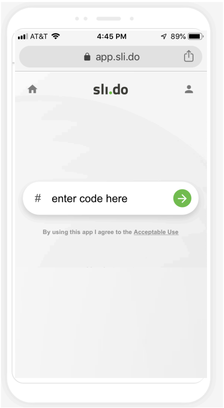
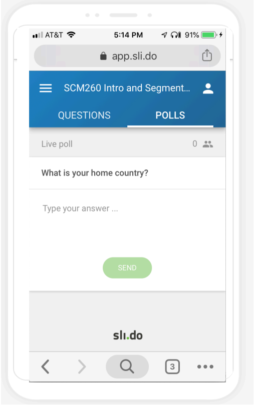
While waiting for us to start, go to: https://www.sli.do/
Enter event code: **#Bayer1**
and answer the polling question

Inventory Management
Live Session 1





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Agenda for Live Session

- Quick recap of concepts from video
- Pre-class survey results & discussion
- Building Intuition
  - Multiple stocking locations
  - Impact of lead time
- Homework and plan for Live Session 2

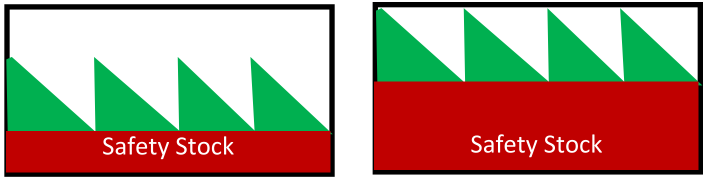
5 Primary Inventory Policies (Demand/Planning Horizon)

- Economic Order Quantity (EOQ) Policy – Deterministic/Infinite
  - Lot sizing
  - Order Q* when Inventory Position = Expected Demand over Leadtime
- Single Period Models – Stochastic/Single
  - Newsvendor Problem
  - Order Q* at start of period where Q*=f(Cost of shortage, Cost of excess)
- Base Stock Policy – Stochastic/Infinite
  - One-for-one replenishment
  - Order for tomorrow what was sold today
- Continuous Review Policy - Stochastic/Infinite
  - Order Point, Order Quantity (s,Q) - event based
  - Order Q* when Inventory Position is equal to or less than Re-order Point (IP≤s)
- Periodic Review Policy - Stochastic/Infinite
  - Order Up To Level Policy (R,S) – time based
  - Order up to S units every R time periods.

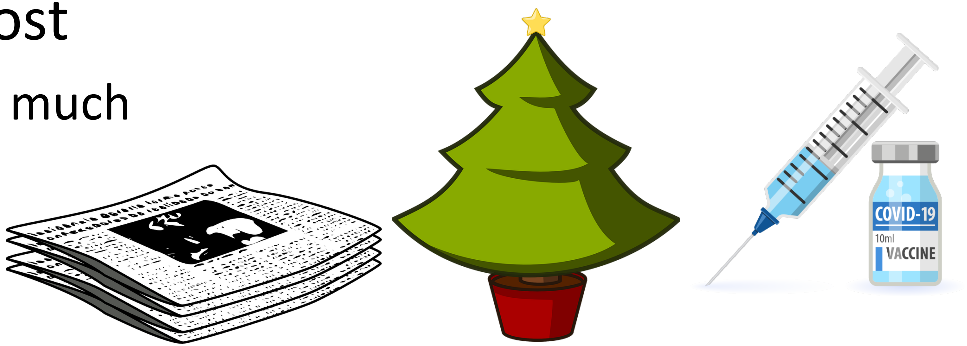
Replenishment Policies make Trade Offs

1. Fixed Cost vs Variable Costs
   - Order larger quantities less frequently or smaller quantities more frequently?

2. Cost vs Level of Service
   - How much safety stock to keep on hand to meet unplanned demand?



3. Shortage Cost vs Excess Cost
   - What is the cost of having too much vs. having too little?



How do we make these trade-offs?

$$TC = \text{Purchase Costs} + \text{Order Costs} + \text{Holding Costs} + \text{Stock Out Costs}$$

$$TC = vD + A\left(\frac{D}{Q}\right) + \left(\frac{Q}{2} + k\sigma_L + DL\right)c_e + B_1\left(\frac{D}{Q}\right)p_{u\geq}(k)$$

Total Cost is a function of Q, order quantity.

