

Management of Uncertainty

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Outline

- ◆ Forecasting
- ◆ Managing uncertainty
- ◆ Aggregation/risk pooling
- ◆ Postponement
- ◆ Mixed strategies
- ◆ Lead time management

Supply Chains are Tough to Manage

- Supply chains are difficult to manage – regardless of industry clockspeed (although more difficult in fast clockspeed industries)
- Managing inventory is one of the difficulties, ranging from shortages as we see for Goodyear racing tires to excess inventory as we see in Cisco's high-tech networking products. The impact of the inventory challenges affect employment levels as we see how GM used layoffs to adjust inventory product price; as we see Palm cut prices to deal with excess inventory profits; as we see USX's net income sink
- It is a cyclical problem that has extremes as we see in Intel's case, going from shortages and backlogs to chip gluts back to shortages
- Supply chains are tough to manage even if you are the dominant player.

Four Rules of Forecasting

1.

2.

3.

4.

Why is the World Less Certain

- ◆
 - ◆
 - ◆
 - ◆
 - ◆
-
- ◆ Aggravated bullwhip; higher variance; irrelevant history
 - ◆ Much more difficult to forecast

Managing Uncertainty

1. Point forecasts are invariably wrong
⇒ Plan for forecast range – use flexible contracts to go up/down
2. Aggregate forecasts are more accurate
⇒ Aggregate the forecast - postponement/risk pooling
3. Longer term forecasts are less accurate
⇒ Shorten forecasting horizons – multiple orders; early detection
4. In many cases somebody else knows what is going to happen
⇒ Collaborate

Managing Uncertainty

- ◆ Centralized inventory (aggregation, risk pooling) – less safety stock
 - Pronounced with high variability and negative correlation
- ◆ Postponement
 - Reduction in forecast horizon beyond the pivot point
 - Risk pooling in “core” product
 - Built-to-order
- ◆ Lead time reduction
 - Proximity; process re-engineering, I/T

Risk Pooling

- ◆ Temporal – over time
- ◆ Geographically – over areas
- ◆ By product line – or product family
- ◆ By consumer group - socio-economic characteristics

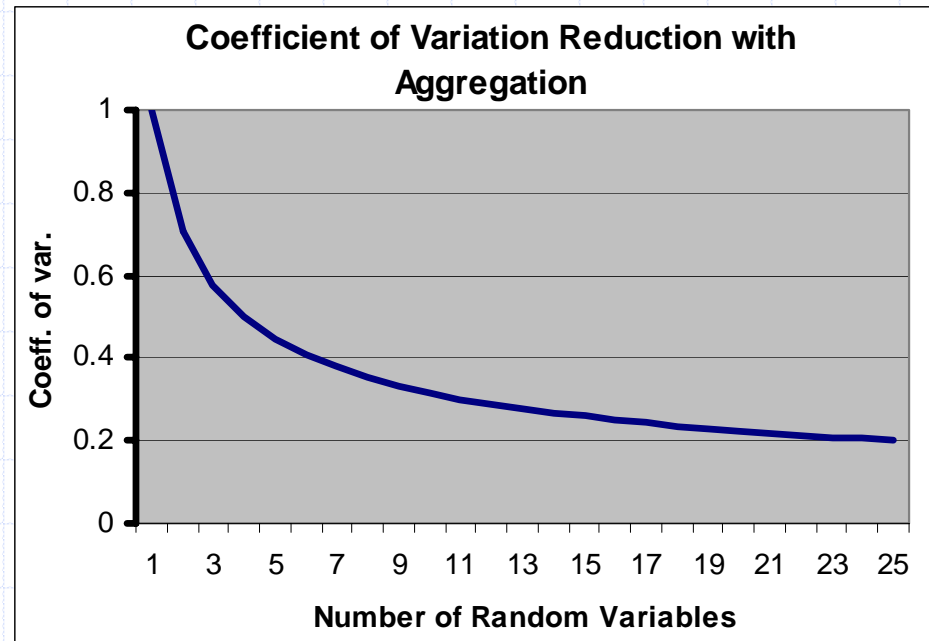
Forecast Error

- ◆ How does one measure accuracy?
 - Variance
 - Absolute error
 - RMSE
- ◆ Coefficient of variation C.V. = $\text{StdDev}/\text{Mean}$)
- ◆ C.V. always smaller for *aggregate* forecast
- ◆ Negative correlation reduces forecast errors even further

