Freight and Margin Optimisation in Building Material Industry using Data Analytics and Network Optimisation Technique (Case Study: Indian Ceramic Product Manufacturing Company)

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Abstract - *This case study aims at understanding the cause of spiraling freight cost and dwindling margin of a building material company in a country in South Asia. In this study, sales data, transportation data and margin variation in different geographies of the country were analyzed and optimisation of freight and profit margin were done using the concept of network optimization tool and data analytics tools like Solver. The results of analysis throw pleasant surprises in the form of potential improvements above 30%.*

Key Words: Average Radial Distance, Freight Index, Freight Optimisation, Margin Optimisation

1. INTRODUCTION

Optimization means maximizing the return at a given risk level or risk is minimized for a given expected return [1]. According to the great management consultant Peter Drucker, "Knowledge has to be improved, challenged and increased constantly, or it vanishes." In reference to a supply chain, without constant study, a company can lose sight of how its supply chain impacts the entire business [2]. This case study is about a building material company in a country in South Asia which has 6 number of manufacturing locations across the country and 26 number of sales hubs. Before the study, the scenario was as follows. The average radial distance over which the finished goods were being transported was 768 miles and the freight index of the company was 3.10 cents/ton/mile. Total weight of material transported from all manufacturing locations in a month was 36 thousand tons on average. The total average freight for the transportation of the finished goods in a month was approximately USD 900,000. Also, the total operating margin of the company was stagnating at USD 5 million per month for last couple of years. We analysed the data to calculate average radial distance and freight index for each manufacturing location. We found that these indices varied from one manufacturing location to another. Further, we tried to analyse the relationship between average radial distance and freight index. Whereas, overall, a good degree of correlation was shown, some manufacturing locations didn't conform to the relationship. Considering the fact that each manufacturing location demonstrated its own pattern of SCM cost, we inferred that SCM networks of all or at least some manufacturing locations were not optimised. Considering this and also the fact that freight bill was considerably high, we decided to carry out network optimisation.

1.1 Aims & Objective

This study was carried out with following objectives:

- To optimize the cost of transportation of finished goods.
- To maximise the profit of the company by analysing the contribution (Price realised – variable cost) variation in different geographies of the country and optimising the same.

2. METHODOLOGY

Following concepts and approach were used in this study

2.1 Concept of Average Radial Distance and Freight Index

Average Radial Distance is the weighted average distance (by weight) from a manufacturing location over which the finished products are being transported. This index gives us an indication about how well the manufacturing location is located with respect to the market.

Freight Index is defined as cents spent to transport 1 ton of finished products over 1 mile.

We calculated this index for all the manufacturing locations. This index provides an indication about freight cost efficiency of each manufacturing location.

We have deliberately selected MS Excel for our analysis because we realized that this is not only the most widely available analytics tool but also the most easily grasped. Besides, smaller companies may not find costly software justifiable unless they have had opportunity to fully appreciate the benefit of analytics; and MS Excel can fill this space.

Calculation Framework:

For a particular manufacturing location:

Let total quantity dispatched per month to each sales hub from that manufacturing location be T1, T2, T3…….,TN

Let Distance of each sales hub from that manufacturing location be D1, D2, D3…….,DN.

Let Freight per ton from the manufacturing location to each sales hub be F1, F2, F3…….,FN.

Total tonnage = Σ Ti

Total freight = Σ Fi Ti

Total Ton-miles = Σ Ti Di

Total freight /miles = Σ (Fi Ti / Di)

Freight Index for the manufacturing location (F.I.) = (Total freight /miles) / Total tonnage = [Σ (Fi Ti / Di)] / [Σ Ti]

Average Radial Distance = Total Ton-miles / Total tonnage = [Σ Ti Di] / [Σ Ti]

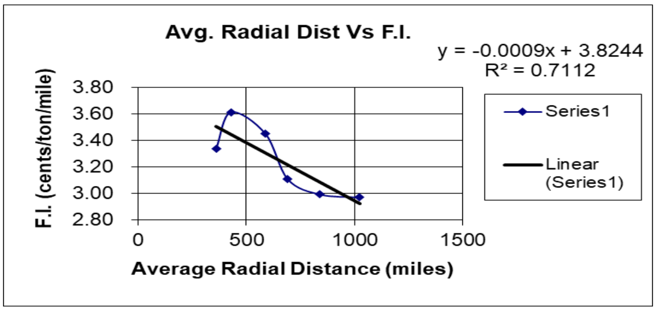
Using above concept, Freight Index and Average Radial Distance of all the manufacturing locations were calculated.

Having calculated the above parameters for individual manufacturing locations, the Freight Index of the Company was calculated which came out to be 3.10 cents/ton/mile. Average Radial Distance before optimisation was 768 miles. As a result of Network Optimisation, the Average Radial Distance came down to 529miles. This in turn lead to significant freight saving.

