Collective Rights Organizations and Upstream R&D Investment

Reiko Aoki Aaron Schiff

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Outline

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    - Economies of scale in negotiations and royalty collection.
  - Promotes **downstream use (production, innovation)** of multiple upstream IP

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- Compare **antitrust rules**

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  - 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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- Ordering of profits by different CROs **differ ex-ante and ex-post**, and by firm (asymmetric) $\Rightarrow$ 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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- **CRO**
  - Licenses on behalf of successful inventors.
  - Objective is to maximize joint royalty revenues of its members.

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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

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- Two CRO royalty distribution rules ($\pi =$ total CRO licensing revenues)
  - **Equal:** With n members, each receives π/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 $(1-z)\pi/n$ with $z \in [0, 1]$. Otherwise, equal shares.

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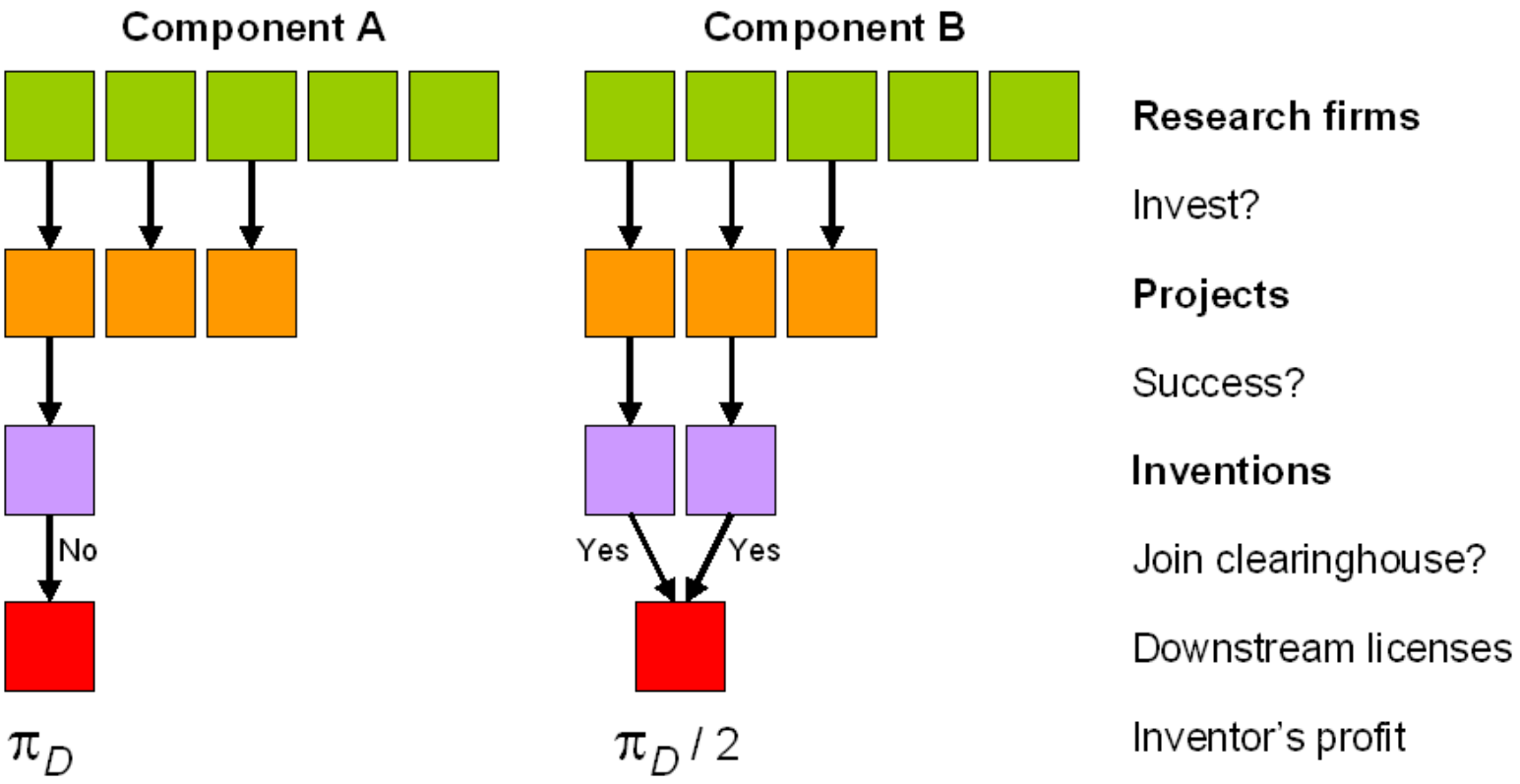
- **Strict antitrust** rule: Licensing of substitutes is prohibited.

