INVENTORY MANAGEMENT ANALYSIS
WHOLESALE FOOD DISTRIBUTOR

OPRE 6304 – Spring 2021

Team 5

Agenda of Items

1. Overview
2. Data Exploration
3. Methodology
4. Findings
5. Recommendations
6. Limitations and Implementation Issues

I. OVERVIEW

GOAL

- Optimize safety stock
- Minimize inventory cost

SCOPE

- Tier 1 has high-priority SKUs
- Tier 2 has low-priority SKUs

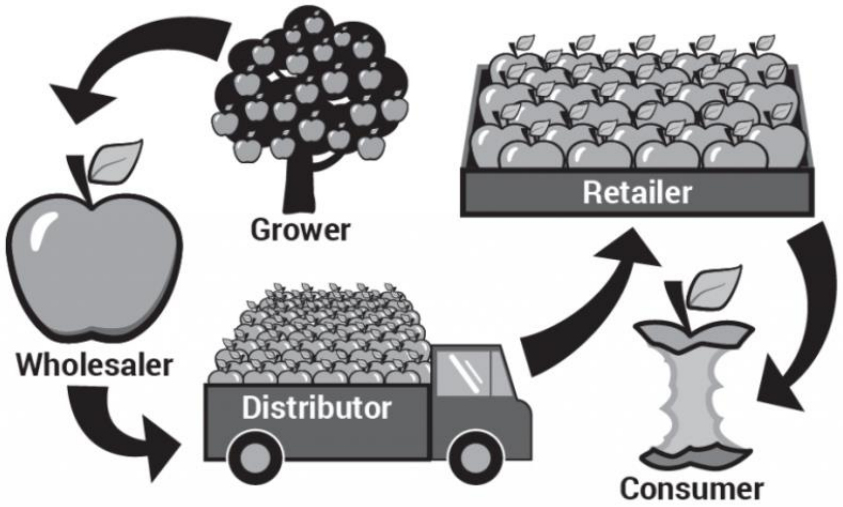
REQUIREMENT

- Maintain 99% service level

I. OVERVIEW

Industry Background – Wholesale Food Distribution

- **Break bulk** and be an intermediary between food producers and food operators
- **Warehouse** products and usually **transport** them to operators
- Distributor purchases, stores, sells, and delivers those products, providing food service operators with access to items from a wide variety of manufacturers.
- Food service distributors need to schedule, track, and manage inventory related to food storage and distribution. They also need to plan shipments, manage customers, and maintain well-documented records of food orders.



II. DATA EXPLORATION

Dataset Information:

- From a wholesale food distributor based out of Chicago area
- Include daily transactions from May - August 2019 with a total of over 45,800 records and 680 unique SKUs
- Have 3 information layers: Transaction, Sourcing and Product

II. DATA EXPLORATION

Transaction

- Delivery Date
- Sum of Quantity (Sales Quantity)
- SKU ID

Upd_DCName	deliverydate	SUMOfqty	SKU ID
DC A	5/5/2019	2	186
DC A	5/5/2019	19	161
DC A	5/5/2019	32	257
DC A	5/5/2019	48	499
DC A	5/5/2019	584	402
DC A	5/5/2019	5	730

Sourcing

- SKU ID
- Lead Time
- Minimum Order Quantity (MOQ)

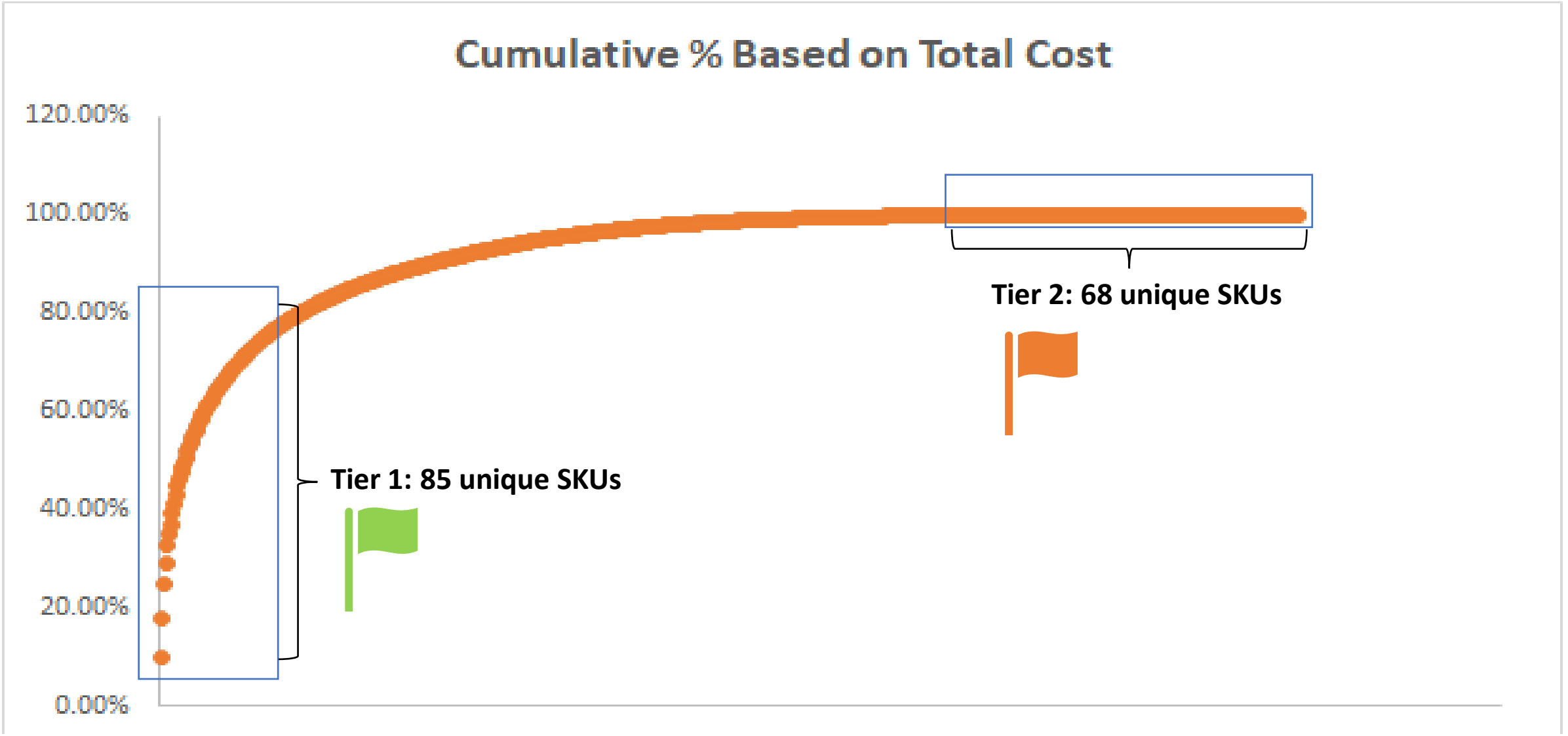
Status	Lead Time	MOQ	Production Policy	SKU ID
Include	9.25	528	Make	668
Include	7.25	180	Make	716
Include	9.25	42	Make	241
Include	9.25	21	Make	732
Include	7.25	400	Make	683
Include	9.25	18	Make	489