It may apparently seem that a manufacturing location with lower Average Radial Distance would have lower average freight. But, through our study, we busted this myth and brought a different perspective through the concept of Freight Index (FI). Freight Index looks at freight with respect to not only per unit weight moved, but also per unit distance moved.

Relation between Average radial distance and Freight Index of individual manufacturing location:

Manufacturing locations	Freight Index (cents/ton/mile)	Average Radial Distance (miles)
RAK04	3.34	362
NUK03	3.61	429
WED02	3.45	588
JIV06	3.11	691
NEP01	2.99	839
JAR05	2.97	1023
Correlation Coefficient between FI and Average Radial Distance	-0.84	



From above table and graph, it can be very well seen that there is a very high degree of negative correlation between average distance moved and Freight Index. This explains, to a great extent, why Freight Index of JAR05, NEP01 and JIV06 are low and that of NUK03, RAK04 and WED02 are high. Manufacturing location with longer average radial distance have lower freight per ton per mile. This is so because a vehicle is better utilized if it moves continuously for longer period of time before every stoppage for loading/unloading.

At the same time, we also realised that the Freight Index of WED02 and NUK03 are higher than that predicted by the regression formula. This shows that apart from distance, there are other reasons which are jacking Freight Index of WED02 and NUK03. Some of these reasons have to do with terrain, local labour situation and so on. For example, geographies with different terrain tend to have higher F.I. Geographies with high labour cost also tend to have higher F.I.

Further, a considerably high value of R- square in the above graph shows high degree of predictability of this equation.

Thus, freight equation developed during this study started being used to benchmark and develop clean sheet costing for use during freight negotiation.

2.2 Concept of Network Optimisation for optimisation of Freight and Margin

- **Freight Optimisation:**

First of all, sales data i.e. dispatched quantities from each manufacturing location to each sales hub were collected and then the data were organised in the following format:

Tonnage matrix: This matrix contains the total dispatched quantities in tons from each manufacturing location to respective sales hub (Table 1).

Distance Matrix: This matrix contains the distance of each manufacturing location from respective sales hub (Table 2).

After arranging data in such format, we optimised the dispatch pattern from each manufacturing location to all sales hub by using Network optimisation technique. While optimising the pattern following assumptions were made:

I. Production capacity of each manufacturing location was considered constant i.e. total dispatched quantity from a particular manufacturing location was considered constant.

II. Total demand of each sales hub was considered constant.

Considering all these factors, the analytical tool called 'Solver', calculates optimal scenario showing which manufacturing location should serve which market to minimise the total freight for the company.

Although, this analysis has been done at product category level, for the sake of simplicity, we are producing analysis result for all the products taken together.

The optimised tonnage matrix is shown in Table 3.

Table 1
As – Is Scenario (For freight optimisation study)

Tonnage Matrix showing As - Is dispatch pattern (Average Monthly 'tons')							
Sales Hubs	Manufacturing locations						Total
	NEP01	WED02	NUK03	RAK04	JAR05	JIV06	
01LED	309	171	9	0	743	51	**1282**
02CUL	118	47	21	0	791	214	**1192**
03AHG	25	73	51	0	541	32	**722**
04AHC	388	158	43	9	1467	185	**2250**
05MOB	0	288	190	52	611	0	**1141**
06NUP	0	79	153	0	608	184	**1024**
07AOG	321	1	80	16	97	49	**564**
08GAN	45	8	29	0	20	25	**127**
09LOK	295	98	93	16	913	932	**2348**
10DYH	401	55	322	121	492	79	**1470**
11ZIV	69	68	43	52	174	491	**897**
12WUG	18	16		0	82	120	**236**
13JIV	56	31	96	121	140	0	**445**
14UHB	57	25	22	0	181	161	**445**
15DNI	211	0	95	0	1012	251	**1569**
16IAJ	146	147	142	0	784	107	**1326**
17MHA	336	149	56	0	734	0	**1275**
18NRE	846	16	286	439	1456	624	**3668**
19LAC	418	41	146	182	351	1113	**2252**
20VRT	282	0	197	5	462	558	**1504**
21DAM	370	78	219	233	399	365	**1664**
22IOC	267	9	73	311	484	548	**1693**
23EHC	958	48	188	332	698	1248	**3473**
24BUH	152	15	168	33	182	49	**598**
25NAB	345	45	0	230	567	517	**1703**
26IRT	160	0	132	214	468	579	**1552**
Total	**6591**	**1668**	**2855**	**2366**	**14457**	**8484**	

Table 2
Distance Matrix (For freight optimisation study)

