Renegotiation & Relationships in Supply Chain Management

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Questions

1. Under what circumstances are supply contracts renegotiated?

2. In what context is incorporating renegotiation important for fidelity of model?

3. What managerial insights can be obtained by modeling renegotiation?
Contracting for Supply: Sharing Demand Forecasts
(Cachon and Lariviere, 2001)

- Supplier must build capacity before demand is realized
  - prior: buyer’s demand = \( \begin{cases} 
  HX & \text{with probability } \rho \\
  LX & \text{with probability } 1-\rho 
\end{cases} \)

- Buyer knows demand forecast \( \{H, L\} \)

- H-Buyer offers higher price to signal H → supplier builds more capacity than with common forecast information
Signalling and Renegotiation (Beaudry & Poitevin, 1993)

- Allow infinitely many rounds of contracting + renegotiation
  - buyer makes TIOLI offers?
  - then, supplier builds capacity

- Equilibrium outcome in 2 Offers
  1. Pooling: L- and H-buyer offer same terms
  2. Separation: too-high price & capacity for H-buyer

- Equilibrium outcome depends on supplier’s prior ρ

- Renegotiation results in greater expected profit for both firms
Renegotiation Design *(Aghion, Dewatripont & Rey 1994)*

Give all bargaining power in renegotiation to one firm
- penalty for delay in bargaining (e.g. financial “hostage”)

**Contract:**
- price
- quantity
- information
- renegotiate

Buyer investment stimulates demand
- revenue(quantity)

Supplier investment reduces production cost
- production cost(quantity)

Investments maximize total expected profit

**Simple Contract + Renegotiation is OPTIMAL**

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**Economics Lit. on Procurement with Renegotiation**

**Incentives for Investment**
- simple contract + renegotiation is optimal *ADR 94, Chung 91, Noldeke & Schmidt 98, Edlin & Reichelstein 96*
- NO contract > incomplete contract for cooperative investment, e.g. quality *Che & Hausch 99*

**Pre-contractual Private Information**
- signalling *Beaudry & Poitevin 93*
- informed principal *Maskin&Tirole 90, 91*
- supplier cost reduction *Laffont&Tirole 90*
- delay in outsourcing *Hart & Tirole 88*
Capacity Allocation: Are Simple Contracts + Renegotiation Optimal?

Model: Supplier with N buyers
- contract for capacity
- investments in capacity & innovation
- renegotiate capacity allocation

Theory: Court remedy for breach affects
- renegotiation
- investments
- optimal contract structure
- profitability

Court Remedy for Breach of Contract

<table>
<thead>
<tr>
<th>Expectation Damages</th>
<th>Specific Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>pay $ to put injured firm in same financial position as if contract were performed</td>
<td>must perform contract (prohibitively large $ penalty)</td>
</tr>
<tr>
<td>supplier can deliver &lt; Q and pay for lost revenue or substitute capacity</td>
<td>supplier must deliver Q unless buyer agrees to less</td>
</tr>
<tr>
<td>routine</td>
<td>increasingly common in procurement</td>
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</table>
Are Simple Contracts + Renegotiation Optimal?

- Contract quantity $Q_i$, $i=1..N$
- Buyers invest $e_i$ in R&D, manufacturer builds capacity $c$
- Demand is realized $R_i(q; \omega)$
- Renegotiate if contract is inefficient: $R'_i(Q_i; \omega) > R'_j(Q_j; \omega)$
- Optimal allocation of capacity: $\max \sum_{i=1}^{N} R_i(q_i; \omega)$

how firms share gain from renegotiation depends on breach remedy

Contract Design Problem

Firms choose $\{Q_i\}_{i=1..N}$ to:

$$\max \{ E_e \left[ \max \sum_{q_i \leq c} R_i(q_i) \right] - \sum_{i=1}^{N} g_i(e_i) - k c \}$$

subject to

- Buyer $i$ invests in innovation $e_i$ to:
  $$\max \{ E_e \left[ R_i(Q_i) + x_i \right] - g_i(e_i) \}$$
  profit from renegotiation depends on breach remedy

- Supplier invests in capacity $c$ to:
  $$\max \{ E_e \left[ \max \sum_{q_i \leq c} R_i(q_i) - \sum_{i=1}^{N} R_i(Q_i) - \sum_{i=1}^{N} x_i \right] - k c \}$$

SP: $c \geq \Sigma Q_i$ system gain from renegotiation
Are Simple Contracts + Renegotiation Optimal?