Product

- SKU ID
- Inventory Value
- Continuous Review Policy
- Carrying cost of 10% (Holding Cost)

Upd_DCName	InventoryValue	Review Period	Stocking Site	Status	Carrying Cost	SKU ID
DC A	6.42	Continuous	TRUE	Include	10%	100
DC A	21.49	Continuous	TRUE	Include	10%	101
DC A	24.43	Continuous	TRUE	Include	10%	102
DC A	39.45	Continuous	TRUE	Include	10%	103
DC A	11.86	Continuous	TRUE	Include	10%	104

II. DATA EXPLORATION



III. METHODOLOGY

➢ An iterative process that is applied across both product tiers

Given Info
At Product Level

- Daily sales quantity
- Lead time
- 99% service level
- 10% holding cost
- MOQ

Step 1:
- Graph distribution of sales quantity by product

- Use transformation if needed

- Gather descriptive statistics (mean, standard deviation) of daily sales quantity

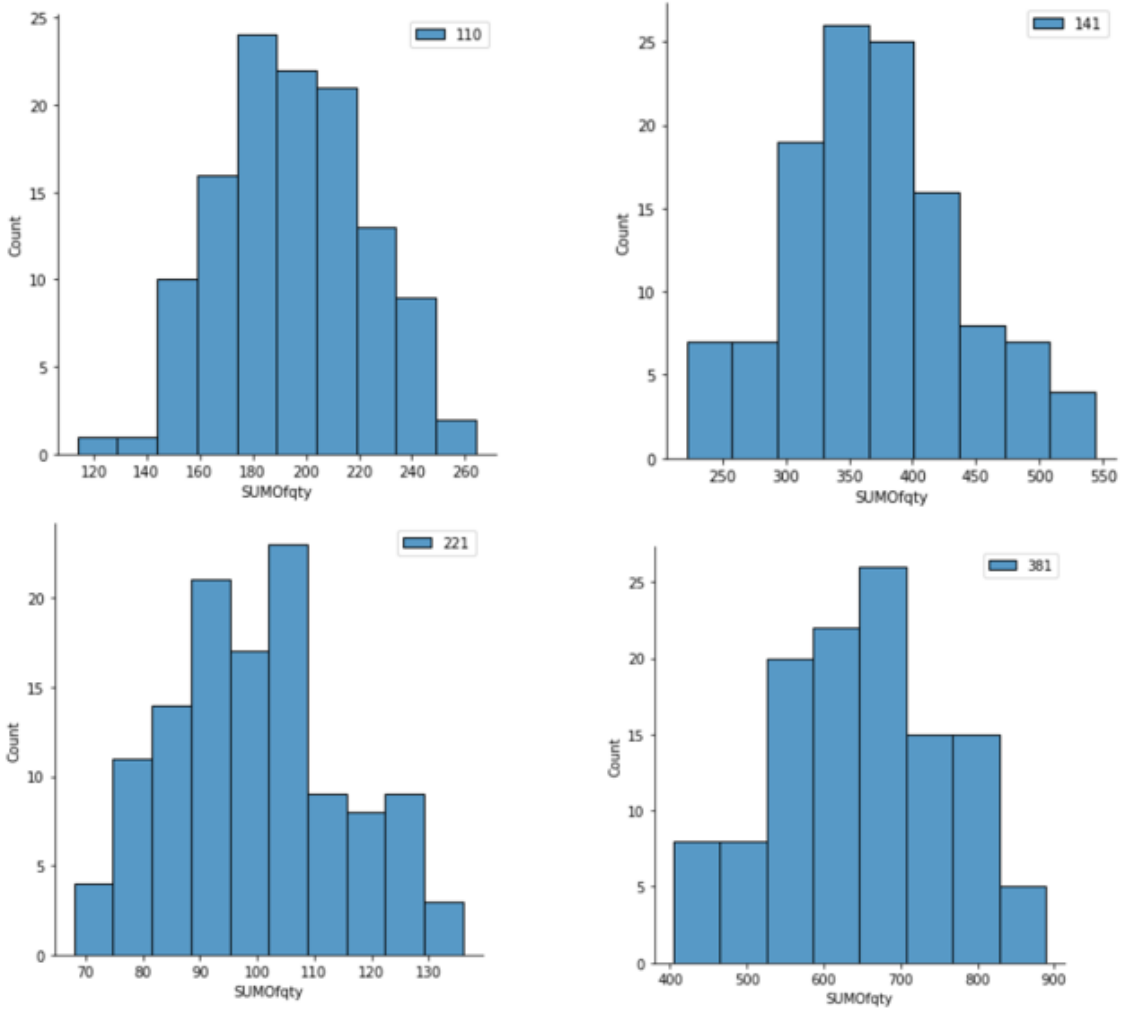
Step 2:
- Estimate unit fixed cost using clustering method & MOQ

Step 3:
- Perform calculations for:
  - ➢ Safety stock
  - ➢ On-hand inventory
  - ➢ Inventory Cost

