SUPPLY CHAIN NETWORK DESIGN-OPPORTUNITIES FOR COST REDUCTION AS APPLIED TO EAST AFRICA BOTTLING SHARE COMPANY IN ETHIOPIA

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ABSTRACT

A mathematical model capturing many practical aspects of network design problems and optimization techniques is proposed. This model is applied to East Africa Bottling Share Company. By the application of this proposed model an annual cost saving of 192,192 Birr, and through alleviating vehicle scheduling problem a cost saving of 405,000 Birr per year may be achieved. Moreover, by reviwing the existing situation of the company, an annual demand of 366,080 cases which is equivalent to 8,785,680 Birr is demonstrated to be realized.

This research methodology and outcome may be applied to other companies intending to emulate the benefits in SC network design illustrated in this study.

Keywords*: Supply Chain Network Design, Mathematical Model, Optimization*

INTRODUCTION

Supply Chain (SC) is an integrated business model for logistics management. It covers the flow of goods from suppliers through manufacturing and distribution chains to the end customers. Effective SC 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 conditions, costs and resources. Given the above 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. Supply chain network design is therefore as such complex process that needs proper investigation of existing and future situations of manufacturing plant.

To verify this fact company is identified based on its need to restructure the supply chain network. A company that involves high transportation, large distribution volumes, and high demand is selected. Therefore, the authors selected East Africa Bottling Share Company for case analysis.

The company has two processing plants and five warehouses in the country. According to the information obtained from the company, the demand for its products is increasing by four percent annually. However, the existing supply chain network is not able to capture available demands at different regions and the customer service level is also not to the satisfactory level with the increased demand. As a result, some segments of the market are experiencing shortage. Currently, the company does not have well-established means to sense the shortage in the market and also mechanisms how to supply the market as soon as possible. The objective of this paper is to design a supply chain network model, which will sense and capture customers demand at acceptable customer service level with minimum cost. Here, a mathematical network model is developed and verified with the solution technique. This model and the optimization technique would be helpful to other companies seeking to emulate similar benefit.

BASICS OF SUPPLY CHAIN MANAGEMENT

As Christopher [1], Suhong et.al [2], and Nicholas [3] have pointed out; effective supply chain management (SCM) has becomes a potentially valuable way of securing competitive advantage and improving organizational performance since competition is no longer between organizations, but among supply chains. The phrase "Supply Chain Management" came in to use in the early 1990s [4]. The Global Supply Chain Forum defined SCM as the integration of key business processes from the end user through original suppliers that provide products, services, and information that add value for customer and other stakeholder [5].

The benefits of an effective SC can be: cycle time reduction, inventory cost reduction, optimized transportation, increased order fill rate, early prediction of disturbance to downstream, increase customer service, and increase returns on assets [4, 6]. To achieve these benefits, the decisions that are to be taken should be strategic, tactical, and operational. The principles of SCM that can ensure the above benefits are: customer segmentation,

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customizing SC networks, demands planning, sourcing suppliers strategically, integration of technology, and performance measure [7, 8]. The supply network must be optimized and react to supply uncertainties and demand variability to serve customers demand [9].

In general, different authors agree that SCM involves in integrating three key flows across the boundaries of the supply chain: product/material, information, and financial flow [1, 4, 10, 11].
Fig. 1 below shows a simplified supply chain management system.

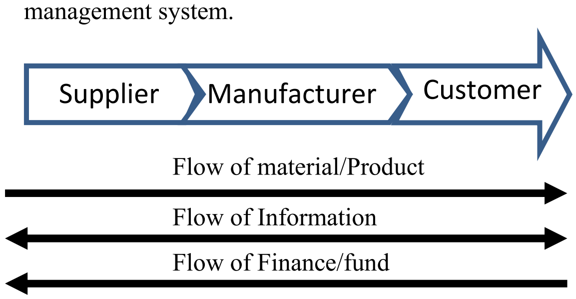


Figure 1 Simplified supply chain diagram

Successful integration of the three flows has produced improved efficiency and effectiveness. Hence, the initial step in implementing and practicing SCM system is supply chain network design. Therefore, the study is mainly focused on SC network design.

Supply Chain Network Design

Many organizations today are forced to increase their global market share in order to survive and sustain growth. At the same time, organizations must defend their domestic market share from international competitors. The challenge is how to expand the global logistics and distribution networks in order to ship products to customers who demand them in a dynamic and rapidly changing set of channels. A Strategic positioning of inventories is essential, so that the products are available when the customer wants them.

Long-term competitiveness therefore, depends on how well the company meets customer preferences in terms of service, cost, quality, and flexibility by designing the SC, which will be more effective and efficient than the competitors. Optimization of this equilibrium is a constant challenge for the companies which are part of the supply chain network.

To be able to optimize this equilibrium, many strategic decisions must be taken and many activities need to be coordinated. This requires careful management and design of the supply chain at first instance followed by well thought execution.

The design of supply chains represents a distinct means by which companies innovate, differentiate, and create value [10, 12]. The challenge here is in the capability to design and assemble assets, organizations, skills, and competences. Depending on the complexity of supply network three chain categories can be defined: [10, 12, 13].