Effects of Aggregate Forecast

The coefficient of variation for n independent random variables with mean μ and standard deviation σ :

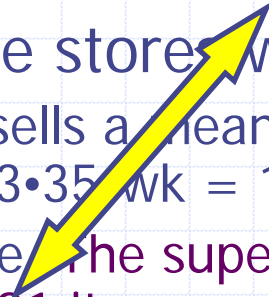
$$CV = \frac{1}{\sqrt{n}} \cdot \frac{\sigma}{\mu}$$



The effects of correlation:
Negative: stronger aggregation effects
Positive: less aggregation effect

Risk Pooling

- ◆ Why do “big box” stores do well?
- ◆ Imagine an urban area with nine store
 - Each store sells a mean of $\mu = 50/\text{wk}$ with a standard deviation of $\sigma = 35/\text{wk}$
 - Lead time = 2 weeks For 97.5% service, Store Safety Stock = $1.96 \cdot 35 \cdot 1.41 = 97$ items
 - Total safety stock = $9 \cdot 97 = 873$ items
- ◆ Now replace these stores with a single super-store
 - The super-store sells a mean of $\mu = 450/\text{wk}$ with a standard deviation of $\sigma = 3 \cdot 35/\text{wk} = 105/\text{wk}$
 - For 97.5% service, the super-store Safety Stock = $1.96 \cdot 105 \cdot 1.41 = 291$ items
- ◆ Note: the inventory required to cover the lead time does not change (900 units). The difference is in the safety stock.



Big Store

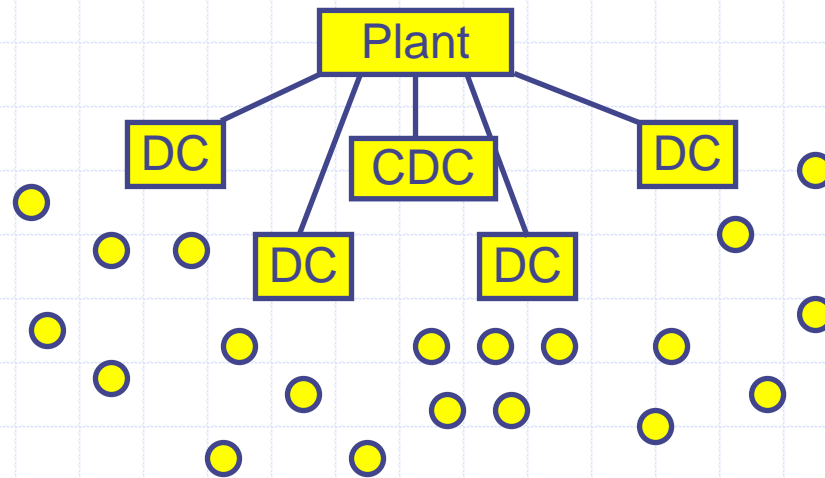
◆ Advantages:

-
-
-
-
-

◆ Disadvantages:

-
-

Centralized Inventory



20 stores (5 per DC)

