Countervailing Vertical Contracting

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Motivation

Ex-ante contracts commonplace in vertical markets.

- A private-cost supplier wants to sell a good to a private-value buyer.
- Before observing cost, must obtain license from a third party to trade.
- Some licensing contracts are complex, involving rebates, royalties, exclusive dealing, and price-maintenance.

Supplier may hold little bargaining power against buyer (e.g., US pharmaceutical distributors & government procurement)

- Our argument: licensor uses **complex contracts to countervail** bargaining power of buyer.
- Price-maintenance clauses, royalties, and performance-based rebates give seller commitment power.

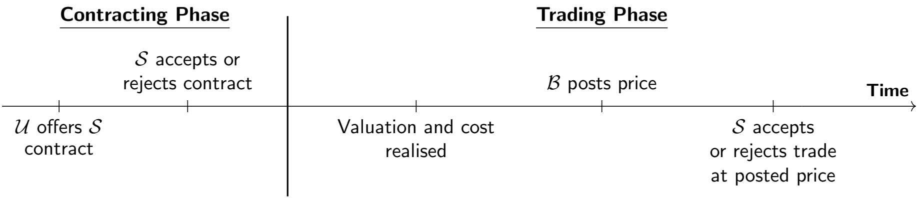
Roadmap

1. Setup vertical licensing model.
2. Show WLOG we may restrict attention to two-part royalty contracts involving a fixed fee and royalty.
3. Simplify the model: assume either buyer value or supplier cost known.
   - Highlight 4 observations from reduced model.
4. Move to general model with bilateral asymmetric information.
   - Employ mechanism design to solve for equilibrium.
   - Show 4 observations generalise to full model.
   - Gain new insights from generalised model beyond those in reduced model.

Setup I: Overview

Three players: an upstream firm $\mathcal{U}$, a supplier $\mathcal{S}$, and a buyer $\mathcal{B}$. Two phases (1) **Contracting Stage** then (2) **Trading Stage**.

- **Trading Stage**: $\mathcal{B}$ and $\mathcal{S}$ privately know value and cost. $\mathcal{B}$ posts price to $\mathcal{S}$.
- **Contracting Stage**: $\mathcal{U}$ offers contract to $\mathcal{S}$ which can condition on price posted and if trade occurs. But, not on cost and value. $\mathcal{B}$ observes contract.



Setup II: Costs and Valuations

- Common prior $c \sim G$, $v \sim F$, with $v \perp c$ and F, G smooth. Full-support densities, g and f over $[\underline{c}, \overline{c}]$ and $[\underline{v}, \overline{v}]$, respectively.
- Distributions overlap: $0 < \underline{c} < \underline{v} < \overline{c} < \overline{v}$.

A1: Increasing Hazard Rate of Values

Buyer's value distribution such that $\frac{f(v)}{1-F(v)}$ strictly increasing over $[\underline{v}, \overline{v}]$.

A2: Decreasing Reverse Hazard Rate of Costs

Supplier's cost distribution such that $\frac{g(c)}{G(c)}$ is strictly decreasing over $[\underline{c}, \overline{c}]$.

A3: No Corner Solutions

Distributions close at bottom end: $\underline{c} > \underline{v} - \frac{1}{f(\underline{v})}$.

Setup III: Licensing Contract

Before observing cost and entering downstream market, $\mathcal{S}$ obtains license from $\mathcal{U}$.

- In **Contracting Stage**, $\mathcal{U}$ offers a contract to $\mathcal{S}$ conditional on price posted ($p \in \mathbb{R}_+$) and whether trade occurs ($x \in \{0, 1\}$),

$$\{0, 1\} \times \mathbb{R}_+ \ni (x, p) \mapsto m(x, p) \in \mathbb{R}$$

  Specifies what $\mathcal{S}$ should pay to $\mathcal{U}$ as a function of the outcome of negotiation in the Trading Stage.

- Let $\mathbb{M}$ be all such measurable contracts which admit trading stage equilibria.
- $\mathcal{S}$ decides whether to accept based on rule $A : \mathbb{M} \to \Delta(\{0, 1\})$.