Model Summary



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$$\pi_M \geq 2\pi_D \text{ and } W_0 \geq W_M \geq W_D.$$

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- $P(n, N)$: **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):

$$\sum_{n=0}^{N} P(n, N) = 1 \text{ and } lim_{N \to \infty} P(n, N) = 0.$$

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- Possible outcomes: n_A and n_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)
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  - **Case CC:** All inventors join.

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- Ex-post equilibrium payoffs of successful inventors (Gains, Losses):

CRO Type\ Profit	π_{MM}	π_{MC}^{M}	$\pi_{MC}^{C}(n)$	$\pi_{CC}(n_A, n_B)$
None	π_D	π_M	0	0
Equal	$\pi_M/2$	π_D	π_D/n	$\pi_M/(n_A+n_B)$
Unequal	$\pi_M/2$	$z\pi_M$	$(1-z)\pi_M/n$	$\pi_M/(n_A+n_B)$
Strict	$\pi_M/2$	$\pi_M/2$	$\frac{1}{n}\pi_M/2$	$\frac{1}{n_i}\pi_M/2$; $i = A, B$

Ex-post Welfare

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

CRO Type\ Welfare	$\mathbf{W_{MM}}$	$\mathbf{W_{MC}}$	$\mathbf{W_{CC}}$
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Equal	W_M	W_D	W_M
Unequal	W_M	W_M	W_M
Strict	W_M	W_M	W_M

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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.
- 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

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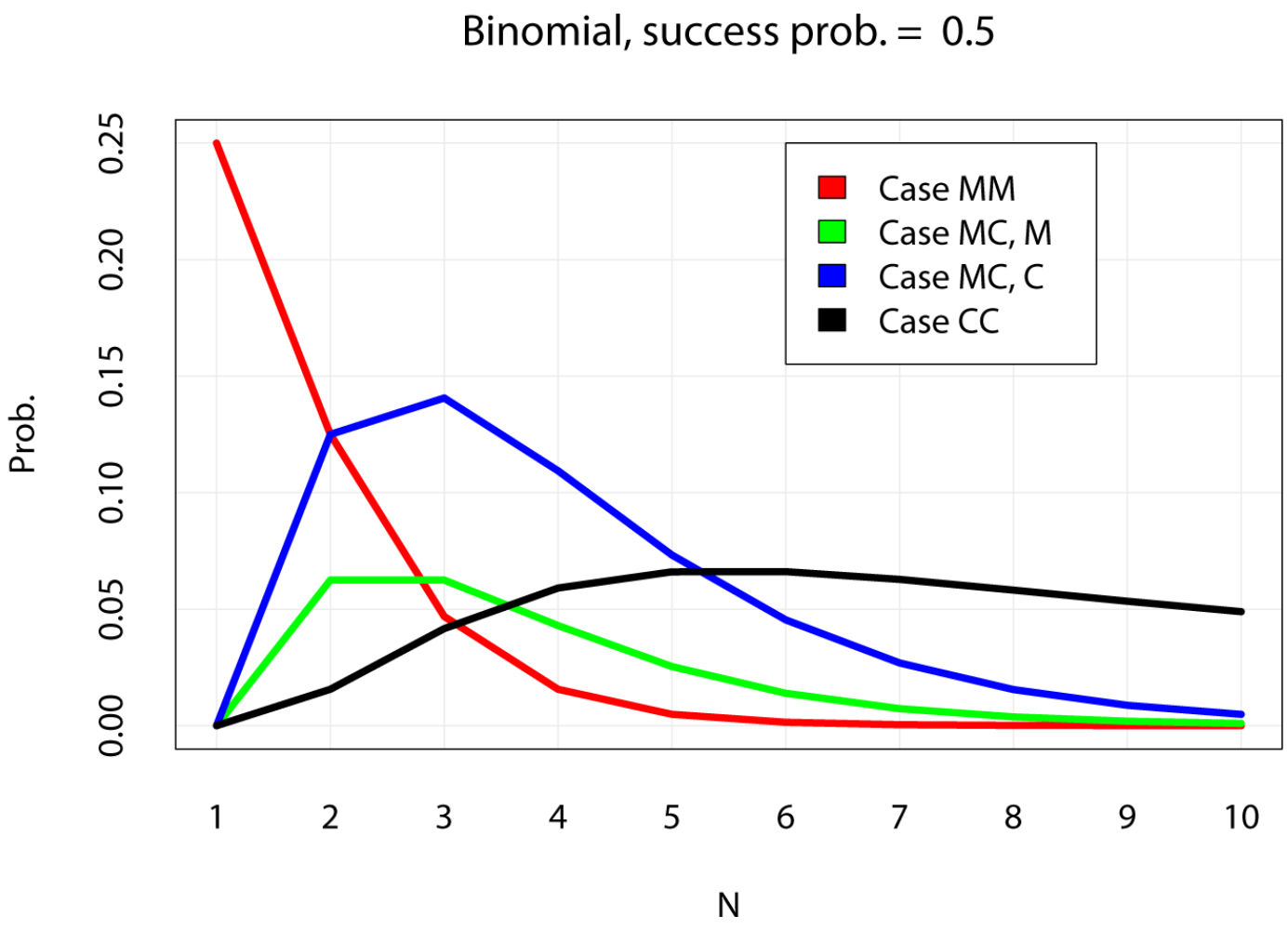
- Ex-ante **expected profit** of a research firm:

$$\begin{aligned}\pi(N) &= \tfrac{1}{N} P(1,N)^2 \pi_{MM} \\ &\quad + \tfrac{1}{N} P(1,N) \sum_{n=2}^{N} P(n,N) \left[\pi_{MC}^{M} + n\pi_{MC}^{C}(n)\right] \\ &\quad + \sum_{m=2}^{N} \sum_{n=2}^{N} \tfrac{m}{N} P(m,N) P(n,N) \pi_{CC}(m,n) - c\end{aligned}$$

Model 1: Probability of Different Outcomes

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



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- 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)

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- Expected welfare:

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  - $W^{UC}(N) = W^{SC}(N) \geq W^{EC}(N)$ 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.

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- 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.

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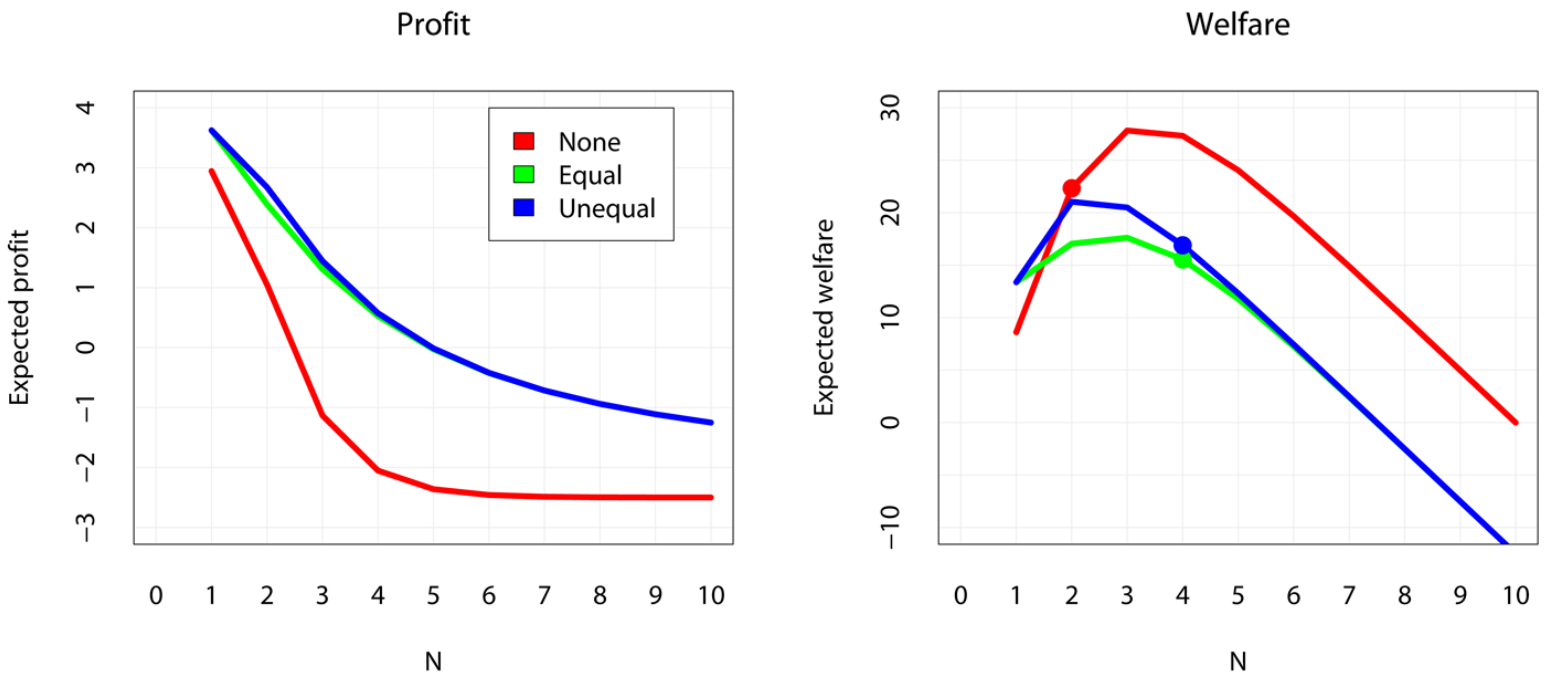
- Given parameter values, use numerical search to find equilibrium value of N under each CRO type.
  - Equilibrium condition: Highest N where $\pi(N) \geq 0$ and $\pi(N+1) < 0$.

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):



