Comparison of Two Outsourcing Structures under Push, Pull and Two-Wholesale-Price Contracts

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Global Outsourcing

AMR report: …About 65% of the brand-owners/OEMs and CMs located primarily in North America frequently used CMs in mainland China and Taiwan…. (Swanton et al. 2005)
Global Outsourcing: Apparel

- Apparel companies that had vertically integrated supply chains, with US owned manufacturing have gone to non-owned, package sourced product from the Far East.

- L&M Global Sourcing, a factory group with facilities in China, Bangladesh and Central America, is serving Target, Macy's, Wal-Mart, Guess, Michael Kors, Nautica and others.
Issues in Outsourcing

- Outsourcing: enlarge the distance between the supply chain parties and lengthen the manufacturing lead time.
- Fashion and High-tech products: short sales season, high demand uncertainty.
- Production planning and capacity decisions are made before demand is observed.
- High Inventory Risk on the suppliers and contract manufacturers (CMs).
- Component and part shortages lead to supply chain disruption.
Two Wholesale-Price Contract

- Two wholesale-price contract
  - First-period wholesale prices: Prebook order
  - Second-period wholesale prices: At-once order
- It helps re-allocate inventory risk and its availability among the supply chain parties through the timing of the order
  - Pull: No prebook in first period.
  - Partial Commitment: Both prebook and at-once order exist.
  - Push: Only prebook in first period, no at-once order.
- Example: O'Neill, a fashion company which designs and sells apparel for water sports, allows its retailers such as REI to make an advance purchase at a discounted wholesale price
Research Questions

- Study the impact of the two-wholesale-price contracts in a three-tier supply chain consisting of the OEM, CM and supplier under different outsourcing structures (delegation and control)
  - What are the optimal pre-book equilibrium quantities?
  - What are the amount of inventory the CM and the supplier build up in anticipation of the at-once order?
  - How does the wholesale prices affect the inventory allocation between the supply chain parties?
  - Which outsourcing structure will be preferred by the OEM?
Literature review

- Two wholesale-price contract
  - Cachon (2004)
  - Dong and Zhu (2007)

- Quantity commitment
  - Ferguson (2003), Ferguson et al. (2005)
  - Ozer et al. (2005)…

- Decentralized capacity decision in multiple-tier supply chains
  - Bernstein and DeCroix (2004)
  - Bernstein et al. (2007)…

- Delegation and control structures
  - Kayis et al. (2007)
  - Chen et al. (2006)
  - Guo et al. (2006)…
Two-Wholesale Price Contract: Control

• Three-stage decision sequence

• Stage 1: OEM prebooks to the CM and supplier, \( q_{m1} \) (\( w_{m1}, w_{m2} \)) and \( q_{s1} \) (\( w_{s1}, w_{s2} \)) respectively. WLOG, \( w_{m1} \leq w_{m2}, w_{s1} \leq w_{s2} \);

• Stage 2: Anticipating the at-once order in sales season, the CM and supplier produce extra \( q_{m2} \) (\( q_{m1}, w_{m2} \)) and \( q_{s2} \) (\( q_{s1}, w_{s2} \) ); Assume \( p > w_{m2} + w_{s2} \).

(Demand is observed)

• Stage 3: The OEM makes the at-once order based on the observed demand and the available inventory.
Two-Wholesale Price Contract: Delegation

- **Stage 1:** The OEM prebooks \( q_{m1} (w_{m1} + w_{s1}, w_{m2} + w_{s2}) \) to the CM; the CM prebooks \( q_{s1} (q_{m1}, w_{s1}, w_{s2}) \) to the supplier;
- **Stage 2:** Anticipating the at-once order, the CM and the supplier produce \( q_{m2} (q_{m1}, w_{m2} + w_{s2}) \) and \( q_{s2} (q_{s1}, w_{s2}) \), respectively; (Demand is observed)
- **Stage 3:** The OEM makes at-once order to CM and the CM makes another at-once order to the supplier (if needed) based on demand and available inventory.

\[
q_{s1}(q_{m1}, w_{s1}, w_{s2}) \quad q_{m1}(w_{m1} + w_{s1}, w_{m2} + w_{s2})
\]

\[
q_{s2}(q_{s1}, w_{s2}) \quad q_{m2}(q_{m1}, w_{m2} + w_{s2})
\]
Assumptions

- Common knowledge: demand distribution, market price $p$ and production costs ($c_s$ and $c_m$).
- Wholesale prices are set before orders and production take place
- Excess inventory has zero salvage value.
- Denote the isolated Newsvendor production quantities of the CM and supplier with respect to the second period wholesale prices as $K_m$ and $K_s$. 
Under both control and delegation, given the prebook quantities and anticipating the second period at-once order,

- the CM will produce the following additional amount:

\[ q_{m2} = (K_m \land K_s - q_{m1})^+ \]

- The supplier will produce the following additional amount:

\[ q_{s2} = (K_m \land K_s - q_{s1})^+ \]
First Stage Equilibrium Analysis: $K_m = K_s = K$

- Prebook equilibrium: Control
  - The OEM partially commits and orders
    \[ q_{m1}^C = \bar{F}^{-1}(w_{m1}/w_{m2}), \quad q_{s1}^C = \bar{F}^{-1}(w_{s1}/w_{s2}) \]
  - The OEM pushes both the CM and supplier
    \[ q_{m1}^C = q_{s1}^C = \max \left( \bar{F}^{-1} \left( \frac{w_{m1} + w_{s1}}{p} \right), K \right) \]
First Stage Equilibrium Analysis: $K_m = K_s = K$

