CASE STUDY ANALYSIS:

MANAGING INVENTORIES AT ALKO, INC.

Instructor

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1. CASE SYNOPSIS:

Alko began in 1943 in a garage workshop set up by John Williams in his Cleveland home and obtained a patent for one of his designs for lighting fixtures. Starting with initial marketing it in the Cleveland area, by 1957 Alko had grown to a $3 million company. Its lighting fixtures were well known for their outstanding quality. By then, it sold five products.

In 1963, John took the company public. Since then, Alko had been very successful, and the company had started distributing products nationwide. As competition intensified in the 1980s, the company's profitability, however, began to worsen as margins had begun to shrink. At this point, the board decided that a complete reorganization was needed, starting at the top. Gary Fisher was hired to reorganize and restructure the company.

When Gary arrived in 2009, he found a company teetering on the edge and spent his first few months trying to understand the company business and the way it was structured. Gary realized that the key was in the operating performance and decided to focuse on ignored its distribution system. Gary set up a task force to review the company's current distribution system and come up with recommendations.

2. PROBLEM STATEMENT:

i. What is the annual inventory and distribution cost of the current distribution system?
ii. What are the savings that would result from following the task force recommendation and setting up the NDC? Evaluate the savings as the correlation coefficient of demand in any pair of regions varies from 0 to 0.5 to 1.0. Do you recommend setting up an NDC?
iii. Discuss the assumptions you employ regarding the distribution of demands for the products, and their validity with respect to the analysis you apply.
iv. Suggest other options that Gary Fisher should consider. Evaluate each option and recommend a distribution system for Alko that would be most profitable. How dependent is your recommendation on the correlation coefficient of demand across different regions?

3. CASE ANALYSIS:

Current Distribution System:

- The Current Distribution Systems has 100 products in its 2009 line.
- All production occurred at three facilities located in the Cleveland area.
- For sales, the United States was divided into five regions each having company owned & operated DC.
- Orders transportation from plants to the DCs in truckload (TL) quantities whereas shipments from the DC to the customer were less-than-truckload (LTL) by a third-party trucking company for both transportation legs.
- TL costs from the plants to DCs averaged $0.09 per unit.
- LTL shipping costs from a DC to a customer averaged $0.10 per unit.
- Average five days were required between the time a DC placed an order with a plant and the time the order was delivered from the plant.
- Part were categorized as types High, Medium, and Low.
- The replenishment lead time was 5 days.
- The DCs ordered using a periodic review policy with a reorder interval of 6 days.
- The holding cost incurred was $0.15 per unit per day whether the unit was in transit or in storage.
- All DCs carried safety inventories to ensure a Cycle Service Level (CSL) of 95 %.

Alternative Distribution System:

- Construct a new national distribution center (NDC) outside Chicago.
- Alko should close its five DCs and move all the inventory to the NDC.
- Recover $50,000 for each warehouse that is closed.
- The CSL out of the NDC would continue to be 95 %.
- New inbound transportation cost from the plants to the NDC would fall to $0.05 per unit.
- The total replenishment lead time for orders from the Chicago NDC would be 5 days.
- As the average distance increases, the outbound transportation cost to customers from the NDC would increase to $0.24 per unit.

Other Possibilities:

- Build a national distribution center while keeping the regional DCs open.
- Stock some products would be at the regional DCs, whereas others would be stocked at the NDC.

4. PROPOSED SOLUTION:

Assumptions regarding the distribution of demands:

1. Demand in each region is normally distributed and is independent of demands in other regions. Also, demand at different DCs for the same item are independent.
2. Demand distribution does not change due to external factors
3. Lead time for every order is same and shipments are carried out without any stoppages.
4. Plants are capable of meeting any demands without stoppages.
5. Product demand variability does not have Bullwhip effect on the production factories and lead delivery time remains the same. The Bullwhip effect can cause information distortion, delays in procurement and delays in availability of goods to the consumer.
6. The coefficient of variation (CV) should be as low as possible.

A. Current Distribution System

The given data is distribution of daily demand at Alko. We have Lead Time of 5 days and Reorder Interval of 6 days. We calculate the Reorder Interval & Replenishment Lead Time Demand and Standard Deviation of every product in each region. Given T = 6 days and L = 5 days, we calculate demand in time (T+L) i.e. 11 days. Mean Demand will be μ(T+L) and Standard Deviation will be σ*sqrt(T+L). Calculations are shown in Table 4.