1. **Direct supply chain**: consists of a company, a supplier, and a customer.
2. **Extended supply chain**: includes suppliers of the immediate supplier, as well as customers of the immediate customer.
3. **Ultimate supply chain**: includes all the organizations involved in all the upstream and downstream flows.

At the highest level, performance of a distribution network should be evaluated along two dimensions: customer needs that are met, and cost of meeting customer needs [10, 12].

Thus, a firm must evaluate the impact on customer service and cost as it compares different distribution network options. Customer services that are influenced by the structure of network include response time, product variety and availability, customer experience, order visibility, and return-ability [10]. For this purpose three distinct outbound distribution strategies are used: direct shipment, warehousing, and cross-docking [14].

After examining the basic concepts and principles, SC network design approaches and input data required for the modeling technique are presented.

Supply Chain Modeling

Numerous modeling approaches in SCM have been proposed so far. These include supply chain network design [6,13,15], mixed integer programming [7,15,16,17], stochastic programming [14,16], heuristic methods, and simulation based methods [4,16]. In this study especial focus is given to SC network design in which optimization techniques are used. This is because it considers the structure of the network and also incorporates other optimization models to reach at final decisions.

Optimization Techniques of Supply Chain Network

Network configuration may involve issues relating to plant, warehouse, transportation, and retailer location. These are strategic decisions since they have a long-lasting effect on the firm. To come up with a better network design, appropriate number of warehouses, location of each warehouse, and the size and capacity of each warehouse has to be identified and determined.

The objective is to design the SC network so as to minimize annual system-wide costs and improve service level requirements, thereafter increase market share. Increasing the number of warehouses typically yields: improvement in service level, increase in inventory costs, increase in overhead and set-up costs, reduction in outbound transportation costs, and increase in inbound transportation costs. In this setting, the tradeoffs are clear. In essence, the firm must balance the costs of opening new warehouses with the advantages of being close to the customer. Thus, warehouse location decisions are crucial determinants for the efficiency of the product distribution. The design approaches therefore, require the following three major activities to produce a good optimized result [10].

1. Data collection and aggregation regarding transportation rates, mileage estimation, warehouse costs, and service level requirements.

2. Modeling.

3. Use of solution techniques.

A general Mathematical Model (MM) of the distribution network design is as presented in Eq. 1. The total cost function is the minimum value of sum of fixed plants and warehouses costs, and transportation cost in supply of raw material and distribution of finished goods. This model can simultaneously identify location of multi plant and warehouses for a company. The constraints that are to be considered in the objective function are given in Eq. 2 to Eq. 9.

Objective function

Total cost = Min

$$\left\{ \sum_{i=1}^{n} F_i Y_i + \sum_{e=1}^{t} F_e Y_e + \sum_{h=1}^{l} \sum_{i=1}^{n} C_{hi} X_{hi} + \sum_{i=1}^{n} \sum_{e=1}^{t} C_{ie} X_{ie} + \sum_{e=1}^{t} \sum_{j=1}^{m} C_{ej} X_{ej} \right\} \quad (1)$$

Subject to constraints

Total amount shipped from supplier cannot exceed supplier's capacity;

$$\sum_{i=1}^{n} X_{hi} \leq S_h \text{ for } h = 1, 2, 3 \ldots L \quad (2)$$

Amount shipped out of factory cannot exceed the quantity of raw material received;

$$\sum_{h=1}^{l} X_{hi} - \sum_{e=1}^{t} X_{ie} \geq 0 \text{ for } i = 1, 2, 3 \ldots n \quad (3)$$

Units produced in factory cannot exceed factory capacity;

$$\sum_{e=1}^{t} X_{ie} \leq K_i Y_i \text{ for } i = 1, 2, 3 \ldots n \quad (4)$$

Amount shipped out of warehouse cannot exceed quantity received from factories;

$$\sum_{e=1}^{t} X_{ie} - \sum_{j=1}^{m} X_{ej} \geq 0 \text{ for } e = 1, 2, 3 \ldots t \quad (5)$$

Amount shipped through warehouses cannot exceed its capacity;

$$\sum_{j=1}^{m} X_{ej} \leq WeYe \text{ for } e = 1, 2, 3 \ldots t \quad (6)$$

Amount shipped to customer must equal the customer demand.

$$\sum_{e=1}^{t} X_{ej} = D_j \text{ for } j = 1, 2, 3 \ldots m \quad (7)$$

Each factory or a warehouse is either open or closed.

$$Y_i, Y_e, \in \{0, 1\} \quad (8)$$

$$X_{ie}, X_{ej} \geq 0 \quad (9)$$

Where:

m= number of markets or demand points

m= number of potential factory locations

l= number of suppliers

t= number of potential warehouse locations

D_j= annual Demand from customer j

K_i= potential capacity of factory at site i

S_h= supply capacity at supplier h

W_e= Potenital warehouse capacity at site e

F_i= fixed cost of locating a plant at site i

F_e= fixed cost of locating a warehouse at site e

C_{hi}= cost of shipping one unit from supply source ha to factory i

C_{ie}= cost of shipping one unit from factory I to warehouse e

C_{ej}= Cost of shipping one unit from warehouse e to customer j

Y_i= 1 if warehouse is located at site e,0 otherwise

Y_e= 1 if warehouse is located at site e, 0otherwise

x_{ej}= quantity transported from warehouse e to market j

X_{ie}= quantity transported from warehouse e to market j

X_{hi}= quantity shipped from supplier h to factory at site i.

