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

Zamatia Ltd. (pronounced zah-MAH-tee-ah, to the cognoscenti) is an Italian upscale maker of eyewear. UV Inc., short for Umbra Visage, is one of their retailers in the United States. To match UV's stylish assortment, UV only operates small boutique stores located in trendy locations. We focus on one of their stores located in Miami Beach, Florida. Zamatia manufactures its sunglasses in Europe and Asia, so the replenishment lead time to the United States is long. Furthermore, the selling season for sunglasses is short and styles change significantly from year to year. As a result, UV receives only one delivery of Zamatia glasses before each season. As with any fashion product, some styles sell out quickly while others are left over at the end of the season.

Consider Zamatia's entry-level sunglasses for the coming season, the Bassano.

- UV purchases each one of those pairs of sunglasses from Zamatia for $75 and retails them for $115.
- Zamatia's production and shipping costs per pair are $35.
- At the end of the season, UV generally needs to offer deep discounts to sell remaining inventory; UV estimates that it will only be able to fetch $25 per leftover Bassano at the Miami Beach store.
- UV's Miami Beach store believes this season's demand for the Bassano can be represented by a normal distribution with a mean of 250 and a standard deviation of 125.

The big question

- 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