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Application Of SC Concept For Designing The Effective Distribution Network For JVVNL

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Abstract

Distribution refers to the steps taken to move and store a product from the supplier stage to a customer stage in the supply chain. Distribution is a key driver of the overall profitability of a firm because it directly impacts both the supply chain cost and the customer experience. Good distribution can be used to achieve a variety of supply chain objectives ranging from low cost to high responsiveness. As a result, companies in the same industry often select very different distribution networks. The objective of this research is to study the existing distribution network of the ***JAIPUR VIDUT VITRAN NIGAM LIMITED (JVVNL), JAIPUR*** *and develop a decision model using SOLVER IN EXCEL to assist re-structuring of their distribution network. The model will decide the optimum number of distribution centres, their locations and supply matrix. The decision model will provide the solution by optimizing transportation cost and inventory costs.*

1. Introduction

To serve customers in a cost- effective way network design consists of decisions regarding the location of plants, suppliers and distribution centers the most important tactical issues that firms have to resolve include allocation of volumes to plants and allocation of plants to markets. The professionals verify their operations on a daily basis. The modern logistic leaders use the tricks like competitive pressures, mergers, acquisitions, new product lines and greater customer expectations, and so forth. This change is a cost of doing business in the latest “new economy”. This research investigates the auction properties that influence efficiency (ability to maximize price and profit) as the distribution link of the supply chain. Also focuses on different key areas that are the roadmap to an effective, flexible and proactively responsive distribution operation (Chopra, 2001). Supply chain network design involves strategic decisions on the number, locations, capacity and mission of the supply, production and facilities of a supply chain in order to provide goods to a predetermined, but possibly evolving, customer base (Kalvi and Martel,2009) Distribution refers to the steps taken to move and store a product from the supplier stage to a customer stage in the supply chain. Distribution is a key driver of the overall profitability of a firm because it directly impacts both the supply chain cost and the customer experience. Good distribution can be used to achieve a variety of supply chain objectives ranging from low cost to high responsiveness. As a result, companies in the same industry often select very different distribution networks.

2. Model Description and Result Analysis for a Distribution System

The objective of the research is to develop a distribution network under supply chain of the Jaipur Vidut Vitran Nigam Limited, Jaipur. The main objectives of the research could be stated in short as:

1. Analyze the existing distribution network.
2. Propose a new distribution strategy
3. Find the optimum number of distribution centers, their locations and
4. Decide the associate minimum cost.

Each model represents a specific business case; hence an optimization model with the suitable constraints was developed. Total cost concept is used along with mathematical optimization technique. The important components of cost used in developing this model are:

1. Fixed initial set up cost.
2. Transportation cost.
3. Inventory cost

After analyzing the current distribution strategy, a new strategy is proposed to overcome its disadvantages. The highlights of the proposed distribution strategy are:

1. Each distribution center would store all products.
2. Each distribution center would serve only the customers in its proximity (no specific distance constraint was modeled).
3. Each customer would be served by only one distribution center.

The important steps in the development of the model can be described as,

1. Data collection.
2. Mathematical formulation.
3. Running the model.

2.1 Data Collection

While developing the model, following data is important:

1. Demand outline of the product.
2. Information regarding location of all customers, existing distribution centers.
3. Distance matrix (i.e. distance between any two locations)
4. Information regarding transportation cost, inventory cost etc.

The actual data for the fiscal year of 2009-2010 is used as input while building the model. The total product line of the company has around 98 active products. This resulted in hundreds of thousands of variables demanding high amount of software as well as hardware resources.

2.1.1 Data Collection of Demand Pattern of the Product:

The required data for the fiscal year of 2009-2010 is collected while designing the effective distribution network of JVVNL, RURAL JAIPUR. All required data are given below in the Table while building the model.

➢ Statement showing 5 KVA single phase transformers issued to sub division:

S N	Store	Sub dv.	apl	may	jun	July	aug	sep	oct	nov	dec	jan	feb	mar	total
1	jpdc	Vkia	3	20	12	6	15	8	8	0	6	13	11	13	115
2	jpdc	Ramgarh	0	19	19	18	3	6	4	7	3	14	8	3	104
3	jpdc	Bassi	26	36	34	0	12	16	28	19	51	12	12	30	276
4	jpdc	Kkd	10	10	21	14	0	20	15	8	27	15	5	9	154
5	jpdc	Chaksu	5	20	25	15	0	9	10	25	22	6	5	19	161
6	jpdc	Bagru	1	10	15	5	0	1	6	2	5	26	4	0	75
7	jpdc	Phagi	3	5	4	9	0	2	14	6	1	2	0	5	51
8	jpdc	Sanganer	0	0	1	5	3	4	6	2	9	4	6	9	49
9	jpdc	Govindgarh	3	10	5	11	3	16	14	14	8	4	9	11	108
10	jpdc	Jetpura	10	16	16	6	9	10	10	2	9	17	11	4	120
11	jpdc	a1 Chomu	4	16	23	8	4	9	12	6	9	33	16	8	148
12	jpdc	a2 Chomu	6	10	9	5	0	10	8	0	12	19	19	9	107
13	jpdc	Radawas	5	4	6	9	5	7	11	3	10	9	6	14	89
14	Jpdc	Jobner	7	5	27	6	2	7	3	0	6	9	8	7	87
15	Jpdc	Sambher	0	1	8	0	2	0	0	12	5	2	5	2	37
16	Jpdc	Renwal	0	11	13	0	0	1	0	0	0	0	3	2	30
17	Jpdc	Dudu	0	14	12	11	0	0	2	0	3	6	0	3	51
18	Jpdc	Shapura	20	21	18	5	2	13	12	10	27	78	27	39	272
19	Jpdc	Poata	22	44	47	20	0	20	19	12	42	80	33	39	378
20	Jpdc	V Nagar	9	16	22	5	2	19	16	12	18	47	19	27	212
21	Jpdc	Kotputli	23	13	47	0	35	25	20	7	50	43	40	76	379
	Total		157	301	384	158	97	203	218	147	323	439	247	329	3003

Table 2.1: Data tabulation of 5KVA single phase transformer

➢ Statement showing 16 KVA single phase transformers issued to sub-division:

S N	store	Sub dv.	apl	may	Jun	july	aug	sep	oct	nov	Dec	jan	feb	total
1	jpdc	Vkia	0	0	2	0	0	0	1	0	0	1	1	5
2	jpdc	Ramgarh	0	1	0	3	0	0	0	0	0	4	4	12
3	jpdc	Bassi	0	2	10	0	0	0	0	0	0	2	4	22
4	jpdc	Kkd	0	0	4	1	0	0	0	0	0	4	5	16
5	jpdc	Chaksu	0	2	0	2	0	0	0	0	0	2	0	6
6	jpdc	Bagru	0	2	4	4	0	0	0	0	1	1	1	13
7	jpdc	Phagi	0	0	0	2	0	0	0	0	0	0	0	2
8	jpdc	Sanganer	0	0	0	0	0	0	0	0	0	2	0	2
9	jpdc	Govindgarh	0	1	0	0	0	0	0	0	0	1	2	4
10	jpdc	Jetpura	0	0	0	1	0	0	0	0	0	0	0	1
11	jpdc	a1 Chomu	0	0	0	1	0	0	0	0	0	1	6	8
12	jpdc	a2 Chomu	0	0	3	0	0	0	0	0	0	1	0	7
13	jpdc	Radawas	0	0	0	0	0	0	0	0	0	0	2	2
14	jpdc	Jobner	0	0	1	1	0	0	0	0	0	0	2	4
15	jpdc	Sambher	0	0	2	0	0	0	0	0	0	0	0	2
16	jpdc	Renwal	0	0	2	0	0	0	0	0	0	1	3	8
17	jpdc	Dudu	0	1	0	1	0	0	0	0	0	0	0	2
18	jpdc	Shapura	0	2	6	3	0	1	0	0	0	0	4	18
19	jpdc	Poata	0	1	5	0	0	0	0	0	0	0	3	9
20	jpdc	V Nagar	0	0	2	2	0	0	0	0	0	3	1	8
21	jpdc	Kotputli	0	0	2	0	0	0	0	0	0	0	2	4
	total		0	12	43	21	0	1	1	0	1	23	40	155

