World Journal of Social Sciences
Vol. 5. No. 3. September 2015 Issue. Pp. 197 – 210

Optimal Supply Chain Network Opportunities: The Case of Bangladesh

Md. Mashum Billal[a], Md. Mohibul Islam[b], Md. Shah Alam[c] and Md. Mosharraf Hossain[d]

The configuration of the supply chain network has a strong influence on the overall performance of the supply chain. A well designed supply chain network provides a proper way for efficient and effective supply chain management. The supply chain network should be designed in the way that could meet the customer needs with an efficient cost and within the lead time. This paper studies the multi-stage supply chain network design (SCND)model in which all market demand is satisfied within the lead time as well as responsive supply chain is followed. Mixed Integer Linear Programming (MILP) approach is applied to this network to realize the design effectively. In this study new facilitates is to be selected at a proper location and correspondingly of its mode of transportation based on transportation cost for maximizing the profit. We show the problem formulation, solution algorithm and discuss computational results.

Keywords: Supply Chain network design, Mixed Integer Linear Programming and mode of transportation.

1. Introduction

A supply chain is a dynamic management system where involves the constant flow of information, products and funds between different stages. In this stages not only included the manufacturer and suppliers, but also included transporters, warehouses and retailers who are directly or indirectly related in fulfilling the customer requirement. The objective of every supply chain is to maximize the overall value of all stages. Basically supply chain performance is evaluated on the basis of qualitative measure (such as customer satisfaction and product quality) and quantitative measures (such as order-to-delivery lead time, supply chain response time, flexibility, resource utilization, delivery performance etc.).

The quantitative performance is directly related with supply chain network. Effective supply chain network is viewed as the driver of reductions in lead times and costs, and improvements in product quality and responsiveness. Despite its benefits structuring supply chain network is a complex decision-making process. The typical inputs to such a process consists of a set of customer zones to serve, products to be manufactured and distributed, demand projections for the different customer zones, information about future

[a]Md.Mashum Billal, Email:mashum.ipe@ruet.ac.bd
[b]Md. Mohibul Islam (Corresponding author), Email:mohibul05ipe@yahoo.com,
[c]Md. Shah Alam, Email:shahalom.ipe08@gmail.com
[d]Md. Mosharraf Hossain, Email: mosharraf80@yahoo.com
[a,b,d]Department of Industrial and Production Engineering, Rajshahi University of Engineering and Technology, Rajshahi-6204, Bangladesh.
[c]Department of Production, Pran RFL Group, Dhaka, Bangladesh.

conditions, costs and resources. Considering these inputs, companies have to decide where to locate new facilities, how to allocate resources to the facilities, and how to manage the transportation of products through the chain in order to satisfy customer demands. Therefore supply chain network design is a complex process that needs proper investigation of existing and future situations of manufacturing plant. So it is the most comprehensive strategic decision problems that need to be optimized for long-term efficient operation of whole supply chain. It determines the number, location, capacity and type of plants, Distribution Center (DC), and distribution centers to be used. It also establishes distribution channels, and the amount of materials and items to consume, produce, and ship from suppliers to customers.

Today's competitive business environment leads to many changes in production and distribution systems. One of these important changes goes back to the competition among the supply chains instead of companies. An efficient and responsive supply chain helps firms to satisfy the two polar needs of customers including low delivery time and low price. It is known to all that today's 'business environment is very much dynamic and competitive. To survive this dynamic and competitive environment proper business strategy should be followed. The problem is that any Business may be failed due to taken poor policy during the commencement of that business though the opportunities are available. So authors are very much interested to gather knowledge how a new business may be commenced to gain profitability that are committed to satisfy all demand within the lead time . In this study authors want to design the supply chain network for a newly launched company in order to select the best supplier, determines the subsets of plant and distribution center and design the distribution network strategy that will satisfy all capacities and demand requirement imposed by the customers. In this study the authors also considered the time value of money though it is a newly launched company and it follows responsive Supply Chain. The authors also considered which mode of transportation is most suited in respect of Bangladesh. In this study the author consider the time value of money, cost of mode of transportation &responsive supply chain in a single model that motivates the authors to carry out this research work. Therefore the main aim of this research work is to determine the optimal number of plant and Distribution Center (DC) that provides maximum profit& maximum customer satisfaction.