We first calculate the Annual Inventory and Distribution cost separately. The Total Annual Cost will be sum of Annual Inventory and Annual Distribution Cost:

(i) Annual Inventory Cost:

- Here we need to find Safety Stock and Cycle Inventory.
- Safety Stock = z*σ*sqrt(T+L).
- For 95% service level z = 1.645. So, Safety Stock (SS) = 1.645*σ*sqrt (11).
- Calculations of safety stock are shown in *Table 3*.
- As there is periodic review policy so Q = μT, the Annual Inventory cost will be (SS+Q/2) *0.15*365
- For Part 1 in all regions, Annual Inventory Cost will be {(SS+Q/2) *0.15*365} *10
- Detailed Annual Inventory Costs are shown in *Table 7.*

(ii) Annual Distribution Cost:

- Annual Distribution Cost can be calculated as $(Q*0.19*365/6)
- There will be 365/6 shipments in a year & total cost of transportation from plant to customer is $0.09 + $0.1 i.e. $0.19.
- So, for Part 1 in all regions, the total Annual Distribution Cost in respective region is $ (Q*0.19*365/6) *10

- Detailed Annual Inventory Costs are shown in *Table 9*.

(iii) Total Annual Cost (Annual Inventory Cost + Annual Distribution Cost) :

- The Total Annual Cost i.e. (Inventory cost + Distribution Cost) for current distribution system is **$ 960371.84**
- Total Annual Costs are shown in *Table 10.*

B. Alternate Distribution System (NDC):

Cost Analysis of NDC

Making an NDC means aggregating all the warehouses in the respective regions. So, the mean demand at the NDC will be $\mu = \mu_{1+}\ \mu_{2+}\ \mu_{3+}\ \mu_{4+}\ \mu_5$ and standard deviation will be $\sigma = \text{sqrt}(\sigma_i^2)$ where $i \in (1:5)$.

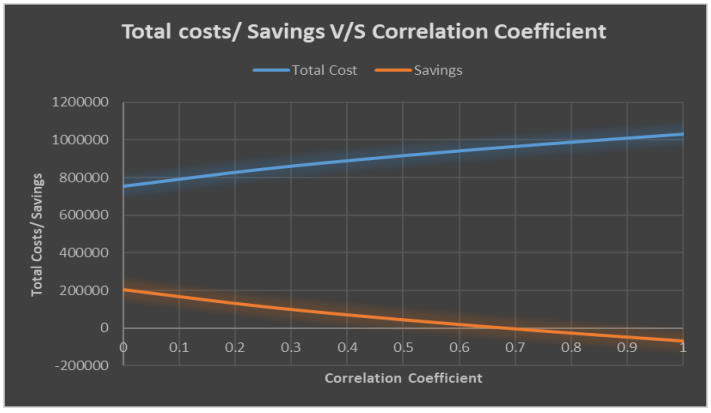
The Mean and Std. Deviation for demand at NDC is shown in the *Table 1* for Correlation Coefficient (ρ) = 0. In a similar way, Annual Inventory Costs, Annual Distribution Costs and Total of Annual Inventory and Distribution Costs are shown in *Table 7, Table 9* and *Table 10* respectively.

As shown, the **Total Cost (Annual Inventory + Annual Distribution Cost) for NDC is $ 755212.92**.

As a result, the **Savings** that would result from following the task force recommendation and setting up the NDC is **$ 205158.93**

The Total Annual Costs and Annual Savings, considering effects of different Correlation Coefficients for different pairs of warehouses, are shown in *Table 12*.

The relation between Total Annual Costs and Annual Savings w.r.t. different Correlation Coefficients is shown in the graph below.



Graph 1: Total Annual Costs/Savings vs Correlation

Corelation Factor	Total Costs	Savings
0	755212.92	205158.93
0.25	845561.21	114810.63
0.5	916233.60	44138.24
0.75	976289.70	-15917.86
1	1029433.49	-69061.65

Table: Total Annual Costs/Savings vs Correlation Coefficient

From the above graph, we observe that as Correlation Coefficient increases, Total Cost increases and the Saving decreases. Additionally, for Correlation Coefficient greater than 0.68, the savings will be negative, and hence no sense in setting up an NDC.