- Compare the results between the proposed policies

III. METHODOLOGY

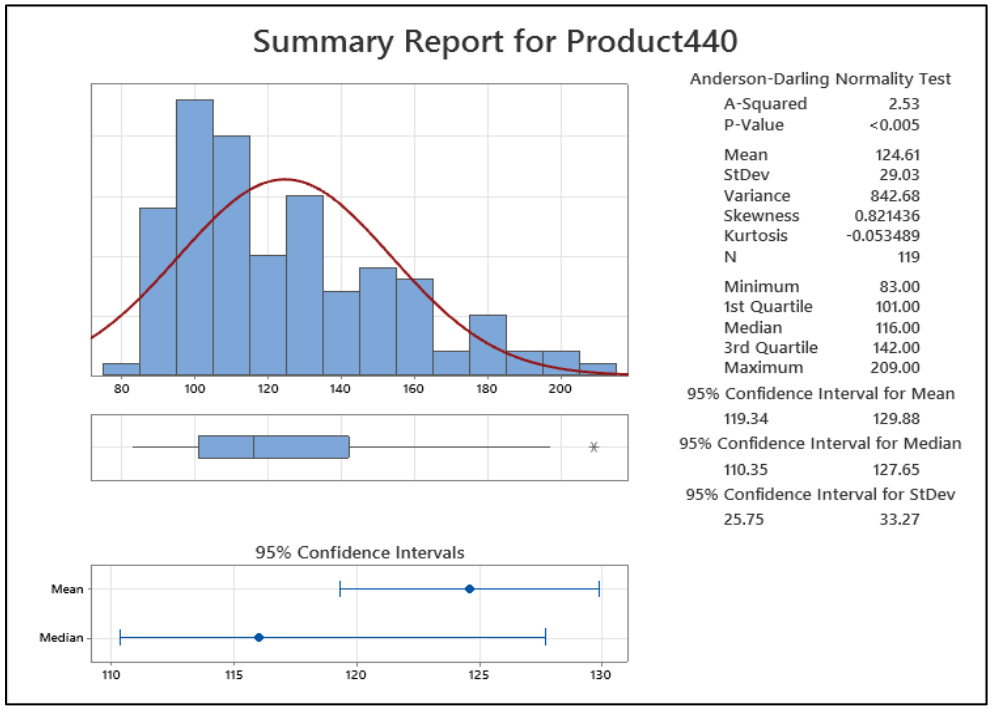
➢ <u>Step 1</u>: Graph distribution and gather descriptive statistics

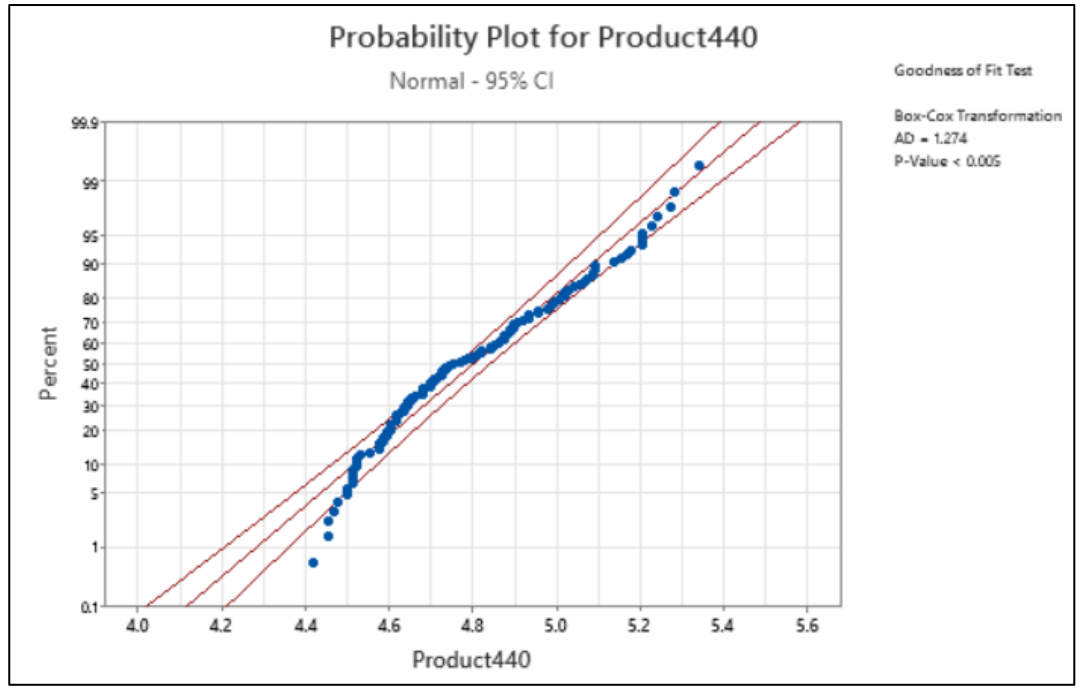


- Majority of our products have their sale quantities that *<u>follow normal distributions</u>*
- Calculative the average and standard deviation for each product's sales based on normal distribution

III. METHODOLOGY

➢ <u>Step 1</u>: Graph distribution and gather descriptive statistics





- Some of our products whose sale quantities <u>do not follow normal distributions</u>
- Use Box-Cox to transform the data to normal distribution
- Calculate the average and standard deviation of the transformed distribution

See Appendix – Slide #20, 21, 22 for more examples

III. METHODOLOGY

➢ Step 2: Estimate unit fixed cost

Rationale:
- Products with similar inventory value will have similar fixed cost

Clustering:
- Rank inventory value in ascending order
- Divide all records into 4 groups based on inventory value

Group Membership
- At member level, compute the average unit fixed cost, where:

$$\text{Unit Fixed } Cost = \frac{MOQ^2 * Unit\ Holding\ Cost}{2 * Daily\ Sales\ Quantity}$$

- Apply average unit fixed cost across all group members as followed:

Group	Imputed Fixed Cost
1	$ 47,160
2	$ 74,998
3	$ 81,197
4	$ 129,597

III. METHODOLOGY

➢ Step 3: Safety Stock and Inventory Calculations

❑ Continuous Review (R,Q) Policy

- $Demand_{LT} = Average\ Daily\ Demand * Lead\ Time$
- $Variance_{LT} = (Std.Deviation\ from\ Daily\ Demand)^2 * Lead\ Time$
- $Standard\ Deviation_{LT} = \sqrt{Variance_{LT}}$
- $Z_{score}\ of\ 99\%\ service\ level = 2.3264$
- $Unit\ Holding\ Cost = Inventory\ Value * 10\%$
- $Safety\ Stock = Z_{score} * Standard\ Deviation_{LT}$
- $Reorder\ Point\ (R) = Demand_{LT} + Safety\ Stock$
- $EOQ\ (Q) = \sqrt{2 * \frac{Demand_{Lt} * Unit\ Fixed\ Cost}{Unit\ Holidng\ Cost}}$
- Final Q = Max (EOQ and MOQ)
- On-hand Inventory = $\left(\frac{Final\ Q}{2}\right) + safesty\ stock$

❑ Periodic Review (T,S) Policy

- $Z_{score} of\ 99\%\ service\ level = 2.3264$
- $Safety\ stock = z_{score} * std.dev * \sqrt{(Lead\ Time + Reorder\ Period}$
- $Base\ Stock\ = Daily\ Demand * (Lead\ Tme + Reorder\ Period) + safety\ stock$
- On-hand Inventory = $\frac{Daily\ Demand * Reorder\ Period}{2} + safety\ stock$

IV. FINDINGS

Product Tier 1 with 85 SKUs

	Continuous Review - (R,Q) Policy	Period Review - (T,S) Policy
$ Total Inventory Cost	$5,361,874	$5,361,874
Avg. Inventory	199,745 cases	194,918 cases
Estimated T (Using Excel Goal Seek)	NA	12.38 days

- If it took the company less than 12.38 days to review inventory level, period review (T,S) policy would incur a lower inventory cost compared to continuous review (R,Q) policy

- Despite the cost saving, due to the nature of the tier 1 (high-priority products), it is recommended that the company continues using continuous review (R,Q) policy for this tier.

