Lecture 11: Supply Chain Coordination

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last updated: August 3, 2021

Outline

1. Why does supply chain need a collaboration?
2. Caterpillar Case Study
3. Deterministic Supply Chain Coordination
4. Collaboration with Revenue Sharing
5. Collaboration with Revenue Sharing

Key Ref.: [JC10] [Bal07] [CM07] [Goe11]

Why do we need collaboration?

- one company finish good = other company raw material → Bullwhip effect
- focus on core competency → fragmental ownership
- supply chain management ≠ logistic → profit
- supply chain management is not zero sum game

Key Question

How to coordinate the supply chain to perform as if they were a single cooperation?

- mutual trust → Caterpillar Case Study
- synergy → Quantitative Model
- information → Chopra & Meindl 2010. Chapter 16

Obstacles to Collaboration

- **Incentive:** multiple participate, local optimization
- **Information processing:** distorted info, forecasting censer data
- **Operational:** replenishment lead times
- **Pricing:**
- **Behavioral:**
  - deciding based on local and incomplete information
  - blame game
  - lack of trust and communication → opportunism, and no information sharing

Achieving Coordination

- **Aligning goals and incentives:** pricing for coordination
- **Improving info. accuracy:** POS, collaborate forecasting and planning
- **Improving performance:**
  - reducing lead time/demand uncertainty $\rightarrow$ safety stock
  - reducing Reducing lot sizes
  - rationing based on past sales and sharing information
- **Designing pricing strategies:**
  - incorporating sale/marketing
  - stabilizing price
- **Building partnerships and trust:**

Caterpillar Case Study

Make Your Dealers Your Partners by D. V. Fites 1990.

- **CAT:** manufacturers of construction & mining equipments
- **Theme:** distribution network, product support, & customer relationship
- **Strength:** distribution and service; not engineering, manufactory, quality
- **Machines:** high prices operating in harsh environments
- **# Dealers:** 186 worldwide
  - close tight with consumer $\rightarrow$ service
  - investment $\rightarrow$ outstanding distribution requires
  - mutual trust & benefit $\geq$ contractual agreement
  - reduce time-to-market

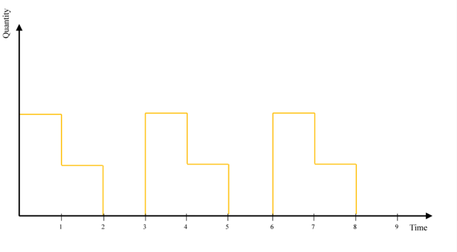
CAT Principles

- don't exploit your dealers $\rightarrow$ establish mutual trust
- give your dealer supports
- ensure your dealer are well run
- communicate freely, honestly, and frequently
- believe in strong business relationship is personal (but no compromised)
- strive to keep dealer ships in family

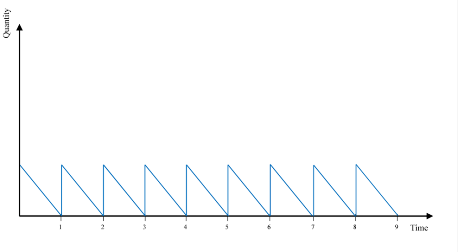
Multi-echelon Inventory

- **What:** coordination with EOQ inventory model
- **Also-Known-As:** multiple stocking points
- **Assumptions**
  - deterministic and external demand
  - no substitute product
  - single channel
- **Idea:** match inventory cycle between a vendor and a retailer
- **Example:** retailer and independent warehouse (*rare*)

Multi-echelon Inventory



supplier $(n = 3)$



retailer

- Retailer has inventory Q^*
- Supplier has inventory $n \cdot Q^*$, where $n \in \mathbb{Z}^+$
- What would be the optimal n and Q^*?