<table>
<thead>
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<th>Expectation Damages</th>
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<tbody>
<tr>
<td>dominant (TIOLI) supplier</td>
<td>optimal investment</td>
</tr>
<tr>
<td>buyers have some bargaining power</td>
<td>too little capacity, excess innovation</td>
</tr>
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* requires separability condition

Renegotiation Increases Total Expected Profit
…if the contract is designed for renegotiation

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2 Buyers, Quantity Flexibility Contracts

- optimal contract
- optimal contract assuming no renegotiation

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<table>
<thead>
<tr>
<th>improvement in expected profit due to renegotiation</th>
<th>0%</th>
<th>5%</th>
<th>10%</th>
<th>15%</th>
<th>20%</th>
<th>25%</th>
<th>30%</th>
<th>35%</th>
</tr>
</thead>
<tbody>
<tr>
<td>cost of capacity k</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>16</td>
</tr>
</tbody>
</table>
Summary

- Simple contract + renegotiation may be optimal
- Outcome of renegotiation depends on:
  - court remedy for breach of contract
  - contract design (e.g. financial “hostages”)
  - information asymmetry

Questions

1. Under what circumstances are supply contracts renegotiated?
2. In what contexts is incorporating renegotiation important for fidelity of model?
3. What managerial insights can be obtained by modeling renegotiation?
Discussion Questions

How, fundamentally, does repeated interaction change how firms in a supply chain behave?

What kinds of research approaches can deepen our understanding of this phenomenon?

What are the important research questions our community should address?

Agenda

How Relationships Transform Supply Chains

- Example: Delivery Performance
- Overview of Initial Research
- Discussion
Buyers provide specific instructions for delivery (e.g., time, packaging, labeling)
Buyers penalize suppliers for asserted delivery noncompliance through “charge backs”
Difficult or impossible for third party to verify delivery compliance

In each period $t$ supplier chooses delivery effort $e_t \in [0,1]$ (the probability of on-time delivery)
$g(e_t) = \text{supplier’s cost of effort; convex, increasing}$
$r(e_t) = \text{buyer’s expected revenue}$

Relational contract specifies
formal payment $f_t$
discretionary payment $d_t$ for on-time delivery
supplier strategy: effort $e_t$, whether to transact
buyer strategy: whether to transact,
make discretionary payment

A relational contract is self-enforcing if it describes a subgame perfect Nash equilibrium
Delivery Performance Commonly Observed – Optimal Relational Contract Design Problem

\[
\begin{align*}
\max_{\{e, f, d\}} \ & \{r(e) - g(e)\} \\
\text{subject to } & \ e \in \arg \max_{\hat{e}} \ \{\hat{e}d - g(\hat{e})\} \quad \text{supplier chooses designated effort} \\
& \ r(e) - f - ed \geq b \quad \text{buyer participates profit without cooperation} \\
& \ f + ed - g(e) \geq s \quad \text{supplier participates} \\
& \ -d + \frac{\delta}{1-\delta}[r(e) - f - ed] \geq \frac{\delta}{1-\delta} b \quad \text{buyer makes discretionary payment}
\end{align*}
\]

Because firms can split profit via transfer payments, objective is to maximize system profit. Firms cooperate if and only if other firm has cooperated in all previous periods.

Delivery Performance Commonly Observed – Optimal Relational Contract

\[
\begin{align*}
S^c = \max_e \ & \{r(e) - g(e)\} \\
\text{subject to } & \ \frac{\delta}{1-\delta}[r(e) - g(e) - (b \cdot s)] \geq g(e)
\end{align*}
\]

Let \(e^c\) denote the solution to the above and \(e^*\) denote the solution for the integrated system. An optimal relational contract is

\[
\begin{align*}
ed_i & = e^c \\
d_i & = g(e^c) \\
f_i & = s \cdot g(e^c) \circ e^c \
\end{align*}
\]

Supplier underinvests: \(e^c, e^*\) \(e^c\) and \(S^c\) are increasing in \(g\) and decreasing in \((b \cdot s)\)
Delivery Performance Privately Observed – Optimal Relational Contract Design Problem

\[
\max_{\{e,f,d,\tau\}} \left\{ \frac{r(e) - g(e)}{1 - \delta[1 - (1 - e)\tau]} \right\}
\]

subject to \(r(e) - f - ed \geq 0\)

\[f + ed - g(e) \geq 0\]

\[-d + \left( r(e) - f - ed \right) \delta[1 - (1 - e)\tau] = (1 - \tau) \left( r(e) - f - ed \right) \frac{1 - \delta[1 - (1 - e)\tau]}{1 - \delta[1 - (1 - e)\tau]} \]

