Contracts to Coordinate
Contracts to Coordinate Supply Chain Costs

◆ Differences in costs at the buyer and supplier can lead to decisions that increase total supply chain costs
  – Ex: Replenishment order placed by the buyer. The buyer’s EOQ ignores the supplier’s costs.
◆ A quantity discount contract may encourage the buyer to purchase a larger quantity (which would lower costs for the supplier). This would result in lower total supply chain costs.
◆ A contract is said to be coordinating a supply chain if the sum of the profits of various decision makers under the contract is equal to the profit of a single decision maker.
Buyback Contracts

- Allows a retailer to return any unsold inventory to supplier at an agreed upon price.
- Increases the optimal order quantity for the retailer, resulting in
  - higher product availability and
  - higher profits for both the retailer and the supplier
- Downsides that buyback contract results in
  - Surplus inventory for the supplier
  - Inflated retail orders, not actual customer demand
- Most effective for products with low variable cost, such as music, software, books, magazines and newspapers so that
  - profit margin is high, product availability is critical
  - consequence of supplier’s surplus inventory is little
Impact of SC Contracts on Profitability: Buyback Contracts

- **Buybacks by publishers**
  - Practice: Custom books are not bought back!
  - Unsold regular books are returned to the publishers at a lower price than the bookstores initially pay. All the unsold books are returned back to the publisher.

- **Buyback by TF**
  - Tech Fiber (TF) produces jackets and sells to Ski Adventure (SA) which sells them in the market. Unsold jackets have no salvage value. Should TF be willing to buy back unsold jackets? Why?

\[\begin{array}{c}
\text{Cost} = \$5 \\
\text{Wholesale Price} = \$100 \\
\text{Market Price} = N(1000, 300^2)
\end{array}\]
Impact of SC Contracts on Profitability: Buyback Contracts

- **Buyback by HP**
  - HP manufactures Pavilion laptops, and sells to its retailer BestBuy. Each Pavilion costs $500 to produce, wholesales price is $700 and retail price is $1000. When a newer model is released, HP promises to buy back the left over laptops at $200 and HP can donate their leftover to charity and gain $50 in tax credit. If $a=$overage cost, $b=$underage cost for BestBuy, what is $(a,b)$ with and without the contract?
    - (700, 300) without contract
    - (500, 300) with contract

- **Buyback by Panasonic**
  - Panasonic sells a DVD player at $120 to BestBuy. BestBuy sells them at $150 to consumers. Unsold players are sold at discount price of $100 to customers, Panasonic compensates BestBuy for $120-100=$20 per player. Is this a buyback scheme, if so what is the buyback price?
    - Hint: Can BestBuy sell all the DVD players at the discount price? Answer: No.
Profits under Centralization (Merger)

c: Supplier’s purchase/production cost;  w: wholesale price
p: Retailer’s sales price;  F(.) cumulative density function of demand

From aside after the summary of this slides, Sales(y) and the change in the sales as function of inventory level y.

\[ \text{Sales}(y) = \int_0^y (1 - F(x)) \, dx; \quad \text{Derivative of Sales}(y) = (1 - F(y)) \]

Coordinated Profits(y) when supplier-retailer merge = \{ p \} [Sales(y)] - < c > y

Derivative of Coordinated Profits(y) = \{ p \} (1 - F(y)) - < c >= 0

Optimal order quantity = \[ y_c^* = F^{-1} \left( 1 - \frac{< c >}{\{ p \}} \right) = F^{-1} \left( \frac{p - c}{c + p - c} \right) \]

This is nothing but the newsvendor formula with understocking cost \( p-c \) and overstocking cost \( c \).
Separately Deciding and Acting

\( b : \) buyback price

Supplier Profit(\( b \mid y \)) = \( wy - b(y - \text{[Sales(y)]}) - cy = b[\text{Sales(y)}] - (c - (w - b))y \)

Retailer Profit(\( y \mid b \)) = \(-wy + b(y - \text{[Sales(y)]}) + p[\text{Sales(y)}] = b \{ p - b \}[\text{Sales(y)}] - (< w - b >)y \)