Once the model has been developed based on network configurations, the next step is to optimize the configuration of the logistics network. In practice, mathematical optimization techniques, which include exact algorithms that are guaranteed to find optimal solutions is used. A case study of East Africa Bottling Share Company has been undertaken to investigate the model developed for the supply chain network design. In the study, extensive data collection and analysis have been carried out.

CASE STUDY: EAST AFRICA BOTTLING SHARE COMPANY IN ETHIOPIA

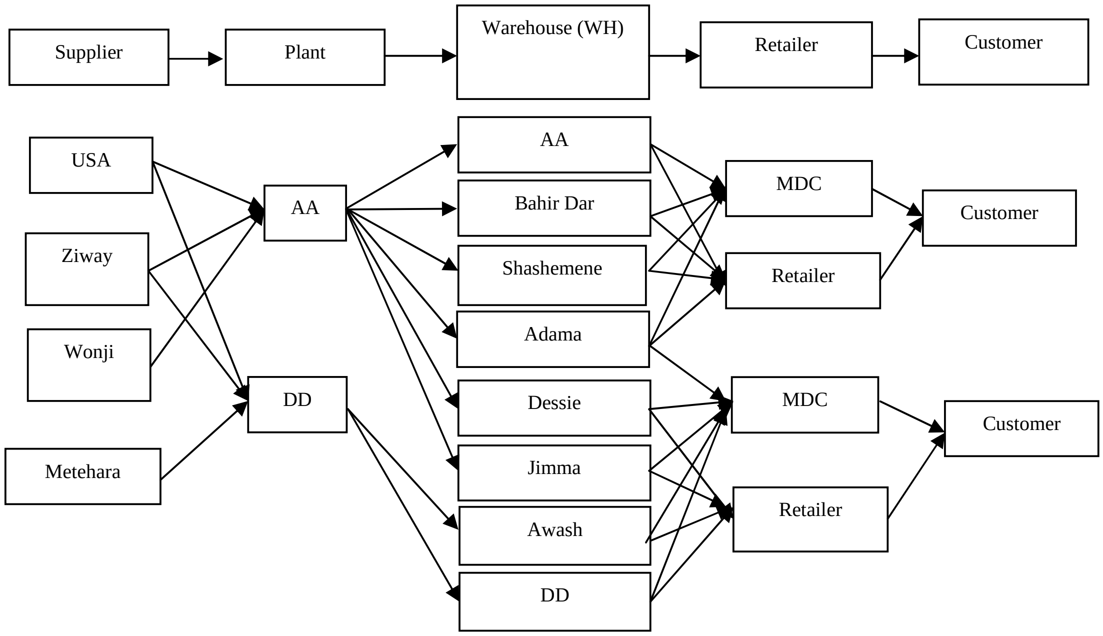
Company's Background

The first Coca-Cola bottler in Ethiopia was established in 1959 as the Ethiopian Bottling Share Company in Addis Ababa. As the business expanded a branch was set in Dire Dawa in 1965. After ten years of operation, the two plants were nationalized in 1975 and for over two decades they operated as a public company until 1996. With the introduction of the privatization program of Federal Democratic Republic of Ethiopia, South Africa Bottling Share Company and Ethiopian Bottling Share Company signed a joint venture agreement on May19, 1999. Finally, it became East Africa Bottling Share Company in 2003.

In the current business operations, some segments of the markets for the company's product experience shortage. The shortage may either be owing to shortage of supply from the company or lack of supply to specific market segment while excess supply is experienced in others. This means the company is losing its sale because the customer may cancel the order or shift to some other brand. However, the company does not have well established means to sense the shortage in the market and mechanisms how to supply the market accordingly. Hence, new supply chain network design will be developed and evaluated with the MM for the company.

Existing Supply Chain Network Diagram of the Company

To clearly portray how the MM of SC network design works, it is important to thoroughly scrutinize the existing SC structure of the company. The company has few geographic regions which it directly supplies, seven regional towns and Addis Ababa, whereas other regions are supplied by agents whose numbers are variable. A simplified schematic diagram of the SC for the company's existing operation is given in Fig. 2



Key: USA= United States of America,AA= Addis Ababa, DD=Dire Dawa, MDC= Manual Distribution Centers

Figure 2 Existing supply chain network of the case company

Data Collection and Aggregation

Raw material type and price analysis

The raw materials that are utilized for the production of the company's product mix include concentrate, sugar, bottle, crown, carbon dioxide (CO_2) and caustic soda. Table 1 depicts the sources of raw materials.

Table 1: Raw material type, sources and their respective prices *(Source : East Africa Bottling Share Company*)

No.	Raw Material	Source
1	Concentrate	USA
2	Sugar	Wonji/Metehara
3	Bottle	AA
4	Crown	AA
5	CO_2	In house production
6	Caustic Soda	Ziway

Production capacity of the company

The two plants of the company, located in Addis Ababa and Dire Dawa are operating at about 80 percent of maximum production capacity as may be observed in Tables 2 and 3. Therefore, for all practical purposes production capacity of 80 percent will be used. Table 2 shows the maximum capacities of the two plants.

