Collective Rights Organizations and Upstream R&D Investment

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Outline

Introduction
  Issues
  What We Do

Model
  Framework
  Licensing Revenue Distribution and Antitrust Rules
  Assumptions

Equilibrium
  Ex-post (upstream innovation)
  Ex-ante: Upstream Innovation Model 1
  Ex-ante: Upstream Innovation Model 2

Conclusion
What is CRO?

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- Examples
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  - ASCAP

Functions
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- Overcome the royalty stacking (complementary IP) problem by collective licensing.
- Economies of scale in negotiations and royalty collection.
- Promotes downstream use (production, innovation) of multiple upstream IP
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- Compare **antitrust rules**
Analysis - Factors to Consider

Licensing (CRO) is optimal ex-post (upstream innovation) given ex-post outcome (market structure).

Maximize joint profit.

Induce IP owners to join.

R&D incentive determined by ex-ante expected profit.

Ex-ante expected profit depends on ex-post profit and R&D technology (probability distribution over outcomes).

Ex-post optimal royalty distribution rule may not provide right incentive ex-ante.

Probability depends on number of firms investing (ex-ante market structure).

Some firms are competitors (substitute technology) and some are partners (complementary technology).
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Main Conclusions

In general, CROs stimulate upstream R&D incentive. But CROs may hurt the incentive of inventors with unique ability (ex-ante monopoly, firms ex-ante asymmetric). CROs dilute rent. CROs that distribute licensing revenue unequally among its members are less likely to lead to welfare loss. Unequal distribution helps form CRO. Ordering of profits by different CROs differs ex-ante and ex-post, and by firm (asymmetric) ⇒ likely to lead to disagreement regarding formation of CRO. CRO rules (revenue distribution, antitrust) should be determined taking into account R&D technology.
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Framework

- New **downstream product** needs two complementary upstream innovations: A and B.
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- Large number of competitive **upstream research firms**:
  - Each has capacity for one research ‘**project**’ at cost $c$
  - Specialized in development of A or B
  - Revenues only from licensing
- Each **project** either succeeds or fails (probabilistic).
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CRO
- Licenses on behalf of successful inventors.
- Objective is to maximize joint royalty revenues of its members.
Timing

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I. The antitrust rule is set and announced.
II. The CRO sets and announces a royalty redistribution rule consistent with the anti-trust rule.
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II. The CRO sets and announces a royalty redistribution rule consistent with the anti-trust rule.

III. Each research firm decides to invest or not to invest in an R&D project and those that invest invent a component according with given probability.

IV. Successful inventors simultaneously decide to join or not to join the CRO or license independently, and then innovations are licensed by the CRO and/or any independent inventors and royalties are paid by licensees.
Licensing Revenue and Antitrust Rules

Two CRO royalty distribution rules

\[ \pi = \text{total CRO licensing revenues} \]

**Equal:** With \( n \) members, each receives \( \frac{\pi}{n} \).

**Unequal:** If one component has a single inventor and the other component has \( n \geq 2 \) substitute inventors, the single inventor receives \( z \pi \) and the others receive \( \left(1 - z\right)\frac{\pi}{n} \) with \( z \in [0, 1] \). Otherwise, equal shares.

**Strict antitrust rule:** Licensing of substitutes is prohibited.
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Model Summary

Component A

Component B

Research firms
Invest?
Projects
Success?
Inventions
Join clearinghouse?
Downstream licenses
Inventor’s profit
Assumptions

▶ Tragedy of Anticommons:
- $\pi_M \geq \pi_D$ and $W_0 \geq W_M \geq W_D$.
- $\pi_M$ and $W_M$: Monopoly licensing profit and welfare.
- $\pi_D$ and $W_D$: Duopoly licensing profit and welfare.
- $W_0$: Welfare when both components are licensed at a zero.