Observable Contracting

The buyer, $\mathcal{B}$ observes the contract signed, if any, between $\mathcal{S}$ and $\mathcal{B}$.

Setup IV: Trading

At the start of **Trading Stage**, costs and values realised.

- $\mathcal{B}$ and $\mathcal{S}$ negotiate over sale of single indivisible good.
- $\mathcal{B}$ offers a take-it-or-leave-it price to $\mathcal{S}$.
- $\mathcal{S}$ either accepts or rejects.

Strategies are,

- $\mathcal{B}$ picks price schedule $p : [\underline{v}, \overline{v}] \times \mathbb{M} \to \Delta(\mathbb{R}_+)$.
- $\mathcal{S}$ chooses price-acceptance rule $a : [\underline{c}, \overline{c}] \times \mathbb{R}_+ \times \mathbb{M} \to \Delta(\{0, 1\})$.

Setup V: Payoffs and Equilibrium

- If $\mathcal{S}$ rejects licensing contract, all agents get 0.
- If $\mathcal{S}$ accepts contract, payoffs are,

$$\pi_{\mathcal{B}}(x, p\ ; v) = x(v - p)$$
$$\pi_{\mathcal{S}}(x, p, m\ ; c) = x(p - c) - m(x, p)$$
$$\pi_{\mathcal{U}}(x, p, m) = m(x, p)$$

- Define supplier trade surplus as $\hat{\pi}_{\mathcal{S}}(x, p\ ; c) := x(p - c)$.

Agents cannot signal what they don't know. A **PBE** is,

- A licensing contract $m \in \mathbb{M}$.
- A price-acceptance strategy $a : [\underline{c}, \overline{c}] \times \mathbb{R}_+ \times \mathbb{M} \to \Delta(\{0, 1\})$ and license contract acceptance strategy $A : \mathbb{M} \to \Delta(\{0, 1\})$ for $\mathcal{S}$.
- A price schedule $p : [\underline{v}, \overline{v}] \times \mathbb{M} \to \Delta(\mathbb{R}_+)$ for $\mathcal{B}$.

Simplifying the Contract Space

Lemma 1

Without loss of generality, we can restrict attention to **two-part contracts**,

$$m(x,p) = xk(p) + F$$

- F is a **Fixed Fee** paid irrespective of downstream trade outcomes.
- $k : \mathbb{R}_+ \to \mathbb{R}$ is a **Royalty Payment** paid if trade occurs and can depend on p.

Proof Sketch: Focus on two-part restriction. Decompose any m as

$$m(x,p) = x(m(1,p) - m(0,p)) + m(0,p) =: xk(p) + F(p)$$

- $F(p)$ paid irrespective of whether trade occurs or not $\implies$ sunk cost so price-acceptance decision of $\mathcal{S} \perp F(p)$.
- Risk-neutral agents, can flatten $F(p)$ to $F = \mathbb{E}[F(p)]$.

Implications of Two-Part Contracting

Only royalties, k, are strategically relevant at Trading Stage. F sunk.

- Revenue-maximising $\mathcal{U}$ picks F to hold $\mathcal{S}$ down to its reservation utility.

$$F = \mathbb{E}[\pi_{\mathcal{S}}] = \mathbb{E}[a(p - k(p) - c)]$$

- Therefore, revenue of $\mathcal{U}$ is,

$$\begin{aligned} \mathbb{E}[\pi_{\mathcal{U}}] &= F + \mathbb{E}[ak(p)] \\ &= \mathbb{E}[a(p - c)] \\ &= \mathbb{E}[\hat{\pi}_{\mathcal{S}}] \end{aligned}$$

- $\mathcal{U}$ picks royalties to maximise expected supplier trade surplus.
- Hereafter, suppress reference to F.

One-Sided Imperfect Information

Begin with only one privately informed party, $\mathcal{B}$ or $\mathcal{S}$.