The rest of this paper is organized as follows; section 2 represents literature review, section 3 represents research methodology, section 4 represents data collection and cost of mode of transportation. Section five represents the discussion of results, section Six represents conclusion and finally references are mentioned after the conclusion portion.

2. Literature Review

In today's world, enterprises have to cope with the growing markets and with the increasing customer expectations. Because of the customer expectations about obtaining the products at the right time and quantity, and besides this the improvements against the risks created by the sudden fluctuations in local and global economies, companies need to analyze their working styles. Today, the success measures for the companies are thought as lower costs, shorter production time, shorter lead time, less stock, larger product range, more reliable delivery time, better customer services, higher quality, and providing the efficient coordination between demand, supply and production.

Nagurney et et al (2002) have been developed supply chain network equilibrium models, which focus on competition among decision-makers such as manufacturers, distributors, and retailers at a tier of the supply chain but cooperation between tiers.Cakravastia, Toha, and Nakamura (2002) present a global supply chain optimization model that maximizes the after-tax profits of a multinational corporation. Their model extends previous research by simultaneously considering transferring prices, transportation cost allocation, inventory costs, and their impact on the selection of international transportation modes. They proposed an algorithm that can produce feasible solutions with small gaps between the solutions and their upper bound. They assumed that each customer has a reserve price, and if the actual price charged by the firm is higher than the reserve price, the firm will lose this customer to competition. They showed that under certain assumptions on the complexity counts, a special case of this problem can be solved in polynomial time. However in supply chain network design the primary concern is facility location decisions where consider a profit-maximizing location model, where a firm needs to decide where to locate a single DC to serve the customers and the price for its product, to maximize its total profit. However, they did not consider any cost related terms in his model, not even the DC location cost. Erol and Ferrell (2004) proposed a model that assigning suppliers to distribution center (DC) and DC to customers. In traditional supply chain management, the focus of the integration of SCN is usually on single objectives such as minimum cost or maximum profit. They considered minimization of total cost of the system, total delivery days and the equity of the capacity utilization ratio for manufacturers as objectives. Chen and Lee (2004) developed a multi-product, multi-stage and multi-period scheduling model for a multi-stage SCN with uncertain demands and product prices. Fair profit distribution among all participants, safe inventory levels for maximize customer service levels, robustness of decision to uncertain demands have been considered as objectives and a two-phased fuzzy decision-making method proposed to solve this problem. Guillen et al (2005) formulated the SCN design problem as a multi-objective stochastic mixed integer linear programming model which was solved by e-constraint method and branch and bound techniques. Objectives were SC profit over the time horizon and customer satisfaction level. Chan, Chung and Wadhwa (2004) developed a hybrid approach based on genetic algorithm and Analytic Hierarch Process (AHP) for production and distribution problems in multi-factory supply chain models. Operating cost and resources utilization had been considered as objectives in their study. Santoso et al (2007) proposed a stochastic programming approach for the same problem. Computational study showed that this new approach is very efficient when solving large-scale problems.Alonso et al (2008) studied a two-stage supply chain planning problem. The first stage deals with the strategic decisions such as plant sizing, product/material selection and allocation decisions and the second stage deals with tactical decisions such as production and inventory levels. The objective is to maximize the expected profit of the supply chain. However, for a profit-maximizing business may not always be optimal to satisfy all potential demands especially if the additional cost is higher than the additional revenue associated with servicing some customers. Furthermore, if the company is facing competition sometimes it might be more profitable to lose some potential customers to competitors since the cost of maintaining these customers high. Supply chain management (SCM) covers a wide range of subject areas including purchasing and supply, logistics and transportation, marketing, organizational behavior, network, strategic management, management information systems and operations management. Stummer, Kiesling, Gutjahr, (2009) developed a multi-objective optimization modeling framework for minimizing cost and maximizing customer satisfaction. As we know, multi-objective optimization is widely used in a variety of areas and is also used to embed into a multitude of decision support system. The SC network becomes a multi-echelon production/distribution system (Altiparmak, Gen, Lin, & Karaoglan, 2009). Xu and Zhai (2010) considered a two-stage supply chain coordination problem under fuzzy demand constraints. They investigated the optimization of the vertically integrated two-stage supply chain under perfect coordination and contrast with the non-coordination in case of the fuzzy demand. They proved that the maximum expected supply chain profit in a coordination situation is greater than the total profit in a non-coordination situation. The imprecision of demand information affects the planning of the logistic process in terms of flexibility and adaptability under the limitations of the capacity to supply with respect to the system dynamics (Chan & Chan, 2010). Klibi, Martel & Guitouni, (2010) developed supply chain network designs of two objective functions is: (1) minimization of total costs and (2) minimization of total delivery tardiness. The first objective is related to supply chain network efficiency and the second one is related to network responsiveness. Indeed, the second objective enables the supply chain to satisfy the customers' expected delivery times and therefore being the order winner in its product-markets. Most of model is used to generate production flexibility so as to minimize the discrepancy between demand and order rate without considering the production capacity and capability in terms of the variability of production lead times. Cheng, Gao, Shen (2011) Production planning and inventory allocation of a single-product assemble-to-order system.