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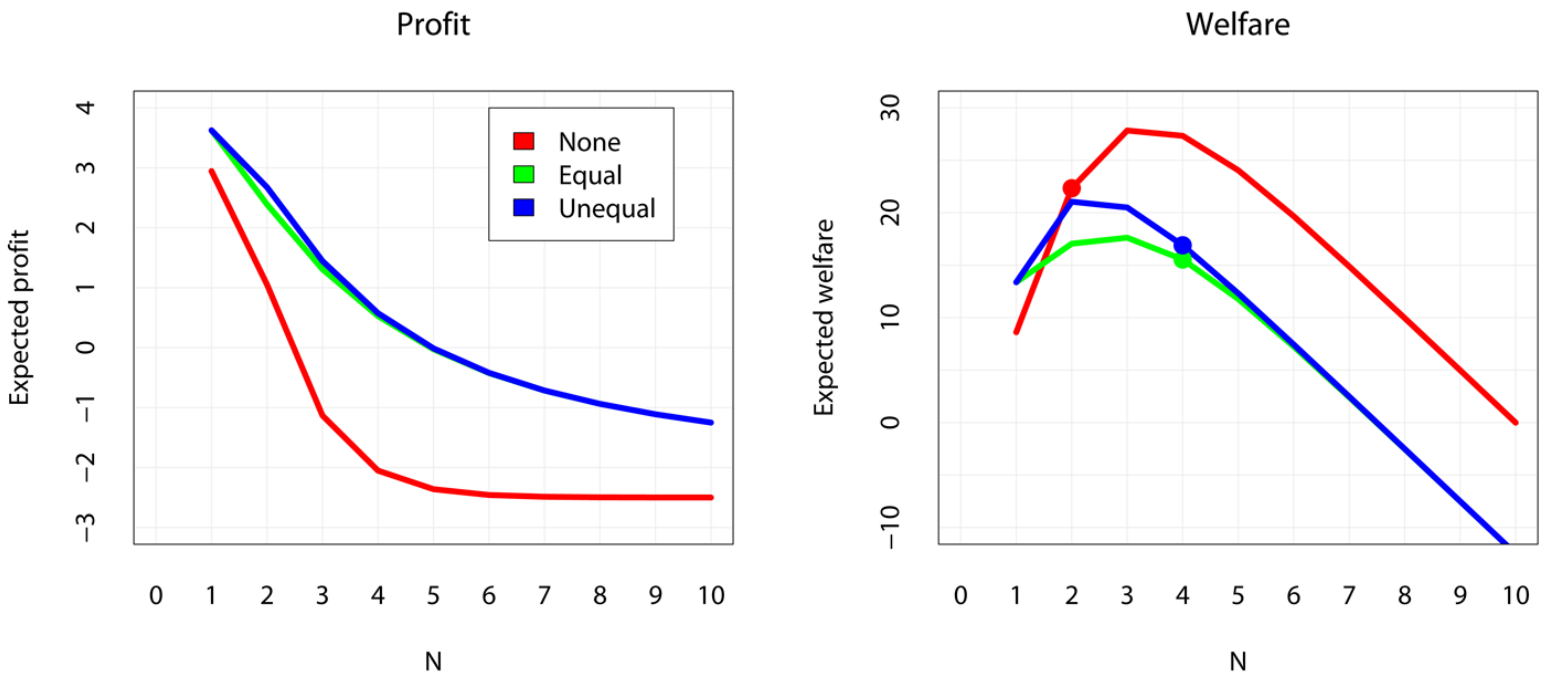
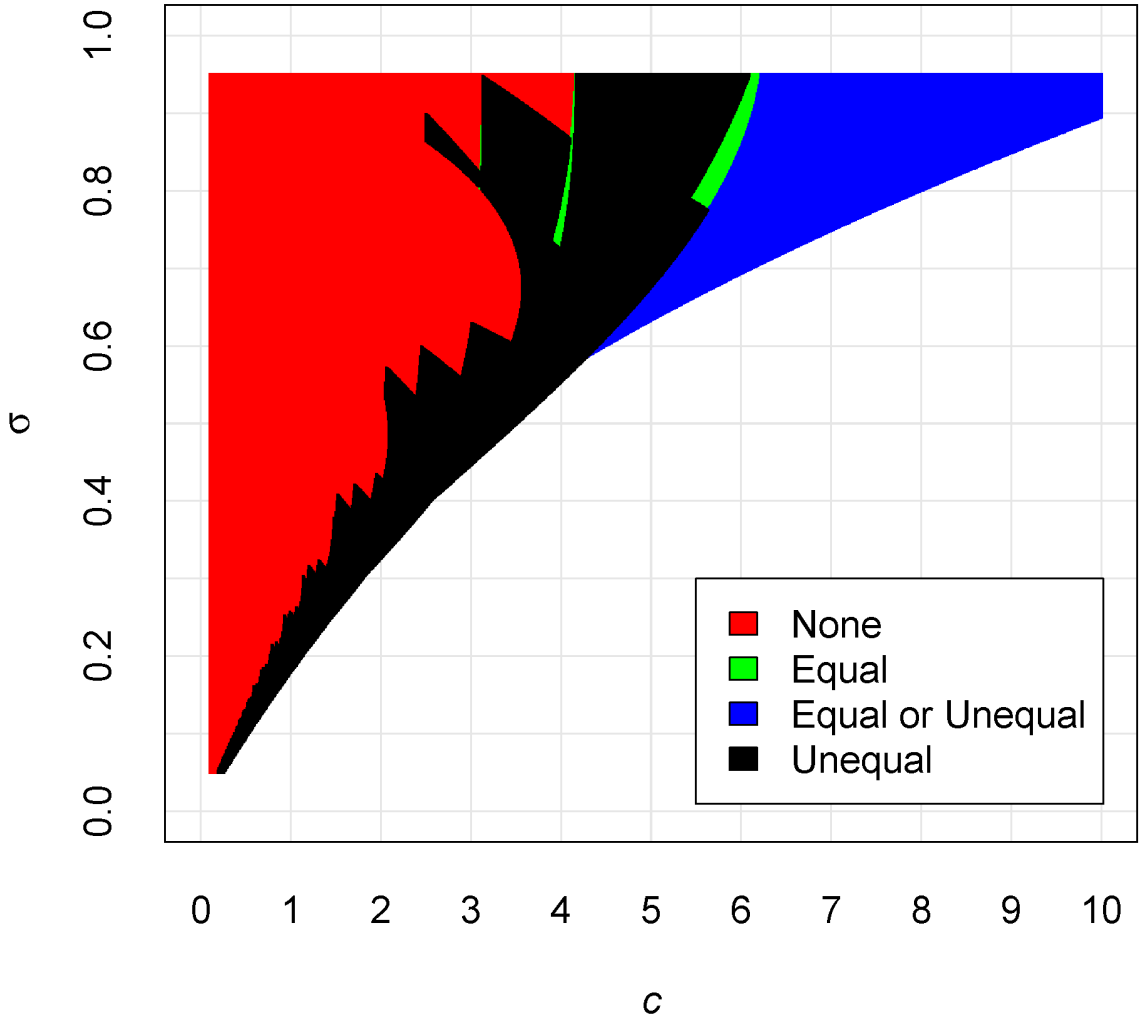