Table 2.2: Data tabulation of 16KVA single phase transformers

2.1.2 Information Regarding Location of all Customers, Existing Distribution Centers

Statement showing position of sources in gps and (x,y) coordinates

S No.	Sources/Positions	gps(N) [degree min sec]	gps(E) [degree min sec]	x(utm)	y(utm)
1	Jpdc	26 54.106	75 46.036	576192	2975786
2	Vkia	26 56.587	75 47.155	578016	2980377
3	Ramgarh	27 02.510	76 03.226	604514	2991506
4	Bassi	26 49.483	76 02.543	603584	2967446
5	Kkd	26 59.002	75 51.183	584650	2984879
6	Chaksu	26 36.132	75 56 54.5	593831	2942722
7	Bagru	26 49.131	75 31.134	554878	2966477
8	Phagi	26 34.426	75 33.251	555190	2939347
9	Sanganer	26 48.403	75 46.594	577180	2965264
10	Govindgarh	27 14.455	75 38.391	563348	3013282
11	Jetpura	27 02.163	75 47.305	578199	2990673
12	a1 Chomu	27 09.585	75 43.108	571183	3004333
13	a2 Chomu	27 09.585	75 43.108	571183	3004333
14	Radawas	27 18.362	75 50.330	583000	3020611
15	Jobner	26 58.164	75 23.082	538179	2983104
16	Sambher	26 54.143	75 10.466	517321	2975635
17	Renwal	26 41.457	75 40.246	566732	2952331
18	Dudu	26 40.471	75 13.475	522346	2950405
19	Shapura	27 07.231	75 52.326	586435	3000084
20	Poata	27 14.543	75 56.358	592995	3013631
21	V Nagar	27 25.596	76 10.397	615970	3034234
22	Kotputli	27 42.053	76 11.570	617609	3064638

Table 2.3: Data tabulation of position of sources in gps and (x,y) coordinates

- ➢ Statement showing distance matrix from source to sub divisions:

S No.	1 Distance Matrix	Poata	S No.	2 Distance Matrix	Jobner
1	Shapura	20 Km	1	Bagru	30 Km
2	Poata	0 Km	2	Jobner	0 Km
3	V Nagar	25 Km	3	Sambher	60 Km
4	Kotputli	35 Km	4	Renwal	50 Km
			5	Dudu	40 Km
S No.	**3 Distance Matrix**	**Jpdc**	**S No.**	**4 Distance Matrix**	**A1 Chomu**
1	Vkia	13 Km	1	Govindgarh	15 Km
2	Ramgarh	45 Km	2	Jetpura	15 Km
3	Bassi	30 Km	3	a1 Chomu	0 Km
4	Kkd	16 Km	4	a2 Chomu	0 Km
5	Chaksu	37 Km	5	Radawas	30 Km
6	Phagi	50 Km			

Table 2.4: Data tabulation distance matrix from source to sub divisions

2.2 Mathematical Formulation

Once the new distribution strategy is identified, it is then translated into the mathematical form and a decision tool solver in excel. Formulation of a model using solver needs the model to be structured in following few steps.

- ➢ Preparing data base in an excel spreadsheet.
- ➢ To use appropriate tool like solver
- ➢ To get optimal results by using solver in excel.

2.2.1 Solver

Solvers, or optimizers, are software tools that help users find the best way to allocate scarce resources. The resources may be raw materials, machine time or people time, money, or anything else in limited supply. The "best" or optimal solution may mean maximizing profits, minimizing costs, or achieving the best possible quality.

2.2.2 Distribution and Networks Using Solver in Excel

1. Routing (of goods, natural gas, electricity, digital data, etc.) involves allocating something to different paths through which it can move to various destinations, to minimize costs or maximize throughput.
2. Loading (of trucks, rail cars, etc.) involves allocating space in vehicles to items of different sizes so as to minimize wasted or unused space.
3. Scheduling of everything from workers to vehicles and meeting rooms involves allocating capacity to various tasks in order to meet demand while minimizing overall costs

To use a solver, we must build a model that specifies:

- The resources to be used, using **decision variables**,
- The limits on resource usage, called **constraints**, and
- The measure to optimize, called the **objective**

In this paper, Gravity location model is being used as this described above in details and it is useful to identify suitable geographic locations within a region. The main purposes of Gravity models are to find locations that minimize the cost of transportation within supply chain.

Jaipur vidut vitran nigam Ltd has one store located near Sodala, Jaipur from which it has supplied the complete rural Jaipur district but there are few problems occurred in distribution of the products so it needs to set up other facility locations. Gravity models assume that both the sources and the markets can be located as grid points on a plane. All distances are calculated as the geometric distance between two points on the plane. This model also assumes that the transportation cost grows linearly with the quantity shipped. The basic inputs of the model as follows:

- x_{n}, y_{n} - coordinate location of either markets or supply sources n

- F_n - cost of shipping one unit for one km between the facility and either market or supply source n
- D_n - quantity to be shipped between facility and market or supply source n

If (x,y) is the location selected for the facility, the distance d_n between the facility at location (x,y) and the supply source or market n is given by

$$\mathbf{d_n=\sqrt{(x-x_n)^2 + (y-y_n)^2}} \qquad (1)$$

The total transportation cost is given by

$$\mathbf{TC=\sum D_n F_n d_n} \qquad (2)$$

The optimal location is one that minimizes the TC in equation 2. The optimal solution is obtained using the solver tool in excel. The first step begins by arranging the data in an Excel spreadsheet. it uses six columns, first one for sources/markets, second one for transportations cost/ton km, third one for quantity in tons, fourth and fifth for x and y coordinates and last one for distance(d) and enter the formula for the model by referencing to the cells containing the model parameters. Next, set the two decision variables (X, Y) and a target cell which has objective function and then calculated using equation (2).