Throughout the literature review it is obvious that problems and limitations are existed in past works. All the previous works describe in the above section gives descriptive knowledge on supply chain management study and all are relevant to real world. This study is oriented to a problem context, in which the author follows a responsive, multi-stage supply chain network design.

The main contribution of this paper that differentiates it from the existing ones in the related literature can be summarized as follows:

To propose a supply chain network design mathematical model that is able to maximize profit configuration of the supply chain network considering network responsiveness by meeting all the customer demands within the lead times. Also the proposed model considers the time value of money though it is more suitable for the newly launched company. The purpose of this research work is to design an optimal responsive supply chain network by considering time value of money in pessimistic & optimistic situation and also the proposed model considers Cost of Mode of Transportation. To the best of our knowledge there is no research paper considering both of the abovementioned features in a single model. Objectives are considered maximization of total profit comprised of fixed costs of plants and distribution centers (DCs), inbound and outbound distribution costs and maximization of customer services that can be rendered to customers in terms of acceptable delivery time.

3. Methodology

Consider a newly launch company which wants to produce cement and meet the customer demand in the divisional markets in the Bangladesh. Based on the market research, the company is planning to produce cement which is used in making buildings, construction of any infrastructure (bridge, road, house and culvert). The market research shows that the company can capture a portion of the divisional market. Limestone is the main raw material of the product to be produced. This raw material is imported from foreign countries that are used manufactured Cement. But only one foreign country cannot be selected because for evaluating the performance measure. Thus, the company has planning to import raw material from different foreign suppliers namely India, China, Vietnam and Philippines.

The company intends to establish new plants. There are three potential locations for the plants. These locations were determined depend on the some specific considerations. The first location has been considered as Munshiganj, as the nearest city of the capital. Dhaka is the more densely populated city in Bangladesh that motivated to establish the plant in the nearest city of Dhaka in Munshiganj. In this location all the land facilities are available and raw materials are collected in easy way. The consideration of facility location cost is less than the other place. Munshiganj plant is to produce the product that will be possible to supply all the divisional distribution centers in Bangladesh at the lowest cost within the lead time. Because one of that the Munshiganj is the adjacent city of the Dhaka on the other hand Dhaka is approximately the central location in Bangladesh.

The second location is considered at Chittagong, because customs and duties are paid, and vessels are entered in customhouses for all imported goods. Chittagong is called that port city of Bangladesh. In these place facility are not available and facility cost are very high than the first place. The last is Khulna in where all other facilities of the company had been located. These types of plants are reducing the transportation cost but increase the facility cost. Another alternative would be consolidating plant in one region, which reduce the facility cost but increase the transportation cost. In the case of Distribution Centers (DC) the company is planning to open at most seven distribution centers (DC).These places are selected because that the last report of Bangladesh Population and Housing Census 2011 all the divisional population increasing rate is very high and their earning rate are in increasing trend. From this report and the relevant company (Lafarge Surma Cement Ltd.) data analysis that all the divisional distribution center to be established. Locations of distribution center (DC) had been determined according to demand densities of 11 customer zones to be served and access time from Distribution Center (DC) to customer zones. The locations of Distribution Center (DC) are Dhaka, Rajshahi, Chittagong, Khulna, Barisal, Sylhet and Rangpur. All the products are supplied the maximum allowable delivery time (12h) from DC to Demand market.