Review: Economic Order Quantity (EOQ)

Economic Order Quantity

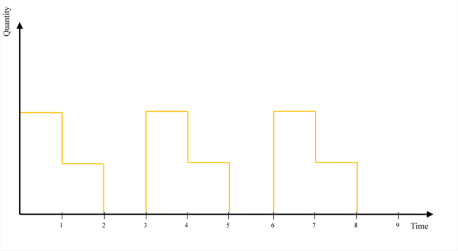
$$\text{Quantity } (Q^*) = \sqrt{\frac{2\lambda\ K}{h}}$$

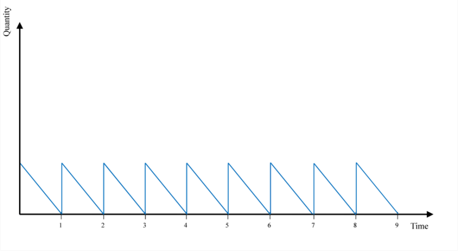
$$\text{Total Cost } (TC(Q^*)) = c\lambda + \sqrt{2\lambda\ K\ h}$$

where,
Q = Quantity
$TC(Q)$ = Total costs
λ = Demand rate
c = Unit purchasing Cost
K = Ordering cost
h = Holding cost

Total holding cost = Total ordering cost

Setting of Multi-echelon Inventory





supplier

Inv. Cost: $h_s \frac{(n-1)\ Q}{2}$

Ord. Cost: $K_s \frac{\lambda}{n\ Q}$

retailer

Inv. Cost: $h_r \frac{Q}{2}$

Ord. Cost: $K_r \frac{\lambda}{Q}$

Echelon Quantity

$$Q^*(n) = \sqrt{\frac{2\lambda\ (K_r + K_s/n)}{h_r + h_s(n-1)}}$$

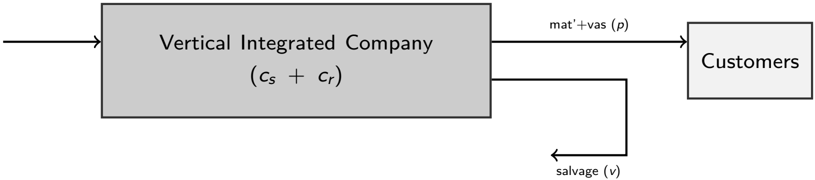
Example of Multi-echelon Inventory

demand: 2,000 units per year

supplier	**retailer**
$K_s = 600$ USD per order	$K_r = 100$ USD per order
$h_s = 10$ USD per unit-year	$h_r = 30$ USD per unit-year

	Ind.	$n = 1$	$n = 2$	$n = 3$	$n = 4$	n= 5
Q_s	489.9	305.5	400.0	464.8	516.4	560.6
Q_r	115.5	305.5	200.0	154.9	129.1	112.1
TC_s	4899.0	3,927.9	4,000.0	4,131.2	4,260.3	4,383.0
TC_r	3464.1	5,237.2	4,000.0	3,614.8	3,485.7	3,465.6
TC	8363.1	9,165.2	8,000.0	7,746.0	7,746.0	7,848.6

Introduction



- **Why Multi-Echelon fails:** perishableor stochastic demands
- **Idea:** stochastic model based on newsvendor model
- **Observations:** lack of communication, local optimum, unbalancing negations power
- **Solutions** with pricing contract (buy-back contract, unit discount, revenue sharing)

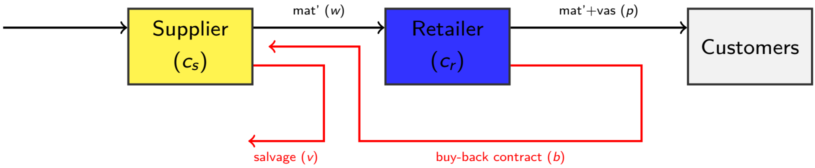
Review: Newsvendor

Newsvendor

$$
\begin{aligned}
\text{Expected total Profit} &= \text{Expected net revenue} - \text{Total net investment} \\
\pi(q) &= (p - v) \cdot S(q) + v \cdot \mu(q) - c \cdot q \\
\text{Quantity } (q^*) &= F^{-1}\left(\frac{p-c}{p-v}\right)
\end{aligned}
$$