LOS: 97.5%

Store Demand = 50 ± 35

Replenishment time = 1 week

Each DC Demand = $5 \cdot 50 \pm \text{SQRT}(5) \cdot 35 = 250 \pm 78$

CDC Demand = $20 \cdot 50 \pm \text{SQRT}(20) \cdot 35 = 1,000 \pm 156$

Total safety stock at stores = $20 \cdot (50 + 1.96 \cdot 35) = 2,372$

Total safety stock at DC-s = $4 \cdot (250 + 1.96 \cdot 78) = 1,612$

Total safety stock at CDC = $1,000 + 1.96 \cdot 156 = 1,306$

Aggregation with a Single Order

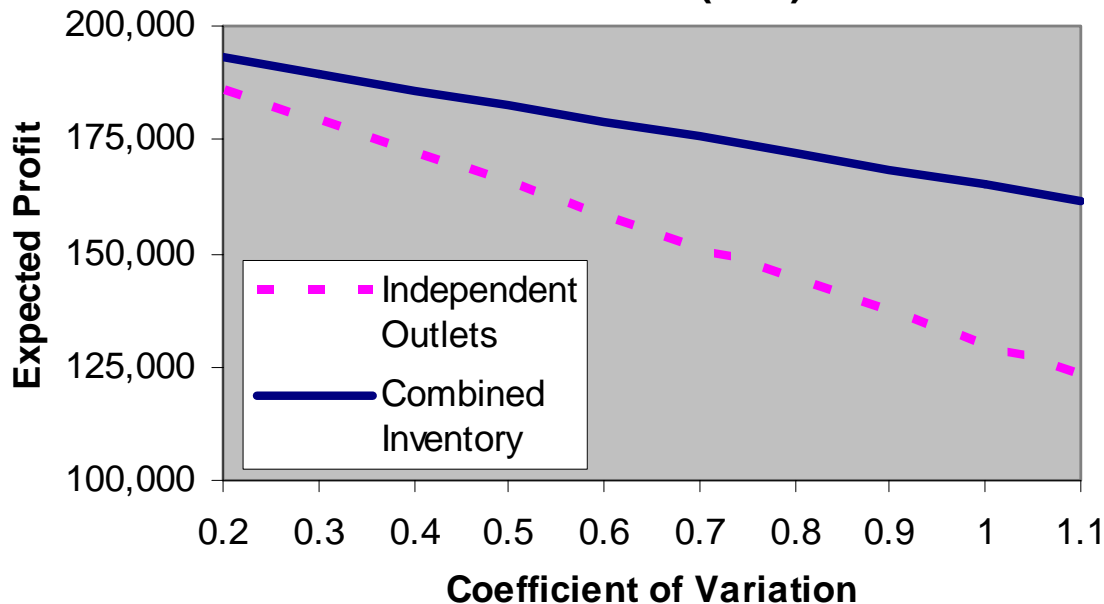
Each of 4 stores:

Price: \$150
 Cost: \$50
 Salvage: \$25
 Mean: 500
 Std. Dev: 150

Each:

$Q^* = \text{NORMINV}(0.8, 500, 150) = 626$
 Profits = \$44,751
 4 independents: \$179,003
Combined
 $Q^* = \text{NORMINV}(0.8, 2000, 300) = 2,252$
 Profits = \$189,501

Effect of Std. Dev (n=4)



Big change:

sold items up 1.73%
 # unsold items dn 50.00%

Shirt Postponement

Regular operation: import shirts from the far East (4 wks lead time)
Need: LOS = 97.5%

Postponement: bring Greige colors and dye to order

Color	Demand	
	Mean shirts/wk	Std Dev shirts/wk
Red	1,500	500
Blue	1,200	450
Green	600	250
Black	2,500	700

Transit Inv	safety Stock	Total Inv
6,000	1,960	7,960
4,800	1,764	6,564
2,400	980	3,380
10,000	2,744	12,744

Total (Individual Shirts)

23,200 7,448 30,648

Total (postponed)

5,800 1,002 23,200 3,930 27,130

- Safety stock
- Owned inventory

Uncertainty Management:

Examples: Risk Pooling and Postponement

- ◆ Cadillac automobiles in Florida
- ◆ Benetton for sweaters and T-shirts
- ◆ HP European printers
- ◆ Gillette for blades in Europe
- ◆ Sherwin Williams paint
- ◆ Motorola modems
- ◆ Zara Fabrics
- ◆ Dell build-to-order

Build-to-Order

- ◆ The ultimate postponement
- ◆ Dell/Gateway build-to-order
 - Better response to changes in demand
 - Better response to changes in component pricing/availability
 - Ability to direct customers to products including existing components
- ◆ The “Pivot” point: from BTS to BTO
 - Pushing the customization/commitment later in the supply chain

Postponement



Mean demand = 800
 Standard deviation = 400
 Price = \$40
 Cost = \$18
 Salvage = \$5

Order size for each color = 931 sweaters
 Total order = 3,724 sweaters
 Expected profit for each color = \$12,301
 Total profit = **\$49,230**