- CRO stimulates investment but may reduce welfare.

Model 1 Equilibrium Expected Welfare

- Simulated CRO equilibrium expected welfare performance across parameter values:



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.
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  - Component A is ex-ante **monopoly**
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- Case CC is no longer possible.

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- 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 $z \leq 1 - \pi_D/\pi_M$.
- Welfare: **Unequal CRO best for all** N. Equal CRO performs better than no CRO for sufficiently low N.

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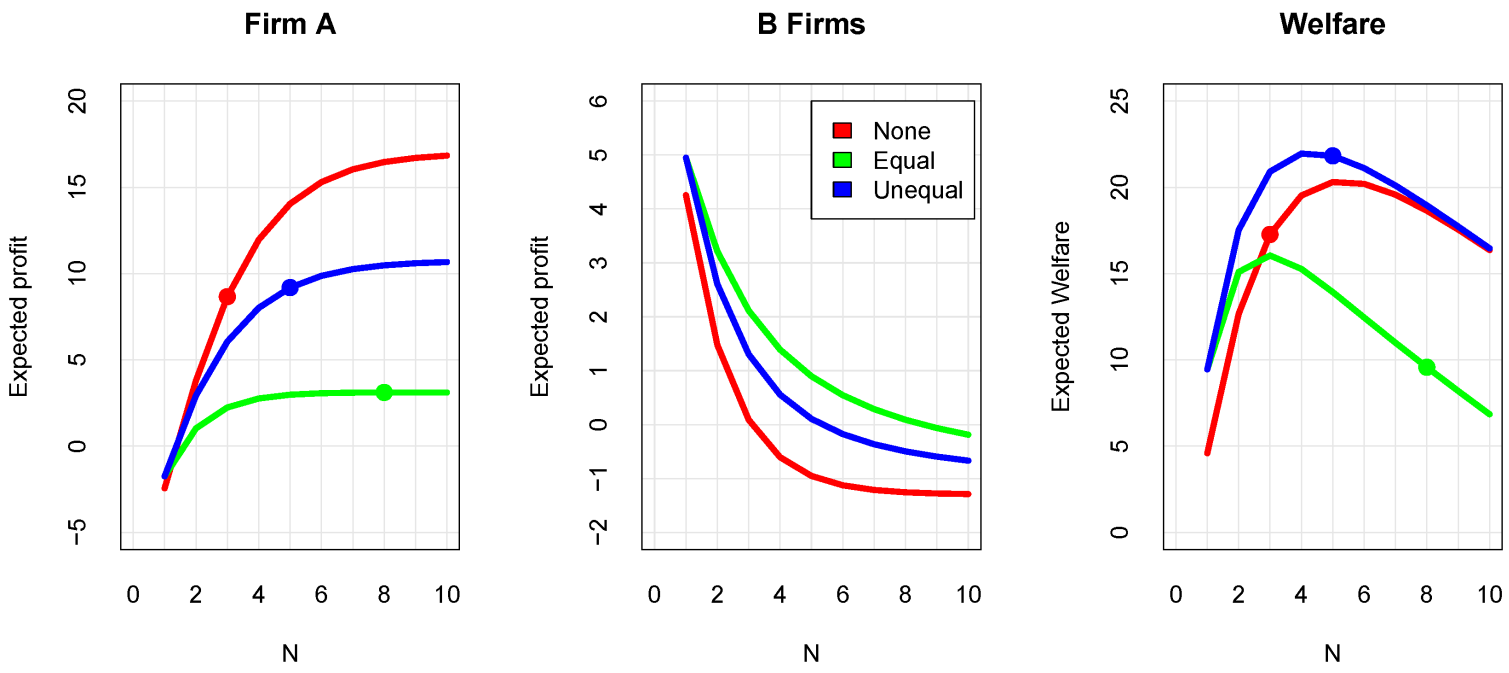
- **Ex-post**, firm A prefers a **high value of** z under an unequal CRO, but this reduces the payoff of component B firms.
- **Ex-ante**, firm A may want to choose a **lower value of** z to give incentive to B firms to invest.