Distance Matrix (Miles)						
Sales Hubs	Manufacturing locations					
	NEP01	WED02	NUK03	RAK04	JAR05	JIV06
01LED	956	500	1313	0	719	1175
02CUL	925	519	1238	0	1063	1081
03AHG	963	531	1313	0	728	1175
04AHC	1100	719	1500	1738	863	1331
05MOB	0	406	650	875	488	0
06NUP	0	400	550	0	563	575
07AOG	344	750	438	688	813	617
08GAN	594	319	738	0	750	528
09LOK	1313	1000	1213	1335	1344	844
10DYH	500	594	400	650	900	234
11ZIV	906	1000	681	794	1300	228
12WUG	1813	1375	0	0	1656	1563
13JIV	688	744	444	556	1063	0
14UHB	1125	844	938	0	1281	559
15DNI	438	0	850	0	397	750
16IAJ	813	438	1269	0	581	1163
17MHA	438	288	963	0	125	0
18NRE	894	1125	338	363	1325	772
19LAC	806	1063	219	344	1206	781
20VRT	1031	0	469	408	1469	833
21DAM	938	1313	363	175	1356	625
22IOC	844	1094	263	219	1300	653
23EHC	875	1063	256	200	1288	338
24BUH	413	656	281	531	825	485
25NAB	688	875	0	300	1081	463
26IRT	875	0	263	91	1281	547

Table 3
Optimised Scenario (For freight optimisation study)

Tonnage Matrix showing optimum dispatch pattern considering same production capacity of each manufacturing location and same demand of each sale hub (Average Monthly 'tons')							
Sales Hub	Manufacturing locations						Total
	NEP01	WED02	NUK03	RAK04	JAR05	JIV06	
01LED	0	0	0	0	1282	0	**1282**
02CUL	0	0	0	485	707	0	**1192**
03AHG	0	0	0	0	722	0	**722**
04AHC	0	0	0	0	2250	0	**2250**
05MOB	1141	0	0	0	0	0	**1141**
06NUP	1024	0	0	0	0	0	**1024**
07AOG	564	0	0	0	0	0	**564**
08GAN	0	0	0	0	127	0	**127**
09LOK	0	0	0	0	2348	0	**2348**
10DYH	0	0	0	0	0	1470	**1470**
11ZIV	0	0	0	0	0	897	**897**
12WUG	0	0	236	0	0	0	**236**
13JIV	0	0	0	0	0	445	**445**
14UHB	0	0	0	445	0	0	**445**
15DNI	0	0	0	0	1569	0	**1569**
16IAJ	0	0	0	0	1326	0	**1326**
17MHA	0	0	0	0	1275	0	**1275**
18NRE	3668	0	0	0	0	0	**3668**
19LAC	0	0	0	0	2252	0	**2252**
20VRT	0	1504	0	0	0	0	**1504**
21DAM	0	0	0	48	0	1616	**1664**
22IOC	194	0	916	0	0	583	**1693**
23EHC	0	0	0	0	0	3473	**3473**
24BUH	0	0	0	0	598	0	**598**
25NAB	0	0	1703	0	0	0	**1703**
26IRT	0	164	0	1388	0	0	**1552**
Total	**6591**	**1668**	**2855**	**2366**	**14457**	**8484**	

Having optimised the dispatched pattern, the savings in freight bill was calculated whose summary is tabulated below:

As Is Condition	
Total Dispatched Tonnage	36,421
As Is Ton-Miles	2,79,75,275

Optimised Condition	
Total Dispatched Tonnage	36,421
Optimum Ton-	1,92,74,287

As Is transportation bill @ 3.10 F.I. (cent/ton/mile)	8,67,713
As Is Average Radial Distance (in Miles)	768

Miles	
Optimum transportation bill @ 3.10 F.I. (cent/ton/mile)	5,97,833
Optimum Average Radial Distance (in Miles)	529

Total savings from the freight optimisation came out to be USD 270,000 per month.

Evaluation of Capacity - Demand Scenarios:

NEP01 manufacturing location is running at 50% capacity utilization. Given this, a case is considered when NEP01 runs at 100% capacity utilization. Now, we wanted to analyse how distribution pattern would get impacted. For the analysis of the case, three scenarios have been considered and in all the scenario, network optimisation is carried out.

Scenario I – When production capacity of NEP01 is doubled, it is assumed that in As-Is condition the increased production would be subsumed by all the markets proportionately because of proportionate increase in demand in all markets.

Table 4 and Table 5 shows the As-Is and Optimised condition tonnage matrices for this scenario respectively.

