MS&E 260

INTRODUCTION TO OPERATIONS MANAGEMENT

Problem Session 5

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What We Learned This Week

- Supply Chain Contracts
- Guest lecture from Dr Colin Kessinger

SCM Big Picture

- Primary tradeoff in SCM models: cost versus response time
  - e.g. less costly to transport goods by truck or boat, but air freight is faster
  - e.g. tradeoff between internal delivery system vs. third party logistics

- Since manufacturing is now a commodity service that is outsourced, cost reductions come from the ***supply chain***
  - Bottom line: firms that *move products quickly and efficiently* will win

- For more in-depth treatment of SCM: MS&E 262: Supply Chain Management

Integrated Firm vs. Two-Firm Supply Chain

Marginal cost $c = \$20$

Integrated Firm

Selling price $p = \$100$
Demand $D = U[0{,}100k]$

Ordering Quantity
$80k > 40k$

Expected Total Profit
$\$3200K > \$2400K$

Double Marginalization (DM)

Marginal cost $c = \$20$

Supplier

Wholesale Price $w = \$60$

Retailer

Selling price $p = \$100$
Demand $D = U[0{,}100k]$

How can we overcome this gap?

Revenue Sharing vs. Buy-Back

- If comparing between revenue sharing (RS) and buyback contracts (BB), what factors are important to consider?
  - Both are subject to retailer effort distortion
  - RS requires huge auditing effort, BB requires good return process
  - RS requires upfront loss for Supplier; BB requires higher upfront investment from Retailer; so can be affected by which part is more financially constrained
  - Loss-averse people would potentially dislike RS more because of the upfront loss
- Bottom line: designing the right parameters is only the first step, needs a lot of care in the implementation details, otherwise the theoretical benefit remains theoretical and would never be materialized

RS- How Do We Find the Right Prices?

- Given:
  - p = retail price
  - c = cost per unit to the supplier
  - s = salvage value
  - f = upfront fee
  - θ = revenue share percentage

$$\frac{p-c}{(p-c)+c-s} = \frac{\theta p - f}{(\theta p - f) + f - s} \Rightarrow \frac{p-c}{p-s} = \frac{\theta p - f}{\theta p - s}$$

Original Critical Ratio

Critical Ratio Under Revenue Sharing

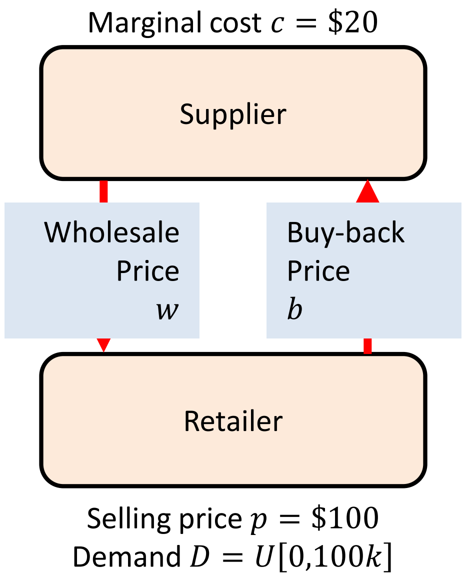
•Any θ and f that satisfies this expression will coordinate the supply chain!

Buy-Back Contract

- To coordinate the supply chain coordination equalize target service level!

$$\frac{p-c}{p} = \frac{p-w}{p-w+w-b}$$

$$\Rightarrow b = p-(p-w)\times\frac{p}{p-c}$$

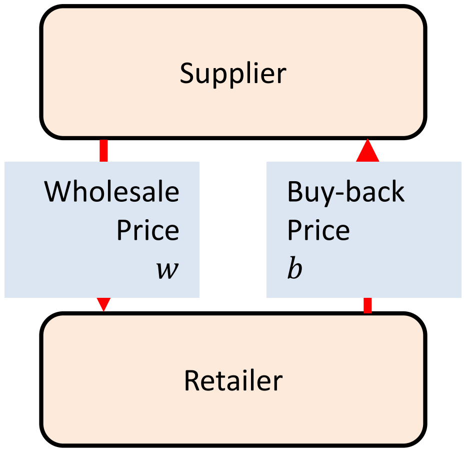


Buy-Back Contract With Salvage Cost

- To coordinate the supply chain coordination equalize target service level!

$$\frac{p-c}{p-s} = \frac{p-w}{p-w+w-b}$$

$$\Rightarrow b = p - (p-w) \times \frac{p-s}{p-c}$$



p = retail price
s = salvage value
w = wholesale price
c = cost per unit to the supplier

Why can it be so hard to implement these theoretical SC contracts?