Definition: p^*-forcing Royalty Scheme

A royalty scheme k is p^*-forcing if it has format

$$k(p) = \begin{cases} \overline{v} & \text{if } p \neq p^* \\ 0 & \text{if } p = p^* \end{cases}$$

- As if $\mathcal{U}$ signs a retail price-maintenance contract requiring $\mathcal{S}$ only trade at p^*.
- $\mathcal{S}$ obligated to pay **liquidated damages** for contractual breach.
- Gives $\mathcal{S}$ credible commitment power to only accept trade at p^*.
- $\mathcal{B}$ either posts price p^* or cannot trade.

One-Sided Imperfect Information: Optimal Contract

If imperfect information is one-sided, the optimal contract is forcing. Define

$$\psi_{\mathcal{B}}(v) = v - \frac{1 - F(v)}{f(v)}$$

Proposition 1

Known Value: If $\mathcal{B}$'s valuation distribution is degenerate on $v \in [\underline{v}, \overline{v}]$, then $\mathcal{U}$ offers a v-forcing contract. Trade if and only if $v \geq c$

Known Cost: If $\mathcal{S}$'s cost distribution is degenerate on $c \in [\underline{c}, \overline{c}]$, then $\mathcal{U}$ offers a $\psi_{\mathcal{B}}^{-1}(c)$-forcing contract. Trade if and only if $v \geq \psi_{\mathcal{B}}^{-1}(c)$.

All supplier types agree on the price they prefer. Royalty scheme forces this price.

One-Sided Imperfect Information: Observations

- $\mathcal{U}$ makes monopoly profit with forcing contracts.
- p^*-forcing contracts require no on-path royalty payments.

Observation 1

$\mathcal{U}$ makes monopoly profit $\implies$ buyer power **fully countervailed by royalties**.

Observation 2

Expected royalty payments are 0.

One-Sided Imperfect Information: Observations

Compare welfare with royalties to when $k \equiv 0$.

- If buyer valuation known, royalties necessarily **improve welfare**.
  - With royalties, trade is efficient.
- If supplier cost known, royalties necessarily **harm welfare**.
  - Without royalties, trade is efficient.
- Buyer could have posted supplier-optimal prices but didn't.
  - $\Longrightarrow$ $\mathcal{B}$ cannot benefit from the royalty contract

Observation 3

The welfare effect of royalties is ambiguous.

Observation 4

The buyer is always worse off from the introduction of royalties.

Bilateral Imperfect Information

Now turn to general problem, $c \sim G$, $v \sim F$, over non-null intervals $[\underline{c}, \overline{c}]$, and $[\underline{v}, \overline{v}]$, respectively.

- Forcing contracts no longer optimal. Different cost types disagree about optimal price.
- Instead, $\mathcal{U}$ permits some pricing discretion to $\mathcal{B}$.

Given royalty scheme k, trading-stage behaviour is

- $\mathcal{S}$ follows *cost-cutoff* acceptance rule, accepts iff $p - k(p) \geq c$.
- $\mathcal{B}$ picks price $p_k(v) \in \arg\max_p G(p - k(p))(v - p)$

For $\mathcal{U}$, full shape of k matters. High dimensionality resists direct search.

Bounding Trade Surplus

Use mechanism design to place upper bound on equilibrium payoffs and show achievable by some royalty contract.

- Identify any trading-stage equilibrium with a direct incentive compatible mechanism $\langle q, t \rangle$ where
  - $q(c, v)$ is probability of trade.
  - $t(c, v)$ is transfer from $\mathcal{B}$ to $\mathcal{S}$.
  - Define interim counterparts for $\mathcal{B}$ and $\mathcal{S}$ as $(Q_{\mathcal{B}}(v), T_{\mathcal{B}}(v))$ and $(Q_{\mathcal{S}}(c), T_{\mathcal{S}}(c))$, respectively.