Table 2: Maximum production capacity of the Company per year *(Source: East Africa Bottling Share Company)*

Plants	Capacity in Cases per year			Total
	Line 1	Line 2	Line 3	
Addis Ababa	660,000	816,000	1,440,000	2,916,000
DD Plant	468,000	-	-	468,000
Grand Total				3,384,000

Warehouses and their supply regions

There are five warehouses that receive deliveries directly from the manufacturing plant at Addis Ababa. Below are the warehouses and their supply regions.

- Addis Ababa market is supplied by 265 Manual Distribution Centers (MDCs).

- Awash is mainly supplied by the plant at Dire Dawa
- Adama warehouse covers Adama, Mojjo, Ziway, Arsi, and Wolenchiti areas.
- Shashemene warehouse covers demand regions of Hawassa, Bale, and Arsi-Negelle.
- Dessie warehouse supplies areas with in radius of 20 km excluding Kombolcha.
- Bahir Dar warehouse covers regions to Chagni and Addis-Zemen.
- Jimma warehouse supplies Jimma-Agaro and Jimma-Sekoro.

The remaining geographic regions are supplied by agents who have franchise from the Company. Other basic data are presented in later.

Basic Data Presentation and Related costs

Described below are some of the issues related to data collection and the calculation of costs required for the optimization models.

(i) Annual demand at warehouses

In Addis Ababa, each retailer is supplied by manual distribution centers (MDCs) nearby. It can be assumed that demand is concentrated at the point of MDC location. The MDCs can further be aggregated based on the total distance to serve a specific market segment. This is determined by the customer service level set by the company, which is 12 hrs a day.

In regions where there are warehouses, demand is taken to be fixed at the warehouse location. In fact there are places which can have supply from multiple warehouses. As there is no warehouse in Addis Ababa, the company directly ships and sells its products to agents at MDCs. In such cases, multiple of MDCs are grouped based on their geographic proximity to represent demand at a specific location. All MDCs at Addis Ababa are summed together to represent a single warehouse. As a result there are demand locations at seven towns. The amount of cases shipped to these destinations annually (average) is given in Table 3.

Table 3: Annual demands at depots (warehouses)

Warehouse	Demand
AA	1284800
Bahir Dar	183040
Dessie	183040
Jimma	183040
Adama	274560
Shashemene	274560
Awash	91520
DD	183040
	Total =3657600

(Source: East Africa Bottling Share Company-Company's sales report, 2009)

(ii) Transportation Rates

The cost of transporting products from a specific source to a specific destination is a function of the distance between these two points. The warehouses at AA and DD are integrated with in the plant. The cost per case of soft drink per km can be calculated in two ways. Firstly, assuming that third party vehicles can be rented and secondly, using own transport system. Considering the relevant carrier and operational costs, the average transportation cost per case per kilometer is found to be 0.06 Birr in a round trip.

A 4 pallet truck has a capacity of transporting 300 cases. A single pallet means 300/4 which is equal to 75 cases. Therefore, capacities of other trucks can be calculated by multiplying their pallet capacity by 75. The summary for all cases are presented in Tables 4 -6

Table 4: Warehouses and their distances from the plants in kilometers (*Source: East Africa Bottling share Company*)

From To	Warehouse Locations							
	AA	Bahir Dar	Dessie	Jimma	Adama	Shashemene	Awash	DD
AA plant	0	560	400	335	100	250	240	515
DD plant	515	1075	915	830	415	695	275	0

Table 5: Type of trucks and their capacity (*Source: East Africa Bottling share Company*)

S.no.	Type	Number of trucks			Capacity in cases	
		AA	DD	Total	AA	DD
1.	4 Pallet truck	15	3	18	4500	900
2.	6 Pallet truck	2	9	11	900	4050
3.	8 Pallet truck	2	2	4	1200	1200
4.	10 Pallet truck	1	0	1	750	0
5.	Hauler Trailer(22 pallet)	15	9	24	33000	19800
				Total	40350	25950

The company uses vender managed inventory and agents must fulfill minimum criteria to qualify for it. Agents owned trucks and their capacity are given in Table 3.6.

Table 6: Types of third party trucks and their capacity (*Source: East Africa Bottling share Company*)

No.	Type	Location									
		AA	WH	Adama	Shash	Mekelle	Jimma	DD	De	BD	Total
1	4 Pallet	16	-	-	-	-	-	1	1	1	18
2	6 Pallet	-	-	-	-	2	-	-	-	-	11
3	8 Pallet	13	-	5	4	7	2	2	-	-	4
4	Hauler Trailer	-	16	-	-	-	-	9		-	24
Key: AA= Addis Ababa, WH= Warehouse, Shash= Shashamane, DD= Dire Dawa, De= Dessie BD= Bihir Dar											

(iii) Potential Warehouse Locations

This factor is considered to use the excess production of 388,000 cases. Hence, potential warehouse locations are identified based on the factors like potential markets, weather condition, and population. Based on these considerations and company's expert discussion; Mekelle and Gonder towns were identified as warehouse locations in addition to the already located ones. The major reasons for establishing warehouses in these towns are:

a. Demand is high in the two towns;

b. MDCs can easily be established;

c. Agents can be cultivated in nearby towns; and

d. Competitor is present in Gonder town (PEPSI COLA)

(iv) Warehouse Capacities

The capacity of warehouses can be calculated by taking in to consideration the total physical size of the demand units. Also, factors on accounts of storing, retrieving, and other recording place allowances are considered. Generally speaking the capacity of warehouse is referred to as the average amount of demand the warehouse serves. In this particular case, the warehouse capacity in each location is found to be the peak weekly demands as shown in Table 3.