5. OTHER CONSIDERABLE OPTIONS:

Gary Fisher can consider the following options:

(i) Centralizing inventory of Part 3 and Part7 and decentralizing inventories of Part 1:

The corresponding Mean demands for different correlation coefficients for this option is shown in *Table 13*. Also, Safety stock and Cycle stock calculations for this option are shown in *Table 14* and Total Annual Inventory and Distribution Costs for different correlation coefficients are shown in *Table 15*. The maximum savings for this option is **$195282.77** which is less compared to savings of NDC. Also, we observe that as correlation coefficient increases, total costs increase and savings decrease.

(ii) Centralizing inventory of Part 7 and decentralizing inventories of Part 1 and Part 3:

The Total Annual Inventory and Distribution Costs for different correlation coefficients are shown in *Table 16*. The maximum savings for this option is **$ 131418.03** which is less compared to savings of NDC. Also, we observe that as correlation coefficient increases, total costs increase and savings decrease.

(iii) Centralizing inventory of Part 3 and Part 7 and serving demand for Part 1 in the Region 5 from Region 4; Closing Warehouse for Part 1 in Region 5:

The corresponding Mean demands for different correlation coefficients for this option is shown in *Table 17*.

Also, Safety Stock and Cycle Stock calculations for this option are shown in *Table 18* and Total Annual Inventory and Distribution Costs for different correlation coefficients are shown in Table 19. The maximum savings for this option is **$208676.62** which is more as compared to that of NDC. Also, we observe that as correlation coefficient increases, total costs increase and savings decrease. Hence, this is the best option that Alko should consider as this is most profitable.

Financial Analysis of different alternatives assuming 10% interest rate:

Options	Construction Cost for Centralizing in $	Salvage Amount in $	Investment in $	Savings in $	Payback period in years (10% interest rate)	Rate of Return in %
Decentralize all parts in Five warehouses	Base Case	0				
Centralize all parts at NDC	1300000.00	250000	1050000	205159	7.52	19.54
Centralize Part 3 & 7, decentralize part 1	650000.00	0	650000	195283	3.89	30.04
Centralize part 7, decentralize part 1 & 3	300000.00	0	300000	131418	2.71	43.81
Centralize part 3 & 7, decentralize part 1 and serve region 5 by region 4	650000.00	50000	600000	208677	3.53	34.78

6. CONCLUSION

- The savings from the centralization of the inventory is affected by the Coefficient of Variation as well as Correlation Coefficient.

- Products with low Correlation Coefficient & high Coefficient of Cariation generate more savings by centralizing. While products with high Correlation Coefficient and low Coefficient of Cariation lead to abatement in savings by centralization.

- Gary Fisher could also consider Option 3 instead of setting up an NDC, which results in more saving than the latter.

7. APPENDIX

Daily Demand						Aggregate demand for different Correlation				
Demand	Region 1	Region 2	Region 3	Region 4	Region 5	Agg (0)	Agg(0.5)	Agg(1)	Agg(0.25)	Agg(0.75)
Part 1 Mean	35.48	22.61	17.66	11.81	3.36	1000.12				
Part 1 Std Dev	6.98	6.48	5.26	3.48	4.49	12.27	20.77	26.69	17.06	23.92
Part 3 Mean	2.48	4.15	6.15	6.16	7.49	290.73				
Part 3 Std Dev	3.16	6.20	6.39	6.76	3.56	12.15	20.34	26.07	16.75	23.38
Part 7 Mean	0.48	0.73	0.80	1.94	2.54	71.39				
Part 7 Std Dev	1.98	1.42	2.39	3.76	3.98	6.45	10.60	13.53	8.77	12.15

Table 1: Daily demand and demand after aggregating

Reorder Quantity						Sum	Aggregate
Part 1	428.36	284.06	222.96	148.90	61.46	1145.74	1067.08
Part 3	44.52	79.48	102.51	104.64	101.81	432.96	357.02
Part 7	16.08	15.78	21.84	41.85	49.65	145.21	106.59

Table 2: Reorder Quantities

Safety Stock						Sum	Agg (0)	Agg(0.5)	Agg(1)	Agg(0.25)	Agg(0.75)
Part 1	38.08	35.35	28.70	18.99	24.50	145.62	66.96	113.33	145.62	93.08	130.48
Part 3	17.24	33.83	34.86	36.88	19.42	142.23	66.29	110.96	142.23	91.40	127.56
Part 7	10.80	7.75	13.04	20.51	21.71	73.82	35.20	57.83	73.82	47.87	66.31