$$
\begin{aligned}
\text{where, } q &= \text{Quantity} \\
\pi(q) &= \text{Total profit} \\
F(\cdot) &= \text{Cumulative probability function} \\
S(q) &= \text{Expected units sold, } S(q) = q - \int_0^q F(y)dy \\
\mu(q) &= \text{Expected units unsold, } \mu(q) = \int_0^q F(y)dy \\
c &= \text{Unit purchasing cost} \\
p &= \text{Unit selling cost} \\
v &= \text{Unit savaging value}
\end{aligned}
$$

Buy-back Contract



- What is a Buy-back contract?
  - Supplier agrees to buy leftover products back from retailer
  - Supplier increases the salvage value from v to b
- What does this scheme help?
  - sharing risk of overstock
  - motivating retailer to buy more $\rightarrow$ more revenue

How much should supplier buy products back?

Derivation: retailer problem

$$
\begin{aligned}
q_V^* &= q_r^* \\
\frac{p-(c_r+c_s)}{p-v} &= \frac{p-(c_r+w_b)}{p-b} \\
w_b &= p-c_r-\frac{(p-b)(p-c_r-c_s)}{p-v}
\end{aligned}
$$

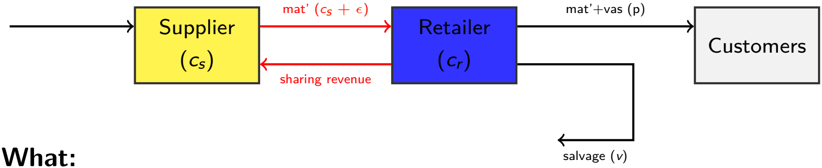
- Given w_b and b, retailer faces a typical Newsvendor problem
- **Rational of bay back price**: $w_b + c_s \geq \ b \geq \ v$
- **Rational of wholesale price**: $p - c_r \geq \ w_b \geq \ c_s$

Example of Buy Back Contract

customer demand	Uniform(0,100)	
	supplier	**retailer**
cost	$(c_s) = 10$ USD	$(c_r) = 5$ USD
sale	$(w) =?$ USD	$(p) = 30$ USD
salvage	$(b) =?$ USD	$(v) = 5$ USD

w	10	11	10	13	16	19
b	5	5	8	10	15	25
$Pr(\cdot)$	0.6	0.56	0.68	0.6	0.6	1.0
$F^{-1}(\cdot)$	60	56	68.18	60	60	100
$E[\text{sold}]$	42	40.32	44.94	42	42	50
$E[\text{unsold}]$	18	15.68	23.24	18	18	50
π_r	450	392	511.36	360	270	350
π_r	0	56	-69.73	90	180	-100
Π	450	448	441.63	450	450	250

Revenue Sharing



- **What:**
  - Supplier agrees to sell products at its marginal cost to retailer
  - Retailer must share portion of profit back to supplier
- **Idea:** reduce cost $\rightarrow$ more demands and revenues
- **Examples:** Blockbuster, Software licensing, 3PL

How Blockbuster Changed The Rules

1. How was Blockbuster doing business before the time of article?
   - Insufficient stock & high marginal cost (i.e., from 65 USD per copy)
2. What is a Revenue Sharing?
   - sell at its marginal cost, but share profit to supplier
3. How does Revenue Sharing help Blockbuster and movie production company?
   - capture more demands & simplify exceeds DVDs demand after peak
4. What are limitations of Revenue Sharing?
   - Profit observation
5. What do contribute to a recent decline of Blockbuster after implementation?
   - **Competitions:** Rental machine, NetFlix (mail-in), Internet file-sharing
   - **Upstream:** Shorter time window, Decline of industry
   - **Outside factors:** Cheaper technology, Format war

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