Shortage costs can take many forms – we will discuss this.

TC = Total Cost

Q = Replenishment Order Quantity (items/order)

D = Average Demand (items/ time)

v = Variable (Purchase) Cost (dollars/item)

A = Fixed Ordering Cost (dollar/order)

c_e = Holding or Carrying Charge (dollars/time)

k = Safety factor (unitless)

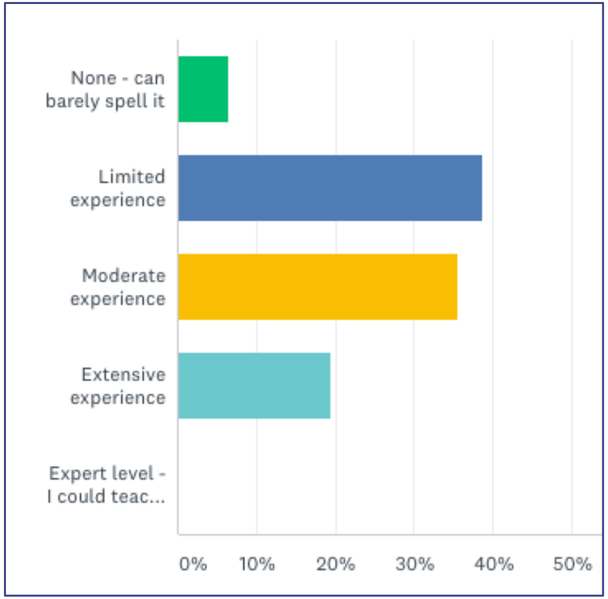
σ_L = Standard deviation of demand during leadtime

L = Leadtime (time)

Pre-class Survey Results

Inventory Experience & Familiarity

Inventory Experience



Familiarity with Concepts

	NEVER HEARD OF IT PRIOR TO THE VIDEO	LIMITED	SOMEWHAT	A FAIR AMOUNT	I AM AN EXPERT
Economic Order Quantity	19.35% 6	35.48% 11	25.81% 8	19.35% 6	0.00% 0
Newsvendor Models	19.35% 6	35.48% 11	32.26% 10	12.90% 4	0.00% 0
Base Stock Models	16.13% 5	38.71% 12	19.35% 6	25.81% 8	0.00% 0
Continuous Inventory Models	16.13% 5	25.81% 8	48.39% 15	9.68% 3	0.00% 0
Periodic Inventory Models	16.13% 5	38.71% 12	32.26% 10	12.90% 4	0.00% 0
Multi-Echelon Models	45.16% 14	35.48% 11	12.90% 4	6.45% 2	0.00% 0
Probability	9.68% 3	19.35% 6	41.94% 13	29.03% 9	0.00% 0
Safety Stock	0.00% 0	9.68% 3	32.26% 10	54.84% 17	3.23% 1
Cycle Stock	6.45% 2	16.13% 5	38.71% 12	35.48% 11	3.23% 1

Relevance of Policies to Bayer

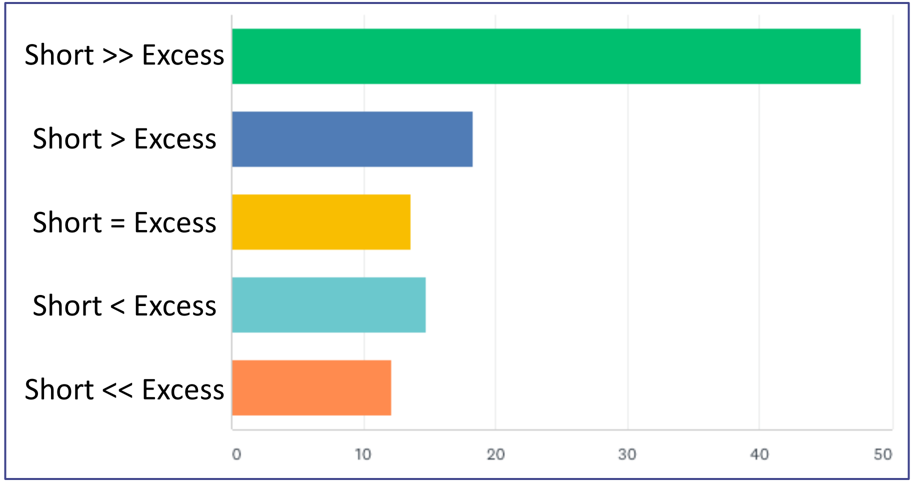
	NOT AT ALL	VERY LIMITED RELEVANCE	SOMEWHAT RELEVANT - AS IS	SOMEWHAT RELEVANT - IF SLIGHTLY MODIFIED	VERY RELEVANT - AS IS	VERY RELEVANT - IF SLIGHTLY MODIFIED
Economic Order Quantity	3.45% 1	20.69% 6	24.14% 7	27.59% 8	10.34% 3	13.79% 4
Base Stock	0.00% 0	13.79% 4	20.69% 6	27.59% 8	20.69% 6	17.24% 5
Continuous Review Policies	3.45% 1	6.90% 2	17.24% 5	44.83% 13	17.24% 5	10.34% 3
Periodic Review Policies	0.00% 0	3.45% 1	20.69% 6	34.48% 10	24.14% 7	17.24% 5
Single Period / Newsvendor Policies	10.00% 3	10.00% 3	20.00% 6	36.67% 11	13.33% 4	10.00% 3