Retailer's optimal order quantity = \( y_R^*(b) = F^{-1}\left(1 - \frac{< w - b >}{p - b}\right) \)

Retailer orders centralized quantity when \( F^{-1}\left(1 - \frac{< c >}{p}\right) = F^{-1}\left(1 - \frac{< w - b >}{p - b}\right) \) which implies

\[ b^c : = \frac{w - c}{1 - c/p} \]

Buyback price \( b^c \) coordinates the supply chain:
With this buyback price, Supply chain achieves the same profits (for any realization of demand) that it does achieve under the merger scenario.
Split of Profits with the Buyback Contract

Given cost $c$, wholesale price $w$ and price $p$,

\[
\text{Retailer's Profit}(y|b^c) = \frac{p-w}{p-c} \quad \text{Centralized Profit}(y)
\]

Retailer obtains the big portion of the profits when the wholesale price is far smaller than the sales price.
### Buyback Contracts: $c=\$5; \ p=\$200$

<table>
<thead>
<tr>
<th>Wholesale Price $w$</th>
<th>Buy Back Price $b$</th>
<th>Optimal Order size for SA</th>
<th>Expected Profit for SA</th>
<th>Expected Returns to TF</th>
<th>Expected Profit for TF(suplr)</th>
<th>Expected Supply Chain Profit</th>
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<tr>
<td>$100$</td>
<td>$0$</td>
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<td>$106,310$</td>
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</tbody>
</table>

$\text{b}_c^c := \frac{w - c}{1 - c/p} = \frac{100 - 5}{1 - 5/200} \approx 95$; $\text{b}_c^c = \frac{110 - 5}{1 - 5/200} \approx 105$; $\text{b}_c^c = \frac{120 - 5}{1 - 5/200} \approx 116$

What happens to the supplier profit with the buyback contract?
Does a buyback contract increase profits?

Which of these are true?

- Buyback contract increases the expected supply chain profit
- supplier profit
- retailer profit
- sales to the market
- sales to the retailer
- demand
Revenue Sharing Contracts

- The buyer pays a minimal amount for each unit purchased from the supplier but shares a fraction of the revenue for each unit sold.
- Decreases the cost per unit charged to the retailer, which effectively decreases the cost of overstocking.
- When the overstocking cost drops, retailer’s order quantity rises.
- Misleading for the supply chain as it reacts to (inflated) retail orders, not to actual customer demand.
Usual Manufacturer – Retailer Supply Chain

Variable Production Cost=$40

Wholesale Price=$70

Selling Price=$100
Revenue Sharing (RS) Contracts

If the manufacturer reduces wholesale price to $w_{rs}$, the retailer can share a percentage of the revenue $p$.

Wholesale Price $= w_{rs} = $50

Production Cost $= $40

Manufacturer

Selling Price $= $100

Retailer

$1 - \theta$: Revenue sharing portion 50%
Blockbuster Case

◆ Demand for a newly released movie typically starts high and decreases rapidly
  – Peak demand lasts about 10 weeks
◆ Blockbuster purchases a copy from a studio for $65 and rents for $3
  – Blockbuster (retailer) must rent the tape at least 22 times before earning profit
◆ Retailers cannot justify purchasing a movie (cassette) by covering the peak demand
  – In 1998, 20% of surveyed customers reported that they could not rent the movie they wanted because the Blockbuster stores did not have that movie.
◆ In 1998, Blockbuster started revenue sharing with the major movie studios
  – In general, the retailer pays the wholesale price $w_{rs}$.
    » Studio charges $w_{rs} = $8 per copy.
  – In general, the retailer shares (1-$\theta$) portion of the sales revenue with the supplier.
    » Blockbuster pays (1-$\theta$)=30-45% of its rental income.
◆ Even if Blockbuster keeps only half of the rental income, the breakeven point is 6 rental per copy
◆ The impact of revenue sharing on Blockbuster was dramatic
  – Rentals increased by 75% in test markets due to higher video availability
  – Market share increased from 25% to 31% (The 2nd largest retailer, Hollywood Entertainment Corp has 5% market share)
Buyback = Revenue Sharing if …

