Strategic Capacity Investments under Hold-up Threats

The Role of Contract Length and Width

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Commodities and equipment

- Many commodities can be consumed only with some specific equipement: *e.g.* for heating, fuel + heater.
- Once equipped with an appliance, a consumer is trapped with the corresponding commodity

  → short-run elasticity is low, and the seller of the commodity can exert market power.
- But in the long run, appliances can be replaced: the commodity seller should not abuse his market power.

  On the contrary, he should encourage consumer equipment. How?
- He may announce a reasonable commodity price to encourage investment, but is he credible?

  If commitment is limited (short contract), buyers may fear *hold-up*.

Is a longer contract the best way to encourage investment?

Commodities and equipment: demand

Bilateral relationship with a purely relationship-specific investment.

- First, the buyer invests in an equipment with capacity A.
- Then he can consume less than A, but not more.
  Example: natural gas imports cannot exceed the pipeline capacity.

Once A is fixed, demand is both elastic and rigid:

- Consumption has a price elasticity ε as long as it does not exceed the investment capacity A: inverse demand function $P(q)$.
- Then it is completely inelastic: $q = A$.

Contracts

- Before the buyer invests, the seller offers him a contract characterized by
  - A pricing scheme (two-part tariff / linear prices).
  - A duration (T, from 0 to ∞).
- Contracts with limited “width” may be optimized with respect to length in compensation.
- In the absence of uncertainty, is the longest contract always the best?
- Who pushes for longer contracts? Do the parties agree on an optimal duration?

References

- Commodities and appliances: econometric literature on estimation of consumer demand:
  Dubin-McFadden (1984), Hanemann (1984), Balestra and Nerlove (1966).
- Standard competition or after-market monopolisation:
  Shapiro (1995), Chen *et al.* (1998), Reitzes and Woroch (2008).
- Contract length and width:
  Crocker and Masten (1988), Joskow (1988).

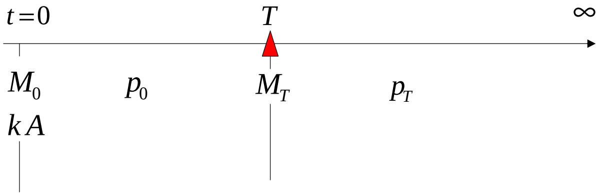
General setting: Contracts (1)

Timing

1. The seller offers a contract valid from $t = 0$ to T: fixed fee+unit fee (M_0, p_0).
2. The contract is accepted or not. Game continues if accepted.
3. The buyer invests A (unit cost k) before trade begin.
4. The quantity q_0 is chosen freely by the buyer at each moment (it cannot be specified in the contract). The seller produces at cost c.
5. At T the contract expires, the seller sets a new pricing scheme (M_T, p_T). The buyer consumes q_T at each moment indefinitely.

The discount rate is r.

General setting: Contracts (2)



- 1st stage ($t = 0$ to T): at the moment the contract is signed, the investment level can still be adjusted.
- 2nd stage ($t = T$ to ∞): at expiry of the contract, the investment cost is sunk: hold-up risk.

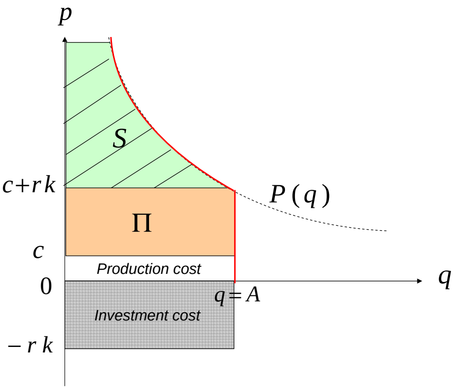
Social optimum

Social surplus:

$$W = \int_0^\infty e^{-rt}\left[U(q_t) - cq_t\right] dt - kA = \frac{1}{r}\left(S_t + \Pi_t - rkA\right)$$

- Let $P = U'$ and $Q = P^{-1}$.
- At social optimum

$$q = A = Q(c + rk).$$



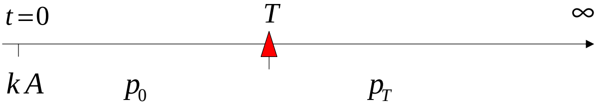
Nonlinear tariffs

- When $T = \infty$, the social optimum can be attained: $p_0 = c$ gives the buyer the right incentive to invest $A = Q(c + rk)$, and M_0 allows the seller to capture all the surplus.
- When commitment is limited, the buyer anticipates hold-up after contract expiry (after T). But the seller can set $p_0 < c$ (consumption subsidy) to give the right investment incentives, and increase M_0 to get all the first-stage surplus.
  Then from T on, the seller can again capture the entire second-stage surplus.
- When the seller cannot commit ($T = 0$), the optimum cannot be attained: once A is invested, the seller will set a "hold-up" price. Knowing this, the buyer will not invest.