Explicitly, given equilibrium price schedule $p_k(v)$

- $q(c, v) = 1$ iff $p_k(v) - k(p_k(v)) \geq c$
- $t(c, v) = q(c, v)p_k(v)$

Bounding Trade Surplus

From Myerson (1981), $(Q_{\mathcal{B}}(v), T_{\mathcal{B}}(v))$ incentive compatible for $\mathcal{B}$ iff

$$Q_{\mathcal{B}}(v) \text{ increasing} \tag{1}$$

$$T_{\mathcal{B}}(v) = Q_{\mathcal{B}}(v)v - \int_{\underline{v}}^{v} Q_{\mathcal{B}}(x)dx - \Pi_{\mathcal{B}}(\underline{v}) \tag{2}$$

$$\Pi_{\mathcal{B}}(\underline{v}) \geq 0 \tag{3}$$

Using (2), revenue of $\mathcal{U}$ is affine in $Q_{\mathcal{B}}, Q_{\mathcal{S}}$,

$$R(\langle q, t\rangle) := \int_{\underline{c}}^{\overline{c}} \int_{\underline{v}}^{\overline{v}} t(c, v) - q(c, v)cdFdG$$

$$= -\Pi_{\mathcal{B}}(\underline{v}) + \int_{\underline{v}}^{\overline{v}} Q_{\mathcal{B}}(v)\psi_{\mathcal{B}}(v)dF - \int_{\underline{c}}^{\overline{c}} Q_{\mathcal{S}}(c)cdG$$

Bounding Trade Surplus

$$R(\langle q,t\rangle) = -\Pi_{\mathcal{B}}(\underline{v}) + \int_{\underline{v}}^{\overline{v}} Q_{\mathcal{B}}(v)\psi_{\mathcal{B}}(v)dF - \int_{\underline{c}}^{\overline{c}} Q_{\mathcal{S}}(c)cdG$$

As $q(c,v)$ induced by equilibrium, $q(c,v) = \mathbb{1}\{h(v) \geq c\}$ for some increasing function h. Allows us to remove $Q_{\mathcal{S}}$ from $R(\langle q,t\rangle)$.

Lemma 3: A Revenue-Equivalence Result

In any equilibrium mechanism $\langle q,t\rangle$, the revenue of $\mathcal{U}$ is

$$-\Pi_{\mathcal{B}}(\underline{v}) + \int_{\underline{v}}^{\overline{v}} \left[Q_{\mathcal{B}}(v)\psi_{\mathcal{B}}(v) - C(Q_{\mathcal{B}}(v))\right] dF$$

where $C(Q) = Q\mathbb{E}[c \mid c \leq G^{-1}(Q)]$ is a differentiable, increasing, and convex function defined in $[0,\mathbb{E}[c]]$, with first derivative $C'(Q) = G^{-1}(Q)$.

Convex cost, C, as trade with the lowest cost types first.

Bounding Trade Surplus

$$\max_{Q_{\mathcal{B}}} -\Pi_{\mathcal{B}}(\underline{v}) + \int_{\underline{v}}^{\overline{v}} [Q_{\mathcal{B}}(v)\psi_{\mathcal{B}}(v) - C(Q_{\mathcal{B}}(v))]\, dF$$

$$st.\ Q_{\mathcal{B}}(v) \text{ increasing } \ \& \ \ \Pi_{\mathcal{B}}(\underline{v}) \geq 0$$

Analogous to Mussa and Rosen (1978) 2nd-degree price discrimination.
Ignoring monotonicity, pointwise maximisation gives $\Pi_{\mathcal{B}}(\underline{v}) = 0$ and

$$C'(Q^*_{\mathcal{B}}(v)) = \psi_{\mathcal{B}}(v) \iff Q^*_{\mathcal{B}}(v) = G(\psi_{\mathcal{B}}(v))$$

Revenue is bounded above by $\int_{\underline{v}}^{\overline{v}} Q^*_{\mathcal{B}}(v)\psi_{\mathcal{B}}(v) - C(Q^*_{\mathcal{B}}(v))dF$.