▶ $P(n, N)$: Probability that $n$ substitute versions of a component are invented when $N$ projects are undertaken for that component (probability of $n$ success from $N$ trials):
- $N \sum_{n=0}^{\infty} P(n, N) = 1$ and $\lim_{N \to \infty} P(n, N) = 0$. 


Assumptions

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CRO Membership (ex-post)

Possible outcomes:

A and B (number of successful inventors of A and B):

Cases

Successful firms

\( n_A \) \( n_B \)

Case MM
1 1

Case MC:
1 (2 or more) 2 or more (1)

Case CC:
2 or more 2 or more

Who will join CRO?

Competitive component inventors (cases MC & CC) always join.

Case MM:
Both inventors join.

Avoid tragedy of anticommons.

Case MC:
Monopoly inventor will join an equal CRO if

\[
\pi_M / (n + 1) \geq \pi_D \quad (n \geq 2 \text{ is the number of inventors of the other component})
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Join an unequal CRO if

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Case CC:
All inventors join.
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Ex-post Profits

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<th>CRO Type</th>
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<th>Profit $\pi_{MC}$</th>
<th>Profit $\pi_{C}$</th>
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<tr>
<td>None</td>
<td>$\pi_D$</td>
<td>$\pi_M$</td>
<td>$0$</td>
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<td>$\pi_D$</td>
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<tr>
<td>Equal</td>
<td>$\frac{\pi_M}{2}$</td>
<td>$\pi_D$</td>
<td>$\frac{\pi_M}{n}$</td>
<td>$\pi_M$</td>
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Ex-post Profits

- Assumption: In case MC, monopoly inventor does not join an equal CRO but does join an unequal CRO.
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Ex-post equilibrium payoffs of successful inventors (Gains, Losses):

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<th>$\pi_{MM}$</th>
<th>$\pi_{MC}^M$</th>
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<td>$\frac{1}{n} \pi_M/2$</td>
<td>$\frac{1}{n_i} \pi_M/2; i = A, B$</td>
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Ex-post Welfare

- Ex-post equilibrium welfare: (Gains, Losses)

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Upstream Innovation

- Ex-ante profit depends on ex-post profit and distribution of outcomes
- We consider two different models
Upstream Innovation

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  - Model 1: There are $N > 1$ firms that can invest in component A. $N > 1$ firms that can invest in B.
    - Symmetric
    - Ex-ante competitive for both components.
Upstream Innovation

- Ex-ante profit depends on ex-post profit and distribution of outcomes
- We consider two different models
- Model 1: There are \( N > 1 \) firms that can invest in component A. \( N > 1 \) firms that can invest in B.
  - Symmetric
  - Ex-ante competitive for both components.
- Model 2: There is only one firm that invests in component A. \( N > 1 \) firms that can invest in B.
  - Asymmetric
  - Ex-ante monopoly for innovation of component A. Competitive for component B.
Model 1 of Upstream Innovation

- **Model 1**: All projects have the same chance of developing a component or developing nothing.

- **Symmetric**: $N$ projects are undertaken for each component (ex-ante competitive)
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- **Model 1**: All projects have the same chance of developing a component or developing nothing.

- **Symmetric**: $N$ projects are undertaken for each component (ex-ante competitive)

- **Ex-ante expected profit** of a research firm:

\[
\pi(N) = \frac{1}{N} P(1, N)^2 \pi_{MM} \\
+ \frac{1}{N} P(1, N) \sum_{n=2}^{N} P(n, N) \left[ \pi_{MC}^M + n\pi_{MC}^C(n) \right] \\
+ \sum_{m=2}^{N} \sum_{n=2}^{N} \frac{m}{N} P(m, N) P(n, N) \pi_{CC}(m, n) - c
\]
Model 1: Probability of Different Outcomes

- Formation of CRO can involve both ex-post gains and losses for research firms.