See Appendix – Slide #24 for Excel Goal Seek Analysis

IV. FINDINGS

Product Tier 2 with 68 SKUs

	Continuous Review - (R,Q) Policy	Period Review - (T,S) Policy
$ Total Inventory Cost	$ 4164.87	$4131.71
Avg. Inventory	243 cases	243 cases
Safety Stock	3 cases	10 cases
Estimated T (Using Excel Goal Seek)	NA	117 days

- If it took the company less than 117 days to review inventory level, period review (T,S) policy would incur a lower inventory cost compared to continuous review (R,Q) policy

- With similar average inventory and cost, it is recommended that the company continues using continuous review (R,Q) policy for this tier to maintain a low safety stock if T is greater than mentioned.

V. RECOMMENDATIONS

Products in Tier 1

- Keep applying continuous review - (R,Q) policy
- Avg. Inventory Cost = $5.3 million
- Avg. On-hand Inventory = 199,745 cases
- Safety stock is recommended for each SKU

Products in Tier 2

- Apply periodic review - (T,S) policy if it takes less than 117 days to review
- Avg. Inventory Cost = $4K
- Avg. On-hand Inventory = 243 cases
- Safety stock is recommended for each SKU

VI. LIMITATIONS/IMPLEMENTATION ISSUES

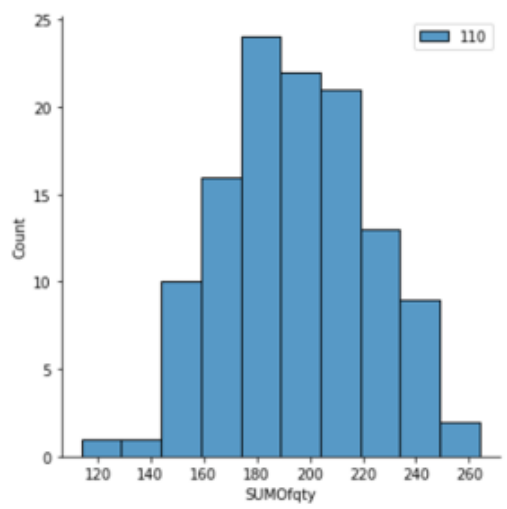
- Lack of information on nature of products and their categories could have impacted the final recommendations
- Sample size might not be representative of the entire inventory population
- Potential variances in the computed fixed costs could have skewed the results
- Organizational and logistic difficultly in implementing 2 policies based on the products

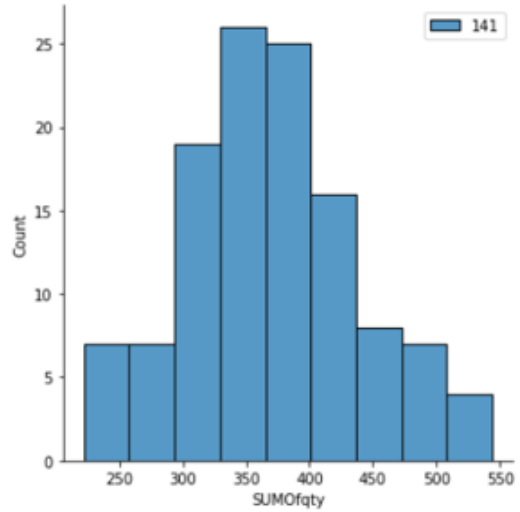
THANK YOU FOR LISTENING
ANY QUESTIONS?

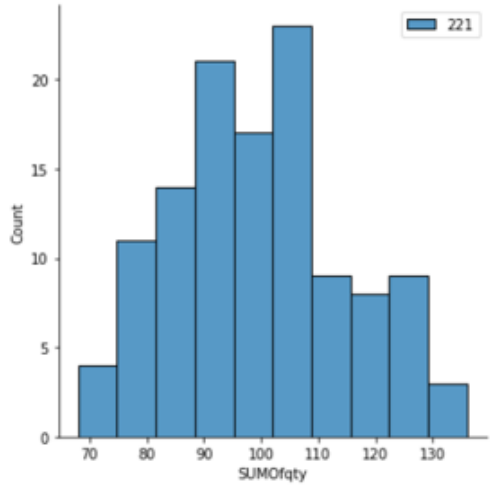
APPENDIX

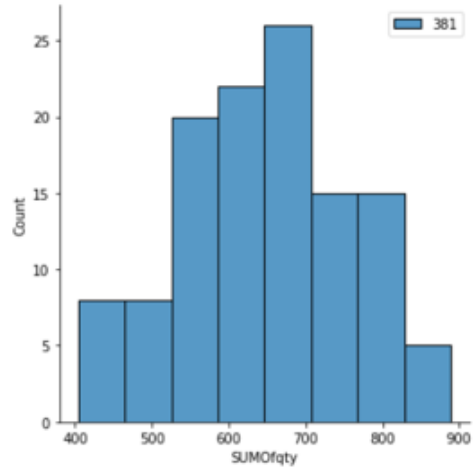
Graph Distribution of Daily Demand Across All SKUs

```
for product, data in df.groupby('product'):
    sns.displot(data = data, x= data['SUMOfqty'], ax=ax, label=product)
    plt.legend()
    plt.show()
```