- For (k^*, p^*_k) to achieve bound, require

$$G(Q^*_{\mathcal{B}}(v))p^*_k(v) = Q^*_{\mathcal{B}}(v)v - \int_{\underline{v}}^{v} Q^*_{\mathcal{B}}(x)dx$$

$$G(p^*_k(v) - k^*(p^*_k(v))) = Q^*_{\mathcal{B}}(v)$$

The Optimal Contract

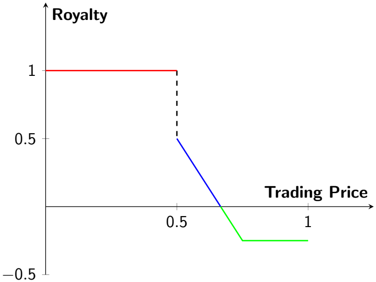


Figure 1: $c \sim U[0,1]$, $v \sim U[0,1]$.

- Price maintenance: No accepting prices less than $1/2$.
- Negative royalties: Subsidise accepting prices greater than $2/3$.
- Decreasing: High royalties at low prices, low/negative at high prices.

The Optimal Contract

Theorem 1

1. The contract

$$k^*(p) = \begin{cases} \overline{v} & p < \psi_{\mathcal{B}}^{-1}(\underline{c}) \\ p - \psi_{\mathcal{B}}((p_k^*)^{-1}(p)) & p \geq \psi_{\mathcal{B}}^{-1}(\underline{c}) \end{cases}$$

$$F^* = \int_{\underline{c}}^{\overline{c}} \int_{\underline{v}}^{\overline{v}} 1_{\{\psi_{\mathcal{B}}(v) \geq c\}} (\psi_{\mathcal{B}}(v) - c)\, dF$$

is proposed by $\mathcal{U}$ and accepted by $\mathcal{S}$.

2. The pricing decision of $\mathcal{B}$ is

$$p_{k^*}^*(v) = \mathbb{E}[\psi_{\mathcal{B}}^{-1}(c) \mid c \leq \psi_{\mathcal{B}}(v)]$$

3. The acceptance decision of $\mathcal{S}$ is given by

$$a_{k^*}(c, p) = \mathbb{1}_{\{c \leq p - k^*(p)\}}.$$

The Optimal Contract: Observation 1

To what extent does the optimal contract 'countervail' the power of $\mathcal{B}$?
Two notions of $\mathcal{S}$ having power:

1. $\mathcal{S}$ can commit ex-ante to a price-acceptance strategy, gives $\pi(Commit)$ revenue.
2. $\mathcal{S}$ picks the mechanism in the downstream market, gives $\pi(Mech)$.
   - $\mathcal{S}$ would post TIOLI prices $p_{\mathcal{S}}(c) = \psi_{\mathcal{B}}^{-1}(c)$.

$$\pi(Mech) = \int_{\underline{c}}^{\overline{c}} \int_{\underline{v}}^{\overline{v}} 1_{\{\psi_{\mathcal{B}}(v) \geq c\}} (\psi_{\mathcal{B}}^{-1}(c) - c) dF dG$$

Optimal royalties earn $\pi(k^*)$. Naturally $\pi(k^*) \leq \pi(Commit) \leq \pi(Mech)$.

Observation 1

$\pi(k^*) = \pi(Commit) = \pi(Mech)$. That is, optimal royalties **completely countervail** the market power of $\mathcal{B}$.

The Optimal Contract: Observation 1

- Can show algebraically that $\pi(k^*) = \pi(Mech)$, i.e.,

$$\underbrace{\int_{\underline{c}}^{\overline{c}} \int_{\underline{v}}^{\overline{v}} 1_{\{\psi_{\mathcal{B}}(v) \geq c\}} \left(\psi_{\mathcal{B}}(v) - c\right) dFdG}_{\text{Royalties}} = \underbrace{\int_{\underline{c}}^{\overline{c}} \int_{\underline{v}}^{\overline{v}} 1_{\{\psi_{\mathcal{B}}(v) \geq c\}} (\psi_{\mathcal{B}}^{-1}(c) - c) dFdG}_{\text{TIOLI price offers}}$$

  - Start with LHS. Apply change of variable $t = \psi_{\mathcal{B}}^{-1}(c)$, then simplify.
- Or, notice that in constructing a bound on trade surplus, only ever used that mechanism was from an equilibrium to conclude cost-cutoff rule $q(c.v) = 1\{h(v) \geq c\}$.
  - But, any extreme point in the space of mechanisms has this property (Yang and Yang 2025).
  - So, bound is over all mechanisms, not just those induced by equilibria.