Here (x,y) is the location selected for the facility and are taken as geographical positioning system. The sources and the markets can be located as grid points on a plane and the distance d_n between the facility at location (x,y) and the supply source or market n is calculated by above formula. The values of (x,y) are obtained as gps values for all sources and markets and then convert these values to (x,y) coordinates. These values are described by the **Universal Transverse Mercator (UTM).** The **Universal Transverse Mercator (UTM)** geographic coordinate system is a grid-based method of specifying locations on the surface of the Earth that is a practical application of a 2-dimensional Cartesian coordinate system. It is a horizontal position representation to identify locations on the earth independently of vertical position, but differs from the traditional method of latitude and longitude in several respects. The UTM system is not a single map projection. The system instead employs a series of sixty zones, each of which is based on a specifically defined secant transverse Mercator projection. (Military map reading, 2005)

A position on the Earth is referenced in the UTM system by the UTM zone, and the easting and northing coordinate pair. The easting is the projected distance of the position eastward from the central meridian, while the northing is the projected distance of the point north from the equator (in the northern hemisphere). Eastings and northings are measured in meters. The point of origin of each UTM zone is the intersection of the equator and the zone's central meridian. In order to avoid dealing with negative numbers, the central meridian of each zone is given a "false easting" value of 500,000 meters. Thus, anything west of the central meridian will have an easting less than 500,000 meters. For example, UTM eastings range from 167,000 meters to 833,000 meters at the equator (these ranges narrow towards the poles). In the northern hemisphere, positions are measured northward from the equator, which has an initial "northing" value of 0 meters and a maximum "northing" value of approximately 9,328,000 meters at the 84th parallel — the maximum northern extent of the UTM zones. In the southern hemisphere, northings decrease as you go southward from the equator, which is given a "false northing" of 10,000,000 meters so that no point within the zone has a negative northing value. As an example, the CN Tower is located at the geographic position 43°38′33.24″N 79°23′13.7″W/ 43.6425667°N 79.387139°W. This is in zone 17, and the grid position is 630084m east, 4833438m north. There are two points on the earth with these coordinates, one in the northern hemisphere and one in the southern. (Military map reading, 2005)

The next step is to use the tools/solver to invoke Solver. Within the solver parameters dialog box the following information is entered to represent the problem.

- Set Target Cell
- Equal to Select Min.
- By changing Variables Cells
- Subject to constraint

This is an existing distribution network of the JVVNL, Jaipur.

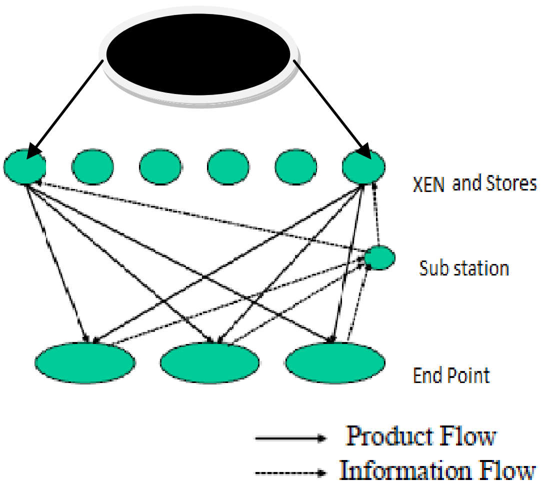

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Figure 2.1: Existing Distribution Network of JVVNL Storage with Direct Shipping

- There are certain problems in such type of distribution network like higher transportation costs, longer response time, expensive and difficult to implement in case of return ability etc.

2.3 Modified Distribution Network

A survey is done to find the optimum number of distribution centers within the region. All sub division is situated on the four ways. First one on the delhi way, second one on the chomu way, third one on the ajmer way and last one jpdc only. These all are suitable locations to serve customer request. This means that there are four numbers of suitable locations in fulfilling customer demands.

The center-of-gravity model helps determine the optimal location for an individual warehouse if proximity to customers is the only criterion. To select a site for an individual distribution center to serve local customers, the model suggests finding the location closest to the center of demand for all customers. Customers are assumed to be located on a grid system, each with a given fixed annual demand. The location of each customer is represented by x and y coordinates.
The following formula is used to find the COG location (x, y) for the warehouse.