Problem Areas for Inventory at Bayer

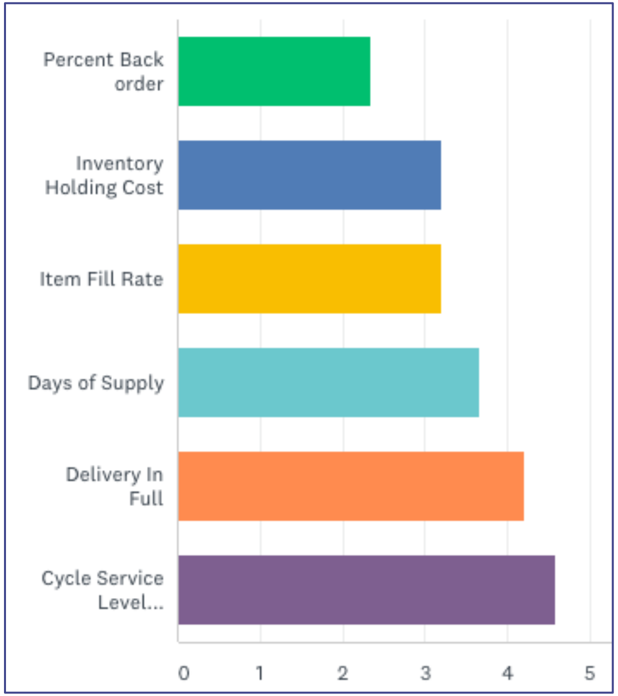
	NOT A PROBLEM	A SLIGHT PROBLEM	A MODERATE PROBLEM	A LARGE PROBLEM	THE MASSIVE PROBLEM	NO IDEA	TOTAL	WEIGHTED AVERAGE
Forecast Accuracy for individual SKU sales	0.00% 0	6.90% 2	20.69% 6	34.48% 10	37.93% 11	0.00% 0	29	4.03
Demand Variability	0.00% 0	3.45% 1	13.79% 4	62.07% 18	20.69% 6	0.00% 0	29	4.00
Forecasting Accuracy for total sales	0.00% 0	3.45% 1	41.38% 12	27.59% 8	27.59% 8	0.00% 0	29	3.79
Supply Uncertainty	3.45% 1	24.14% 7	24.14% 7	37.93% 11	10.34% 3	0.00% 0	29	3.28
Order Lead Time (from customers)	3.45% 1	17.24% 5	55.17% 16	20.69% 6	3.45% 1	0.00% 0	29	3.03
Order Lead Time (to Bayer)	10.34% 3	17.24% 5	48.28% 14	17.24% 5	0.00% 0	6.90% 2	29	3.00

Comparison of Shortage to Excess Costs

Percentage of Bayer SKUs By
Cost of Shortage to Cost of Excess



Metric Importance to Bayer
(lower is more important)



What are the problems and what actions can we take?

$$TC = \text{Purchase Costs} + \text{Order Costs} + \text{Holding Costs} + \text{Stock Out Costs}$$

$$TC = vD + A\left(\frac{D}{Q}\right) + \left(\frac{Q}{2} + k\sigma_L + DL\right)c_e + B_1\left(\frac{D}{Q}\right)p_{u\geq}(k)$$