(v) Warehouse Costs

From related warehouse costs, only warehouse fixed cost is needed to be found for the very reason that (1) it is this cost that widely differs from place to place, and (2) it is incurred regardless of the amount of material stored. Fixed warehouse costs at both Addis Ababa and Dire Dawa are integrated with the main plants. The fixed cost of warehouse for different locations is given in Table 7.

Table 7: Annual warehouse fixed costs*(Source: East Africa Bottling Share Company-Company's financial report, 2009)*

Warehouse	Fixed Cost
Bahir Dar	120000
Dessie	100000
Jimma	120000
Adama	170000
Shashemene	120000
Awash	100000

(vi) Service Level Requirements

Though not exclusively mentioned, the company aspires to meet demand with in 12 hrs. Assume that order processing and loading/unloading as well as waiting time will take a total of 6 hrs. The remaining 6 hrs can be taken for the service level that the company wants to maintain, i.e about 180 km assuming 30 km/hr loaded truck travels.

MODEL FORMULATION AND DATA VALIDATION

Model formulation and data validation are typically done by reconstructing the existing network configuration using the collected data, and comparing the output of the model to existing data. Here, to validate the model, existing distribution costs to warehouses are calculated using analytical method and is compared against the excel optimization model. The cost of transport/km/case is 0.06 Birr, and the distances between the plants and warehouses are given in Table 4. Accordingly, the transportation costs/case is as depicted in Table 8

Table 8: Average transportation cost in Birr/case between plants and WH locations (*Source: East African Bottling Share Company-Company's financial report, 2009)*

To From	AA plant	DD plant
AA	0	30.9
BD	33.6	64.5
Dessie	24	54.9
Jimma	18.9	49.8
Adama	6	24.9
Shashemene	15	41.7
Awash	14.4	16.5
DD	30.9	0

Based on the available data the total transportation cost for existing network can be calculated first analytically and then compared with the optimization solution techniques. Finally, optimization with the renewed setting will be made

(a) Analytical approach

Table 9 shows the results of the transportation costs. Analytically, the total annual transportation cost from plants to warehouses using Eq. 1 results 21,278,400 Birr. The actual transportation cost obtained from plants is almost equal to this value.

Table 9: Annual Costs based on transportation cost in Birr between plants and warehouses

To / From	Warehouses							
	AA	BD	Dessie	Jimma	Adama	Shashemene	Awash	DD
AA Plant	0	33.6	24	18.9	6	15	14.4	30.9
DD Plant	30.9	64.5	54.9	49.8	24.9	41.7	16.5	0
Demand	1284800	183040	183040	183040	274560	274560	91520	183040
Cost	0	6150144	4392960	3459456	1647360	4118400	1510080	0

(b) Using Solution Techniques to Optimize Distribution Costs

A general form of the mathematical model for the distribution network is given in Eq 1.,and the related Constraints are given in Eqs. 2 to 9.

For the present case the constraints indicated in Eq. 2 and Eq 3 shall be omitted since there is only one source of each categorie of raw material consumed. Hence, the optimization formula can therefore, be modified to suit the company, i.e.

$$\text{Totalcost}=\text{Min}\left\{\sum_{i=1}^{n} F_i Y_i + \sum_{e=1}^{t} F_e Y_e + \sum_{i=1}^{n}\sum_{e=1}^{t} C_{ie} X_{ie} + \sum_{e=1}^{t}\sum_{J=1}^{m} C_{ej} X_{ej}\right\} \quad (10)$$

To see the benefit of supply chain network design for the company: two sets of optimization are considered:

1. **Optimization based on existing set of operation of the company**: In this case, the existing plant and warehouse location are fixed.
2. **Optimization with renewed setting:** In this option, all warehouse locations are set to change and optimization techniques are used to arrive at a minimum cost scenario.

Optimization Based on Existing Set of Operation

Based on the existing network structures, the plant at Addis Ababa supplies all the WH locations except Dire Dawa, which is supplied by the Dire Dawa plant. In the optimization approach, a built-in MS-Excel tool called **SOLVER** is utilized. In this scenario, the total annual cost is found to be 21, 086,208 Birr. Thus, it resulted in 192,192 Birr annual saving from the actual cost investigated with the analytical method which is 21,278,400 Birr. All the demand is met and all warehouses supply demands within their proximity. The excess transportation capacities to transport 149, 840 cases from Addis Ababa and 248,960 cases from Dire Dawa are used to serve third party distributors or agents who directly take shipments from plants. The detailed analysis is shown in Appendix 1.