- Prebook equilibrium: Delegation
  - Given the OEM’s prebook $q_{m1}$, the CM’s best response function is to prebook to the supplier
    
    $q_{s1}^D = \max\left\{ q_{m1}, F^{-1}\left(\frac{w_{s1}}{w_{s2}}\right) \right\}$
  - The OEM either partially commits or fully pushes the CM
    
    $q_{m1}^D = F^{-1}\left(\frac{w_{m1} + w_{s1}}{w_{m2} + w_{s2}}\right)$

    $q_{m1}^D = \max\left( F^{-1}\left(\frac{w_{m1} + w_{s1}}{p}\right), K \right)$
System Performance When $K_m=K_s=K$

- No matter which strategy the OEM adopts, the OEM (weakly) prefers control to delegation, and the CM (weakly) prefers delegation to control. The supplier and the overall supply chain are indifferent.

- If $\frac{w_{m1} + w_{s1}}{p} \geq (\frac{c_m}{w_{m2}} = \frac{c_s}{w_{s2}})$, then the OEM will only choose the partial commitment strategy under both control and delegation.

- If the OEM adopts the push strategy, then every supply chain party is indifferent to the choice between control and delegation.
First Stage Equilibrium Analysis: Km<Ks

- Prebook equilibrium: Control
  - The OEM partially commits
    \[ q_{m1}^{C} = F^{-1}\left(\frac{w_{m1}}{w_{m2}}\right), \quad q_{s1}^{C} = F^{-1}\left(\frac{w_{s1}}{w_{s2}}\right) \wedge K_{m} \]
  - The OEM pushes only the CM
    \[ q_{s1}^{C} = F^{-1}\left(\frac{w_{s1}}{w_{s2}}\right), \quad q_{m1}^{C} = \max\left(F^{-1}\left(\frac{w_{m1}}{p - w_{s2}}\right) \wedge K_{s}, K_{m}\right) \text{, if } \frac{w_{s1}}{w_{s2}} \geq \left(\frac{w_{m1}}{p - w_{s2}} \wedge \frac{c_{m}}{w_{m2}}\right) \]
    \[ q_{m1}^{C} = q_{s1}^{C} = \max\left(F^{-1}\left(\frac{w_{m1} + w_{s1}}{p}\right), K_{m}\right) \text{, if } \frac{w_{s1}}{w_{s2}} \leq \left(\frac{w_{m1} + w_{s1}}{p} \wedge \frac{c_{m}}{w_{m2}}\right) \]
  - The OEM pushes both the CM and supplier
    \[ q_{m1}^{C} = q_{s1}^{C} = \max\left(F^{-1}\left(\frac{w_{m1} + w_{s1}}{p}\right), K_{s}\right) \]
First Stage Equilibrium Analysis: $K_m < K_s$

- Prebook equilibrium: Delegation
  - Given the OEM’s prebook $q_{m1}$, the CM’s best response:
  
  $$q_{s1}^D = \max \left\{ q_{m1}, K_m \wedge \bar{F}^{-1} \left( \frac{w_{s1}}{w_{s2}} \right) \right\}$$

  - The OEM’s prebook strategy:
    - The OEM partially commits to the CM
      
      $$q_{m1}^D = \bar{F}^{-1} \left( \frac{w_{m1} + w_{s1}}{w_{m2} + w_{s2}} \right) \wedge K_m$$
    - The OEM pushes the CM
      
      $$q_{m1}^D = \max \left( \bar{F}^{-1} \left( \frac{w_{m1} + w_{s1}}{p} \right), K_m \right)$$
System Performance: $K_m < K_s$

No matter which strategy the OEM adopts, partial commitment or push, control is always preferred by the OEM.
First Stage Equilibrium Analysis: \( K_m > K_s \)

- We can derive similar prebook equilibrium quantities as those under \( K_m < K_s \) for both control and delegation.
- We find that control may not be beneficial to the OEM.
- Delegation may be preferred by the OEM.
The Impact of Wholesale Prices on Prebook Equilibrium

- Fix the second period wholesale prices and study how the first period wholesale prices affect the OEM’s equilibrium prebook strategy.
- We show that as the prebook prices increases, the advantage of taking full inventory responsibility over partial one diminishes for the OEM.
- We show that Pareto improvement can be achieved for all the parties in the push regime by reducing the wholesale prices.
The Impact of Demand on Outsourcing Structure Performance

When the c.v. of market demand distribution is decreasing, the OEM’s profit difference between the two outsourcing structures decreases.
The Impact of Information Asymmetry

- Assume that the supplier has vaguer demand information than the CM.
- We show that the supplier may establish a larger/smaller production quantity than the CM.
- This affects the performance of delegation and control and thus the optimal choice of the outsourcing structure.
Conclusions

- Control is more beneficial to the OEM as long as the supplier has incentive to build (weakly) more inventory than the CM
- Delegation may be preferred by the OEM
- Pareto Improvement opportunity exists for control/delegation structure under the push regime
- Information asymmetry affects the optimal choice of outsourcing structures, and the incentives of the supplier and CM to build up inventory
Thank you!

Q & A