Only buyer observes delivery performance
Termination relational contract:
Buyer reports delivery performance truthfully
Following report of unsuccessful delivery, buyer refuses to make discretionary payment & firms terminate relationship with probability \(\tau\)
For simplicity assume \(b = s = 0\)

\[e \in \arg\max_{\hat{e}} \left\{ f + \hat{e}d - g(\hat{e}) + [1 - (1 - \hat{e})\tau] \frac{\delta[r(e) - f - ed]}{1 - \delta[1 - (1 - e)\tau]} \right\}\]

supplier chooses designated effort

Delivery Performance Privately Observed – Optimal Relational Contract

\[S^p = \max_{\{e, \tau\}} \left\{ \frac{r(e) - g(e)}{1 - \delta[1 - (1 - e)\tau]} \right\}\]

subject to \(e \in \arg\max_{\hat{e}} \left\{ [1 - (1 - \hat{e})\tau] \frac{\delta[r(e) - g(e)]}{1 - \delta[1 - (1 - e)\tau]} - g(\hat{e}) \right\}\)

Let \((e^p, \tau^p)\) denote the solution to the above
An optimal relational contract is
\(e_i = g_{\tau^p}[r(e^p) \circ f_j]/[1 - g_{\tau^p}(1 \circ \tau^p)]\)
\(f_j = \{[10 \circ (1 \circ \tau^p)]g(e^p) \circ g_{\tau^p} r(e^p) \circ \delta[10 \circ (10 e^p) \circ \tau^p], r(e^p)\}\)

Private monitoring necessitates termination: \(\tau^p \geq 0\)

Common monitoring (e.g., RFID, 3PL) increases profit: \(S^e \geq S^p\)
but may lead to lower delivery effort: \(e^c < e^p\)
### Economics Literature

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Description</th>
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|                                  | - Under common monitoring, stationary contract optimal  
|                                  | - Under private monitoring in which informed party does not maintain private information from period to period, termination contract optimal                                                                 |
| Abreu, Milgrom, Pearce (1991)    | Under private monitoring, can improve on termination contracts where performance is reviewed every period                                                                                                  |
| Kandori and Matsushima (1998)    | Instead, review performance every $T$ periods                                                                                                                                                                 |
|                                  | Lengthening review period improves incentives by allowing more accurate performance assessment, provided $g$ is sufficiently large                                                                               |

### Overview of Initial Research

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Topic</th>
<th>Description</th>
<th>Insights</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohen, Ho, Ren, Terwiesch (2003)</td>
<td>Sharing demand forecasts</td>
<td>Privately informed buyer shares non-binding forecast with supplier</td>
<td>Empirically, suppliers penalize buyer for unreliable forecasts by providing lower service level</td>
</tr>
<tr>
<td>Terwiesch, Ren, Ho, Cohen (2004)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Plambeck and Taylor (2004)</td>
<td>Joint production</td>
<td>Success of production process depends on efforts of buyer and supplier</td>
<td>Optimal relational contract has simple form (correlated termination), even allowing for Markovian dynamics</td>
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Overview of Initial Research (cont.)

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<th>Insights</th>
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<tbody>
<tr>
<td>Tunca and Zenios (2004)</td>
<td><strong>Auctions vs. Relationships</strong> Suppliers sell low-quality products in auction</td>
<td>Presence of auction may facilitate or undermine ability of supplier to sell high-quality product</td>
</tr>
<tr>
<td></td>
<td>Supplier sells high-quality product through long-term relationship</td>
<td></td>
</tr>
<tr>
<td>Taylor and Plambeck (2003)</td>
<td><strong>Innovative product procurement</strong> Being unable to contractually commit to purchase, buyer instead promises to do so</td>
<td>Type of promise buyer should make depends on exogenous factors</td>
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Limitations of Formal Contracts

At least in some cases, contractual commitments to purchase are not enforced:
“Long-term agreements are not worth the paper they’re written on”
“We can go sue our customers, but that’s not the smartest option” because enforcement is costly and acrimonious:
short-term gain for supplier is outweighed by long-term future loss from damaged relationship

To what extent is firm behavior is driven by long-term relationships rather than the coercive power of court system?
Impact of Repeated Interaction in Contracting Cooperation

Investments
- In capabilities (capacity, reducing production cost)
- Effort to increase value, quality of product

Information Sharing
- Capabilities (capacity, costs)
- Market conditions

Learning
- Infer capabilities of other firm
- Understanding exogenous factors

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