Optimization with Renewed Setting

The basic problem with agents is that, they are not likely to travel longer distances to collect shipments. For instance, it is difficult to find distributors and MDCs in towns located far from plants. The total cost they incur coupled with their capacity to satisfy market largely hampers their performance. Besides, the opportunity the company loses is taken up by competitors right away. Therefore, it is better for the company to outreach as much markets as possible. Accordingly, warehouses at Mekelle and Gondar towns are identified as potential sites in addition to the already existing ones. Other places in the country have relatively level topography and nearby to AA and DD plant, hence, agents can easily be found.
After potential places in the country are proposed, the optimal solution taking into consideration all potential market locations is formulated in the MS-Excel Solver. The problem formulation and results are presented in Appendix 2.

In the renewed network optimization, the Dire Dawa Plant which was used to supply only Dire Dawa and its area is now utilized to supply Dire Dawa, Awash and half of Adama. In doing so, the company can increase its responsiveness by fully utilizing its whole capacity to supply itself. In this scenario a total of 366,080 market demands in cases which is equivalent to 8,785,680 Birr are achieved, and at the same time all demands are met. The final SC network design is therefore, as given in Fig. 3 and 4 respectively.

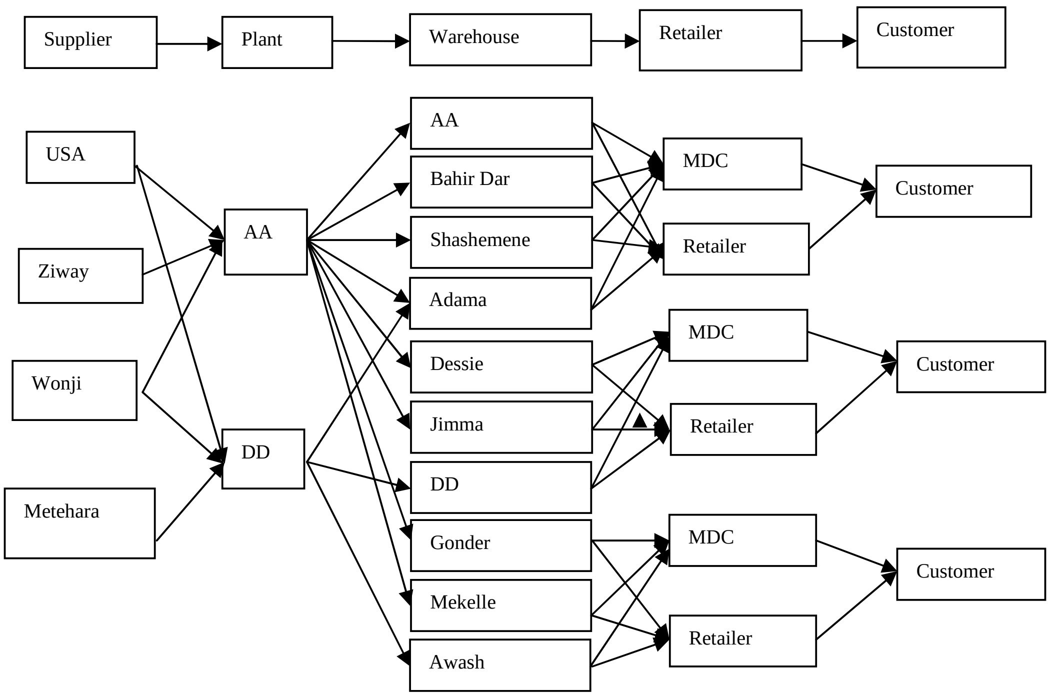


Figure 3 Renewed supply chain network design of the case company

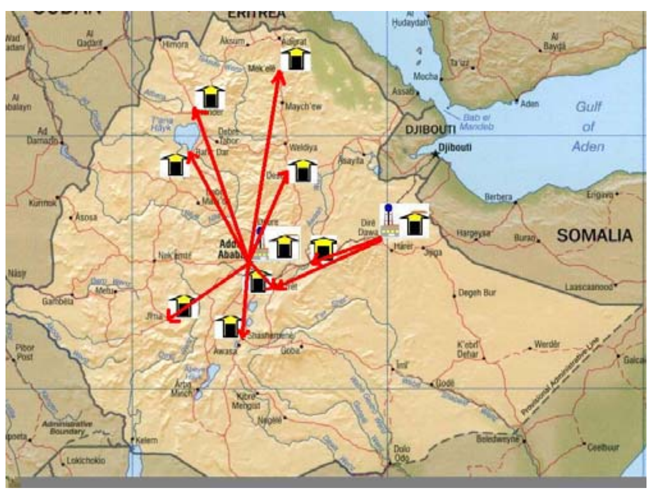


Figure 4. Renewed warehouse locations on the map of Ethiopia

Proposed Distribution Centers for the Company in Addis Ababa

The capital city, Addis Ababa and the surrounding area has a population of about 5 million people. As it is a major trading area in the country, it is very essential to locate distribution centers in and around the city. Accordingly, demand for the company's product within AA region is aggregated in to the following clusters based on their relative distance from the plant. All MDCs available are included in the aggregation. The location of the demand is found on account of center points and demand areas. (Table 10)

