XRetailer Supply Chain Network Design

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Executive Summary

Different factors determine the success of a supply chain network and influence its network design decisions. Location and distance, current and future demand, service requirements, mode of transportation, size and frequency of shipment and operational costs are among the most important ones. Since organizations are increasingly looking to find optimal solutions to minimize total costs and maximize overall profit, they rely on supply chain network design to improve their current network design status by performing model's optimization. Optimizing a supply chain network means researching mathematical/statistical techniques and models to identify the optimal distribution footprint as well as to meet long-term strategic objective of the organization.

This is what the Board of Directors of XRetailer's, a major retailer in the United States that market a variety of products through online and brick-and-mortar stores, is looking to achieve. Specifically, XRetailer is aiming to perform a supply chain network design analysis in an attempt to determine the optimal number and location of their Distribution Centers (DC) in order to meet the demand of each customer for each SKU. The company currently satisfies the demands of 181 customers located in the United State territory through their 7 Distribution Centers (NY, HS, LA, OG, SL, OL, DT). Each Distribution Center fulfil the need for products of the closest customer and holds distinct capacity levels as well as different fixed, variable and transportation costs. The purpose of our analysis is to assist XRetailer in identifying the optimal number and location of sources to satisfy customers' demands by providing multiple possible solutions.

The analysis is structured in 3 phases. The first phase called "Phase 1" focuses on understanding the data and calculating through different formulas the various costs associated with each of the distribution center. The second phase or "Phase 2" addresses the need to understand the baseline model (as-is), that the company is currently using, to calculate the total cost of network and throughput of each facility, and to identify pros and cons of this baseline configuration. “Phase 3” provides two what-if scenarios and different questions to which we answer by doing additional calculations and by suggesting possible recommendations.

Scope and Limitation of the Analysis

This analysis aims to identify the optimal number and location for 6 DC’s to satisfy the demand of each customer for each product. The limitation of this analysis is that XRetailer’s network analysis can focus only on the outbound flow from Distribution Center (DC) to customer.

Explanation of Methodology

To find the optimal number and location for XRetailer we had to analyze the data given using the outbound flow from each distribution center (DC) to the customer. The dataset presented information on each customer and distribution center locations, the fixed and variable cost for each of the seven distribution centers, DC capacity, product SKU weight, cubic, and price, and overall for each product per customer and the quantity purchased. We started by looking over the datasets presented, and we quickly found out that some of the files are very big and working on the analysis in just excel was going to be a challenge so we used python to help with the heavy analysis like the aggregation portion of this project.

Phase 1 – Current Baseline Model

In order to understand the current network cost, we first used a baseline model to demonstrate the network cost based on today's operations and rules. To find the total network cost, we had to first calculate the average_unite_cost for each customer, product and DC to find the minimal transportation cost.

As we know the average_unite_cost formula is $\sqrt{}(lati-latj)2+(longi-longj)2/Kp$, so we ran a minimum formula on the transportation cost for each row and found where each customer belongs based on the DC locations. Once we found that, we started grouping the customers to their locations, added the transportation cost for each DC based on the assigned customer, found the throughput for each location, capacity, fixed and variable cost. We also added the total variable cost by multiplying the cost per unite * throughput. The total cost of network was then calculated by adding the total transportation cost + total fixed cost + total variable cost.

Phase 2 - Scenario 1

The first scenario introduces capacity limitation for each DC to be factored into the final decision. The percentage of demand for each DC was calculed using the demand/throughput and capacity for each DC. After finding the difference for each DC, we find that DC_LA and

DC_OG are in the negative which means their demand is way more than the location capacity limits.

As part of the scenario, we are asked to come up with a solution for the shortage on the two DC's identified. We first decided to double the capacity for the two DC's. By doing so, we not only increased the capacity limitation, but we also increased the fixed and variable costs which overall increased our network cost. Our new network cost was increased by 34% from the original network cost.

Based on the first solution we explored another option which was capacity reshuffling to the second nearest DC. We investigated the data and found that DC_OG can reshuffle its excess demand to DC_HS and DC_LA can reshuffle its excess to DC_OL. The distribution between DC_OG and DC_HS worked perfectly, but DC_LA couldn't transfer all its excess to DC_OL because it would exceed the capacity limit. We decided to filter DC_LA demand by products quantity that are more than 500 and drop the remaining products. After the reshuffling between DC's we ended up saving 13% of the total network cost compared to the original network cost.

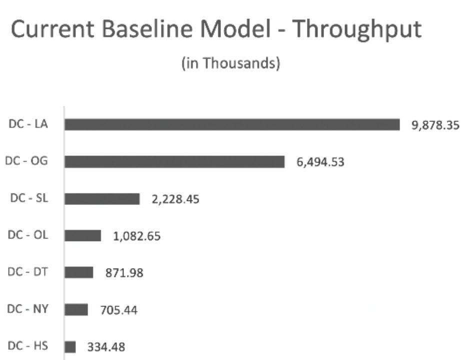
We decided to do one more analysis and compare the network costs to make sure we are using the most optimal solution for our company. Our third approach was reshuffling the capacity and dropping one of the DC's. We used the same model from our second analysis and moved DC_LA excess to DC_OL and DC_OG to DC_HC and dropped DC_DT by moving all its demand to the second closest DC which was DC_SL. We ran our numbers one last time and found out we saved 28% on our new network cost compared to the original.

