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OPTIMIZATION OF RETAIL DISTRIBUTION NETWORK: A CASE STUDY

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ABSTRACT

Recently retail business in Bangladesh is expanding in a substantial amount. Supermarket biggies have attempted a massive expansion drive recent years to catch up more shoppers who still depend on unorganized wet market to buy their essentials. To catch up all the customer it is obligatory for retail business to have a good coordination among their business and therefore good coordination between retail outlet and distribution centre is must. A good communication between these two is required for a better schedule and thus a better schedule will reduce transportation cost. Again there incur a huge transportation cost within the retail outlets and distribution centers'. Therefore network distribution for retail industry is so vital. Besides a proper network distribution reduce transportation cost and improve product availability. The objective of the study is to develop a mathematical model for network distribution of a retail business. The study has been conducted at ACI Logistics to facilitate maintaining a proper network distribution.

Keywords: Optimization, Network Distribution, Transportation Cost.

1. INTRODUCTION

Network distribution is so vital for any kind of industry. In retail business, there incur huge amount of transportation. So transportation cost is also high.

Different studies have been conducted over transportation model over the years. As it is important to identify and protect the essential components of the transportation system of an urban intelligent transportation network to ensure its survivability. A study had been conducted in the critical point identification in the physical and communication layers of a small urban transportation system by Paul Oman and Brian Johnson[1]. Assessment of intermodal transportation planning at state department of transportation is conducted by Andrew R. Goetz[2]. Another study show how decisions concerning transportation programmes and projects can be made in the context of sustainable transportation [3]. Multinational firms face problem of optimal transportation route to inland destination in land locked country and Honkey Mon studied over this issue [4]. Some studied for development of sustainable transportation system which identifies issues related to the definition, evaluation and implementation of sustainable transportation. Significant issues include the range of definitions of sustainability, the range of issues considered under sustainability, the range of perspectives, criticism of sustainability analysis, evaluating sustainability, transportation impacts on sustainability, goals vs. objectives, sustainable transport decision making[5].Two modeling approaches using spreadsheets for the transportation assignment problem is conducted by Xiang Ye, Xiao Zong [6]. Another study develops a regional city forecasting mode lit is developed within the national traffic model to ensure that all traffic components, internal and external trips, can be predicted through socio-economic data [7]. Surapati Pramanika presented a priority based fuzzy goal programming approach for solving a multiobjective transportation problem [8].

This study is concern about retail business transportation system. Retail business need to maintain a smooth transportation system. They need to transport products within time to the outlet otherwise business will definitely go down. Again to compete with its competitor they need to reduce their transportation cost, make the product available and reduce inventory cost. This model is concern about the demand of the retail outlet and supply capacity of the warehouses. Coordination is made within these two. The model formulated in this study is solved using MATLAB programming.

2. RETAIL BUSINESS IN BANGLADESH

Retail is the sale of goods to end users, not for resale but for use and consumption by the purchaser. The retail transaction is at the end of the supply chain. Manufacturers sell large quantity of products to retailers and retailer sell small quantities of those products to consumers. Retail business may be in the format of convenience store, automatic vending, door to door sales, telephone and direct mail.

In the recent years the retail business like superstore in Bangladesh increased in a massive way. In 2009 ACI logistics has opened 52 outlets named SWOPNO. Meena Bazar, Rahimafrooz, Nandan Mega Shop also set up for

new retail outlet. In Bangladesh, 3S Shopping Mall, Almas General Store, PQS Super Centre, Nandan Mega Shop etc.