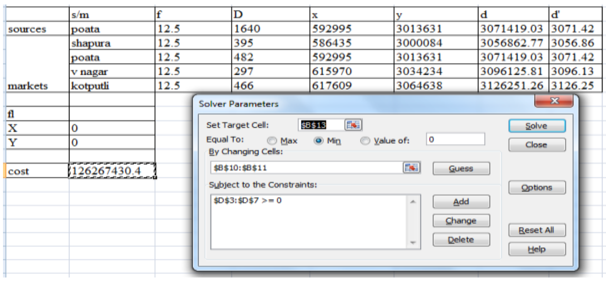
$$X = \frac{\sum_i^n xidi}{\sum_i^n di} \qquad (1)$$

$$Y = \frac{\sum_i^n yidi}{\sum_i^n di} \qquad (2)$$

Where x_i and y_i are the coordinates of the i_{th} customer, and d_i is annual demand of the i_{th} customer.

2.3.1 Transportation Cost and Optimal Location

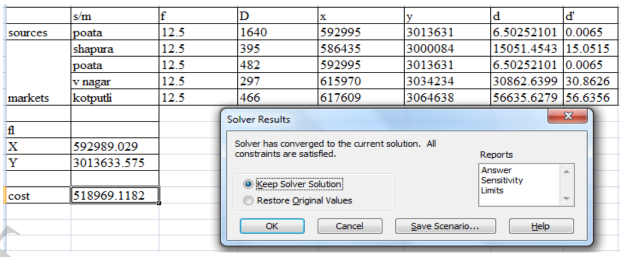
The optimal locations and Transportation Cost in the supply chain as a distribution centre or store is obtained by using Solver Tool. Again repeat the whole procedure as used in existing distribution network to obtain modify distribution.
This time, there is a source (Poata) and four markets.



	s/m	f	D	x	y	d	d'
sources	poata	12.5	1640	592995	3013631	3071419.03	3071.42
	shapura	12.5	395	586435	3000084	3056862.77	3056.86
	poata	12.5	482	592995	3013631	3071419.03	3071.42
	v nagar	12.5	297	615970	3034234	3096125.81	3096.13
markets	kotputli	12.5	466	617609	3064638	3126251.26	3126.25
fl							
X	0						
Y	0						
cost	126267430.4						

Figure 2.2: Model formulation containing solver parameters (source: Poata)

- Click on the solver button and the optimal solution is returned in cells and thus identifies the coordinates (X,Y) = (3013631,407004) as the location of the new facility that minimizes the total cost as shown in Figure below:

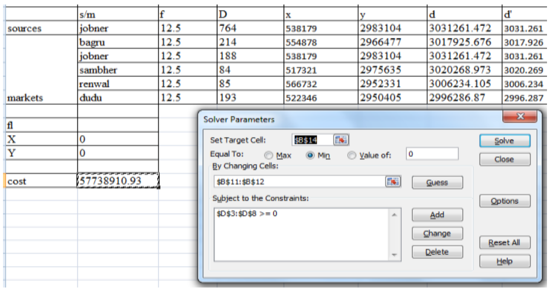


	s/m	f	D	x	y	d	d'
sources	poata	12.5	1640	592995	3013631	6.50252101	0.0065
	shapura	12.5	395	586435	3000084	15051.4543	15.0515
	poata	12.5	482	592995	3013631	6.50252101	0.0065
	v nagar	12.5	297	615970	3034234	30862.6399	30.8626
markets	kotputli	12.5	466	617609	3064638	56635.6279	56.6356
fl							
X	592989.029						
Y	3013633.575						
cost	518969.1182						

Figure 2.2: Model formulation containing solver results (source: Poata)

From the map, these coordinates are close to the Poata sub division. The optimal location is Poata that minimizes the total transportation cost.