The objectives are maximization of profits and customer service that can be rendered to customers in terms of acceptable delivery time. The aim of this company is to determine the optimal number of plant and Distribution Center (DC) that provides maximum profit. The company intends to establish supply chain network that satisfying the company objectives for the product. The company objectives, as given in mathematical model, are the maximization of overall supply chain profit, maximization of customer services, i.e. the percentage of customer demand that can be delivered within the stipulated access time. Fixed cost of plants consists of expenditures such as hiring costs of buildings and facilities, amortization of machines and tools, salaries of managers and guardians, and insurance premiums. Although amortizations, fixed man-power and insurance cost are approximately equal in Dhaka, land and building costs depend on the developing and industrialization level of cities. Thus, differences between fixed costs of plants come from this fact. Location and capacity allocation decision has to be made for factories and warehouse. The company is planning to meet customer demands from distribution center (DC) approximately12 hour.

In this supply chain network design problem responsive supply chain is followed that means the customer response is the primary concern. In this network design all the customer demands are satisfied within the lead time. In this model distance is considered from distribution center to market because it is the function of customer response. The main target markets of this network are Dhaka, Rangpur, Bogra, Kustia, Rajshahi, Mymensing, Sylhet, Comilla, Khulna, Barisal, and Chittagong. Approximately all the demands are covered in Bangladesh by supplying above places. The author's analysis the Lafarge Shurma Cement industry in Bangladesh about one year time period and estimated the data used in this proposed model. From the report of Population and Housing Census and relevant company data analysis one year time period above markets are selected because demands of these markets are high. In the Models for facility location and capacity allocation (Chopra &Mendil2009) describe a simple supply chain model and the authors have improved the model by incorporating inflation rate, stipulated lead time etc. Supply chains network in which supplier send raw material to plant that the producing product to supply distribution center (DC). From distribution center (DC) product is supplied to markets which all the stage of supply chain network.

3.1 Problem Formulation

Notation
m = number of markets
n= number of potential plants
l= number of supplier
t= number of potential distribution centers
D_j= monthly demand from customer j
K_i= potential capacity at plant i
S_h= supply capacity at supplier *h*
r_j= Revenue from selling one unit in Market j
W_e= potential DC capacity at site *e*
f_i= fixed costs of locating a plant at site *i*
f_e= fixed cost of locating a DC at site e
C_{hi}= cost of transportation one unit from supplier h to plant*i*
C_{ie}= cost of transportation one unit from plant*i* to DC*e*
C_{ej}= cost of transportation one unit from DC*e* to market*j*
X_{hi}= quantity transported from supplier h to plant i
X_{ie}= quantity transported from plant i to DC e
X_{ej}= quantity transported from DC e to market j
D_{hi}=distance from supplier h to plant i
D_{ie}= distance from plant i to DC e
D_{ej}= distance from DC e to market j
Z = Inflation rate, p = Number of years.

The problem is formulated as the following mixed integer linear program
Maximize = $\sum_{e=1}^{t}\sum_{j=1}^{m}\left(r_j - C_{ej}\right)(1+Z)^p D_{ej}X_{ej} - \sum_{i=1}^{n} f_i(1+Z)^p y_i - \sum_{e=1}^{t} f_e(1+Z)^p y_e - \sum_{h=1}^{l}\sum_{i=1}^{n} C_{hi}(1+Z)^p X_{hi}D_{hi} - \sum_{i=1}^{n}\sum_{e=1}^{t} C_{ie}(1+Z)^p X_{ie}\,D_{ie}$
Subject to

$$\sum_{i=1}^{n} X_{hi} \le S_h \qquad \text{for h=1,……....,}l \qquad \text{……………………………….. (1)}$$

$$\sum_{h=1}^{l} X_{hi} - \sum_{e=1}^{t} X_{ie} \ge 0 \qquad \text{for i = 1,………,n} \qquad \text{……………………………….. (2)}$$

$$\sum_{e=1}^{t} X_{ie} \le K_i y_i \qquad \text{for i = 1,…...…,n} \qquad \text{……………………………….. (3)}$$

$$\sum_{i=1}^{n} X_{ie} - \sum_{j=1}^{m} X_{ej} \geq 0 \qquad \text{for } e = 1,\ldots,t \qquad \ldots\ldots (4)$$

$$\sum_{j=1}^{m} X_{ej} \leq W_e y_e \qquad \text{for } e= 1,\ldots,t \qquad \ldots\ldots (5)$$

$$\sum_{e=1}^{t} X_{ej} = D_j \qquad \text{for } j= 1,\ldots,m \qquad \ldots\ldots (6)$$

$$y_i, y_e \in \{0,1\} \qquad \text{for all i and j} \qquad \ldots\ldots (7)$$

The objective function maximizes profits of the supply chain network. The constraint in equation