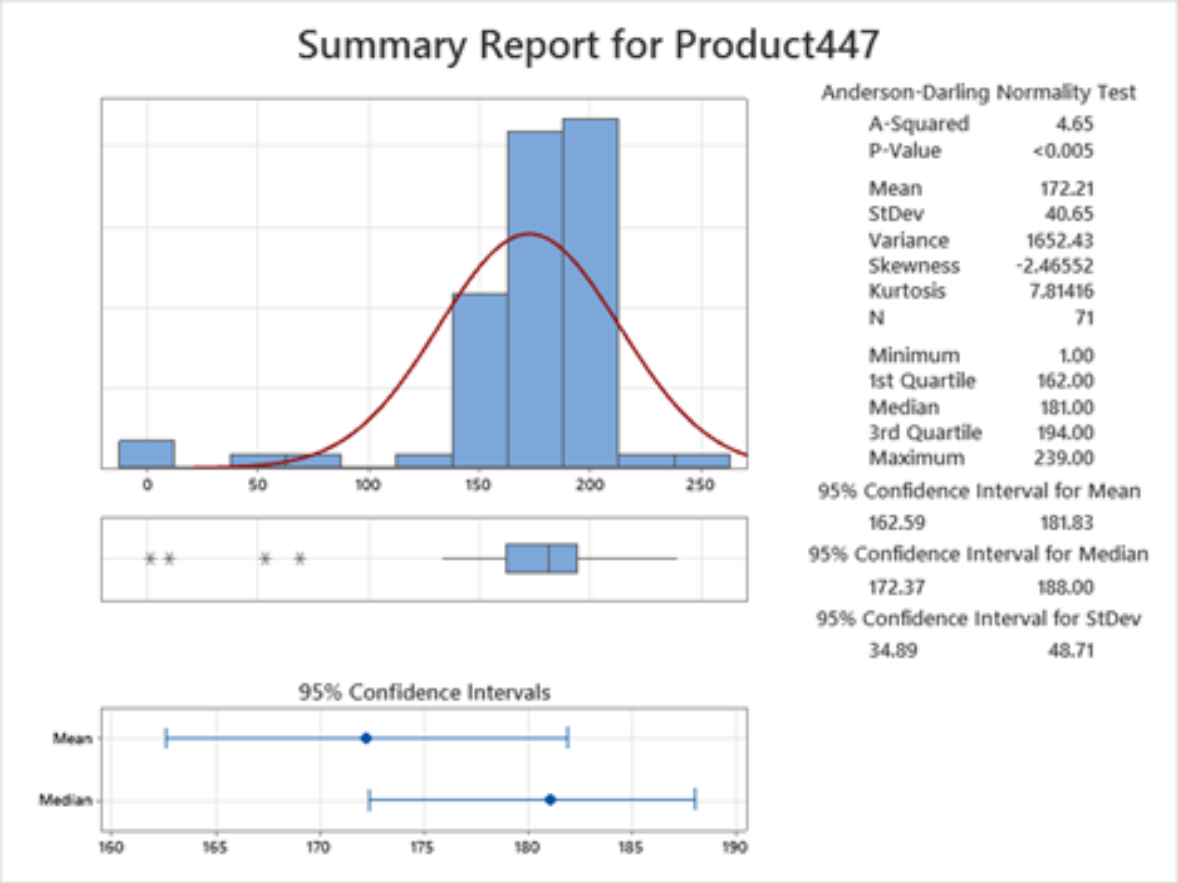


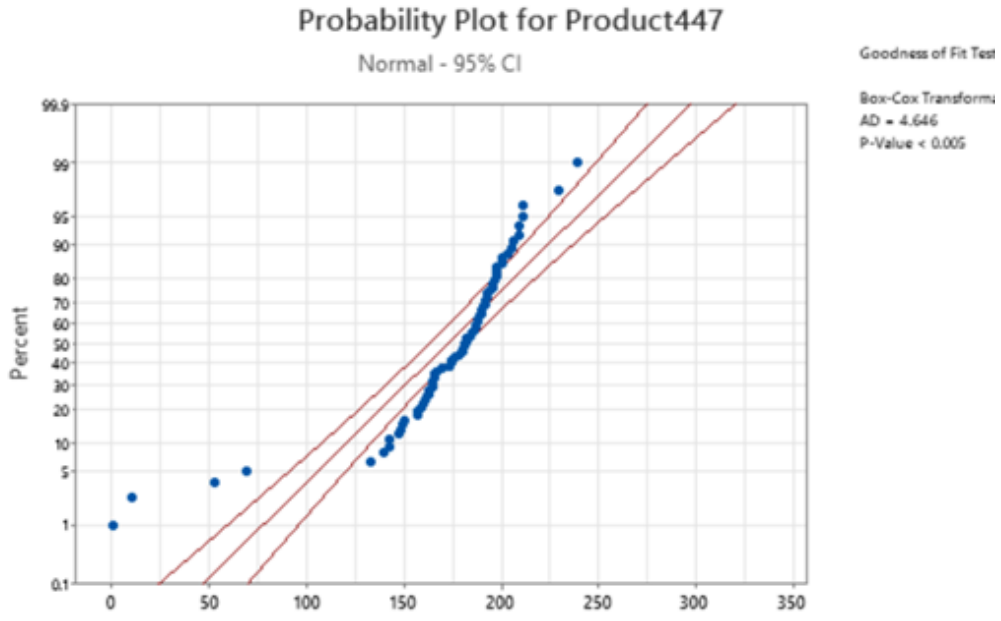


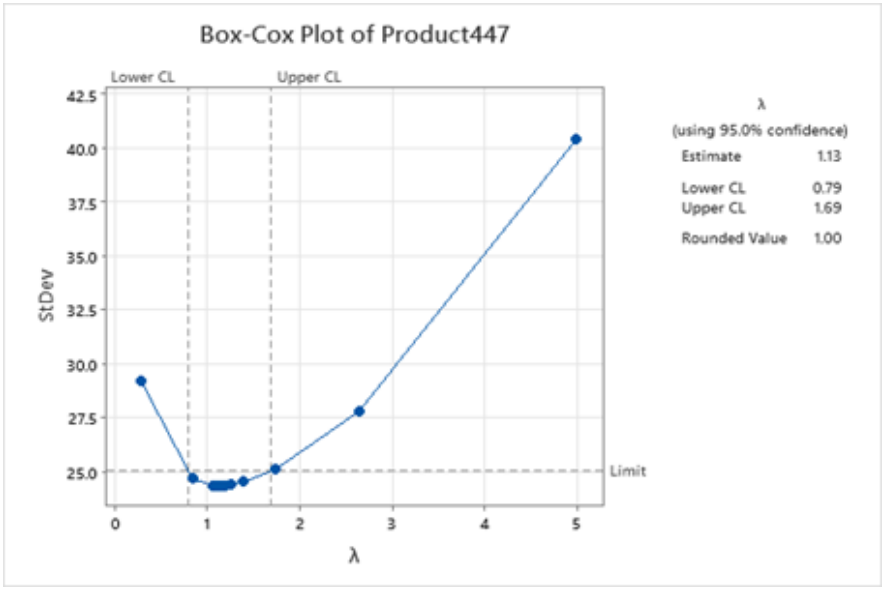




Example of Non-Normal Distribution of Daily Demand







Use Minitab to graph distribution and perform box-cox transofmration with the optimal lambda value.