This time, there is a source (Jobner) and four markets.



	s/m	f	D	x	y	d	d'
sources	jobner	12.5	764	538179	2983104	3031261.472	3031.261
	bagru	12.5	214	554878	2966477	3017925.676	3017.926
	jobner	12.5	188	538179	2983104	3031261.472	3031.261
	sambher	12.5	84	517321	2975635	3020268.973	3020.269
	renwal	12.5	85	566732	2952331	3006234.105	3006.234
markets	dudu	12.5	193	522346	2950405	2996286.87	2996.287
fl							
X	0						
Y	0						
cost	57738910.93						

Figure 2.4: Model formulation containing solver parameters (source: Jobner)

- Click on the solver button and the optimal solution is returned in cells and thus identifies the coordinates (X,Y) = (2983102,461813) as the location of the new facility that minimizes the total cost as shown in Figure below:

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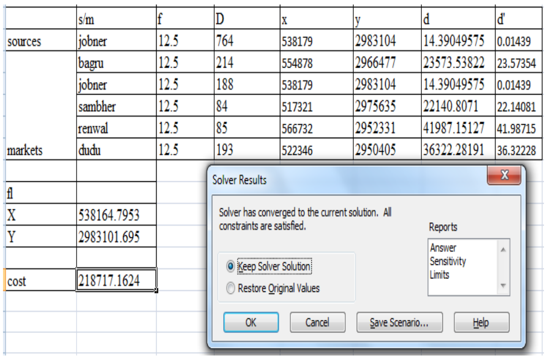
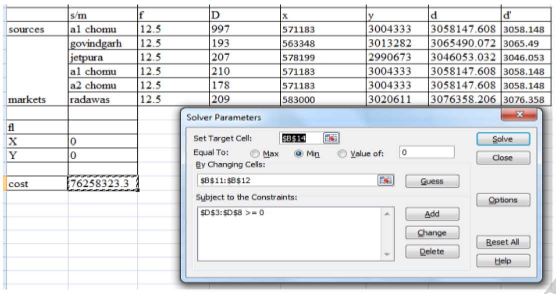


	s/m	f	D	x	y	d	d'
sources	jobner	12.5	764	538179	2983104	14.39049575	0.01439
	bagru	12.5	214	554878	2966477	23573.53822	23.57354
	jobner	12.5	188	538179	2983104	14.39049575	0.01439
	sambher	12.5	84	517321	2975635	22140.8071	22.14081
	renwal	12.5	85	566732	2952331	41987.15127	41.98715
markets	dudu	12.5	193	522346	2950405	36322.28191	36.32228
fl							
X	538164.7953						
Y	2983101.695						
cost	218717.1624						

Figure 2.5: Model formulation containing solver results (source: Jobner)

From the map, these coordinates are close to the Jobner sub division. The optimal location is Jobner that minimizes the total transportation cost.

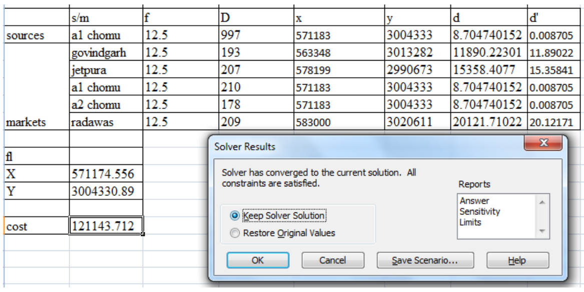
This time, there is a source (a1 Chomu) and four markets.



	s/m	f	D	x	y	d	d'
sources	a1 chomu	12.5	997	571183	3004333	3058147.608	3058.148
	govindgarh	12.5	193	563348	3013282	3065490.072	3065.49
	jetpura	12.5	207	578199	2990673	3046053.032	3046.053
	a1 chomu	12.5	210	571183	3004333	3058147.608	3058.148
	a2 chomu	12.5	178	571183	3004333	3058147.608	3058.148
markets	radawas	12.5	209	583000	3020611	3076358.206	3076.358
fl							
X	0						
Y	0						
cost	76258323.3						

Figure 2.6: Model formulation containing solver parameters (source: a1 Chomu)

- Click on the solver button and the optimal solution is returned in cells and thus identifies the coordinates (X,Y) = (3004323,428817) as the location of the new facility that minimizes the total cost as shown in Figure below:

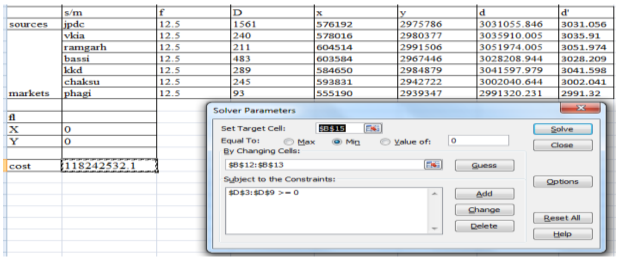


	s/m	f	D	x	y	d	d'
sources	a1 chomu	12.5	997	571183	3004333	8.704740152	0.008705
	govindgarh	12.5	193	563348	3013282	11890.22301	11.89022
	jetpura	12.5	207	578199	2990673	15358.4077	15.35841
	a1 chomu	12.5	210	571183	3004333	8.704740152	0.008705
	a2 chomu	12.5	178	571183	3004333	8.704740152	0.008705
markets	radawas	12.5	209	583000	3020611	20121.71022	20.12171
fl							
X	571174.556						
Y	3004330.89						
cost	121143.712						

Figure 2.7: Model formulation containing solver results (source: a1 Chomu)

From the map, these coordinates are close to the a1 Chomu sub division. The optimal location is a1 Chomu that minimizes the total transportation cost.