(1) Specifies that the total amount transported from a supplier cannot exceed the supplier's capacity. The constraint in equation
(2) States that the amount transported out of a factory cannot exceed the quantity of raw material received. The constraint in equation
(3) Enforces that the amount transported in the distribution center from plant i cannot exceed its plant capacity. The constraint in equation
(4) Specifies that the amount of transported out of a Distribution Center (DC) cannot exceed the quantity received from the factories. The constraint in equation
(5) Specifies that the amount transported from through a Distribution Center (DC) cannot exceed its capacity. The constraint in equation
(6) Specifies that the amount transported to a customer must cover the demand. The constraint in equation
(7) Enforces that each Plant or Distribution Center (DC) is either open or closed.
In the financial world money it is a commodity, and like other goods that are bought and sold, money costs money and it is measured by an inflation rate r.

4. Data Collection and Cost of Mode of Transportation

4.1 Data Collection

It is necessary to know about the capacity of every supplier before selecting a specific supplier. Capacity of every supplier is mentioned as follows:

Table 1: Monthly Supplier Capacity (Raw Material)

Supplier	India	China	Vietnam	Philippine
Capacity (MT)	200000	145000	121000	125000

(Data Source: Estimated based on Lafarge Shurma Cement Ltd.)

Table 2: Fixed Cost / Month and Production Capacities / Plant / Month

Plant	Fixed Cost (Tk.)	Capacity (MT)
Munshiganj	1150000	120000
Chittagong	1300000	100000
Khulna	1200000	105000

(Data Source: Estimated based on Lafarge Shurma Cement Ltd.)

Fixed cost of plants consists of expenditures such as hiring costs of buildings and facilities, amortization of machines and tools, salaries of managers and guardians and insurance premiums.

Table 3: Transportation Cost / MT from DC to Demand Market (Tk.)

DC \ Market	Dhaka	Rangpur	Bogra	Kustia	Rajshahi	Mymensing	Sylhet	Comilla	Khulna	Barisal	Chittagong
Dhaka	0	2844	1845	2358	2349	1170	2430	846	4041	4446	2340
Rajshahi	2349	1926	999	972	0	2097	4221	3312	2637	2943	4815
Chittagong	2340	5184	3951	1629	4815	3258	3618	1791	6156	6786	0
Rangpur	2844	0	954	2268	1926	2583	4293	6093	4032	4212	5184
Barisal	4446	4212	3942	2043	2943	5040	3960	2034	1602	0	3609
Khulna	4041	4032	3024	1512	2637	5040	5868	4887	0	1602	6156
Sylhet	2430	3843	3654	3393	4221	2655	0	2178	6471	3960	3618

From table 3, it is seen that transportation cost from distribution center Dhaka to market Dhaka is Tk.0 per Metric Ton Cement. Similarly the Transportation costs from different DC to different Markets are given in this table. The authors assume the transportation cost in respect of Bangladesh per kilometer per metric ton cement is BDT TK.9.

4.2Cost of Mode of Transportation

Selecting a transportation mode is both a planning and an operational decision in a supply chain. The decision regarding carriers with which a company contracts is a planning decision, whereas the choice of transportation mode for a particular shipment is an operational decision. For both decision it must be balanced between transportation and inventory cost. The mode of transportation that results in the lowest transportation cost does not necessarily lower total costs for a supply chain. Cheaper modes of transportation typically have longer lead times and larger minimum transportation quantities both of which results in higher levels of inventory that means the higher holding cost. In Table 4, it has been seen that the transportation cost is lower in case of water but the holding cost is higher that's why the total cost is greater than truck mode, the detail calculation is shown in **Appendix II.** The lead time is very short in case of air mode but both the transportation and holding cost is very high. This is why it is not considered as an optimal mode of transportation. Though the transportation cost of truck mode is high than water mode but the holding cost is very low compare to the others.

Table 4: Costs Comparisons of Different Transportation Modes

Transportation Mode	Holding Cost (Tk.)	Transportation Cost (Tk.)	Total Cost (Tk.)
Truck	247500	8456400	8703900
Rail	795000	9132480	9927480
Water	1320000	7488000	8808000

Consider of all over the country to be covered in this supply chain network for this reasons all the demand market are considered with respect to growth of the population and their monthly earning capacity.