Binomial, success prob. = 0.5

![Graph showing probability distribution for different outcomes](image-url)
Model 1 Result: Ex-ante Expected Profit (Given $N$)

- Ex-ante, the **expected gains always outweigh any losses**.
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- CRO also benefits inventors with substitute inventions.
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- Ex-ante, the **expected gains always outweigh any losses**.
- CRO increases incentive to invest in upstream R&D.
- Strict antitrust restriction (SC) does equally well as un-equal CRO (UC)
- CRO also benefits inventors with substitute inventions.
- However, it may reduce the ex-post profits of sole inventors of a component.
Model 1: Ex-ante Expected Welfare (Given $N$)

- Introducing a CRO also involves ex-post **welfare** gains and losses.
Model 1: Ex-ante Expected Welfare (Given $N$)

- Introducing a CRO also involves ex-post welfare gains and losses.
- Expected welfare:

$$W(N) = P(1, N)^2 W_{MM} + 2P(1, N) \sum_{n=2}^{N} P(n, N) W_{MC}$$

$$+ \sum_{m=2}^{N} \sum_{n=2}^{N} P(m, N) P(n, N) W_{CC} - 2Nc$$
Model 1 Result: Ex-ante Expected Welfare (Given $N$)

$\begin{align*}
\text{Given } N, \text{ expected welfare with an unequal CRO (or a strict CRO) is always higher than that with an equal CRO:} \\
W_{UC}(N) &= W_{SC}(N) \geq W_{EC}(N) \quad \text{for all } N \geq 1. \\
\text{When } N \text{ is large, case CC likely and } W_0 \text{ achieved.} \\
\text{When } N \text{ is small, case MM likely and CRO beneficial.} \\
\text{Expected welfare with no CRO is highest when } N \text{ is large but lowest when } N \text{ is small:} \\
&(i) \quad W_{UC}(N) = W_{SC}(N) \geq W_{EC}(N) \geq W_{NC}(N) \quad \text{for small } N, \\
&(ii) \quad W_{NC}(N) \geq W_{UC}(N) = W_{SC}(N) \geq W_{EC}(N) \quad \text{for large } N.
\end{align*}$
Given $N$, expected welfare with an **unequal CRO** (or a strict CRO) is always higher than that with an **equal CRO**:

- $W^{UC}(N) = W^{SC}(N) \geq W^{EC}(N)$ for all $N \geq 1$. 
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- Given $N$, expected welfare with an unequal CRO (or a strict CRO) is always higher than that with an equal CRO:
  - $W^{UC} (N) = W^{SC} (N) \geq W^{EC} (N)$ for all $N \geq 1$.
- When $N$ is large, case CC likely and $W_0$ achieved.
- When $N$ is small, case MM likely and CRO beneficial.
- Expected welfare with no CRO is highest when $N$ is large but lowest when $N$ is small:
  (i) $W^{UC} (N) = W^{SC} (N) \geq W^{EC} (N) \geq W^{NC} (N)$ for small $N$,
  (ii) $W^{NC} (N) \geq W^{UC} (N) = W^{SC} (N) \geq W^{EC} (N)$ for large $N$. 
Binomial Model Simulation of Upstream R&D Investment (Determination of $N$)

Linear demand for licenses: $Q = 100 - \rho$ gives parameter values:

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<td>$\pi_D$</td>
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</tr>
<tr>
<td>$W_0$</td>
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Assume $P(n, N)$ is binomial; $\sigma$ is success prob. of each project.

Other parameters: $z$, $c$ (model 1), $c_A$ and $c_B$ (model 2).

Given parameter values, use numerical search to find equilibrium value of $N$ under each CRO type.

Equilibrium condition: Highest $N$ where $\pi(N) \geq 0$ and $\pi(N+1) < 0$. 