Nonlinear tariffs: surplus sharing

- Whenever some seller commitment is possible, the seller can achieve the socially optimal investment with two-part tariffs. But the buyer gets no surplus.
- Linear tariffs are less efficient, but they always leave the buyer with some surplus.
  $\rightarrow$ they may be imposed in the buyer's interest to protect him against full rent extraction.

Linear tariffs



The contract seems to protect the investor from hold-up. The longer, the better?

Contract-Investment Paradox

The investment level decreases with respect to the contract duration.

Effects

p_T: Classical hold-up effect. When the buyer invests, he incurs costs that maybe he will not recover due to hold-up from T on. This investment-deterring effect decreases as T increases.

A: Hold-up mitigating effect. By investing, the buyer "commits" to a higher demand, which allows him to obtain lower prices after contract expiry, from T on.
This investment-enhancing effect decreases as T increases.

p_0: Contract leverage effect. The seller can use the contract price as a tool to stimulate investment (set a low p_0, valid until T). In case he does, this investment-enhancing effect increases as T increases.

Active/Passive

Definition

The buyer is *active* when his investment choice A induces a response p_T from the seller that differs from the unconstrained monopoly price $\frac{\varepsilon c}{\varepsilon - 1}$. Otherwise he is *passive*.

Definition

The seller is *active* when his price choice p_0 induces a response A from the buyer that differs from $A = Q(p_0)$. Otherwise he is *passive*.

Theorem (Equilibrium prices in the general case)

1. *If* $\frac{c}{rk} \geq (\varepsilon - 1)e^{rT}$*, both parties are passive and*

$$p_0 = p_T = \frac{\varepsilon c}{\varepsilon - 1}.$$

2. *If* $(\varepsilon - 1)e^{rT} - \frac{1}{\varepsilon} \leq \frac{c}{rk} < (\varepsilon - 1)e^{rT}$*, the buyer is active and the seller is passive, and*

$$p_0 = p_T = re^{rT}\varepsilon k.$$

3. *If* $\frac{c}{rk} < (\varepsilon - 1)e^{rT} - \frac{1}{\varepsilon}$*, both parties are active and*

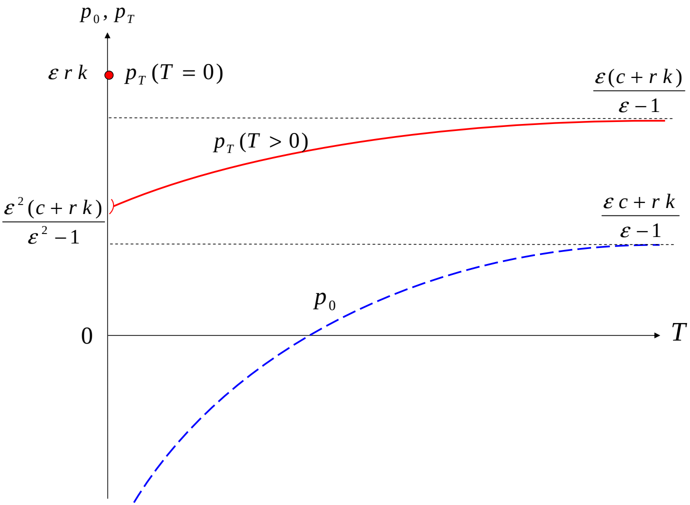
$$\begin{cases} p_0 & = \frac{1}{1-e^{-rT}}\left[\left(1 - \frac{\varepsilon e^{-rT}}{\varepsilon + e^{-rT}}\right)\frac{\varepsilon c}{\varepsilon - 1} + \left(1 - \frac{\varepsilon^2 e^{-rT}}{\varepsilon + e^{-rT}}\right)\frac{rk}{\varepsilon - 1}\right], \\ p_T & = \frac{\varepsilon^2 (c + rk)}{(\varepsilon + e^{-rT})(\varepsilon - 1)}. \end{cases}$$

Active/Passive

When the investment cost is sufficiently high, both parties will be active whatever T. At equilibrium,

- $q_t = A$ for all t: capacity is never idle;
- $p_T = P(A) > \frac{\varepsilon c}{\varepsilon - 1}$: active buyer, induces the seller to adjust p_T to capacity A;
- $p_0 < p_T$: active seller, subsidizes consumption to encourage investment.

