **20**	11	5	41	40	34 **40**	21 **37**	49 **35**	31 **41**	29	48	173
W3	6	9	12	5 **60**	35 **26**	33 **39**	31	40	51	35	34	52	125
Demand	20	20	50	60	30	39	40	37	37	41	38	36	∑ supply = ∑ demand = 448

$$\begin{aligned} Total\ cost &= (1 \times 20) + (10 \times 50) + (38 \times 4) + (55 \times 2) + (31 \times 38) + (51 \times 36) \\ &\quad + (8 \times 20) + (34 \times 40) + (21 \times 37) + (49 \times 35) + (31 \times 41) + (5 \times 60) \\ &\quad + (35 \times 26) + (33 \times 39) \\ &= 11576 \end{aligned}$$

The 'C' program is correct & it can solve all the transportation models by 'Vogel's approximation method' under the stated assumptions.

4. CONCLUSIONS

Red Tech BD has become great satisfied after minimizing their transportation cost with a permanent system development for solving any time with new demand & supply amount. The demand may be changed suddenly. For new demand & supply it would be required to minimize transportation costs again. So, the 'C' program removes all difficulties & time to solve any problem at any time. There is no chance of mistakes in calculation also. A reliable & permanent solution helps a business organization to run their business smoothly & to achieve target benefit easily.

Acknowledgement

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