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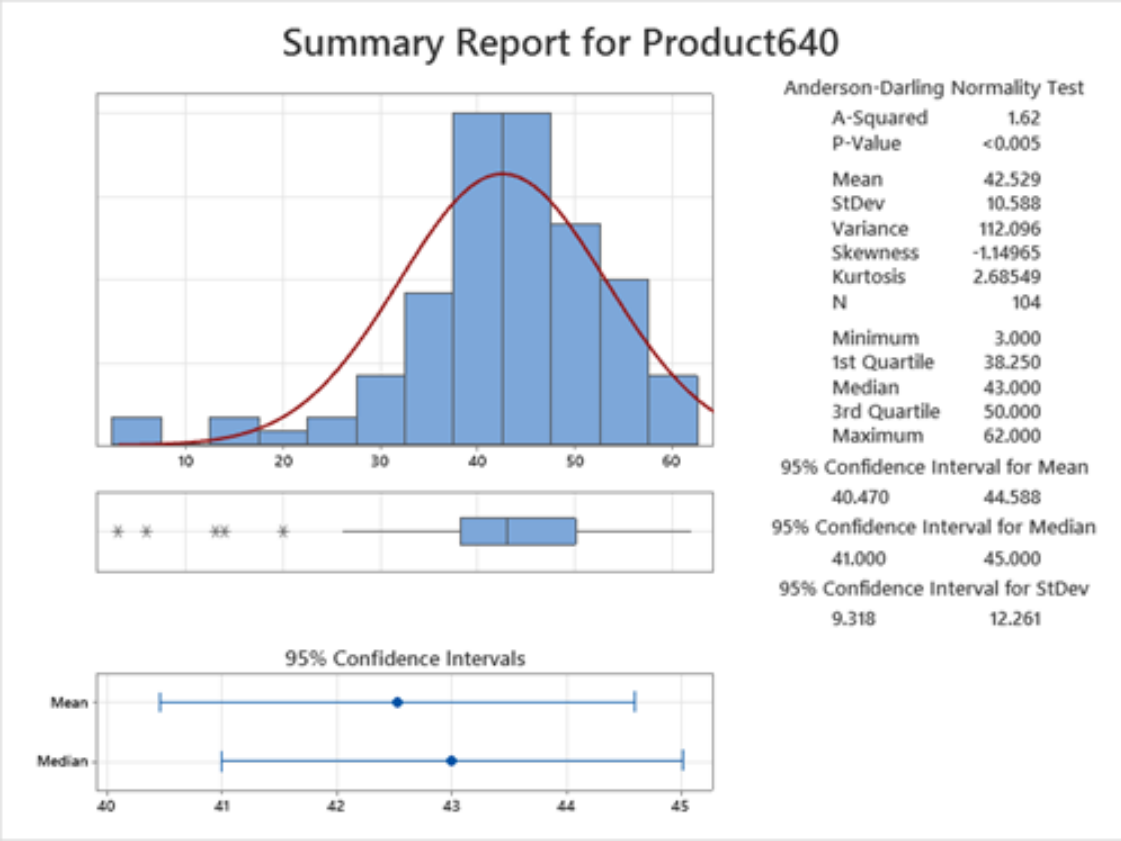