Phase 3 - Scenario 2

Our last second scenario asked to work on a new baseline network cost based on the new average_unit_cost formula which included the weight and volume of the products. The new formula is $New\_Average\_unit\_cost_{i,j,p} = \frac{\sqrt{(Weight_p) \times (Volume_p)} \times \sqrt{(lat_i - lat_j)^2 + (long_i - long_j)^2}}{20000 + 10 * Gr\_Num}$. We first calculated the new network cost and found it was cheaper than the original network cost from phase 1. We then decided to aggregate the data into two section, calculate the new network cost and compare the results with the current network cost from phase 3. We first grouped the SKU into 120 groups by multiplying the weight * volume, grouping by product quantity range and then take the average for weight*volume and use for each group. We used Python in this analysis because it was faster to create the different bins, group the products and calculate the new network cost based on the minimum average_unti_cost for the location. The new aggregated network cost was higher than the network cost without aggregation by 0.91 %. The second aggregation was grouping SKUs into 12 and the network cost higher by of 1.35% from network cost without aggregation.

Results

Total Throughput -

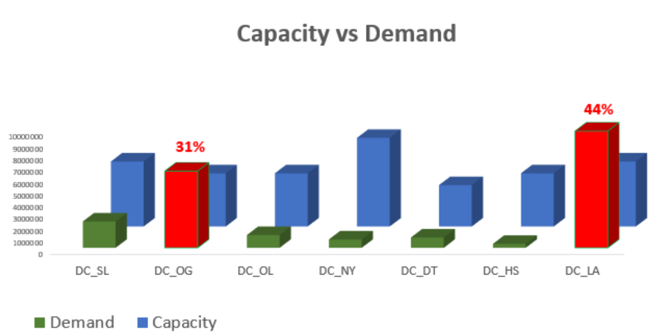


Original Total Network Cost -

Total Network Cost	122.6 M

Unfulfilled Demand –

DC's Capacity Restriction _ Un-Fulfilled Demand



New Baseline Network Cost -

Total Cost of Network	$	122,600,422
New Total Cost of Network	$	164,404,928
Increased Total Cost of Network	$	41,804,506

Reshuffling Demand –

	DC_NY	DC_HS	DC_LA	DC_OG	DC_SL	DC_OL	DC_DT
DC_NY	0	1419.069	2448.517	984.3115	1143.475	2262.269	1156.231
DC_HS	1419.069	0	1370.748	644.1505	755.112	1202.684	398.7156
DC_LA	2448.517	1370.748	0	1990.633	1308.672	187.2613	1364.835
DC_OG	984.3115	644.1505	1990.633	0	1001.293	1813.598	695.0329
DC_SL	1143.475	755.112	1308.672	1001.293	0	1123.954	372.471
DC_OL	2262.269	1202.684	187.2613	1813.598	1123.954	0	1179.351
DC_DT	1156.231	398.7156	1364.835	695.0329	372.471	1179.351	0

New Baseline Network Cost –

Original Baseline Network Cost	$122,600,422
New Total Cost of Network	$102,406,011
Total Cost of Network Saved	$ 20,194,411
Demand Revenue Lost	$ (3,722,067)
Total Saved	$ 23,916,478

