Supply Chain Coordination using contracts

Agenda

- Recap
- Betting on uncertain demand – the newsvendor model
- The problem of Double Marginalization
- Using Contracts to Manage a Specific Supply Chain Risk
- Conclusion

RECAP

Sunglasses supply chain

- Refer Handout
- How many units of 'Bassano' should the UV's Maimi beach store order?

Newsvendor model

- Inventory decision under uncertainty
- The "too much/too little problem":
  - Order too much and inventory is left over at the end of the season
  - Order too little and sales are lost.
- Can be generalized to many other contexts
  - Fire crackers
  - Apparel – seasonal time horizon
  - Airline seat class – perishable service
  - Electronic goods with upgrade cycles

Notation

- Demand **D** is a random variable
  - Cumulative distribution function **F(D)**
- Wholesale price **W**
- Selling price **R**
- Salvage value **S** (**<W**)
- How much should the retailer order?

"Too much" and "too little" costs

- C_o = overage cost
  - The cost of ordering one more unit than what you would have ordered had you known demand.
  - Increase in profit you would have enjoyed had you ordered one unit lesser.
  - For UV, C_o = *Cost – Salvage value* = $W - S$ = *Solve here*
- C_u = underage cost
  - The cost of ordering one fewer unit than what you would have ordered had you known demand.
  - Increase in profit you would have enjoyed had you ordered one unit more.
  - For UV, C_u = *Price – Cost* = $R - W$ = *Solve here*
- How many units of 'Bassano' should the Maimi beach store order?

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Balancing the risks and benefits

- Risk : Ordering one more unit increases the chance of overage
  - Expected loss on the Q^{th} unit = C_o x F(Q), where F(Q) = Prob{Demand <= Q)
- Benefit: Ordering one more unit decreases the chance of underage:
  - Expected benefit on the Q^{th} unit = C_u x (1-F(Q))

Expected profit maximizing order quantity

- To minimize the expected total cost of underage and overage, order Q units so that the expected marginal cost with the Q^{th} unit equals the expected marginal benefit with the Q^{th} unit:

$$C_o \times F(Q) = C_u \times (1 - F(Q))$$

- Rearrange terms in the above equation -> $F(Q) = \frac{C_u}{C_o + C_u}$

- The ratio C_u / (C_o + C_u) is called the *critical ratio.*
  - In other terms, *(R-W)/(R-S). R and S are determined by the market.*
- UV's ordering decision – excel file
  - Critical ratio = (115-75)/(115-25)= 0.444

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Determination of the final ordering quantity

- Final ordering quantity
  - $Q^* = F^{-1}[(R-W)/(R-S)]$
- Final Ordering Quantity
  - Norm.inv(0.444,250,125) = 234 units

Other performance metrics

- Other performance metrics
  - Expected number of shortages given the ordering quantity
    - $L(Q) = \sigma * L(z)$
      - $L(z)$: probability loss function
  - Expected sales given the ordering quantity
    - $S(Q) = \mu - L(Q)$
  - Expected leftover
    - $V(Q) = Q - S(Q)$

Other performance metrics Contd.

- Stockout probability
  - $1-F[(R-W)/(R-S)]$
- Expected profit of the buyer
  - $Co*S(Q)+Cu*V(Q)$
- UV's expected profit?
  - $5555

Thinking of the supplier

- Zamatia's manufacturing cum shipping costs per unit of 'Bassano'
  - **M** = $35
- Zamatia's profit?
  - 234*$75 – 234*$35= $9360
- Put together both are now earning
  - $5555 + $9360 = $14915

Integrated supply Chain profit

- What if Zamatia and UV were one business entity?
- C_u = R – W = ?
- $C_o = W - S = W - M = ?$
- OQ = ?
- Final expected profit = ?

Double Marginalization

- Why does the supply chain perform significantly worse than it could?
  - UV maximizing its own profit
  - UV stocking less
  - Actual production cost does not matter for UV
- **Even if every firm in a supply chain chooses actions to maximize its own expected profit, the total profit earned in the supply chain may be less than the entire supply chain's maximum profit.**

Can Zamatia decide on a better W?

- Supplier can choose W to increase profits further
- Zamatia's profit = (W-M)*Q(W)
- Zamatia knows UV's Q(W)
- Change W to 85.9
  - Zamatia makes $ 9861; UV makes $3234 ☹
- If W is 65 instead
  - Zamatia makes $8056; UV makes $8025 ☺
- Can we do better than this???

Aligning incentives…

- Marginal cost pricing:
  - Zamatia charges $35 per sunglass, then UV's critical ratio equals the supply chain's critical ratio.
  - But Zamatia makes zero profit.
- What they need is a method to share inventory risk so that the supply chain's profit is maximized (coordinated) and both firms are better off.

Buy-back contract

- Zamatia buys back left over inventory at the end of the season.
  - At a rate higher than the salvage price to UV
  - Zamatia salvages the sunglasses
- Say, Zamatia buys back from UV at **B** = $70
  - C_u = R – W = ?
  - C_o = $R - B$ = *?*
  - OQ = ?

More on buy-back contracts

- How do they improve supply chain performance?
  - The retailer's overage cost is reduced, so the retailer stocks more.
  - With a buy-back the supplier shares with the retailer the risk of left over inventory.
- Other uses for buy-back contracts:
  - Allow for the redistribution of inventory risk across the supply chain.
  - Helps to protect the supplier's brand image by avoiding markdowns.
  - Allows the supplier to signal that significant marketing effort will occur.

Role of Power

- What if one of the player is more powerful?
  - They would seek a higher proportion of profit.

Other methods to align incentives

- Revenue sharing:
  - Supplier accepts a low upfront wholesale price in exchange for a share of the revenue.
  - Under appropriately chosen parameters, the retailer has an incentive to stock more inventory, thereby generating more revenue for the supply chain.

Comparing RS and BB contracts

Buyback contracts

- Buyback contracts
  - Reduces overage costs

Revenue Sharing contracts

- Revenue Sharing contracts
  - Reduces underage cost

For every buyback contract, there is an equivalent revenue sharing contract.

$$W_B = W_R + r; B = r + S$$

Options contract

- What are they?
  - The buyer purchases the option to buy at a future time.
  - Each option costs p_o and it costs p_e to exercise each option.
- How can they improve supply chain performance?
  - Provides an intermediate level of risk:
    - Fixed long term contract requires a commitment at a price greater than p_o.
    - Procuring on the volatile spot market could lead to a price greater than $p_o + p_e$.
- Where are they used?
  - Semiconductor industry, energy markets (electric power), commodity chemicals, metals, plastics, apparel retailing, air cargo, …

Other methods to align incentives

- Quantity discounts:
  - Used to induce larger downstream order quantities so that downstream service is improved and/or handling and transportation efficiency is improved.
- Franchise fees:
  - Marginal cost pricing coordinates actions, but leaves the upstream party with no profit.
  - So charge a franchise fee to extra profit from the franchisee.

Downsides of contracts

- Determination of the right set of contract parameters is a challenge
- Additional administrative burden
- Verification costs
- Arbitrage/credit risk
- Impact of sales effort
- Multiple competing retailers

Summary

- Coordination failure:
  - Supply chain performance may be less than optimal with decentralized operations (i.e., multiple firms making decisions) even if firms choose individually optimal actions.
- A reason for coordination failure:
  - The terms of trade do not give firms the proper incentive to choose supply chain optimal actions.
- Why fix coordination failure:
  - If total supply chain profit increase, the "pie" increases and everyone can be given a bigger piece.
- How to align incentives:
  - Design terms of trade to restore a firm's incentive to choose optimal actions.

Thank you