Table 3: Safety Stock for DCs and NDC

Mean						Sum
Part 1	390.28	248.71	194.26	129.91	36.96	1000.12
Part 3	27.28	45.65	67.65	67.76	82.39	290.73
Part 7	5.28	8.03	8.8	21.34	27.94	71.39

Table 4: Mean Demand in Replenishment Lead Time and Reorder Interval

Cycle Inventory						Sum
Part 1	106.44	67.83	52.98	35.43	10.08	272.76
Part 3	7.44	12.45	18.45	18.48	22.47	79.29
Part 7	1.44	2.19	2.4	5.82	7.62	19.47

Table 5: Cycle Inventory for DCs

Coefficient of Variance	Region 1	Region 2	Region 3	Region 4	Region 5
Part 1	0.20	0.29	0.30	0.29	1.34
Part 3	1.27	1.49	1.04	1.10	0.48
Part 7	4.13	1.95	2.99	1.94	1.57

Table 6: Coefficient of Variance for different products in different Regions

Annual Inventory cost (for correlation coefficient =0)								
Product Category	No. of parts	Region 1	Region 2	Region 3	Region 4	Region 5	All regions	Agg (0)
Part 1	10	79125.70	56493.18	44718.57	29792.95	18930.77	229061.18	185999.21
Part 3	20	27025.12	50672.50	58377.59	60620.88	45872.64	242568.73	159410.09
Part 7	70	46919.68	38084.72	59171.79	100925.01	112423.61	357524.81	209524.83

Table 7: Annual Inventory Cost for DCs and NDC

Annual Inventory cost for different correlation coefficients				
Product Category	Agg(0.5)	Agg(1)	Agg(0.25)	Agg(0.75)
Part 1	211385.56	229061.18	200298.44	220772.17
Part 3	208325.27	242568.73	186902.17	226500.36
Part 7	296243.98	357524.81	258081.82	328738.39

Table 8: Annual Inventory Cost for Different correlation coefficients for NDC

Annual Distribution cost								
Product Category	No. of parts	Region 1	Region 2	Region 3	Region 4	Region 5	All regions	Aggregate
Part 1	10.00	24605.38	15680.04	12247.21	8190.24	2330.16	63053.02	96238.82
Part 3	20.00	3439.76	5756.05	8530.05	8543.92	10388.63	36658.41	55952.31
Part 7	70.00	2330.16	3543.79	3883.60	9417.73	12330.43	31505.71	48087.66

Table 9: Annual Distribution Cost for DCs and NDC

Annual Inventory and Distribution cost of DC's								
Product Category	No. of parts	Region 1	Region 2	Region 3	Region 4	Region 5	All Regions	Aggregate
Part 1	10	103731.08	72173.22	56965.78	37983.19	21260.93	292114.20	282238.03
Part 3	20	30464.88	56428.55	66907.64	69164.80	56261.27	279227.14	215362.40
Part 7	70	49249.84	41628.50	63055.39	110342.74	124754.04	389030.51	257612.49
All Parts		183445.80	170230.27	186928.82	217490.72	202276.24	960371.84	755212.92

Table 10: Annual Inventory and Distribution Cost for DCs and NDC

Corelation Factor	Total Costs	Savings
0	755212.92	205158.93
0.25	845561.21	114810.63
0.5	916233.60	44138.24
0.75	976289.70	-15917.86
1	1029433.49	-69061.65

Table 11: Total Costs and Savings of NDC for different correlation coefficient

Annual Inventory and Distribution cost of DC's										
Product Category	Aggregate	Savings	Aggregate(0.5)	Savings(0.5)	Aggregate(1)	Savings(1)	Aggregate(0.25)	Savings(0.25)	Aggregate(0.75)	Savings(0.75)
Part 1	282238.03	9876.16	307624.38	-15510.19	325300.00	-33185.80	296537.26	-4423.06	317010.99	-24896.79
Part 3	215362.40	63864.74	264277.58	14949.56	298521.04	-19293.90	242854.48	36372.66	282452.67	-3225.54
Part 7	257612.49	131418.03	344331.64	44698.87	405612.46	-16581.95	306169.47	82861.04	376826.04	12204.47
All Parts	755212.92	205158.93	916233.60	44138.24	1029433.49	-69061.65	845561.21	114810.63	976289.70	-15917.86