Table 4
As-Is Condition (For freight optimisation with enhanced capacity - Scenario I)

Tonnage Matrix showing As - Is dispatch pattern (Average Monthly 'tons')							
Sales Hubs	Manufacturing Locations						Total
	NEP01	WED02	NUK03	RAK04	JAR05	JIV06	
01LED	618	171	9	0	743	51	**1591**
02CUL	236	47	21	0	791	214	**1310**
03AHG	49	73	51	0	541	32	**747**
04AHC	776	158	43	9	1467	185	**2638**
05MOB	0	288	190	52	611	0	**1141**
06NUP	0	79	153	0	608	184	**1024**
07AOG	642	1	80	16	97	49	**885**
08GAN	90	8	29	0	20	25	**172**
09LOK	591	98	93	16	913	932	**2643**
10DYH	802	55	322	121	492	79	**1871**
11ZIV	138	68	43	52	174	491	**966**
12WUG	36	16		0	82	120	**254**
13JIV	112	31	96	121	140	0	**501**
14UHB	113	25	22	0	181	161	**502**
15DNI	422	0	95	0	1012	251	**1780**
16IAJ	292	147	142	0	784	107	**1472**
17MHA	672	149	56	0	734	0	**1611**
18NRE	1692	16	286	439	1456	624	**4513**
19LAC	835	41	146	182	351	1113	**2669**
20VRT	564	0	197	5	462	558	**1786**
21DAM	740	78	219	233	399	365	**2034**
22IOC	534	9	73	311	484	548	**1960**
23EHC	1915	48	188	332	698	1248	**4430**
24BUH	304	15	168	33	182	49	**750**
25NAB	689	45	0	230	567	517	**2048**
26IRT	320	0	132	214	468	579	**1712**
Total	**13183**	**1668**	**2855**	**2366**	**14457**	**8484**	

Table 5
Optimised Condition (For freight optimisation with enhanced capacity - Scenario I)

Tonnage Matrix showing optimum dispatch pattern considering same production capacity of each manufacturing location and same demand of each sale hub (Average Monthly 'tons')							
Sales Hub	Manufacturing Locations						Total
	NEP01	WED02	NUK03	RAK04	JAR05	JIV06	
01LED	0	0	0	0	1591	0	**1591**
02CUL	0	0	0	0	1310	0	**1310**
03AHG	0	0	0	0	747	0	**747**
04AHC	0	0	0	0	2638	0	**2638**
05MOB	1141	0	0	0	0	0	**1141**
06NUP	1024	0	0	0	0	0	**1024**
07AOG	885	0	0	0	0	0	**885**
08GAN	0	0	0	0	172	0	**172**
09LOK	0	0	0	0	2643	0	**2643**
10DYH	676	0	0	0	490	705	**1871**
11ZIV	0	0	0	0	0	966	**966**
12WUG	0	0	254	0	0	0	**254**
13JIV	0	0	0	0	0	501	**501**
14UHB	0	0	0	502	0	0	**502**
15DNI	0	0	0	0	1780	0	**1780**
16IAJ	0	0	0	0	1472	0	**1472**
17MHA	0	0	0	0	1611	0	**1611**
18NRE	4513	0	0	0	0	0	**4513**
19LAC	2115	0	553	0	1	0	**2669**
20VRT	118	1668	0	0	0	0	**1786**
21DAM	0	0	0	152	0	1881	**2034**
22IOC	1960	0	0	0	0	0	**1960**
23EHC	0	0	0	0	0	4430	**4430**
24BUH	750	0	0	0	0	0	**750**
25NAB	0	0	2048	0	0	0	**2048**
26IRT	0	0	0	1712	0	0	**1712**
Total	**13183**	**1668**	**2855**	**2366**	**14457**	**8484**	

Having optimised the dispatched pattern, the savings in freight bill was calculated whose summary is tabulated below:

Scenario I – When NEP01 capacity doubles and all the demands are subsumed by all the markets			
As Is Condition		**Optimised Condition**	
Total Dispatched Tonnage	43,013	Total Dispatched Tonnage	43,013
As Is Ton-Miles	3,33,43,800	**Optimum Ton-Miles**	2,30,67,718
As Is transportation bill @ 3.10 F.I. (cent/ton/miles)	10,34,229	**Optimum transportation bill @ 3.10 F.I. (cent/ton/miles)**	7,15,495
As Is Average Radial Distance (in Miles)	775	Optimum Average Radial Distance (in Miles)	536

Scenario II – When production capacity of NEP01 is doubled, it is assumed that in As-Is condition the increased production would be subsumed by only South and West markets proportionately because of proportionate increase in demand in South and West markets. It is also assumed that the demand of North and East markets would remain unchanged.

Table 6 and Table 7 shows the As-Is and Optimised condition tonnage matrices for this scenario respectively.

Table 6
As-Is Condition (For freight optimisation with enhanced capacity - Scenario II)

Tonnage Matrix showing As - Is dispatch pattern
(Average Monthly 'tons')