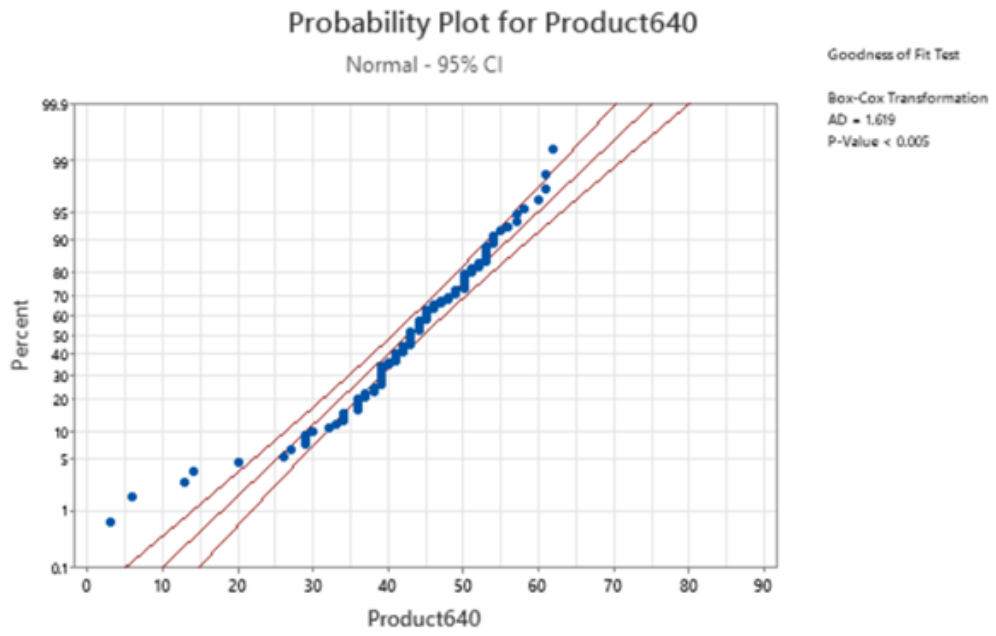

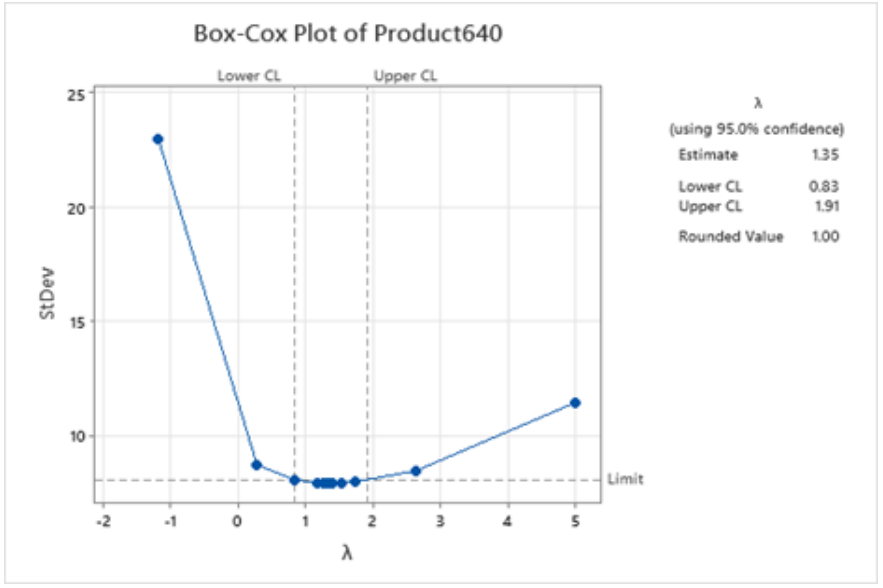

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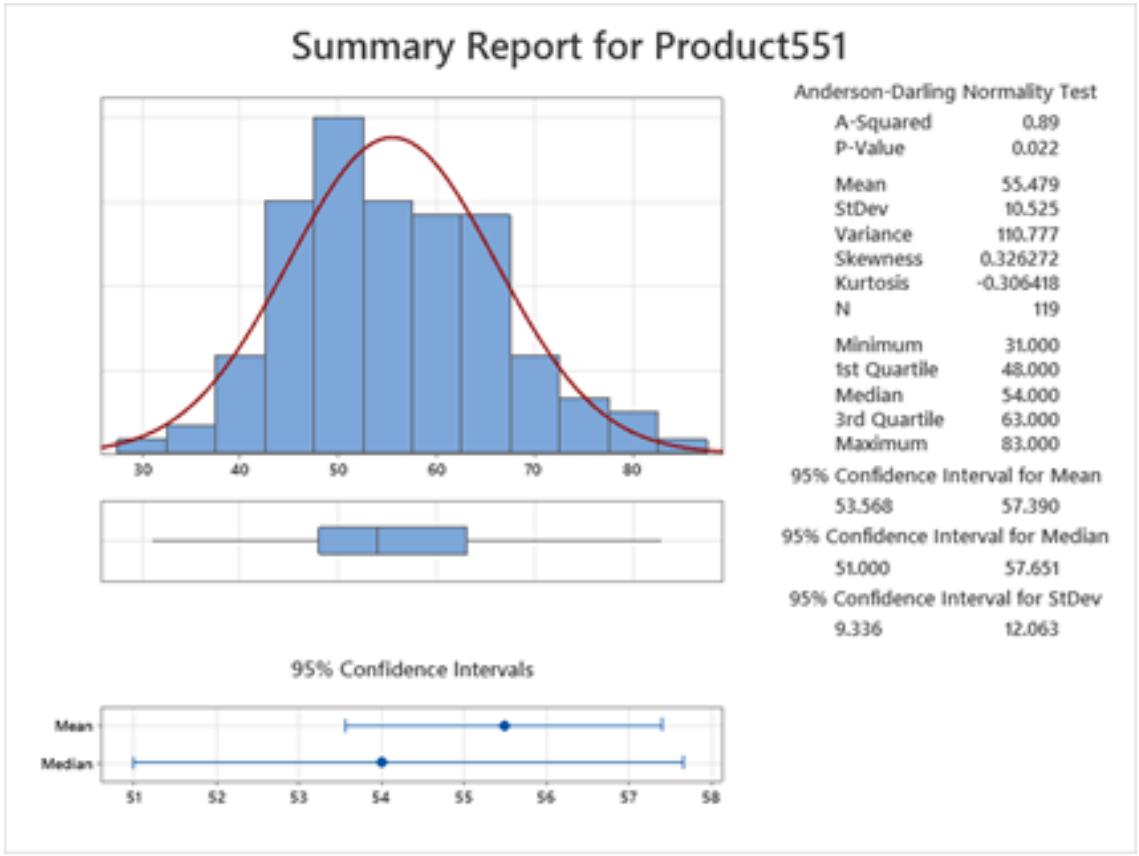
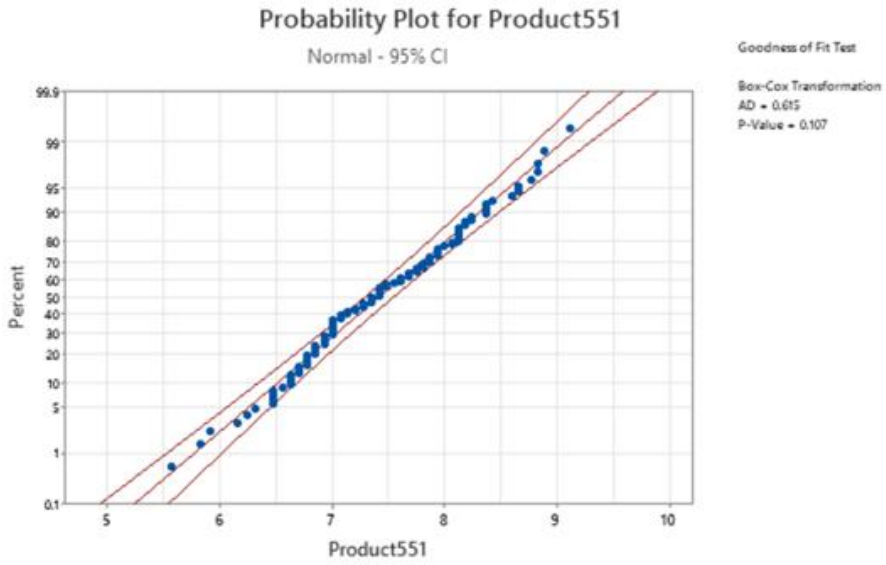
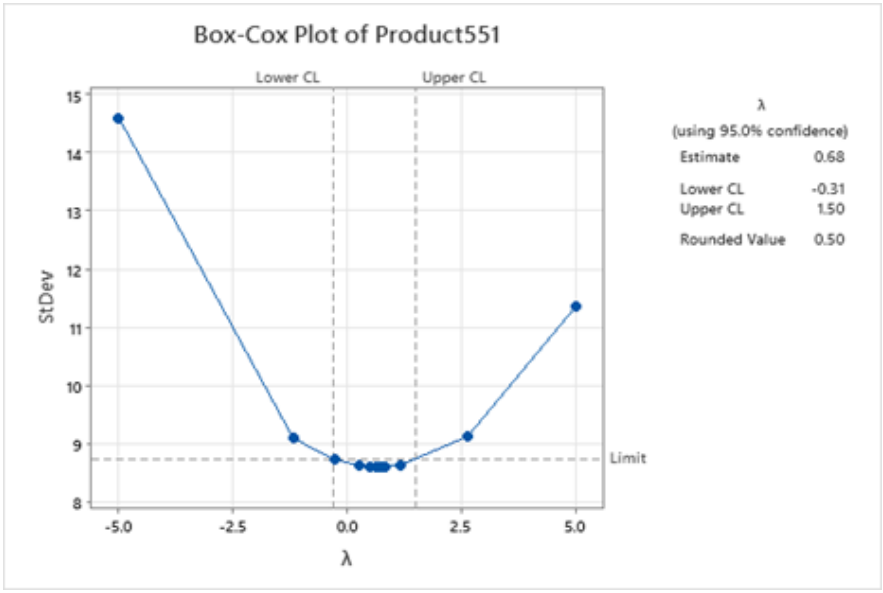






Use Minitab to graph distribution and perform box-cox transofmration with the optimal lambda value.