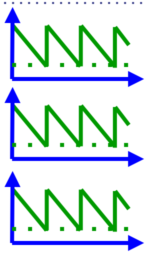
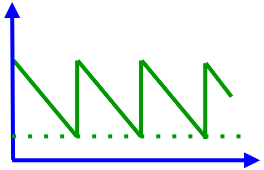
Slido Poll

- Forecasting accuracy is lacking
- Promised lead time to customers is unrealistic
- Customer behavior leads to bunched ordering
- Too many stocking locations
- Unclear strategic objectives
  - Highest quality product at limited availability or
  - Fill every order no matter
- Segmentation (chemicals vs. seeds) is not being considered

Building Intuition

Multiple Locations: Pooled vs. Independent Stocking

Slido Poll

		Cycle Stock	Safety Stock
	Independent	$q_i^* = \sqrt{\frac{2c_t d_i}{c_e}} = \sqrt{\frac{2c_t D}{c_e n}}$ $\overline{IOH} = \sum_{i=1}^{n}\left(\frac{q_i^*}{2}\right) = \sqrt{n}\left(\frac{Q^*}{2}\right)$	$\overline{SS}_{independent} = k\sigma_{d_i} = k\sigma_D\sqrt{n}$
	Pooled	$Q^* = \sqrt{\frac{2c_t D}{c_e}}$ $\overline{IOH} = \left(\frac{Q^*}{2}\right)$	$\overline{SS}_{pooled} = k\sigma_D$

Square root rule –

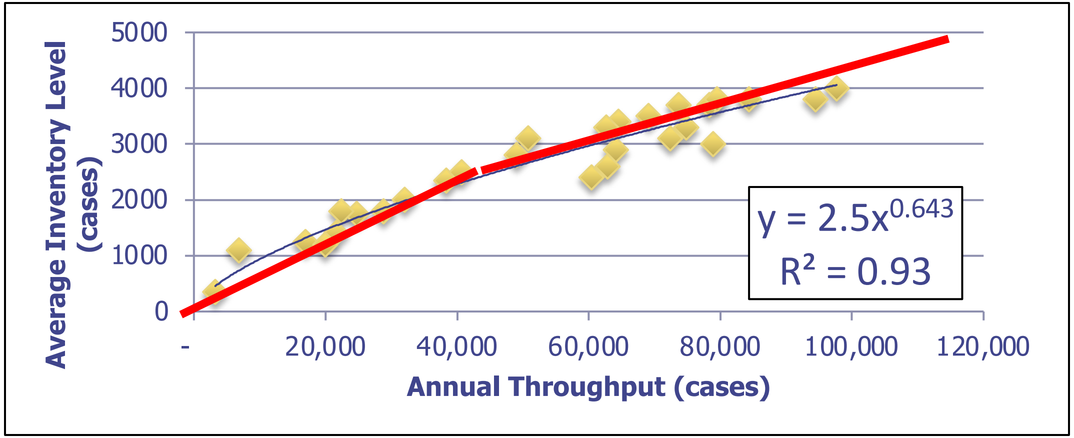
Going from 1 to n stocking locations increases inventory by √n, but this assumes . . .

- Inventory stocking follows the economic order quantity (EOQ),
- The size of locations and inventory levels are identical, and
- Each location has perfect operations.

Estimating Inventory Costs for NW Design

- Pipeline inventory – add in to the per unit transportation costs
- Cycle & Safety stock - tends to follow a non-linear function with respect to throughput at a facility:
  - I_i = Average inventory level at facility i
  - T_i = Throughput of inventory at facility i
  - α = Estimated parameter (positive)
  - β = Estimate of inventory concentration (ranges from 0.5 to 0.8)
- Regress on existing facilities to estimate the parameters for your firm

$$I_i = \alpha T_i^{\beta}$$



What are the inventory implications of:

a) 1 DC where T=80,000

b) 2 DCs where T_1=T_2=40,000

Case a) Inventory I = $2.5(80000)^{0.643}$
= 3,553 cases

Case b) Inventory = $2(2.5)(40000)^{0.643}$
= 4,551 cases

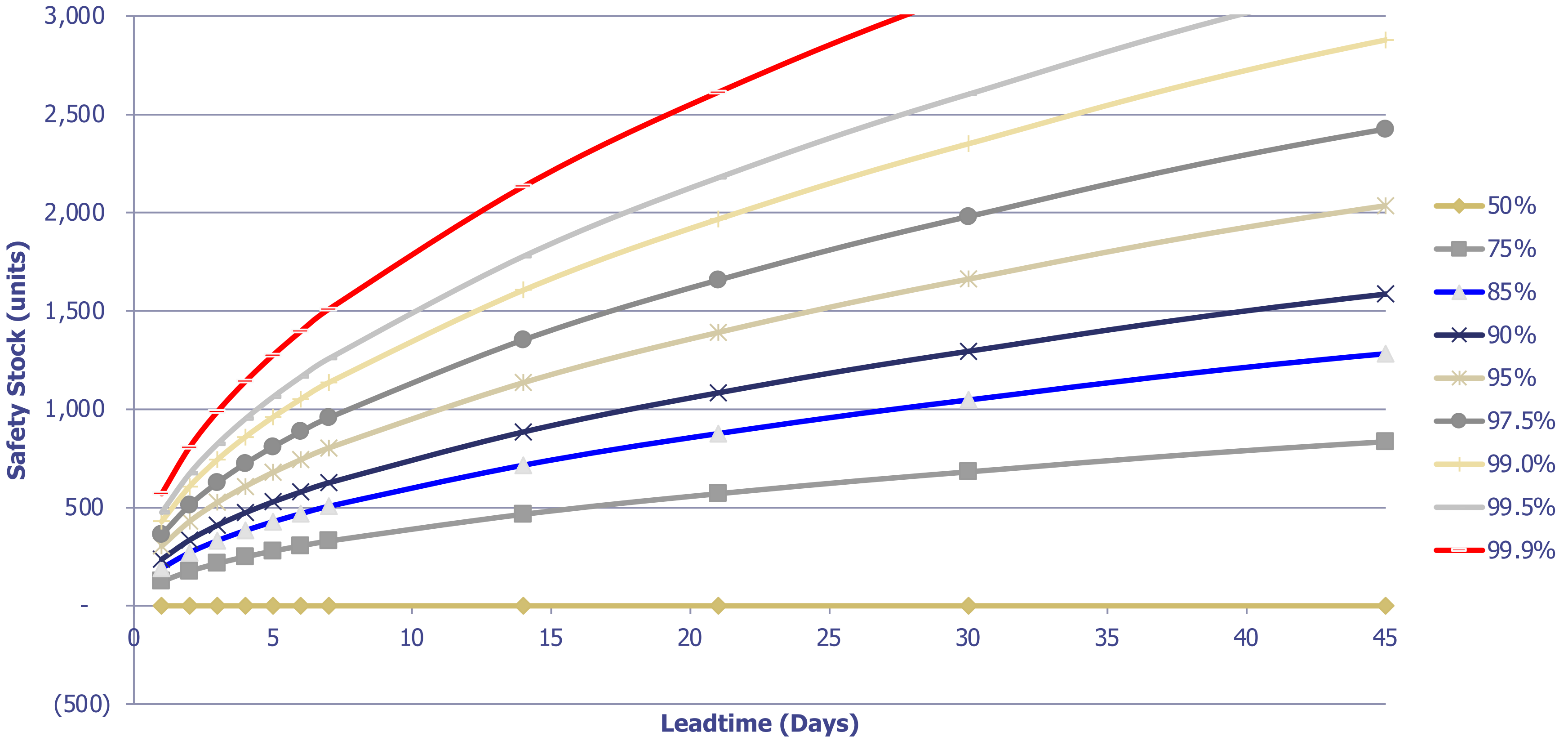
Look familiar????
- Tempers theoretical √2 relationship with actual behavior

Impact of Leadtime to Customers

Slido Poll

- Different leadtimes along the supply chain
  - Grow – plant to harvest
  - Replenishment – fields to distribution points
  - Customer - from distribution points to customers
- Bayer on both sides of the inventory equation

Trade Off between Cost, LOS, and Leadtime



For next time

- Survey to be sent out this week and due NLT 12 Aug
  - Segment out Chemicals and Seeds
  - Ask for 3-5 thoughts on how to improve inventory management at Bayer
- Live Session 2 (17 August)
  - Open discussion on recommendations by segment
  - Converge on 2-3 actions to potentially pursue

Questions, Comments, Suggestions?

Wilson & Gidget hoping there is plenty of dog food inventory.