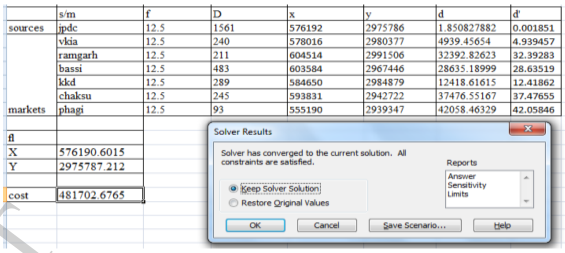
This time, there is a source (JPDC) and four markets.



	s/m	f	D	x	y	d	d'
sources	jpdc	12.5	1561	576192	2975786	3031055.846	3031.056
	vkia	12.5	240	578016	2980377	3035910.005	3035.91
	ramgarh	12.5	211	604514	2991506	3051974.005	3051.974
	bassi	12.5	483	603584	2967446	3028208.944	3028.209
	kkd	12.5	289	584650	2984879	3041597.979	3041.598
	chaksu	12.5	245	593831	2942722	3002040.644	3002.041
markets	phagi	12.5	93	555190	2939347	2991320.231	2991.32
fl							
X	0						
Y	0						
cost	118242532.1						

Figure 2.8: Model formulation containing solver parameters (source: modified JPDC)

- Click on the solver button and the optimal solution is returned in cells and thus identifies the coordinates (X,Y) = (2975785,423808) as the location of the new facility that minimizes the total cost as shown in Figure below:



	s/m	f	D	x	y	d	d'
sources	jpdc	12.5	1561	576192	2975786	1.850827882	0.001851
	vkia	12.5	240	578016	2980377	4939.45654	4.939457
	ramgarh	12.5	211	604514	2991506	32392.82623	32.39283
	bassi	12.5	483	603584	2967446	28635.18999	28.63519
	kkd	12.5	289	584650	2984879	12418.61615	12.41862
	chaksu	12.5	245	593831	2942722	37476.55167	37.47655
markets	phagi	12.5	93	555190	2939347	42058.46329	42.05846
fl							
X	576190.6015						
Y	2975787.212						
cost	481702.6765						

Figure 2.9: Model formulation containing solver results (source: JPDC modified)

From the map, these coordinates are close to the JPDC division. The optimal location is JPDC that minimizes the total transportation cost.

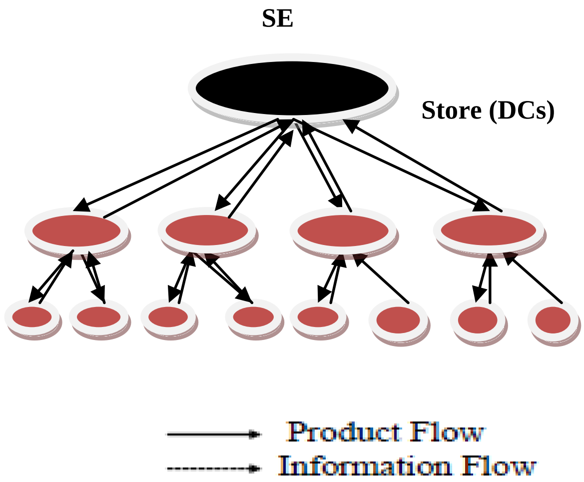


Figure 2.10: Modified Distribution Network of JVVNL Storage

The model developed in this research is run and results are obtained using few steps. In first step, the model is made to choose the locations of the distribution centers by specifying the number of distribution centers desired in the network. The model is run for five times, first one for existing distribution and rest of modified distribution network in the supply chain.

Now, the total cost is obtained for each division. The total cost consist three costs mainly. These are listed below:

1. Fixed initial set up cost.
2. Transportation cost.
3. Inventory cost

The Total Transportation cost is obtained already by using solver tool and in next steps, inventory cost will be calculated

- **Assumption**

Fixed initial set up cost is not being calculated because the optimal locations which obtained from solver very near to one of the sub divisions so there is no need to any infrastructure cost and machinery cost. Here two costs are being considered only.