Table 12: Total Costs and Savings of NDC for different correlation coefficient and product type

Product Category	Region 1	Region 2	Region 3	Region 4	Region 5	Aggregate
Part 1	390.28	248.71	194.26	129.91	36.96	
Part 3						290.73
Part 7						71.39

Tables 13: Demand during Replenishment Lead Time and Reorder Interval for Option (i)

Product		Region 1	Region 2	Region 3	Region 4	Region 5	Agg(0)	Agg(0.25)	Agg(0.5)	Agg(0.75)	Agg(1)
Part 1	Cycle Stock	106.44	67.83	52.98	35.43	10.08					
	Safety Stock	38.08182	35.35389	28.69776	18.98635	24.49676					
Part 3	Cycle Stock						79.29	79.29	79.29	79.29	79.29
	Safety Stock						66.289987	91.39692	110.9614	127.5596	142.234
Part 7	Cycle Stock						19.47	19.47	19.47	19.47	19.47
	Safety Stock						35.200536	47.87033	57.82784	66.30649	73.81762

Table 14: Cycle Stock and Safety Stock for Option (i)

Annual Inventory and Distribution Cost										
Product	Region 1	Region 2	Region 3	Region 4	Region 5	Agg (0)	Agg(0.25)	Agg(0.5)	Agg(0.75)	Agg(1)
Part 1	103731.08	72173.22	56965.78	37983.19	21260.93					
Part 3						215362.40	242854.48	264277.58	282452.67	298521.04
Part 7						257612.49	306169.47	344331.64	376826.04	405612.46
			Total Cost			765089.08	841138.15	900723.41	951392.91	996247.69
			Cost for Current System			960371.84				
			Savings			195282.77	119233.69	59648.43	8978.93	-35875.85
			Savings after decentralizing all parts			205158.93				

Table 15: Annual Inventory and Distribution cost for Option (i)

Annual Inventory and Distribution Cost										
Product	Region 1	Region 2	Region 3	Region 4	Region 5	Agg (0)	Agg(0.25)	Agg(0.5)	Agg(0.75)	Agg(1)
Part 1	103731.08	72173.22	56965.78	37983.19	21260.93					
Part 3	30464.88	56428.55	66907.64	69164.80	56261.27					
Part 7						257612.49	306169.47	344331.64	376826.04	405612.46
			Total Cost			828953.82	877510.81	915672.97	948167.38	976953.79
			Cost for Current System			960371.84				
			Savings			131418.03	82861.04	44698.87	12204.47	-16581.95
			Savings after decentralizing all parts			205158.93				

Table 16: Annual Inventory and Distribution Cost for Option (ii)

Product	Region 1	Region 2	Region 3	Region 4	Region 5	Aggregate
Part 1	390.28	248.71	194.26	166.87		
Part 3						290.73
Part 7						71.39

Table 17: Demand during Replenishment Lead Time and Reorder Interval for Option (ii)

Product		Region 1	Region 2	Region 3	Region 4	Region 5	Agg(0)	Agg(0.25)	Agg(0.5)	Agg(0.75)	Agg(1)
Part 1	Cycle Stock	106.44	67.83	52.98	35.43						
	Safety Stock	38.08	35.35	28.70	30.99						
Part 3	Cycle Stock						79.29	79.29	79.29	79.29	79.29
	Safety Stock						66.29	91.40	110.96	127.56	142.23
Part 7	Cycle Stock						19.47	19.47	19.47	19.47	19.47
	Safety Stock						35.20	47.87	57.83	66.31	73.82

Table 18: Cycle Stock and Safety Stock for Option 3

Annual Inventory and Distribution Cost										
Product	Region 1	Region 2	Region 3	Region 4	Region 5	Agg (0)	Agg(0.25)	Agg(0.5)	Agg(0.75)	Agg(1)
Part 1	103731.08	72173.22	56965.78	45850.27						
Part 3						215362.40	242854.48	264277.58	282452.67	298521.04
Part 7						257612.49	306169.47	344331.64	376826.04	405612.46
			Total Cost			751695.22	827744.30	887329.56	937999.06	982853.84
			Cost for Current System			960371.84				
			Savings			208676.62	132627.55	73042.28	22372.79	-22482.00
			Savings after decentralizing all parts			205158.93				

Table 19: Annual Inventory and Distribution Cost for Option (iii)

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