2,790 sold; 934 unsold

Make "Griego" sweaters and die to demand

Mean demand = 3,200
 Standard deviation = 800
 Cost = \$21
 Salvage = \$5

Order size for each color = 3,286 sweaters
 Expected total profit = **\$53,327**

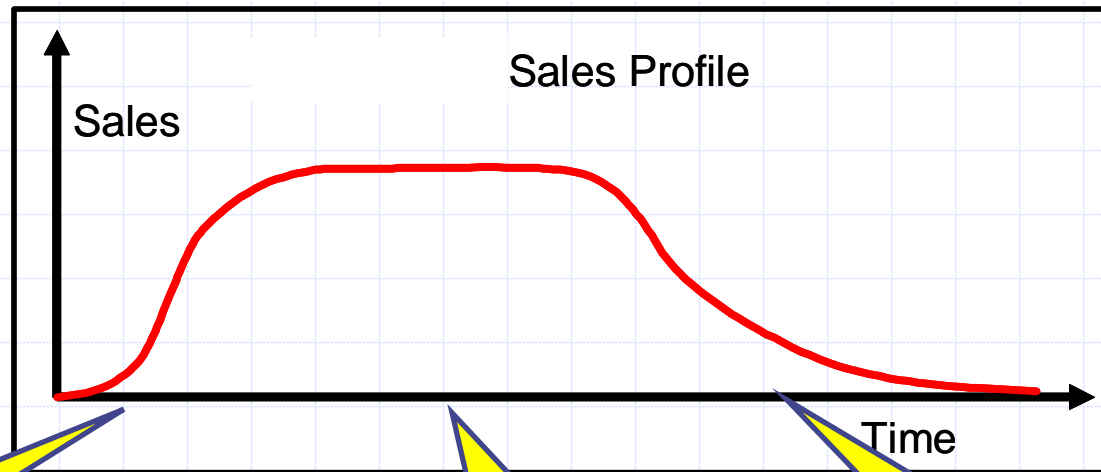
3,026 sold; 260 unsold



A Mixed Strategy

- ◆ Idea: order some pre-colored sweaters and sell those first
- ◆ Order also some griege sweaters and sell them as demand materializes
- ◆ Question: how many of each to maximize profit
- ◆ Use: simulation
- ◆ Answer:
 - Only colored: order 931 of each 3,724 Tot.): Exp. profit: \$49,230
 - Only griege: order 3,280: Exp. Profit: \$53,327
 - 600 colored each and 1,100 griege: Exp. profit: \$54,487

HP Printers for the US



Vancouver plant

Singapore plant

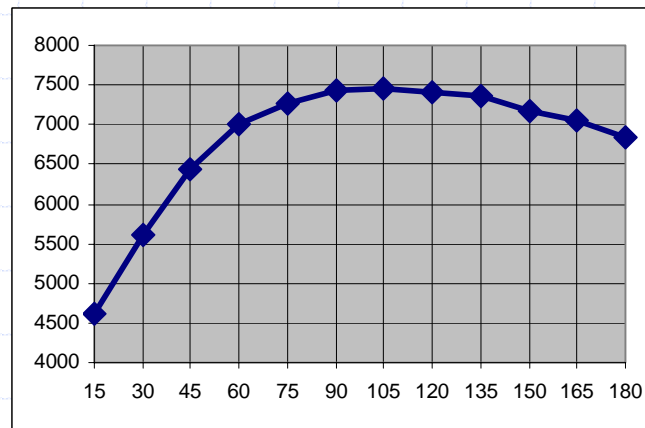
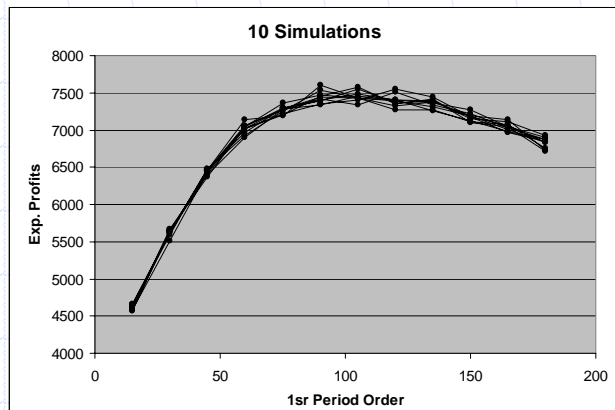
Vancouver plant

Multiple Orders (QR)

Price	\$120
Cost	\$40
Salvage	\$25
Mean (1 period)	50
Std. Dev	25

Order once for the whole period:
 Mean = 100; Std. Dev = 35.4
 $Q^* = 135$
 Exp. Profits = \$7,190

Order at the beginning & again in mid period:
 2nd period:
 Mean = 50; Std. Dev = 25
 Order "up to": = 75
 How much in 1st period?