Descriptive Statistics Across All 680 SKUs (Mean, Standard Deviation)

In [7]:
```
# Descriptive Statistics of daily demand (based on Total Quantity)
df1 = df.groupby("product")['SUMOfqty'].describe().reset_index()
df1
#df1.to_excel("output.xlsx")
```

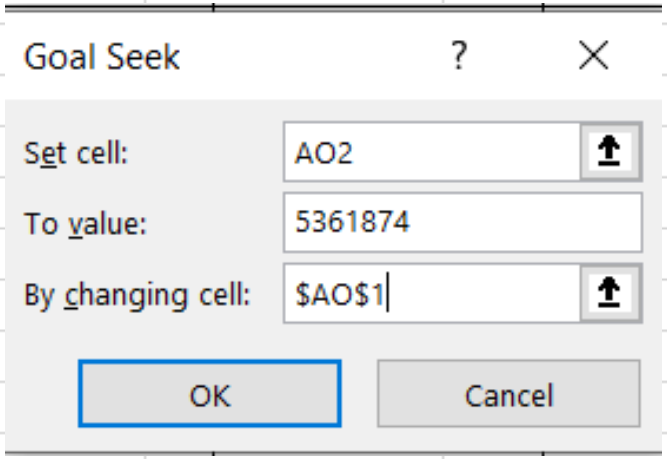
Out[7]:

	product	count	mean	std	min	25%	50%	75%	max
0	100	36.0	1.166667	0.377964	1.0	1.00	1.0	1.00	2.0
1	101	119.0	112.159664	14.773994	81.0	102.00	110.0	119.50	160.0
2	102	41.0	36.585366	22.164133	1.0	11.00	46.0	52.00	67.0
3	103	51.0	1.450980	0.923336	1.0	1.00	1.0	2.00	6.0
4	104	3.0	1.000000	0.000000	1.0	1.00	1.0	1.00	1.0
...	...	...	...	...	...	...	...	...	...
674	774	1.0	1.000000	NaN	1.0	1.00	1.0	1.00	1.0
675	775	10.0	44.600000	58.939140	1.0	1.50	7.0	90.25	143.0
676	776	119.0	257.050420	33.778152	165.0	241.00	256.0	278.50	340.0
677	777	8.0	104.750000	69.236138	5.0	53.75	129.5	147.25	192.0
678	778	21.0	29.619048	31.265758	1.0	5.00	12.0	57.00	97.0

679 rows × 9 columns

Goal Seek Analysis To Find "T" for Tier 1 Under (T,S) Policy

AI	AJ	AK	AL	AM	AN	AO
Safety stock (TS)	**Cycle stock (TS)**	**Inventory(TS)**	**Inventory Value (TS)**		**T**	12.38
64.79613503	694.04445	758.840585	$ 16,307.48		**Total $ Inventory**	$ 5,361,874
124.2388357	1204.476781	1328.715617	$ 33,018.58			
102.9234824	1058.148686	1161.072168	$ 15,883.47			
2224.849066	21843.55016	24068.39923	$ 449,838.38			
122.4126727	1076.712698	1199.125371	$ 39,151.44			
270.4745816	2187.121418	2457.596	$ 29,982.67			
262.1961184	2299.545491	2561.741609	$ 18,598.24			
44.94870467	505.2323276	550.1810322	$ 33,082.39			
91.22706927	700.8044544	792.0315236	$ 29,542.78			
87.89043103	609.8563954	697.7468264	$ 49,819.12			
83.7137004	973.3366311	1057.050331	$ 19,830.26			
99.25703089	474.285865	573.5428959	$ 34,452.72			
60.57742907	354.9522301	415.5296592	$ 14,688.97			
46.90564263	370.3962401	417.3018828	$ 15,757.32			
65.4233321	615.2123989	680.635731	$ 14,191.25			



Results for Tier 1 – 85 SKUs Under (R,Q) Policy

SKU	Reoder Point	Quantity	Safety Stock
101			
110			
114			
129			
134			
139			
141			
162			
181			
189			
200			
201			
205			
217			
221			
225			
263			
265			

SKU	Reoder Point	Quantity	Safety Stock
277	5,030		
283	2,554		
284	1,006		
294	352		
296	269		
313	2,303		
317	2,829		
337	4,583		
338	456		
348	730		
355	574		
376	694		
378	2,138		
381	4,680		
383	2,467		
397	2,859		
402	5,984		
403	8,879		
410	1,992		

SKU	Reoder Point	Quantity	Safety Stock
277	5,030		
283	2,554		
284	1,006		
414	1,747		
431	13,752		
440	45		
447	2,172		
467	1,040		
482	743		
486	589		
488	2,271		
490	3,078		
491	1,092		
508	1,913		
514	769		
519	453		
528	1,960		
538	1,150		
540	1,179		
551	97		
567	1,919		

SKU	Reoder Point	Quantity	Safety Stock
277	5,030	9	
283	2,554	5	
284	1,006	2	
569	12,161	6	
576	3,135	4	
583	9,222	18	
585	861	1	
589	875	1	
593	8,214	7	
598	6,692	10	
605	1,644	3	
609	1,550	3	
624	453	1	
626	3,840	5	
636	10,312	5	
640	120		
645	2,394	4	
649	394		
652	28,662	25	
666	303	1,224	
668	922	1,565	101

SKU	Reoder Point	Quantity	Safety Stock
277	5,030	9,934	616
283	2,554	5,298	314
284	1,006	2,516	160
670	462	1,212	67
674	2,967	4,601	309
678	1,787	2,603	256
702	3,211	3,955	307
710	795	1,927	107
711	1,602	2,580	165
724	397	1,515	59
731	1,619	3,623	119
736	977	1,960	87
763	695	1,352	98
765	3,278	3,427	340
776	2,346	4,228	226