3. LOGISTICS FOR RETAIL INDUSTRY

A lot of companies all around the world have put up logistics measures. These companies have found that these indicators can actually ensure faster and timelier service. These procedures are quite important to any company, particularly in the retail business. The manufacture and sale of goods all depend on timely execution of all aspects of the whole process. If one part bogs down, then the entire sale process fails as well. These procedures that companies put up in their respective logistics department are there to ensure a smooth transition of operations. Logistics is the portion of supply chain management that encompasses distribution, transportation and inventory management. To put in the context with the simplified description given above regarding the supply chain management functions of plan, buy, make, store, move, sell and return. Logistics is the store and move functions. It is not unusual for transportation cost for alone to be more than 10% of revenue. For many companies, transportation is the single largest cost element on their financial statements. Transportation costs are often double the expense of warehousing and inventory carrying cost (which means that warehousing and inventory costs can be 5% of revenue, which is no small matter). And every single taka saved in transportation cost goes straight to bottom line. The measures of logistics are in the form of key performance indicators. These indicators grade certain aspects of the whole supply chain. It is usually just a selection between pass or fail nothing in between. The failing grades will help managers locate which part of the whole chain needs further work and improvement. Usually the aspect involved the following: warehouse site selection, interplant movement, order processing, inventory, forecasting, packaging, and a whole lot more. Each aspect of these will be grade differently. However time will always be an unchanging factor. Again it is to be realized that the support of logistics of one type of business will be entirely different from another type of business. So the company will put in place must be tailor made to fit the logistical department. In reality policies and measures of logistics are not difficult to make. They are just quite tedious. The point of all about of logistics is to satisfy end user i.e. customer. If it is possible to deliver a product on a timely manner, then supply chain will work properly. It will give and added bonus to the prestige to the company since the customers are satisfied with the deliveries. Logistics measures can really help to ensure the success and productivity of the organization whole.

4. TRANSPORTATION NETWORK

The design of a transportation network impacts the performance of a supply chain to establishing the infrastructure within which operational transportation decisions regarding scheduling and routine are made. A well designed transportation network allows a supply chain to achieve a desired degree of responsiveness at low cost.

Transportation network can be designed to any of the following:

- Direct shipping network
- Direct shipping with milk run
- All shipment via central distribution centre
- Shipping via DC using milk runs

Factors to be considered during transportation are the followings:

- Per week Demand of retail house
- Capacity of the retail house
- Inventory cost of goods
- Availability of product from source, i.e., from warehouse
- Distance between source and destination
- Transportation cost
- How much amount of product can be delivered from each warehouse?
- Time to deliver from source to destination
- Mode of transportation (rail, truck, rented or own vehicle)
- Types of products (sophisticated, solid, sensitive or other types)
- Equality of demand and supply
- Product cost
- Trade off between own or rented vehicle

5. CASE STUDY

ACI logistics run distribution strategy with direct shipment network. It has 5 warehouses in 5 different districts – Dhaka, Bogra,Sylhet, Chittagong, Jessore. And they have to deliver goods to their outler located in 64 districts. So it is necessary for them to develop a schedule by which they can deliver their products from warehouse to outlets with minimum cost.

To develop the mathematical model some assumptions have been considered. These are

- One delivery at each outlet from warehouse
- Sufficient amount of demand at each outlet so it is considered that one vehicle at each outlet
- Per vehicle capacity is constant and it is considered to be7 ton
- Demand at each retail house is fixed and it is 7 ton per week
- Demand is considered as fixed
- Each warehouse can supply a limited amount of goods to the outlet

The following steps have been performed for model development

- Developing a distance matrix
- Developing cost matrix from the developed distance matrix
- Formulating the model

5.1 Distance Matrix Development

ACI logistics have 5 distribution centers at Dhaka, Bogra, Chittagong, Jessore and Sylhet. It has to distribute products to 64 districts. So the distance matrix is made between 5 districts and 64 districts. The distance matrix is made between warehouses to retail outlets.

Table 1: Part of Distance Matrix (km)

	Dhaka	Bagerhat	Bandorbon	----------	Thakurgaon
Dhaka	0	178	316	----------	407
Bogra	197	328	510	----------	210
Chittagong	242	363	85	----------	646
Jessor	164	93	476	----------	443
Shylet	241	414	454	----------	616

Table 2: Part of Cost Matrix (km)

	Dhaka	Bagerhat	Bandorbon	----------	Thakurgaon
Dhaka	0	6610.67	8634.67	----------	9969.33
Bogra	6889.33	8810.67	11480	----------	7080
Chittagong	7549.33	9324	5246.67	----------	13474.67
Jessor	6405.33	5364	10981.33	----------	10497.33
Shylet	7534.67	10072	10658.67	----------	13034.67

Table 1 shows the distance matrix required for the formulation of the mathematical model.