$Q^* \approx 104$; Exp Profits = \$7,450

Asymmetric Aggregation

- ◆ You can always upgrade to keep consumers happy
- ◆ Example: two-cars automobile rental company: Buick and Cadillac
- ◆ Assume: equal demand (order 500 each for independent demand)
- ◆ For upgrade option: order more Cadillacs and less Buicks

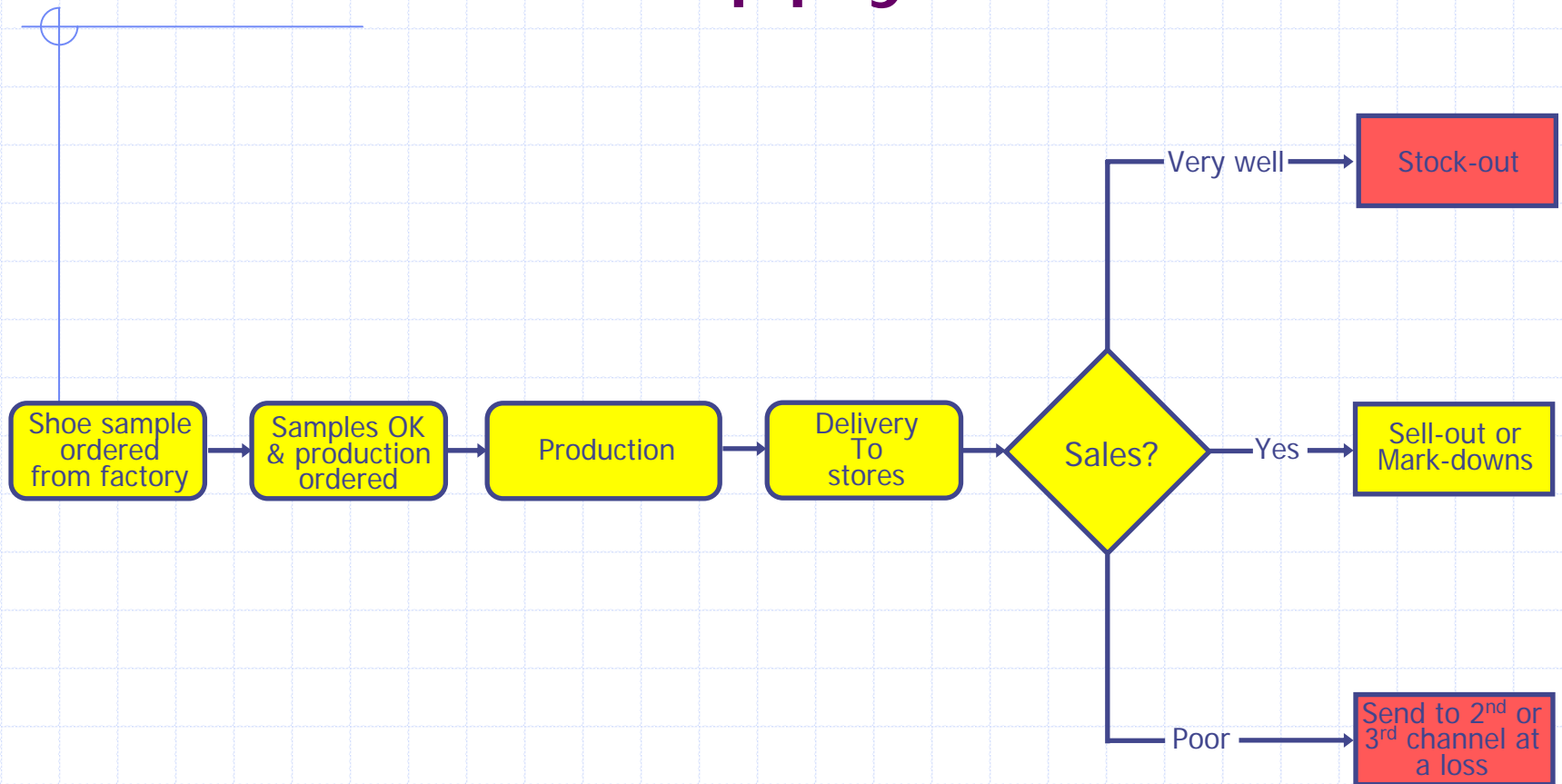
Uncertainty Management: Lead Time

Nine West Offerings

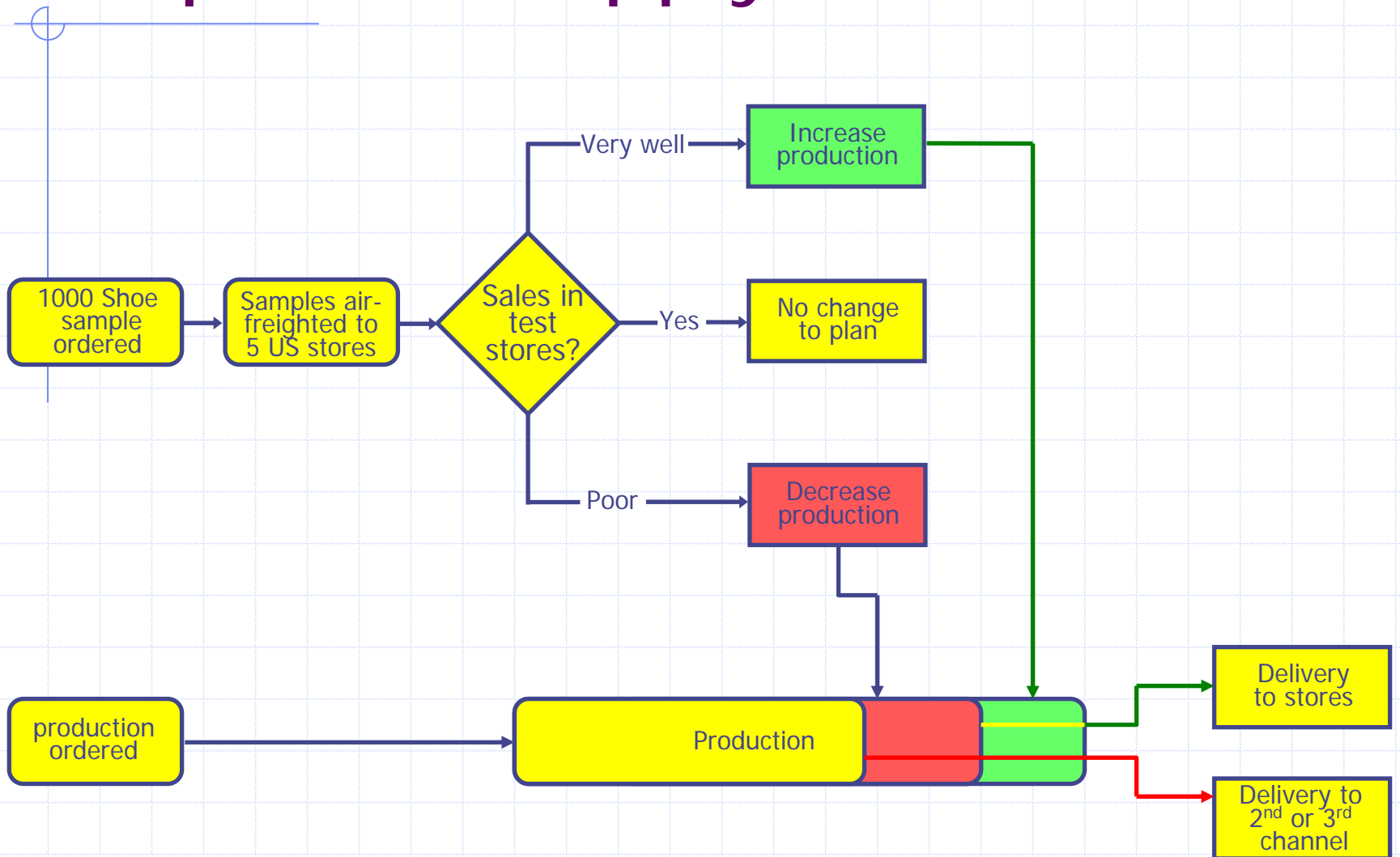
◆ Nine West **InCrowd** \$64.95

◆ Nine West **Alsina** \$66.95

Traditional Supply Chain



Improved Supply Chain



Any Questions?



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