Buyback contract: The retailer
- pays $w$ for each unit purchased from supplier
- gets $b$ for each unit unsold to market
  Equivalently,
- pays $w - b$ for each unit purchased from supplier
- pays $b$ more for each unit sold to market

Revenue Sharing: The retailer
- pays $w_{rs}$ for each unit purchased from supplier
- pays $(1-\theta)p$ more for each unit sold to market

The contracts are the same if
- $w_{rs} = w - b$ for each unit purchased from supplier
- $(1-\theta)p = b$ more for each unit sold to market

If the supplier cares about the time value of money (prefers to receive payments earlier and to send payments later), does it prefer a buyback or a (n equivalent) revenue sharing contract?
Quantity Flexibility Contracts

- Allows the buyer to modify the order (within limits) as demand visibility increases towards the point of sale
- Better matching of supply and demand
- Increased overall supply chain profits if the supplier has flexible capacity
- Lower levels of misleading demand information than either buyback contracts or revenue sharing contracts
1. Retailer knows the demand $D$ distribution $F$ and decides to order $q > E(D)$.

2. Supplier guarantees to supply $q(1+\alpha)$, $\alpha \geq 0$.
   Retailer guarantees to buy $q(1-\beta)$, $0 \leq \beta \leq 1$.
   Supplier produces $Q \geq q(1+\alpha)$.

3. Demand realizes as $D = d$ and the retailer buys
   $\text{Min}\{\text{Max}\{q(1-\beta), d\}, q(1+\alpha)\}$

Uncertainty reduction for
Retailers by avoiding lack of supply availability
Suppliers by avoiding lack of retailer demand
Insights from Quantity Flexibility Contract

◆ Without coordination the supplier produces less than with coordination.
◆ The contract is advantageous to the retailer only if $Q < q(1 + \alpha)$.
  – Otherwise, the supplier orders more than the contract would have indicated without the contract.
  – If such a high order is optimal for the supplier without the contract, it should also be optimal with the contract.
  – Then the retailer does not benefit by committing to buy $q(1 - \beta)$ with the contract.
◆ The supplier can coordinate the chain by setting the wholesale price appropriately.
  – See course notes to find out how the wholesaler price $w$ is computed.
## Quantity Flexibility Contracts

<table>
<thead>
<tr>
<th>$\alpha$</th>
<th>$\beta$</th>
<th>Wholesale price w</th>
<th>Order size O</th>
<th>Expected purchase by SA</th>
<th>Expected sale by SA</th>
<th>Expected profits for SA</th>
<th>Expected profits for TF(supp)</th>
<th>Expected supply chain profit</th>
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Larger values of $\alpha$ and $\beta$ give more flexibility to the retailer. Supplier prices for this flexibility via the wholesale price w.
Summary

- Contracts
  - Buyback
  - Revenue Sharing
  - Quantity Flexibility
Aside

Sales(y): Expected sales with inventory y

- If we increase inventory from y to y+1, how much does the sales increase? In other words, what is Sales(y+1)-Sales(y)?

\[ \text{Increase In Sales} \]

Demand is more than y, so y+1st inventory can be sold
\[ 1 - F(y) \]

\[ y \leftarrow y+1 \]

Demand is less than or equal to y, so y+1st inventory cannot be sold
\[ F(y) \]

- When we increase the inventory from 0 to 1, the expected sales increase from 0 to \((1-F(0))\). Increasing inventory from 1 to 2 increases sales by an additional amount of \((1-F(1))\). Increasing inventory to 3 increases sales by \((1-F(2))\). Increasing inventory to y increases sales by \((1-F(y-1))\), summing these increases up:

\[
\text{Sales}(y) = (1 - F(0)) + (1 - F(1)) + \ldots + (1 - F(y-1)) = \sum_{x=0}^{y-1} (1 - F(x)) \approx \int_0^y (1 - F(x))dx
\]

\[
\text{Sales}(y) = \int_0^y (1 - F(x))dx; \quad \text{Derivative of Sales}(y) = 1 - F(y)
\]