Sales Hubs	Region	Manufacturing Locations						Total
		NEP01	WED02	NUK03	RAK04	JAR05	JIV06	
01LED	N&E	309	171	9	0	743	51	**1282**
02CUL	N&E	118	47	21	0	791	214	**1192**
03AHG	N&E	25	73	51	0	541	32	**722**
04AHC	N&E	388	158	43	9	1467	185	**2250**
05MOB	S&W	0	288	190	52	611	0	**1141**
06NUP	S&W	0	79	153	0	608	184	**1024**
07AOG	S&W	757	1	80	16	97	49	**1000**
08GAN	N&E	45	8	29	0	20	25	**127**
09LOK	N&E	295	98	93	16	913	932	**2348**
10DYH	S&W	946	55	322	121	492	79	**2015**
11ZIV	N&E	69	68	43	52	174	491	**897**
12WUG	N&E	18	16		0	82	120	**236**
13JIV	N&E	56	31	96	121	140	0	**445**
14UHB	N&E	57	25	22	0	181	161	**445**
15DNI	N&E	211	0	95	0	1012	251	**1569**
16IAJ	N&E	146	147	142	0	784	107	**1326**
17MHA	S&W	792	149	56	0	734	0	**1731**
18NRE	S&W	1994	16	286	439	1456	624	**4816**
19LAC	S&W	984	41	146	182	351	1113	**2819**
20VRT	S&W	665	0	197	5	462	558	**1887**
21DAM	S&W	872	78	219	233	399	365	**2166**
22IOC	S&W	629	9	73	311	484	548	**2055**
23EHC	S&W	2258	48	188	332	698	1248	**4773**
24BUH	S&W	358	15	168	33	182	49	**805**
25NAB	S&W	812	45	0	230	567	517	**2171**
26IRT	S&W	377	0	132	214	468	579	**1769**
Total		**13183**	**1668**	**2855**	**2366**	**14457**	**8484**	

Table 7
Optimised Condition (For freight optimisation with enhanced capacity - Scenario II)

Tonnage Matrix showing optimum dispatch pattern considering same production capacity of each manufacturing location and same demand of each sale hub
(Average Monthly 'tons')

Sales Hub	Region	Manufacturing Locations						Total
		NEP01	WED02	NUK03	RAK04	JAR05	JIV06	
01LED	N&E	0	0	0	0	1282	0	**1282**
02CUL	N&E	0	0	0	0	1192	0	**1192**
03AHG	N&E	0	0	0	0	722	0	**722**
04AHC	N&E	0	0	0	0	2250	0	**2250**
05MOB	S&W	1141	0	0	0	0	0	**1141**
06NUP	S&W	1024	0	0	0	0	0	**1024**
07AOG	S&W	1000	0	0	0	0	0	**1000**
08GAN	N&E	0	0	0	0	127	0	**127**
09LOK	N&E	0	0	0	0	2348	0	**2348**
10DYH	S&W	1414	0	0	0	247	355	**2015**
11ZIV	N&E	0	0	0	0	0	897	**897**
12WUG	N&E	0	0	236	0	0	0	**236**
13JIV	N&E	0	0	0	0	0	445	**445**
14UHB	N&E	0	0	0	445	0	0	**445**
15DNI	N&E	0	0	0	0	1569	0	**1569**
16IAJ	N&E	0	0	0	0	1326	0	**1326**
17MHA	S&W	0	0	0	0	1731	0	**1731**
18NRE	S&W	4816	0	0	0	0	0	**4816**
19LAC	S&W	709	0	448	0	1662	0	**2819**
20VRT	S&W	219	1668	0	0	0	0	**1887**
21DAM	S&W	0	0	0	152	0	2014	**2166**
22IOC	S&W	2055	0	0	0	0	0	**2055**
23EHC	S&W	0	0	0	0	0	4773	**4773**
24BUH	S&W	805	0	0	0	0	0	**805**
25NAB	S&W	0	0	2171	0	0	0	**2171**
26IRT	S&W	0	0	0	1769	0	0	**1769**
Total		**13183**	**1668**	**2855**	**2366**	**14457**	**8484**	

Having optimised the dispatched pattern, the savings in freight bill was calculated whose summary is tabulated below:

Scenario II - When NEP01 capacity doubles and all the demands are subsumed by S & W markets

As Is Condition		Optimised Condition	
Total Dispatched Tonnage	43,013	Total Dispatched Tonnage	43,013
As Is Ton-Miles	3,29,86,596	**Optimum Ton-Miles**	2,34,02,348
As Is transportation bill @ 3.10 F.I. (cent/ton/miles)	10,23,150	**Optimum transportation bill @ 3.10 F.I. (cent/ton/miles)**	7,25,874
As Is Average Radial Distance (in Miles)	767	Optimum Average Radial Distance (in Miles)	544

Scenario III – When production capacity of NEP01 is doubled, it is assumed that in As-Is condition the increased production would be subsumed by only North and East markets proportionately because of proportionate increase in demand in North and East markets. It was also assumed that the demand of South and West markets would remain unchanged.

Table 8 and Table 9 shows the As-Is and Optimised condition tonnage matrices for this scenario respectively.