Table 10: Aggregated demands in Addis Ababa city

Center Point	Demand	Demand Areas
Sidist Kilo	187200	Arat Kilo, Shiromeda, Ferensay, Bela, and Menelik
Abune Petros	171600	Piazza, Merkato, Teklehaymanot, Semen mazagaja and adjoining area
Ayer Tena	47000	Ayer Tena and Alemgena
Bole	94600	Bole and adjoining area
Gulele	47000	Yohannes, Paster, Asko, Gulele
Kazanchis	45700	St.Urael, Aware, Kebena
Kera	44000	Kera, Gotera, Mekanisa
Kolfe	45000	Kolfe area
Megenagna	182700	22 Mazoria , Maganagna , and Kotebe
Meskel Square	134500	Meskel Square Ambassador, Lancha
Mexico	150500	Mexico and adjoining area
Nefassilk	135000	Nefassilk, Saris, Kaliti, Akaki

To simplify the SC operation, WHs should be established away from the plant. This is a basic issue for the company with the objective to relieve the queue at the AA plant, to respond faster to demands with higher customer service level, to simplify information processing between MDCs and the company, and to use different set of trucks for different purposes.

There is an excess number of trailers within Addis Ababa Plant. By proper scheduling of the shipments, cost savings and resource utilization will be assured. Table 11 shows the proposed schedule for shipments to warehouses in the city. For distribution outside the city only 12 trailers are required, the remaining can be used for distribution with in the city.

Number of Warehouses to be Established

To determine the number of warehouses to be established and find the right locations, waiting time to load shipment from plant to MDCs and lost market demand have to be considered. To respond to demand at any MDC, a vehicle spends an average of one hour in the queue, another one hour to get empty bottles to inspect and load. Moreover, to arrive at the destination an average of one hour is lost. Therefore, a total of two and a half hours are spent on average. An average of (1284800/365) or 3520 cases have to leave the plants per day. As the company uses trucks of capacity 300 cases for Addis Ababa shipments, a total of 18 trucks have to wait to get their shipment done. This means 18 hrs are wasted per day only in the queue, which is equivalent to 6570 hrs per year. If we assume that

Table 11: Vehicle scheduling for out of AA shipment from Plant at Addis Ababa

Place	Days of the Week								
	Distance	Mon	Tue	Wed	Thurs	Fri	Sat	Sun	Max no. of trucks required
Nazareth	100	x		x		x			2
Awash	240								
Shashemene	250	x		x		x			2
Jimma	335		x			x			2
Dessie	400		x				x		2
DD	515								
Bahir Dar	560		x				x		2
Gonder	738		x				x		2

cost of one hour of a vehicle is 60 Birr (average) a total of 405,000 Birr is lost in queuing. This cost is enough to open a warehouse in another place within the city. In addition to the existing plant warehouse in Addis Ababa, it would be advisable to establish one warehouse in Kazanchis with a capacity of 1770 cases. This warehouse supplies shipments to areas included under Kazanchis, Sidist Kilo, Megenagna, Bole and Nefassilk. Initial shipment is made directly from plant to the warehouse at Kazanchis by a truck of capacity 1760 per day and then the shipment can further be distributed by trucks of capacity 300 cases. After utilizing 12 Hauler Trailers with a capacity of 1760 outside the city, the company remains with other trucks with a combined capacity of carrying 12630 cases per day.

CONCLUSIONS

In this paper, an attempt has been made to model the SC network design and justify with the case analysis. The following are the results of the case analysis for East Africa Bottling Share Company:

1. Three new warehouses should be established at Mekelle, Gonder, and Kazanchis.
2. The Plant at Addis Ababa, supplies warehouses at Kazanchis, Bahir Dar, Dessie, Shashemene, Jimma, Gonder, Mekelle, Adama, and part of Awash.
3. The Plant at Dire Dawa supplies to Dire Dawa, Awash and some part of Adama.

Furthermore, interesting results are observed. First, by the application of network model optimization techniques, an annual cost saving of 192,192 Birr could be achieved. Secondly, by renewing the existing network design of the company, a market share of 366,080 cases per year which is equivalent to 8,785,680 Birr could be realized. Moreover, by analyzing and revising the vehicle scheduling problem a cost saving of 405,000 Birr per year could be achieved.

To sum up, SC network design has a high economic benefit for manufacturing company. The MM developed and optimization techniques employed here will be good grounds for any similar bottling companies with a need to design appropriate SC network thereby reducing their costs. This model could be easily adapted to another manufacturing plant based on their existing operating situations.

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Appendix1. Optimized Minimum Cost for the Existing Network

	A	B	C	D	E	F	G	H	I	J	K
10											
11			Average Transportation cost per case(crate) between Potential WH locations								
12			Addis Ababa	Bahir Dar	Dessie	Jimma	Nazret	Shashemene	Awash	DD	Capacity
13		AA plant	0	33.6	24	18.9	6	15	14.4	30.9	2624400
14		DD plant	30.9	64.5	54.9	49.8	24.9	41.7	16.5	0	432000
15		Demand	1284800	183040	183040	183040	274560	274560	91520	183040	
16											
17											
18			Amount to be transported from plant to WH								
19			Addis Ababa	Bahir Dar	Dessie	Jimma	Nazret	Shashemene	Awash	DD	Capacity
20		AA plant	1284800	183040	183040	183040	274560	274560	91520	0	2624400
21		DD plant	0	0	0	0	0	0	0	183040	432000
22		Demand	1284800	183040	183040	183040	274560	274560	91520	183040	
23											
24											
25		Supply plant	Excess Capacity								
26		AA	149840								
27		DD	248960								
28		Unmet Demand	0	0	0	0	0	0	0	0	
29	TC	21086208									