The Optimal Contract: Observation 2

Observation 2

Expected royalty payments are 0.

Under optimal royalties $p_k^*(v) - k^*(p_k^*(v)) = \psi_{\mathcal{B}}(v)$, so fixed fee is

$$F^* = \int_{\underline{c}}^{\overline{c}} \int_{\underline{v}}^{\overline{v}} 1_{\{\psi_{\mathcal{B}}(v) \geq c\}} [p_k^*(v) - k^*(p_k^*(v)) - c] dFdG$$
$$= \int_{\underline{c}}^{\overline{c}} \int_{\underline{v}}^{\overline{v}} 1_{\{\psi_{\mathcal{B}}(v) \geq c\}} [\psi_{\mathcal{B}}(v) - c] dFdG$$

Revenue of $\mathcal{U}$ achieves trade surplus bound,

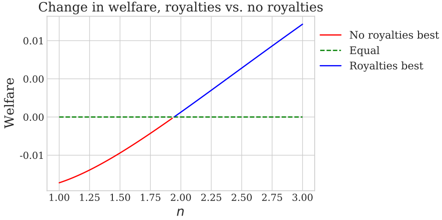
$$R = F^* + \int_{\underline{c}}^{\overline{c}} \int_{\underline{v}}^{\overline{v}} 1_{\{\psi_{\mathcal{B}}(v) \geq c\}} k^*(p_k^*(v)) dFdG = \int_{\underline{c}}^{\overline{c}} \int_{\underline{v}}^{\overline{v}} 1_{\{\psi_{\mathcal{B}}(v) \geq c\}} [\psi_{\mathcal{B}}(v) - c] dFdG$$

$$\implies \int_{\underline{c}}^{\overline{c}} \int_{\underline{v}}^{\overline{v}} 1_{\{\psi_{\mathcal{B}}(v) \geq c\}} k^*(p_k^*(v)) dFdG = 0$$

The Optimal Contract: Observation 3

Observation 3

The welfare effect of royalties is ambiguous.



Costs on $[0,1]$ with $G(x) = \frac{1-e^{-2x}}{1-e^{-2}}$.
Valuations on $[0,1]$ with $F(c;n) = x^n$.

The Optimal Contract: Observation 4

Observation 4

Royalties always harm the buyer.

With royalties, welfare and revenue of $\mathcal{U}$ is

$$W = \int_{\underline{c}}^{\overline{c}} \int_{\underline{v}}^{\overline{v}} 1_{\{\psi_{\mathcal{B}}(v) \geq c\}}(v - c)dFdG$$

$$R(\langle q, t \rangle) = \int_{\underline{c}}^{\overline{c}} \int_{\underline{v}}^{\overline{v}} 1_{\{\psi_{\mathcal{B}}(v) \geq c\}}(\psi_{\mathcal{B}}(v) - c)dFdG$$

As $\mathcal{S}$ is held down to 0 utility, with royalties $\mathcal{B}$ obtains $BS = W - R$,

$$\underbrace{\int_{\underline{c}}^{\overline{c}} \int_{\underline{v}}^{\overline{v}} 1_{\{\psi_{\mathcal{B}}(v) \geq c\}}(v - \psi_{\mathcal{B}}(v))dFdG}_{\text{With Royalties}} \leq \underbrace{\max_{p:[\underline{v},\overline{v}] \to [0,1]} \int_{\underline{c}}^{\overline{c}} \int_{\underline{v}}^{\overline{v}} 1_{\{p(v) \geq c\}}(v - p(v))dFdG}_{\text{Without Royalties}}$$

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THANK YOU

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