Dropping to 6 DC's –

	DC_NY	DC_HS	DC_LA	DC_OG	DC_SL	DC_OL	DC_DT
DC_NY	0	1419.069	2448.517	984.3115	1143.475	2262.269	1156.231
DC_HS	1419.069	0	1370.748	644.1505	755.112	1202.684	398.7156
DC_LA	2448.517	1370.748	0	1990.633	1308.672	187.2613	1364.835
DC_OG	984.3115	644.1505	1990.633	0	1001.293	1813.598	695.0329
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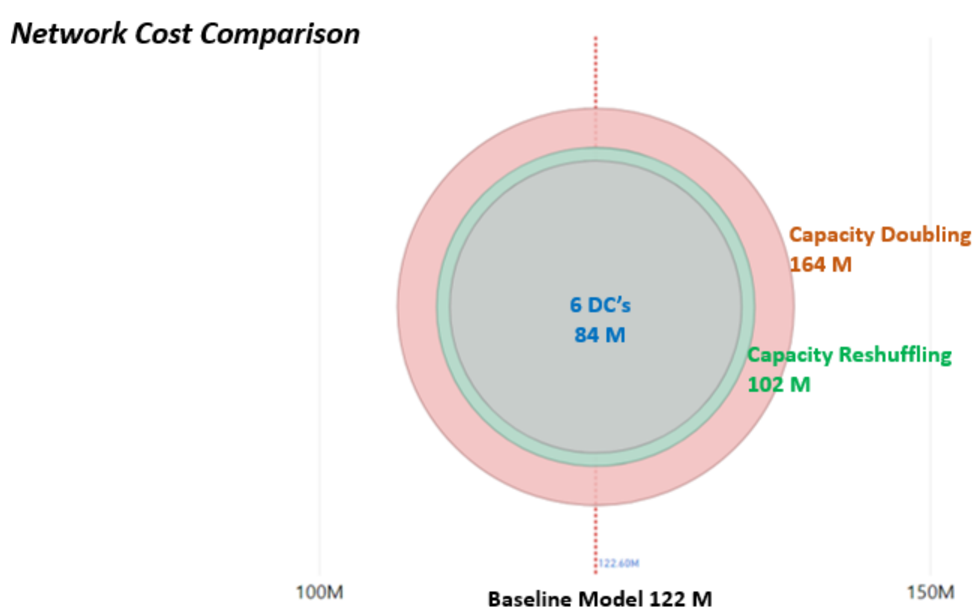
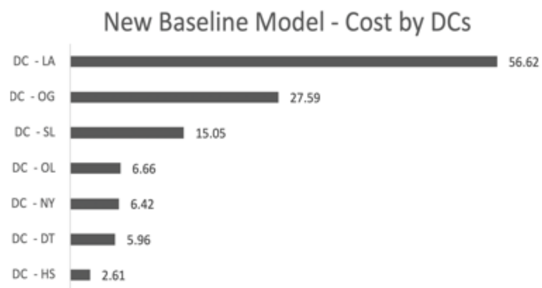
DC_OL	2262.269	1202.684	187.2613	1813.598	1123.954	0	1179.351
DC_DT	1156.231	398.7156	1364.835	695.0329	372.471	1179.351	0

New Baseline Network Cost –

Original Baseline Network Cost	$122,600,422
New Total Cost of Network	$ 84,033,134
Total Cost of Network Saved	$ 38,567,288
Demand Revenue Lost	$ (3,722,067)
Total Saved	$ 42,289,355



New Baseline Network Cost without grouping –



Total Network Cost	120.92 M

Groping SKUs into 120 and 12 -

(Group size – 120)

Qty Range	Equal Interval Bins Count
0 - 10	10
11 - 60	10
60 - 200	10
200 - 1000	50
1000 - 5000	25
5000 - 10000	10
10000+	5
Total	120

(Group size – 12)

Qty Range	Equal Interval Bins Count
0 - 1000	10
1000+	2
Total	12

Network Cost with 120 groups –

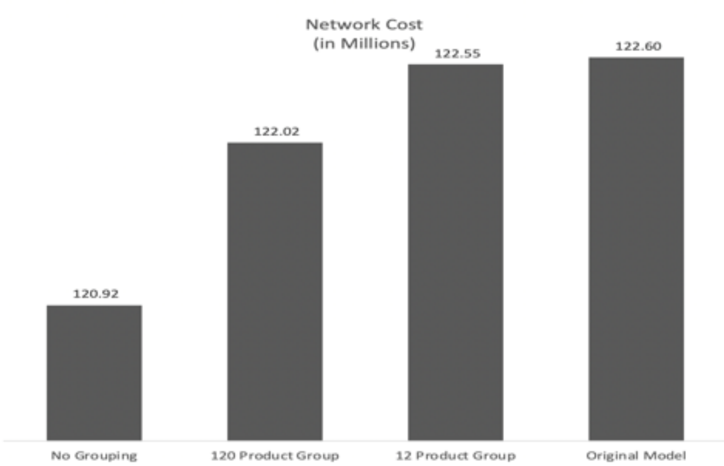
Total Network Cost	122.02 M

Network Cost with 12 groups –

Total Network Cost	122.55 M

Comparison of all Network Costs –

Original Baseline Model – vs - New Baseline Model - vs – New Baseline Model with grouped products



Grouping effect on network cost:

- + 0.91 % @ 120 groups
- + 1.35 % @ 12 groups

Recommendations:

- New Baseline Model
- 1.37% Network Cost Saving

Conclusion

A Baseline Model can have its limitations like using historical data, grouping the products/Inventory into a big segment instead of having the actual number of products/Inventory on hand, and new costs are not calculated. As a consultant we recommend using the Baseline model as a tool to help communicate and visualize the old network cost to the new network cost. You can also compare the costs from the historical data to the new data, build different scenarios to determine the best possible solution that can either be more beneficial or use the same network design as the Baseline model is presenting.

Aggregation indicate the practice of grouping together identical or similar data. In order to proceed with this practice, one must take into consideration the type of data that is being aggregated. For example, cost and price cannot be grouped together whereas orders, revenue and sales can. This is because, cost or price aggregation require using the average or weighted average. By aggregating the SKU into 120 groups, we were able to obtain a network cost slightly higher (+0.91 %) and, by grouping SKUs into 1, we obtained a higher network cost (+ 1.35%) compared to the non-aggregated network cost. For our dataset, we have seen that aggregation improves accuracy for items with low volume and that is not suited for optimization models