2.3.2 Inventory cost

There are mainly three types of inventory cost:

1. Cycle inventory
2. Safety inventory
3. In-transit inventory

Cycle inventory (CI) = [lot size (Q)/2] (3)

Safety inventory (SI) = [RLT/2days of demand] (4)

In – transit inventory
(TI) = [total demand* (LT/365)] (5)

Some data are directly provided by the company only like holding cost in percentage, cost of item, total demand etc. those played an important role to obtain the total annual holding cost.

	Given	given	given									
ırces	H	ct	D	Q	LT	RLT	AHC	CI	SI	TI	TAI	TAHC
c	0.01	40000	5100	86	5	6	400	43	41.918	69.863	154.781	61912.3
ıta	0.01	40000	1640	28	5	6	400	14	13.479	22.4658	49.9452	19978.1
ıner	0.01	40000	764	12	5	6	400	6	6.2795	10.4658	22.7452	9098.08
ımu	0.01	40000	997	16	5	6	400	8	8.1945	13.6575	29.8521	11970.7
c	0.01	40000	1561	26	5	6	400	13	12.83	21.3836	47.2137	18885.5
												59932.3

Table 2.5: Showing different values associate with inventory

In the above Table, Different values are calculated by using above equations and formulas and make an excel spreadsheet like CI, SI, TI and total annual holding cost of the different sources.

Total Annual Holding Cost (TAHC) of existing distribution network = 61912.3 **Rs**

Total Annual Holding Cost (TAHC) of modified distribution network
= 19978.1+ 9098.08 + 11970.7 + 18885.5
= **59932.3 Rs**

Difference of Total Annual Holding Cost in both cases = 61912.3- 59932.3 = **1980 Rs**

This difference of Total annual holding cost in both cases can be ignored so total transportation cost will be considered as total cost. In both cases, total transportation cost has been obtained.

Total transportation cost of existing distribution network = **2492313 Rs**

Total transportation cost of modified distribution network = 518669 + 218717 + 121143 + 481702
= **1340231 Rs**

Difference of Total transportation cost in both cases = **2492313- 1340231 = 1152082 Rs**

3. Result

From the above calculations, it can be clearly seen that the total cost of the existing distribution network is less than the total cost of the modified distribution network. Hence it can be concluded that the optimum number of distribution centers the company should have is four. The locations are selected by the model as given below in the Table:

S. No.	Name of Distribution Centers	Associate transportation cost(Rs)	Associate inventory cost(Rs)	Nearby route
1.	JPDC (Existing)	2492313	61912.3	Sodala, Jaipur
2.	Poata	518669	19978.1	Delhi, alwar
3.	Jobner	218717	9098.08	Ajmer
4.	al Chomu	121143	11970.7	Chomu
5.	JPDC (Modified)	481702	18885.5	Sodala, Jaipur

Table 3.1: Showing results

Calculate the efficiency of the distribution network

The efficiency of the distribution network = [(initial total cost- final total cost)/(initial total cost)] = [(2492313- 1340231)/ 2492313]* 1
= **46.22%**

The model with four distribution centers results in approximate **46.22%** of the cost savings. The proposed distribution network, suggests three distribution centers in the network than the present situation.

4. Conclusion

This research studied the problem of designing a distribution network under a supply chain system that involves determining the best locations stores and the best strategy for distributing the product from the plants to the stores and from the stores to the customers. This research is developed a model by using a tool Solver in Excel for the problem. The results of model indicate that the procedure is both effective and efficient for a wide variety of problem sizes and structures.

The results of this model indicate that large cost savings can be achieved through systematic analysis of the logistics process of this company. The model with four distribution centers results in approximate **46.22%** of the cost savings. Optimally designed distribution network would primarily results in

1. Lower transportation costs
2. Increased customer service level
3. Decrease in order fulfillment lead time
4. Greater demand visibility as each distribution center will be closer to customers

This approach suggested here can be easily used to design any model under supply chain and can be flexibly updated to reflect any changes in the process, strategy or demand pattern. The well defined structure of the data sets allows easy maintenance of the data. Using solver tool in Excel requires relatively less time to compute the feasible solution. This is an important feature from the user point of view, since the user can build different scenarios by making necessary changes in the model and achieve the results relatively quickly so that all customer demand is satisfied at minimum total costs of the distribution network resulted from the Store location, transportation, and inventory. This model is developed for Jaipur Vidut Vitran Nigam Limited, Jaipur and minimized the expected total cost for designing an effective distribution network system in a supply chain.

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