Table 5: Monthly Market Demand and Revenue/Metric Ton of Cement

Market	Revenue (Tk.)	Demand (MT)
Dhaka	12500	4100
Rangpur	11500	3600
Bogra	12000	3300
Kustia	11500	2800
Rajshahi	12000	3600
Mymensing	12000	3100
Sylhet	12000	3500
Comilla	12000	3300
Khulna	12300	3400
Barisal	12000	3400
Chittagong	12400	3700

Data Source: Estimated based on Lafarge Shurma Cement Ltd.

5. Discussions of Results

The value of the objective function is obtained **Tk. 9041552** after executing the program at Lingo optimization software. This profit will be earned monthly from total supply chain network. Others summary of the solutions are given below as follows:

Table 6: Monthly Transportation Volume (MT) from Supplier to Plant

Supplier \ Plant	Munshiganj	Chittagong	Khulna
India	37800	0	0
China	0	0	0
Vietnam	0	0	0
Philippine	0	0	0

It is seen that the raw material is supplied only from India to plant Munshiganj because the transportation & purchasing cost are lower than other foreign countries.

Table 7: Monthly Transportation Volume (MT) from Plant to (DC)

DC / Plant	Dhaka	Rajshahi	Chittagong	Rangpur	Barisal	Khulna	Sylhet
Munshiganj	13800	3600	3700	3600	3400	6200	3500
Chittagong	0	0	0	0	0	0	0
Khulna	0	0	0	0	0	0	0

From Table 7, it has been noticed that the final product is supplied only the plant Munshiganj to seven DC& the other plants are closed. Only the plant Munshiganj is opened because Munshiganj is the comparative nearest location of all the divisional DC in Bangladesh and in the case of profit maximization it is optimum.

Table 8: Transportation Volume (MT) DC to Market

Market / DC	Dhaka	Rangpur	Bogra	Kustia	Rajshahi	Mymensing	Sylhet	Comilla	Khulna	Barisal	Chittagong
Dhaka	4100	0	3300	2800	0	3100	0	3300	0	0	0
Rajshahi	0	0	0	0	3600	0	0	0	0	0	0
Chittagong	0	0	0	0	0	0	0	0	0	0	3700
Rangpur	0	3600	0	0	0	0	0	0	0	0	0
Barisal	0	0	0	0	0	0	0	0	0	3400	0
Khulna	0	0	0	0	0	0	0	0	3400	0	0
Sylhet	0	0	0	0	0	0	3500	0	0	0	0

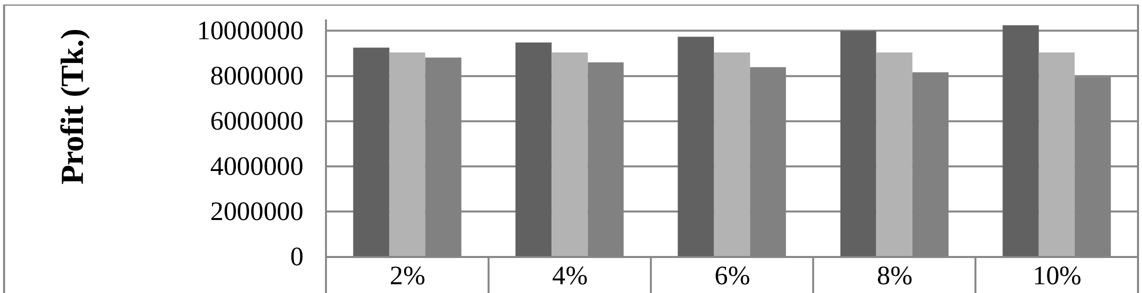
It is known that if the number of facilities is increased, it provide higher customer responsiveness as well as customer satisfaction but for reducing lead time transportation cost is increased. For the causes stated above seven distribution centers have been set for the seven divisional markets in Bangladesh. In the result (Table 8) it has been seen that the product is supplied from Dhaka Distribution center to Dhaka market and other region near the Dhaka city. The distribution center located in Chittagong will cover all the divisional demands of that city. Similarly all divisional demands will be satisfied by their respective divisional distribution centers. If the one divisional Distribution Center (DC) is closed then the transportation cost is increased and the customer response decreased. As responsive supply chain is primary concern, the seven distribution centers are located in seven divisions in Bangladesh. In the result it has been seen that the demand of Dhaka division will not be fulfilled by the distribution center located in Chittagong. The cause is the distance between two divisional centers. The market where DC is not situated the demand is fulfilled by the near DC. It has been noticed that the Bogra, Kustia, Mymensing & Comilla's market demand is fulfilled by the near Dhaka DC. It has shown that the above mentioned market the maximum distance from Dhaka DC to the market is Comilla and is270 km (shown in table 3). The maximum time needed to satisfy this market demand is 8 hours that strongly supported that this model follows responsive supply chain & that satisfy the primary objective of this research work. The authors concluded that the proposed model is very much appropriate in respect of Bangladesh as well as the competition is growing up day by day. Though the demand is uncertain the authors calculated demand fluctuation in optimistic and pessimistic situation.