Table 8
As-Is Condition (For freight optimisation with enhanced capacity - Scenario III)

Tonnage Matrix showing As - Is dispatch pattern
(Average Monthly 'tons')

Sales Hubs	Region	Manufacturing Locations						Total
		NEP01	WED02	NUK03	RAK04	JAR05	JIV06	
01LED	N&E	1481	171	9	0	743	51	**2454**

02CUL	N&E	566	47	21	0	791	214	**1640**
03AHG	N&E	118	73	51	0	541	32	**815**
04AHC	N&E	1862	158	43	9	1467	185	**3724**
05MOB	S&W	0	288	190	52	611	0	**1141**
06NUP	S&W	0	79	153	0	608	184	**1024**
07AOG	S&W	321	1	80	16	97	49	**564**
08GAN	N&E	216	8	29	0	20	25	**298**
09LOK	N&E	1416	98	93	16	913	932	**3469**
10DYH	S&W	401	55	322	121	492	79	**1470**
11ZIV	N&E	331	68	43	52	174	491	**1159**
12WUG	N&E	85	16		0	82	120	**304**
13JIV	N&E	269	31	96	121	140	0	**657**
14UHB	N&E	271	25	22	0	181	161	**660**
15DNI	N&E	1013	0	95	0	1012	251	**2371**
16IAJ	N&E	699	147	142	0	784	107	**1880**
17MHA	S&W	336	149	56	0	734	0	**1275**
18NRE	S&W	846	16	286	439	1456	624	**3668**
19LAC	S&W	418	41	146	182	351	1113	**2252**
20VRT	S&W	282	0	197	5	462	558	**1504**
21DAM	S&W	370	78	219	233	399	365	**1664**
22IOC	S&W	267	9	73	311	484	548	**1693**
23EHC	S&W	958	48	188	332	698	1248	**3473**
24BUH	S&W	152	15	168	33	182	49	**598**
25NAB	S&W	345	45	0	230	567	517	**1703**
26IRT	S&W	160	0	132	214	468	579	**1552**
Total		**13183**	**1668**	**2855**	**2366**	**14457**	**8484**	

Table 9
Optimised Condition (For freight optimisation with enhanced capacity - Scenario III)

Tonnage Matrix showing optimum dispatch pattern considering same production capacity of each manufacturing location and same demand of each sale hub (Average Monthly 'tons')

Sales Hub	Region	Manufacturing Locations						Total
		NEP01	WED02	NUK03	RAK04	JAR05	JIV06	
01LED	N&E	0	0	0	0	2454	0	**2454**
02CUL	N&E	0	0	0	1640	0	0	**1640**
03AHG	N&E	0	0	0	0	815	0	**815**
04AHC	N&E	0	0	0	0	3724	0	**3724**
05MOB	S&W	1141	0	0	0	0	0	**1141**
06NUP	S&W	1024	0	0	0	0	0	**1024**
07AOG	S&W	564	0	0	0	0	0	**564**
08GAN	N&E	0	0	0	0	298	0	**298**
09LOK	N&E	0	0	0	0	1640	1829	**3469**
10DYH	S&W	1470	0	0	0	0	0	**1470**
11ZIV	N&E	0	0	0	0	0	1159	**1159**
12WUG	N&E	0	0	304	0	0	0	**304**
13JIV	N&E	0	0	0	0	0	657	**657**
14UHB	N&E	0	0	0	660	0	0	**660**
15DNI	N&E	0	0	0	0	2371	0	**2371**
16IAJ	N&E	0	0	0	0	1880	0	**1880**
17MHA	S&W	0	0	0	0	1275	0	**1275**
18NRE	S&W	3668	0	0	0	0	0	**3668**
19LAC	S&W	2252	0	0	0	0	0	**2252**
20VRT	S&W	0	1504	0	0	0	0	**1504**
21DAM	S&W	773	0	0	0	0	891	**1664**
22IOC	S&W	1693	0	0	0	0	0	**1693**
23EHC	S&W	0	0	0	0	0	3473	**3473**
24BUH	S&W	598	0	0	0	0	0	**598**
25NAB	S&W	0	0	1703	0	0	0	**1703**
26IRT	S&W	0	164	848	66	0	474	**1552**
Total		**13183**	**1668**	**2855**	**2366**	**14457**	**8484**	

Having optimised the dispatched pattern, the savings in freight bill was calculated whose summary is tabulated below:

Scenario III - When NEP 01 capacity doubles and all the demands are subsumed by N & E markets

As Is Condition		**Optimised Condition**	
Total Dispatched Tonnage	43,013	Total Dispatched Tonnage	43,013
As Is Ton-Miles	3,43,42,354	**Optimum Ton-Miles**	2,26,35,547
As Is transportation bill @ 3.10 F.I. (cent/ton/miles)	10,65,202	**Optimum transportation bill @ 3.10 F.I. (cent/ton/miles)**	7,02,090
As Is Average Radial Distance (in Miles)	798	Optimum Average Radial Distance (in Miles)	526

Inference: Summary of the transportation bills in all 3 scenarios are tabulated below:

	Transportation Bill	
	As Is Condition	**Optimised Condition**
Scenario I	10,34,229	7,15,495
Scenario II (S&W)	10,23,150	7,25,874
Scenario III (N&E)	10,65,202	7,02,090

- From the above table, we can see that Scenario III in the optimised condition has lowest freight bill. Thus, company would be most benefitted if demand rises specifically in North and East regions to consume entire additional production from NEP01 manufacturing location.

