The Length of Contracts and Collusion

Richard Green and Chloé Le Coq
Reported trades by energy volume, Britain, 1 December 2004

<table>
<thead>
<tr>
<th>Length of contract</th>
<th>Electricity</th>
<th>Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day</td>
<td>2.1%</td>
<td>22.6%</td>
</tr>
<tr>
<td>Week</td>
<td>4.4%</td>
<td>10.5%</td>
</tr>
<tr>
<td>Month</td>
<td>29.1%</td>
<td>36.1%</td>
</tr>
<tr>
<td>Quarter</td>
<td>26.3%</td>
<td>14.3%</td>
</tr>
<tr>
<td>Season</td>
<td>38.1%</td>
<td>16.5%</td>
</tr>
</tbody>
</table>

Source: Heren
The issue

• Commodities sold on spot markets and via long-term contracts
• Contracts make one-shot spot markets more competitive (Allaz & Vila, JET, 1993)
• Repeated spot markets can have collusion
• Do contracts affect this?
  – One-period contracts make collusion worse, (Liski and Montero, JET, 2004)
  – Multi-period contracts, this paper
Timing: spot periods and contract rounds

<table>
<thead>
<tr>
<th>Spot market period</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\lambda = 2$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>$\lambda = 3$</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\lambda = 4$</td>
<td></td>
<td></td>
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</tbody>
</table>
The spot market

- 2 firms, constant cost of \( c \) per unit
- Future discounted by factor \( \delta \)
- Demand is \( D(p) \)
  - Met by contract deliveries and spot sales
  - Does not depend on contract price
- Firms bid prices simultaneously
- Share market if prices are equal
- Lower bidder takes all spot sales if not
Collusion

• Grim trigger strategy
  – Agree collusive price of $p^c$
  – While collusion holds, set $p^c$ and share sales
  – After defection, set price to $c$ for ever

• Sustain collusion if $\delta \geq \frac{1}{2}$, *in the absence of contracts*
The contract market

• Sell forward contracts equal to proportion $x \in [0,1]$ of expected total sales
• Same amount delivered (& paid for) in each of $\lambda$ spot periods until next contract round
• No arbitrage condition implies contracts sell for expected spot price
  – Can sell for $p^c$ iff this is a sustainable collusive price in the spot market
Collusion with contracts

- Agree to sell $xD(p^c)/2$ contracts for $p^c$
- If collusion holds, bid $p^c$ in spot market
- After defection,
  - bid $c$ in spot market in every period
  - sell arbitrary volume of contracts for $c$
- If collusion holds, continue with contract sales as in previous rounds
- Don’t defect in a contract round!
Deviating in the spot market

- Choose the lower price of two options:
  - Undercut $p^c$ by a small amount
  - Set residual monopoly price in spot market

$p^m$ is the price a monopoly would set in the spot market

$p^{Rm}$ is the price a monopoly would set in the residual spot market (net of contract sales)
The consequences of deviation

\[ \text{Profit from colluding} \]
\[ \text{Short-term gain from deviation} \]
\[ \text{Loss during punishment} \]

\[ \mathcal{D}(p) \]

\[ c \]

Quantity per period

\[ \mathcal{P}_c \]

\[ \text{£/unit} \]
The consequences of deviation

- Initial protection from contracts
  - $p_c$
  - Loss during punishment
  - Short-term gain from dev.

Graph:
- £/unit
- Contracted output
- Quantity per period
- $D(p)$
- $c$

Legend:
- Blue: Initial protection from contracts
- Yellow: Loss during punishment
- Green: Short-term gain from dev.
Two effects

• Gain-cutting effect
  – reduces the initial gain from deviation, relative to collusive profit

• Protection effect
  – reduces the loss during the punishment, until the contracts expire
  – applies if contracts last more than one period
The consequences of deviation

£/unit

$ p^c $

Initial protection from contracts

Loss during punishment

Short-term gain from dev.

Contracted output

Quantity per period

$ D(p) $
Sustaining collusion

- Whether collusion is sustainable depends on $\delta$, $x$, $\lambda$, and $pc$.
- Minimum $\delta$ rises as $\lambda$ increases.
  - Protection effect grows stronger, collusion is harder.
- Minimum $\delta$ may rise or fall as $x$ increases.
  - Both protection effect and gain-cutting effect grows stronger.
Maximum sustainable price

- Increases with the discount factor
  - Punishment has a greater weight, collusion is easier
- Decreases as contract length increases
  - Protection effect is stronger, collusion harder
- May rise or fall as \( x \) increases
  - Protection effect and gain-cutting effect are stronger
Linear case: Sustainable collusive prices with $\lambda = 1$

In region 1, deviate with a small price cut, in region 2, with a large one
Linear case: Sustainable collusive prices with $\lambda = 2$

In region 1, deviate with a small price cut, in region 2, with a large one
Linear case: Sustainable collusive prices with $\lambda = 4$

In region 1, deviate with a small price cut, in region 2, with a large one.
A surprising result?

For *any* discount factor and *any* contract length, given an appropriate level of contracts, firms can sustain *some* price above marginal cost.

But in general, longer contracts make collusion harder to sustain!