5.2 Cost Matrix Development

Cost matrix is developed considering all the fixed and variable cost for a single trip.

Fixed cost involves wages, servicing, depreciation and miscellaneous whereas the variable cost include per kilometer.

The calculation of cost matrix considers the following fixed and variable costs:

- Depreciation cost =1000 taka
- Miscellaneous cost =500 taka
- Servicing cost = 500 taka
- Personnel cost = 2000 taka
- So total fixed cost for each trip = 4000 taka
- Distance goes for per liter fuel =3 km
- Cost of fuel per liter = 44 taka
- Total variable cost per km =14.667 taka

Part of the cost matrix generated using this calculation is shown in Table 2.

5.3 Model Formulation

To formulate the mathematical model, let's consider a sample cost matrix shown in Table 3.

Table 3: A sample cost matrix

	D_1	……..	D_n	Supply
O_1	C_{11}	…….	C_{1n}	A_1
……	…….	…….	……	……
O_m	C_{m1}	……	C_{mn}	A_m
Demand	B_1	……	B_n	

Objective function of the problem can be written as:

$$\begin{aligned} Min\, Z = {} & C_{11}X_{11} + C_{12}X_{12} + ... + C_{1\,64}X_{1\,64} + ... \\ & C_{21}X_{21} + C_{22}X_{22} + ... + C_{2\,64}X_{2\,64} + ... \\ & ..... \\ & C_{51}X_{51} + C_{52}X_{52} + ... + C_{5\,64}X_{5\,64} \end{aligned} \quad (1)$$

Constraints equations for the problem are:

$$\begin{aligned} & X_{11} + X_{21} + ... + X_{51} = 1 \\ & X_{12} + X_{22} + ... + X_{52} = 1 \\ & ..... \\ & X_{1\,64} + X_{2\,64} + ... + X_{5\,64} = 1 \end{aligned} \quad (2)$$

and

$$\begin{aligned} & X_{11} + X_{12} + ... + X_{1\,64} \le A_1 \\ & X_{21} + X_{22} + ... + X_{2\,64} \le A_2 \\ & ..... \\ & X_{51} + X_{52} + ... + X_{5\,64} \le A_5 \end{aligned} \quad (3)$$

The non-negativity constraints are

$$X_{ij} \ge 0 \quad \text{for } i = 1 \text{ to } 5;\ j = 1 \text{ to } 64 \quad (4)$$

In the above equations, C_{ij} = cost incurred to transport goods from i locations to j destinations.

X_{ij} = 1; if goods are transported from location *i* to destination *j*;

= 0; if goods are not transported from location *i* to destination j.

Table 4: Outlets to be supplied from each warehouse

Source (Warehouse)	Destination (Retail Outlet)
Dhaka	Dhaka, Barisal, Bhola, Faridpur, Gazipur, Jamalpur, Madaripur, Manikgonj, Munshigonj, Mymensing, Narayangonj, Potuakhali, Rajbari, Sherpur, Tangail
Bogra	Bogra, Dinajpur, Gaibandha, Joypurhat, Kurigram, Lalmonirhat, Naogaon, Natore, Nawabgonj, Nilphamary, Panchagar, Rajshahi, Rangpur, Sirajgonj, Thakurgonj
Chittagong	Bandorbon, Chandpur, Chittagong, Comilla, Cox's Bazar, Feni, Khagrachari, Lakhshampur, Noakhali, Rangamathi, Shariatpur
Jessore	Bagherhat, Borguna, Chuadanga, Gopalgonj, Jessor, Jhalkhati, Jinaydhoho, Khulna, Kustia, Magura, Meherpur, Narail, Pabna, Pirojpur, Shatkhira
Sylhet	Bramnhanbaria, Habigonj, Kishorgonj, Moulivibazar, Narshidhi, Netrokona, Sunamgonj, Sylhet

The program to solve this is linear programming problem has been generated using MATLAB software.