In this context, it is interesting to note that Scenario III had highest freight bill in As-Is Condition. This might be due to the fact that North and East regions are farther away from the manufacturing location NEP01.

However, after optimiser is run, a redistribution takes place to optimise the freight as a result of which, Scenario III gets the lowest freight bill. Thus, our study helped bust a 'myth' in minds of business team.

- Our second observation is that the difference between highest freight bill and lowest freight bill in As-Is Condition is USD 42,052. This reduces to USD 23,784 in optimised condition. Thus, no matter which demand scenario emerges in future, difference in freight bills would not be significant.

  Besides, since Scenario I is the most likely scenario, the intensity of risk of higher freight bill is only USD 13,405. So, management can safely opt for increasing the capacity utilisation in NEP01 manufacturing location.

- **Optimisation of Contribution Margin**

While optimising the freight network, it was realized that the company is realizing different margin for different products in different markets. Therefore, an optimisation analysis to maximize the overall margin of the company from the market was also carried out.

To carry out this analysis, the data were organised in the following format:

Contribution Margin = Realised Selling price – Variable cost of product in the market.

Margin Matrix: This matrix contains the margin on different products in different markets (Table 10).

Tonnage Matrix: This matrix contains the total dispatched quantities in tons from each manufacturing location to respective sales hub during a month (on average) (Table 11).

After arranging data in such format, we optimised the dispatch pattern from each manufacturing location to all sales hub by using Network optimisation technique. While optimising the dispatch pattern following assumptions were made:

I. Total production capacity of a manufacturing location for a product was considered constant.
II. Total demand of each sales hub was considered constant.

Although, this analysis had been carried out for all the manufacturing locations, but for the sake of simplicity, we are producing data of the manufacturing location with highest potential. Product wise details of all manufacturing locations would have been too cumbersome to be included in this note.

In this case study, we found that margin was not only dependent on freight, but it is a factor of following parameters, among others:

I. Freight: Lower the freight from the manufacturing location, lower the landed cost of product and hence higher margin
II. Competition: Less presence of competitors in a market, higher the margin, since supply creates pressure on price
III. Local taxes: Higher the local taxes, lower the margin
IV. Relative cost of manufacturing at different manufacturing location: If two manufacturing locations serve the same market, one with lower cost of manufacturing would fetch better margin

Considering all these factors, the analytical tool called 'Solver', calculates optimal scenario showing which manufacturing location should serve which market to maximise the margin.

The optimised margin matrix is shown in Table 12.

Table 10
Margin Matrix (For Margin Optimisation study)

Margin Matrix in USD per ton							
Sales Hubs	Products						
	BM66	BM99	BM43	BM16	PG66	AW34	AW36
01LED	179	122	90	310	59	51	77
02CUL	169	87	78	296	55	55	74
03AHG	169	86	89	292	50	51	71
04AHC	126	74	42	218	50	45	50
05MOB	58	82	69	312	41	34	41
06NUP	54	40	31	44	51	41	52
07AOG	67	130	38	297	55	17	66
08GAN	37	16	49	97	45	41	61
09LOK	167	129	92	303	49	33	30
10DYH	80	77	106	238	62	70	84
11ZIV	75	108	99	318	66	67	91
12WUG	153	86	59	289	39	41	57
13JIV	74	61	106	327	59	57	79
14UHB	152	45	50	208	51	49	70
15DNI	195	58	37	230	75	35	37
16IAJ	151	90	96	299	47	40	20
17MHA	214	106	70	287	55	25	44
18NRE	55	69	62	264	45	34	58
19LAC	94	71	62	229	61	47	53
20VRT	69	50	63	217	54	43	54
21DAM	34	87	57	287	51	33	64
22IOC	76	78	46	295	67	38	71
23EHC	107	81	62	230	61	45	58
24BUH	62	122	111	319	61	39	33
25NAB	99	103	103	321	66	51	68
26IRT	43	101	18	295	69	34	52

Table 11
As – Is Scenario (For Margin Optimisation study)

Tonnage Matrix showing As is Dispatch in ton								
Sales Hub	Products							Total
	BM66	BM99	BM43	BM16	PG66	AW34	AW36	
01LED	114	31	-	-	22	69	20	257
02CUL	47	11	-	-	107	-	20	185
03AHG	3	-	-	-	17	-	-	20
04AHC	90	3	2	2	33	27	117	274