RS- Example problem

- Imagine a two-firm supply chain that consists of a supplier and a retailer. The supplier has a marginal cost c = $25 and a wholesale price w = $55. The retailer is looking to sell its product at p = $100; at this price point, demand over the lifespan of the product is distributed normally with mean 185 and standard deviation of 10. The salvage value of the product is s = $5 for the retailer.
  - What is the expected profit for the supplier and the retailer assuming each of them maximizes their own profit.
  - Suppose the supply chain was integrated (or alternatively, the supply chain is perfectly coordinated). What is the optimal order quantity of the retailer? What is the expected total profit for the supply chain?

BC- Example problem

- Now assume the firms seek to form a revenue sharing contract. Let f be the upfront fee and θ be the revenue share percentage. Suppose they decide on an upfront fee of $20 the retailer per unit.
    - What is the share θ so that the chain is perfectly coordinated?
    - What is the expected profit for the retailer and the supplier under this contract?

- Assume now that the firms are looking to form a buyback contract. What would be the buy-back price that perfectly coordinates the supply chain assuming the wholesale remains 55 per unit?

Solutions

a. Notations for problem 1:

p = retail price
c = production cost
s = retailer's salvage value
w = wholesale price
b = buy-back price

Underage cost: $c_u = 100 - 55 = 45$
Overage cost: $c_0 = 55 - 5 = 50$
The retailer's critical ratio is:

$$\frac{c_u}{c_u + c_0} = \frac{45}{50 + 45} = 0.4736$$

$$z = \Phi^{-1}(0.4736) = -0.07$$

So the retailer's optimal order quantity is:

$$Q = \mu + \sigma z = 185 - 0.07 * 10 \approx 184$$

We can evaluate the retailer's expected profit. Let π = profit:

$$E[\pi] = pE[sales] - cQ + s(Q - E[sales])$$

$$E[\pi] = p[\mu - \sigma L(z)] - cQ + s(Q - \mu + \sigma L(z))$$

We have:

$$E[sales]\ (units) = \mu - \sigma L(z) = 185 - 10 * 0.4349 = 180.651$$
$$E[leftover]\ (units) = Q - E[sales] = 194 - 180 = 4$$
$$E[\pi] = \$7965.1$$

The supplier's profit is 184*(55-25) = $5520.
Total supply chain's profit = $13485.

Solutions

b. Supply chain optimal quantity

$c_u = \$100 - \$25 = \$75.$

$c_0 = \$25 - \$5 = \$20.$

The supply chain's critical ration is: $\frac{c_u}{c_u + c_0} = \frac{75}{95} = 0.7894$

$$z = \Phi^{-1}(0.7894) = 0.81$$

So the retailer's optimal order quantity is:

$$Q = \mu + \sigma z = 185 + 0.81 * 10 \approx 193$$

We can evaluate the integrated chain's expected profit:

$$E[sales]\,(units) = \mu - \sigma L(z) = 185 - 10 * 0.1181 \approx 183.819$$

$$E[leftover]\,(units) = Q - E[sales] = 193 - 183 = 10$$

$E[\pi] = \$100 * 184 - 25 * 193 + 5 * 10 = \$13{,}625.$

Solutions

Critical ratio (f is up-front fee, θ is the revenue sharing percentage for the retailer): $\frac{p-c}{p-s} = \frac{\theta p - f}{\theta p - s}$

So:

$$\frac{75}{95} = \frac{100\theta - 20}{100\theta - 5}$$

$$\theta = .7625$$

The expected profit is the same as in the integrated firm case, which is $=$ $\$13{,}625$.

Solutions

Optimal buy back price:

$$\frac{p-c}{p-s} = \frac{p-w}{(w-b)+p-w}$$

So: $b = p - (p-w) * \frac{p-s}{p-c} = 100 - (100-55) * \frac{100-5}{100-25} = \$43$

$$\frac{c_u}{c_u + c_0} = \frac{75}{95} = 0.789$$

$$z = \Phi^{-1}(0.789) = 0.81$$

So the retailer's optimal order quantity is:

$$Q = \mu + \sigma z = 185 + 0.81 * 10 \approx 193$$

Retailer's expected profit:

$$E[sales]\ (units) = \mu - \sigma L(z) = 185 - 10 * 0.1181 \ \approx 183.819$$
$$E[leftover]\ (units) = Q - E[sales] = 193 - 183.819 = 10$$
$$E[\pi] = 100 * 184 - 55 * 193 + 43 * 10 = \ \$8215$$

Supplier's profit:

$E[profit] = 194 * (55 - 25) - 10 * 43 = \$5390.$