Minimization of the function *f(x)* is solved by using the following equations

$Ax \le B$

$Aeq.x = Beq$

$ub \le x \le lb$

$And\,[x] = linprog(f, A, B, Aeq, Beq, lb, ub)$

Here, $f = [C_{11} \quad C_{12} \quad \cdots \quad C_{21} \quad \cdots \quad C_{5\,63} \quad C_{5\,64}$

Let, $a = ones(1, 64))$

$z = zeroes(1, 64))$

Then $A = \begin{bmatrix} a & z & z & z & z \\ z & a & z & z & z \\ z & z & a & z & z \\ z & z & z & a & z \\ z & z & z & a & z \end{bmatrix}$

Value of B is the limit for each warehouse that how many retail outlets that can be served by each warehouse. It may be equal for all warehouses or can vary. Equal quantity is considered during the problem solution and it is considered as 15, 16, 17, 18 etc.

So, $B = \begin{matrix} 15 \\ 15 \\ 15 \\ 15 \end{matrix}$ or $B = \begin{matrix} 16 \\ 16 \\ 16 \\ 16 \end{matrix}$

Again, let, $a_{eq} = eye(64)$

So, $a_{eq} = \begin{bmatrix} 1 & 0 & \cdots & 0 & 0 \\ 0 & 1 & \cdots & 0 & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & \cdots & 1 & 0 \\ 0 & 0 & \cdots & 0 & 1 \end{bmatrix}$

Then $A_{eq} = \lfloor a_{eq} \quad a_{eq} \quad a_{eq} \quad a_{eq} \quad a_{eq} \rfloor$

and $B_{eq} = ones(64,1)$

$ub = ones(320,1)$

$lb = zeroes(320,1)$

As it is seen that the limit of warehouses distribution capacity can be altered easily to the main program so it is easy to analyze for various conditions. Again the main program read the data from excel spreadsheet and the result of the program will automatically generate in another excel spreadsheet. Thus, this program is user friendly. Each warehouse has certain capacity to supply at the outlet. Varying the capacity limit of the warehouse the programming can be modified and the relevant result can be obtained.

6. RESULTS

After execution of the program the result can be obtained. It can be easily seen from the result that which warehouse has to choose to deliver products to a certain retail outlet.

If we consider the limit of warehouse that each can supply at maximum 18 outlets then the result is shown in Table 4.

If it is considered that each warehouse can supply at maximum 15 retail outlet then total transportation cost is 3409000 taka. Table 5 shows total transportation cost for different number of maximum retail outlets.

Table 5: Total transportation cost for maximum outlet

Maximum retail outlet	Total transportation cost (Tk.)
15	3409000
16	334590
17	331080
18	330160
19	330160

For a maximum retail outlet of 18 and above, transportation cost remain same. It is observed that the

minimum cost can be obtained when the limit for the warehouse is set to minimum 18 i.e. if each warehouse can supply at least 18 outlets. So it would be better if each warehouse have a capacity to supply at least 18 retail outlets. Again the inventory cost to hold this capacity need to be considered as well. Overall cost and which warehouse has to deliver to which retail outlet is automatically generated by the program.

7. CONCLUSIONS

Retail industries have to make decision about the distribution process i.e. how to distribute their products from warehouse to outlet. Each warehouse has certain capacity to supply to the outlet. Again the outlets have a weekly demand which may vary over time. Retail industries often face the problem that which warehouse will be most economical to supply to a certain retail outlet. They mostly face it when they have a situation where outlet demand, warehouse capacity, delivery times, transportation cost etc vary over time. In this paper, a mathematical model has been developed to find the optimum distribution network of a company. As the model is formulated considering the outlet demands, warehouse capacity and overall transportation cost, it will help the retailers to choose the exact warehouse for the delivery of products to the outlets. Again the result will help to achieve the overall minimum transportation cost for the delivery of products from warehouse to outlet. This will also assist the retailers to smooth their transportation system because it chooses the minimum distance path for the delivery of retail goods.

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