05MOB	1,530	274	8	29	763	174	750	3529
06NUP	1,523	115	5	8	899	299	287	3135
07AOG	540	48	2	6	130	65	151	942
08GAN	18	-	-	-	9	14	12	52
09LOK	127	34	1	-	206	25	112	504
10DYH	212	45	2	4	16	140	179	597
11ZIV	21	3	0	2	24	36	52	138
12WUG	36	-	-	-	19	6	-	61
13JIV	82	-	-	-	-	-	-	82
14UHB	19	-	-	-	43	-	-	63
15DNI	23	13	0	27	57	9	109	238
16IAJ	14	1	7	-	3	31	61	117
17MHA	61	37	8	7	9	36	43	201
18NRE	532	62	7	0	134	60	50	846
19LAC	249	4	1	0	37	32	3	326
20VRT	194	-	-	-	150	-	-	344
21DAM	464	43	10	10	120	41	192	880
22IOC	281	2	7	-	5	4	8	307
23EHC	611	369	18	11	275	14	137	1435
24BUH	212	2	-	4	5	7	36	265
25NAB	349	13	4	2	72	75	143	657
26IRT	178	1	-	0	49	19	21	268
TOTAL	**7530**	**1112**	**82**	**112**	**3202**	**1181**	**2502**	

Table 12
Optimised Scenario (For Margin Optimisation study)

Tonnage Matrix showing Optimised Dispatch in ton								
Sales Hub	Products							**Total**
	BM66	**BM99**	**BM43**	**BM16**	**PG66**	**AW34**	**AW36**	
01LED	257	-	-	-	-	-	-	257
02CUL	185	-	-	-	-	-	-	185
03AHG	20	-	-	-	-	-	-	20
04AHC	274	-	-	-	-	-	-	274
05MOB	2,848	-	-	112	-	569	-	3529
06NUP	-	-	-	-	2,921	214	-	3135
07AOG	-	942	-	-	-	-	-	942
08GAN	-	-	-	-	-	-	52	52
09LOK	504	-	-	-	-	-	-	504
10DYH	-	-	-	-	-	398	198	597
11ZIV	-	-	-	-	-	-	138	138
12WUG	61	-	-	-	-	-	-	61
13JIV	-	-	-	-	-	-	82	82
14UHB	63	-	-	-	-	-	-	63
15DNI	238	-	-	-	-	-	-	238
16IAJ	117	-	-	-	-	-	-	117
17MHA	201	-	-	-	-	-	-	201
18NRE	-	-	-	-	-	-	846	846
19LAC	326	-	-	-	-	-	-	326
20VRT	344	-	-	-	-	-	-	344
21DAM	-	-	-	-	-	-	880	880
22IOC	-	-	-	-	-	-	307	307
23EHC	1,435	-	-	-	-	-	-	1435
24BUH	-	169	82	-	13	-	-	265
25NAB	657	-	-	-	-	-	-	657
26IRT	-	-	-	-	268	-	-	268
TOTAL	**7530**	**1112**	**82**	**112**	**3202**	**1181**	**2502**	

Since, total demand from a sales hub from a manufacturing location was kept constant, the freight bill did not change much. In fact, in this study, the freight bill came down by almost USD 5000 per month because in ton-miles terms there was a saving.

The result of the Margin Optimisation study is summarised as below:

Products:	**BM66**	**BM99**	**BM43**	**BM16**	**PG66**	**AW34**	**AW36**
Weighted average contribution, per ton, for as is dispatch pattern (USD)	72	82	65	257	51	43	52
Weighted average contribution, per ton, for optimised dispatch pattern (USD)	101	129	111	312	53	47	67

Total contribution for as is dispatch pattern:	**1,015,891**
Total contribution for optimised dispatch pattern:	**1,341,957**
Increase in contribution per month in USD	**326,066**

3. CONCLUSIONS

We are fully conscious of the fact that the result of this analytics shows an ideal final result (IFR). However, in practice, the company might face some constraints while practically implementing the entire recommendation.

Therefore, a series of brainstorming sessions between interfacing departments were held leading to a number of action items which finally resulted in considerable cost saving and margin improvement for the company. The major changes brought about were related to following aspects:

- Change of product mix of various manufacturing locations.
- Change of product mix in various markets.
- Construction of a new manufacturing location in a geographical region which had high demand and had locally available raw material but no manufacturing location.
- A number of recipe optimisation study were also carried out to reduce the inbound transportation cost.
- Overall value turn around achieved in the company in one year on account of various cost optimisation initiatives was more in the range of 10 million USD.

REFERENCES

[1] Pragnya Parimita Mishra, Kunal Sharma, "Inventory and Logistics Cost Optimization in Automobile Industry", *International Journal of Engineering Research and Applications (IJERA)*, ISSN: 2248-9622, Vol. 3, Issue 4, Jul-Aug 2013, pp.1632-1635.

[2] Craig, Don. "What is Supply Chain Network Optimization?" TransportationInsight (blog), June 10, 2014, // www.transportationinsight.com/blog/networks/2014/06/supply-chain-network-optimization/.

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