

Chapter 12

Managing Uncertainty in a Supply Chain

Chapter 13

Determining the Optimal Level of Product Availability

Condensed presentation of the slides
made available by the authors.

Impact of Desired Product Availability and Uncertainty

- Goal is to reduce the level of safety inventory required in a way that does not adversely affect product availability
 1. Reduce the supplier lead time L
 2. Reduce the underlying uncertainty of demand (represented by σ_D)

Impact of Supply Uncertainty on Safety Inventory

- We incorporate supply uncertainty by assuming that lead time is uncertain

D : Average demand per period

σ_D : Standard deviation of demand per period

L : Average lead time for replenishment

s_L : Standard deviation of lead time

$$D_L = DL \quad s_L = \sqrt{L\sigma_D^2 + D^2s_L^2}$$

Impact of Aggregation on Safety Inventory

- How does aggregation affect forecast accuracy and safety inventories

D_i : Mean weekly demand in region i , $i = 1, \dots, k$

σ_i : Standard deviation of weekly demand in region i , $i = 1, \dots, k$

ρ_{ij} : Correlation of weekly demand for regions i, j ,
 $1 \leq i \neq j \leq k$

Impact of Aggregation on Safety Inventory

Total safety inventory
in decentralized option

$$= \sum_{i=1}^k F_S^{-1}(CSL) \sqrt{L} s_i$$

$$D^C = \sum_{i=1}^k D_i; \quad \text{var}(D^C) = \sum_{i=1}^k s_i^2 + 2 \sum_{i>j} r_{ij} s_i s_j;$$

$$s_D^C = \sqrt{\text{var}(D^C)}$$

$$D^C = kD \quad s_D^C = \sqrt{kS^2 + k(k-1)rs^2}$$

Simplified to $s_D^C = \sqrt{k} s_D$

Impact of Aggregation on Safety Inventory

Require safety inventory
on aggregation

$$= \sum_{i=1}^k F_S^{-1}(CSL) \sqrt{L} s_D^C$$

Holding – cost savings on
aggregation per unit sold

$$= \frac{F_S^{-1}(CSL) \sqrt{L} H}{D^C} \sum_{i=1}^k s_i - s_D^C$$

Product Substitution

- The use of one product to satisfy demand for a different product
 1. *Manufacturer-driven substitution*
 - Allows aggregation of demand
 - Reduce safety inventories
 - Influenced by the cost differential, correlation of demand
 2. *Customer-driven substitution*
 - Allows aggregation of safety inventory

Key Point

Manufacturer-driven substitution increases overall profitability for the manufacturer by allowing some aggregation of demand, which reduces the inventory requirements for the same level of availability.

Key Point

Recognition of customer-driven substitution and joint management of inventories across substitutable products allows a supply chain to reduce the required safety inventory while ensuring a high level of product availability.

Component Commonality

- Without common components
 - Uncertainty of demand for a component is the same as for the finished product
 - Results in high levels of safety inventory
- With common components
 - Demand for a component is an aggregation of the demand for the finished products
 - Component demand is more predictable
 - Component inventories are reduced

Managerial Levers to Improve Supply Chain Profitability

- Based on Newsvendor setting, but think more general
- “Obvious” actions
 1. Increase salvage value of each unit
 2. Decrease the margin lost from a stockout

- 1. Improved forecasting*
- 2. Quick response*
- 3. Postponement*
- 4. Tailored sourcing*

1. Improved Forecasts

- Improved forecasts result in reduced uncertainty
- Less uncertainty results in
 - Lower levels of safety inventory (and costs) for the same level of product availability, or
 - Higher product availability for the same level of safety inventory, or
 - Both

2. Quick Response

- Set of actions taken by managers to reduce replenishment lead time
- Reduced lead time results in improved forecasts
- Benefits
 - Lower order quantities thus less inventory with same product availability
 - Less overstock
 - Higher profits

Quick Response: Multiple Orders Per Season

- Two ordering policies
 1. Supply lead time is more than 15 weeks
 - Single order placed at the beginning of the season
 2. Supply lead time is reduced to six weeks
 - Two orders are placed for the season
 - One for delivery at the beginning of the season
 - One at the end of week 1 for delivery in week 8

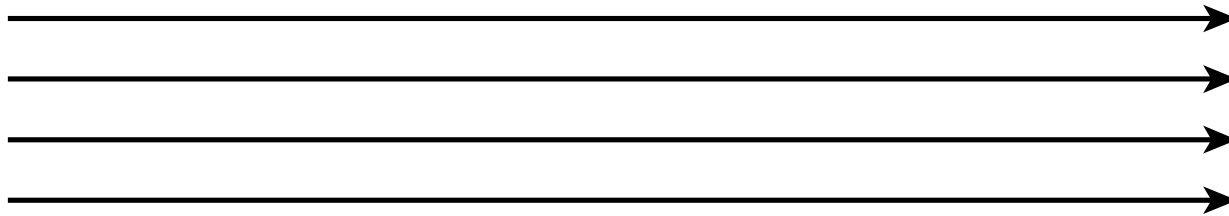
Quick Response: Multiple Orders Per Season

- Three important consequences
 1. The expected total quantity ordered during the season with two orders is less than that with a single order for the same cycle service level
 2. The average overstock to be disposed of at the end of the sales season is less if a follow-up order is allowed after observing some sales
 3. The profits are higher when a follow-up order is allowed during the sales season

3. Postponement

- Delay product differentiation or customization until closer to the time the product is sold
 - Have common components in the supply chain for most of the push phase
 - Move product differentiation as close to the pull phase of the supply chain as possible
 - Inventories in the supply chain are mostly aggregate

Postponement vs Classical



Supply Chain Flows Without Postponement



Supply Chain Flows with Component
Commonality and Postponement

FIGURE 12-5

Postponement: Impact on Profits and Inventories

- Delay of product differentiation until closer to the sale of the product
- Activities prior to product differentiation require aggregate forecasts more accurate than individual product forecasts
- Individual product forecasts are needed close to the time of sale
- Results in a better match of supply and demand
- Valuable in online sales
- Higher profits through better matching of supply and demand

Tailored Postponement: Benetton

- Use production with postponement to satisfy a part of demand, the rest without postponement
- Tailored postponement allows a firm to increase profits by postponing differentiation only for products with uncertain demand

4. Tailored Sourcing

- A firm uses a combination of two supply sources
 - One is lower cost but is unable to deal with uncertainty well
 - Second more flexible but is higher cost
- Focus on different capabilities
- Increase profits, better match supply and demand
- May be volume based or product based

Tailored Sourcing

- *Volume-based tailored sourcing*
 - Predictable part of demand produced at efficient facility
 - Uncertain portion produced at flexible facility
- Considered by firms with overseas production to take advantage of lower costs
 - Lower costs accompanied by longer lead times
 - Flexible local source with short lead times
 - Results in lower safety inventories

Final Comments: Setting Levels of Product Availability in Practice

1. Beware of preset (current system) levels of availability
2. Use approximate costs because profit-maximizing solutions are quite robust
3. Estimate a range for the cost of stocking out
4. Estimate costs involved in several upgrade alternatives
5. Tailor your response to uncertainty