Equilibrium prices as a function of T



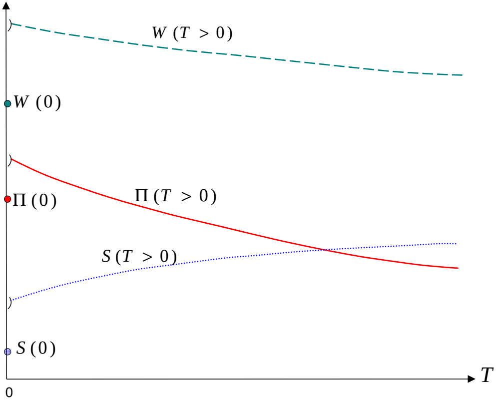
Impact of contract duration on prices and investment

"Bargain then Rip-off"

- Everybody knows the seller will exert hold-up from T on: $p_T = P(A)$.
- Since k is large, the buyer is not willing to invest much. The seller suffers from small volumes due to under-investment.
- The seller can use p_0 as a tool to stimulate investment: offer a bargain until T.
- The smaller T, the better the bargain must be: $p_0 \to -\infty$ when $T \to 0$.
- But when $T = 0$, no contract price p_0, no tool so stimulate investment: investment falls, the price jumps, and both profits and consumer's surplus fall.

To increase investment, the smallest contract is the best, no contract at all is the worst.

Surpluses and welfare as a function of T



- The seller's profit decreases with T.
- The buyer's surplus increases (hold-up occurs later).

Summary of results

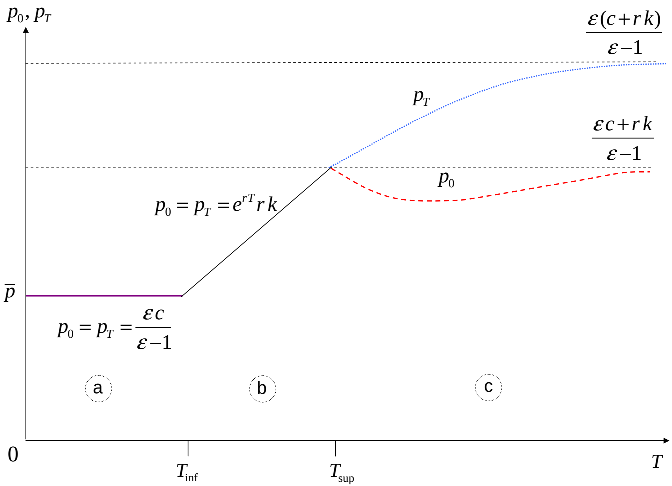
Paradox

The longer the contract, the smaller the investment

- Therefore social welfare decreases with the contract duration, even though there is no need for flexibility (uncertainty).
- The seller always prefers a shorter contract.
- The buyer prefers the longest possible contract when the investment cost is high. When this cost is low, he can be better off with the shortest possible contract.
- If the investment cost is high, no contract is the worst solution, and a very short contract is the best for social welfare.

Backup slides

Impact of T when k is small: Equilibrium prices



Impact of T when k is small: Intuitions (1)

Suppose the seller does not suffer too much from under-investment (no bargain with p_0: p_0 is just chosen to have $p_0 = P(A)$). For an intermediate T, what is the impact for the buyer of reducing A?

- Immediate advantage: cost reduction (k)
- From T on, cost: $p_T = P(A)$ will be higher.

Zone ⓐ: Low T

The "punishment" comes too soon, and since k is low the buyer prefers not to reduce A below $Q(\frac{\varepsilon c}{\varepsilon - 1})$.
Buyer accommodates, invests $A = Q(\frac{\varepsilon c}{\varepsilon - 1})$.

Impact of T when k is small: Intuitions (2)

Zone ⓑ: Intermediate T

The punishment comes late enough, it is worth reducing A: Equalizing marginal cost/marginal benefit ($k = \frac{e^{-rT}}{r} \frac{P(A)}{\varepsilon}$) yields $A = Q\left(e^{rT} \varepsilon r k\right)$.

But when T becomes large, the investment capacity decreases too much from the seller's point of view... He changes his strategy.

Impact of T when k is small: Intuitions (3)

When A decreases too much, the seller stops setting p_0 equal to the marginal willingness to pay of the buyer $P(A)$: he lowers p_0 to stimulate investment. How low should be p_0?

Zone ⓒ: Large T

- Immediate loss of revenues: lower price $p_0 < P(A)$.
- Profit increase from T on: higher volumes A at hold-up price $p_T = P(A)$.

$\Rightarrow$ good strategy as long as T is not too large.

When $T \to \infty$ the profit increase is too remote: the seller increases p_0 again, and $p_0 \to p_{pA}$ for $T \to \infty$.