Appendix2. Minimum Cost Scenario for the Renewed Network

	Distance Matrix between the Plants and potential warehouse locations										
	Addis Ababa	Bahir Dar	Dessie	Jimma	Nazret	Shasheme	Awash	DD	Gonder	Mekelle	Capacity
AA plant	0	560	400	335	100	250	240	515	738	780	2624400
DD plant	515	1075	915	830	415	695	275	0	1253	1295	432000
Demand	1284800	183040	183040	183040	274560	274560	91520	183040	1760	183040	

	Average Transportation cost per case(crate) between Potential WH locations										
	Addis Ababa	Bahir Dar	Dessie	Jimma	Nazret	Shasheme	Awash	DD	Gonder	Mekelle	Capacity
AA plant	0	33.6	24	20.1	6	15	14.4	30.9	44.28	46.8	2624400
DD plant	30.9	64.5	54.9	49.8	24.9	41.7	16.5	0	75.18	77.7	432000
Demand	1284800	183040	183040	183040	274560	274560	91520	183040	1760	183040	

	Amount to be transported from plant to WH										
	Addis Ababa	Bahir Dar	Dessie	Jimma	Nazret	Shasheme	Awash	DD	Gonder	Mekelle	Capacity
AA plant	1284800	183040	183040	183040	149840	274560	0	0	183040	183040	2624400
DD plant	0	0	0	0	124720	0	91520	183040	0	0	432000
Demand	1284800	183040	183040	183040	274560	274560	91520	183040	183040	183040	

Supply plant	Excess Capacity									
AA	0									
DD	32720									
Unmet Dema	0	0	0	0	0	0	0	0	0	0

	B	C	D	E	F	G	H	I	J	K	L	M	N
48		Total Transportation cost/case(crate) between potential WH locations											
49		AA	Bahir Dar	Dessie	Jimma	Nazret	Shashem	Awash	DD	Gonder	Mekelle	Capacity	Fixed WH co
50	AA	3	33.6	24	20.1	6	15	14.4	30.9	44.28	46.8		0
51	Bahir Dar	33.6	1.2	29.4	53.7	39.6	48.6	48	64.5	10.68	52.2		200000
52	Dessie	24	29.4	0.9	44.1	30	45	38.4	54.9	40.08	22.8		150000
53	Jimma	20.1	53.7	44.1	0.6	26.1	53.1	34.5	51	64.38	66.9		100000
54	Nazret	6	39.6	30	26.1	1.8	11.4	8.4	24.9	50.28	52.8		170000
55	Shashemen	15	48.6	39	53.1	11.4	1.2	19.8	36.3	59.28	61.8		150000
56	Awash	14.4	48	38.4	34.5	8.4	19.8	0.3	16.5	58.68	61.2		75000
57	DD	30.9	64.5	54.9	51	24.9	36.3	16.5	1.5	75.18	77.7		0
58	Gonder	44.28	10.68	40.08	64.38	50.28	59.28	58.68	75.18	0.9	62.88		120000
59	Mekelle	46.8	52.2	22.8	66.9	52.8	61.8	61.2	77.7	62.88	1.2		120000
60	Demand	1284800	183040	183040	183040	274560	274560	91520	183040	1760	183040		
61													

	B	C	D	E	F	G	H	I	J	K	L	M	N
64		Amount to be transported from WHs to market locations											
65		AA	Bahir Dar	Dessie	Jimma	Nazret	Shashem	Awash	DD	Gonder	Mekelle	Open = 1	
66	AA	1284800	0	0	0	0	0	0	0	0	0	1	
67	Bahir Dar	0	183040	0	0	0	0	0	0	0	0	1	
68	Dessie	0	0	183040	0	0	0	0	0	0	0	1	
69	Jimma	0	0	0	183040	0	0	0	0	0	0	1	
70	Nazret	0	0	0	0	274560	0	0	0	0	0	1	
71	Shashemen	0	0	0	0	0	274560	0	0	0	0	1	
72	Awash	0	0	0	0	0	0	91520	0	0	0	1	
73	DD	0	0	0	0	0	0	0	183040	0	0	1	
74	Gonder	0	0	0	0	0	0	0	0	183040	0	1	
75	Mekelle	0	0	0	0	0	0	0	0	0	183040	1	
76	Demand	1284800	183040	183040	183040	274560	274560	91520	183040	183040	183040		

	B	C
81	WH	Excess Capacity
82	AA	0
83	Bahir Dar	0
84	Dessie	0
85	Jimma	0
86	Nazret	0
87	Shashemen	0
88	Awash	0
89	DD	0
90	Gonder	0
91	Mekelle	0

	C	D	E	F	G	H	I	J	K	L
93	Unmet Demand									
94	AA	Bahir Dar	Dessie	Jimma	Nazret	Shashem	Awash	DD	Gonder	Mekelle
95	0	0	0	0	0	0	0	0	0	0

	A	B
98	TC	47470227