Table 9: Demand Fluctuation Effect on Total Supply Chain Profit

Market demand increased %	Profit (Tk.)/ month	Market demand decreased %	Profit (Tk.) / month
2	9259497	2	8823607
4	9488758	4	8605661
6	9740921	6	8387716
8	9993084	8	8169770
10	10245250	10	7951825

From table 9, it is observed that if the market demand is fluctuated then corresponding objective function value is also fluctuated.

Figure 1: Bar Chart of Profit for Percentage of Market Demand



	2%	4%	6%	8%	10%
Demand Increase (Tk.)	9259497	9488758	9740921	9993084	10245250
Actual Demand (Tk.)	9041552	9041552	9041552	9041552	9041552
Demand Decrease (Tk.)	8823607	8605661	8387716	8169770	7951825

From table 9 & figure 1 it can be concluded that in optimistic and pessimistic situation the proposed model is profitable.

If more than one market is needed to satisfy in one distribution center the capacity must be considered because it enhance the total supply chain cost. The annual profit of the company is low in Tk.108498624.In terms of analyzing, assumption has been considered that the cost to transportation per kilometer in Dhaka city is same as the cost in another city which, in real case, is not possible. Despite of having the low cost mode of transportation such as launch, steamer in this network always considered truck as mode of transportation because of high responsiveness which is one of the reasons of lowering the profit.

6. Conclusions

The design of the supply chain network is the most important strategic decision in supply chain management. This paper studies the responsive supply chain network design problem in order to increase customer satisfactions and that is the main objective of this model. The authors also considered time value of money though SCND is for a newly established company. Finally it is concluded that in a single model the time value of money, cost of mode of transportation &responsive supply chain is maintained. There also some limitations in the model those are (a) the major limitation of the proposed model is that all parameters are not considered uncertain for the time horizon. (b)Secondary data are used in the proposed model.(c)The authors only used MILP algorithm to solve the proposed model & there is no comparison between different algorithms. Therefore, many possible future research works can be defined in this context. For example in case of the closed-loop or multi-product SCND problems it can be used or taking into account the uncertainty in SCND problems that may results in stochastic or fuzzy optimization models are attractive future research works. The formulated model can also be solved by other optimization technique such as particle swarm optimization (PSO), Genetic algorithm that may give good result in future research work.

References

Alonso-ayuso LF, Escudero A, Garin MT, Ortuno G and Perez, 2003, ‘An approach for strategic supply chain planning under uncertainty based on stochastic 0–1 programming’, J. *Global Optimization, vol. 26, pp.* 97–124.

Altiparmak, F, Gen, M, Lin, L &Karaoglan, 2009, ‘A steady-state genetic algorithm for multi-product supply chain network design’, *Computers and Industrial Engineering,* vol.56 issue 2, pp. 521–537.

Cakravastia A, Toha IS & Nakamura, N 2002, ‘A two-stage model for the design of supply chain networks’ *International Journal of Production Economics,* vol. 80, issue 3, pp. 231–248.

Chan, FTS, Chung, SH and Wadhwa, S 2004, ‘A hybrid genetic algorithm for production and distribution’,*Omega, vol. 33*,pp. 345–355.

Chen, C and Lee, W 2004, ‘Multi-objective optimization of multi-echelon supply chain networks with uncertain product demands and prices’, *Computers and Chemical Engineering, vol. 28*, pp. 1131–1144.

C. Stummer, E. Kiesling, W.J. Gutjahr, 2009, ‘A multi criteria decision support system for competence-driven project portfolio selection’, *International Journal of Information Technology & Decision Making,* vol. 8, issue 2, pp. 379–401

Guillen, G,Mele, FD, Bagajewicz, MJ, Espuna, A &Puigjaner, L 2005, ‘Multiobjective supply chain design under uncertainty’, *Chemical Engineering Science, vol. 60*, pp.1535–1553.