70 / 97
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Equilibrium Investment and Ex-ante Profit and Welfare by Simulation

- Single simulation of model 1, for \( c = 2.5 \) and \( \sigma = 0.7 \) (symmetry makes value of \( z \) irrelevant):

- CRO stimulates investment
Equilibrium Investment and Ex-ante Profit and Welfare by Simulation

- Single simulation of model 1, for $c = 2.5$ and $\sigma = 0.7$ (symmetry makes value of $z$ irrelevant):

- CRO stimulates investment but may reduce welfare.
Model 1 Equilibrium Expected Welfare

- Simulated CRO equilibrium expected welfare performance across parameter values: 

![Graph showing simulated CRO equilibrium expected welfare performance across parameter values with different colors representing different conditions: None, Equal, Equal or Unequal, and Unequal. The graph has axes labeled sigma and c, with color keys indicating the conditions.]
Model 2 of Upstream Innovation

- Model 2: **One** research firm (firm A) has the **unique ability** to develop component A for certain at a cost of $c_A$; Development of component B is as before.

- **Asymmetric**
  - Component A is ex-ante **monopoly**
  - Component B is ex-ante **competitive**, $N$ firms

- Case CC is no longer possible.
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  - Component A is ex-ante monopoly
  - Component B is ex-ante competitive, $N$ firms

- Case CC is no longer possible.

- Firm profits when $N$ projects undertaken for component B:

\[
\pi_A (N) = P(1, N) \pi_{MM} + \sum_{n=2}^{N} P(n, N) \pi_{MC}^M - c_A
\]

\[
\pi_B (N) = \frac{1}{N} P(1, N) \pi_{MM} + \sum_{n=2}^{N} \frac{n}{N} P(n, N) \pi_{MC}^C (n) - c_B
\]
Model 2 Results: Ex-ante Expected Profits and Welfare (Given $N$)

- Firm A prefers no CRO when $N$ is large and an unequal CRO when $N$ is small:
  (i) $\pi_A^{NC} (N) \geq \pi_A^{UC} (N) \geq \pi_A^{EC} (N)$ for large $N$
  (ii) $\pi_A^{UC} (N) \geq \pi_A^{EC} (N) \geq \pi_A^{NC} (N)$ for small $N$.

- For any given $N$, a component B firm is always better off under either an equal or unequal CRO compared to no CRO. Such a firm is better off under an unequal CRO compared to an equal CRO if $z \leq 1 - \pi_D / \pi_M$.

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Upstream R&D Incentives with a Unique Ability Firm

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- Ex-post, firm A prefers a high value of $z$ under an unequal CRO, but this reduces the payoff of component B firms.
- Ex-ante, firm A may want to choose a lower value of $z$ to give incentive to B firms to invest.
Equilibrium Investment, Ex-ante Profit and Ex-ante Welfare by Simulation

Single simulation of model 2, for $c_A = 8$, $c_B = 1.3$, $\sigma = 0.5$ and $z = 0.75$.
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Effect of Technology by Simulation

Effect of changing $z$ in an unequal CRO on equilibrium expected profits of firm A and expected welfare:

Level of $z$ affects equilibrium investment level of component B firms. CRO licensing revenue distribution policies need to be related to the innovation environment.
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Effect of Sharing Rule by Simulation

Simulated CRO equilibrium expected welfare performance across parameter values ($c_A = 5$):

- High $z$ makes unequal CRO generate similar outcomes to no CRO, but the CRO performs better when both components have a single successful inventor.

- However, an equal CRO may outperform an unequal CRO with high $z$ as the equal CRO gives greater incentives to component B firms to invest.
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Effect of Sharing Rule by Simulation

- Simulated CRO equilibrium expected welfare performance across parameter values (fixed $c_A = 5$):

  ![Graphs showing CRO performance across different $z$ values.]

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Conclusions

▶ CRO can generate both ex-post and ex-ante gains and losses to welfare and profits of research firms.

▶ CRO generally stimulate investment in upstream R&D except possibly by inventors who have unique abilities.

▶ Unequal CRO redistribution is less likely to lead to welfare losses.

▶ Likely conflict between existing and potential inventors regarding CRO support.

▶ CRO design and royalty distribution rule needs to reflect conditions of the innovation environment.
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