H. K. Chan, F.T.S. Chan, 2010, ‘Comparative study of adaptability andflexibility in distributed manufacturing supply chains’, *Decision Support Systems,* vol. 48, pp. 31–41.

Jayaraman, V and Ross, A 2003, ‘A simulated annealing methodology to distribution network design and management’, *European Journal of Operational Research, vol. 144*(3), 629

Mohammad Ebrahim R, Razmi J, Haleh, H 2009, ‘Scatter search algorithm for supplier selection and order lot sizing under multiple price discount environment’. AdvEng Software, vol.40, pp.766–76

Nagurney, A, Dong, J, and Zhang, D 2002, ‘A supply chain network equilibrium model’, *Transportation Research, Part E 38*, pp. 281–303

Sabrian, EH &Beamon, BM 2000, ‘A multi-objective approach to simultaneous strategic and operational planning in supply chain design’, *Omega, vol. 28*, pp. 581–598

Santoso T, Ahmed S, Goetschalckx, M, and Shapiro, A 2007, ‘A stochastic programming approach for supply chain network design under uncertainty’, *European Journal of Operational Research, vol. 167*, pp. 96–115.

T.C.E. Cheng, C. Gao, H. Shen, 2011, ‘Production planning and inventory allocation of a single-product assemble-to-order system’, *International Journal of Production Economics,* vol. 131, issue 2, pp. 604–617

R. Xu, X. Zhai 2010, ‘Analysis of supply chain coordination under fuzzy demand in a two-stage supply chain’, *Appl. Math. Model*, vol. 34, pp.129–139

W. Klibi, A. Martel, A. Guitouni 2010, ‘the design of robust value-creating supply chain networks: a critical review’, *European Journal of Operational Research,* vol. 203, pp. 283–293

Appendix-II

D= Monthly Demand
Q= minimum transportation capacity of each track
L= lead time [in-transit lead time (a) + loading & unloading time (b)]
H=annual cost of holding inventory (h) × cost per unit (c)

In case of truck

Q=300 bags, D=72000 bags, L= 0.5 day, a=0.375 day, b=0.125 day, h=0.25, c=Tk. 600, TC=117.45
Cycle Inventory = $\frac{Q}{2}$=$\frac{300}{2}$= 150 bags
Safety Inventory = $\frac{L}{2}$ ×day of demand = $\frac{0.5}{2} \times \frac{72000}{30}$ = 600 bags
In-transit Inventory = day of demand ×a = 72000 × $\frac{0.375}{30}$ = 900 bags
Total Average Inventory =150+600+900 =1650 bags
Holding cost using truck = 1650×600×0.25 = **Tk.247500**
Transportation cost using truck = demand × TC =72000×117.45= **Tk. 8456400**

In case of Rail

Q=4000 bags, D=72000 bags, L= 1 day, a=0.875 day, b=0.125 day, h=0.25, c=Tk. 600, TC=131.04
Cycle Inventory = $\frac{Q}{2}$=$\frac{4000}{2}$= 2000 bags
Safety Inventory = $\frac{L}{2}$ ×day of demand = $\frac{1}{2} \times \frac{72000}{30}$ = 1200 bags
In-transit Inventory = day of demand ×a = 72000 × $\frac{0.875}{30}$ = 2100 bags
Total Average Inventory =2000+1200+2100 =5300 bags
Holdingcost using truck = 5300×600×0.25 = **Tk. 795000**
Transportation cost using truck = demand × TC = 72000×131.04= **Tk. 9132480**

Water

Q=8000 bags, D=72000 bags, L= 1.5 day, a=1.25 day, b=0.25 day, h=0.25, c=Tk. 600, TC=104
Cycle Inventory = $\frac{Q}{2}$=$\frac{8000}{2}$= 4000 bags
Safety Inventory = $\frac{L}{2}$ ×day of demand = $\frac{1.5}{2} \times \frac{72000}{30}$ = 1800 bags
In-transit Inventory = day of demand ×a = 72000 × $\frac{1.25}{30}$ = 3000 bags
Total Average Inventory =4000+1500+2400 =8800 bags
Holding cost using truck = 8800×600×0.25 = **Tk. 1320000**
Transportation cost using truck = demand × TC = 72000 × 104= **Tk. 74880**