Equilibrium Investment, Ex-ante Profit and Ex-ante Welfare by Simulation

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 $z = 0.75$:



Effect of Technology by Simulation

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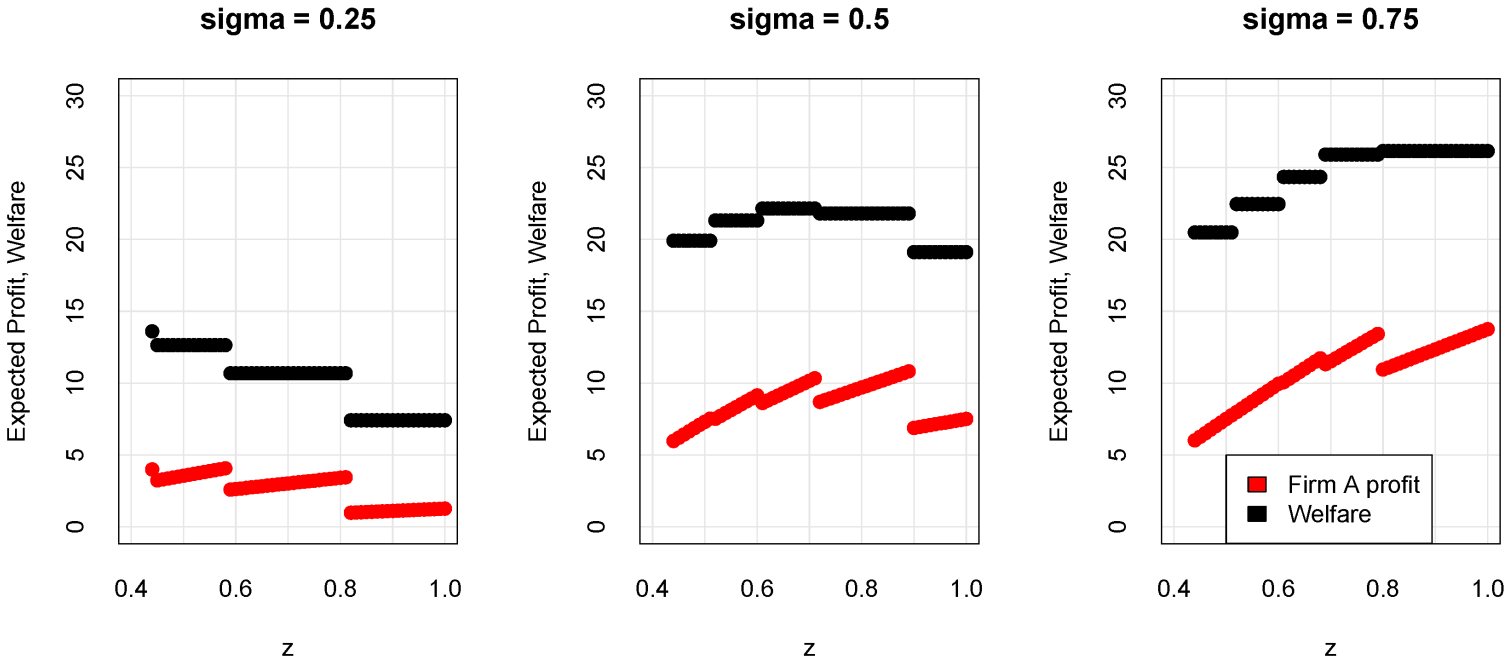
- Effect of changing z in an unequal CRO on equilibrium expected profits of firm A and expected welfare:



- Level of z affects equilibrium investment level of component B firms.

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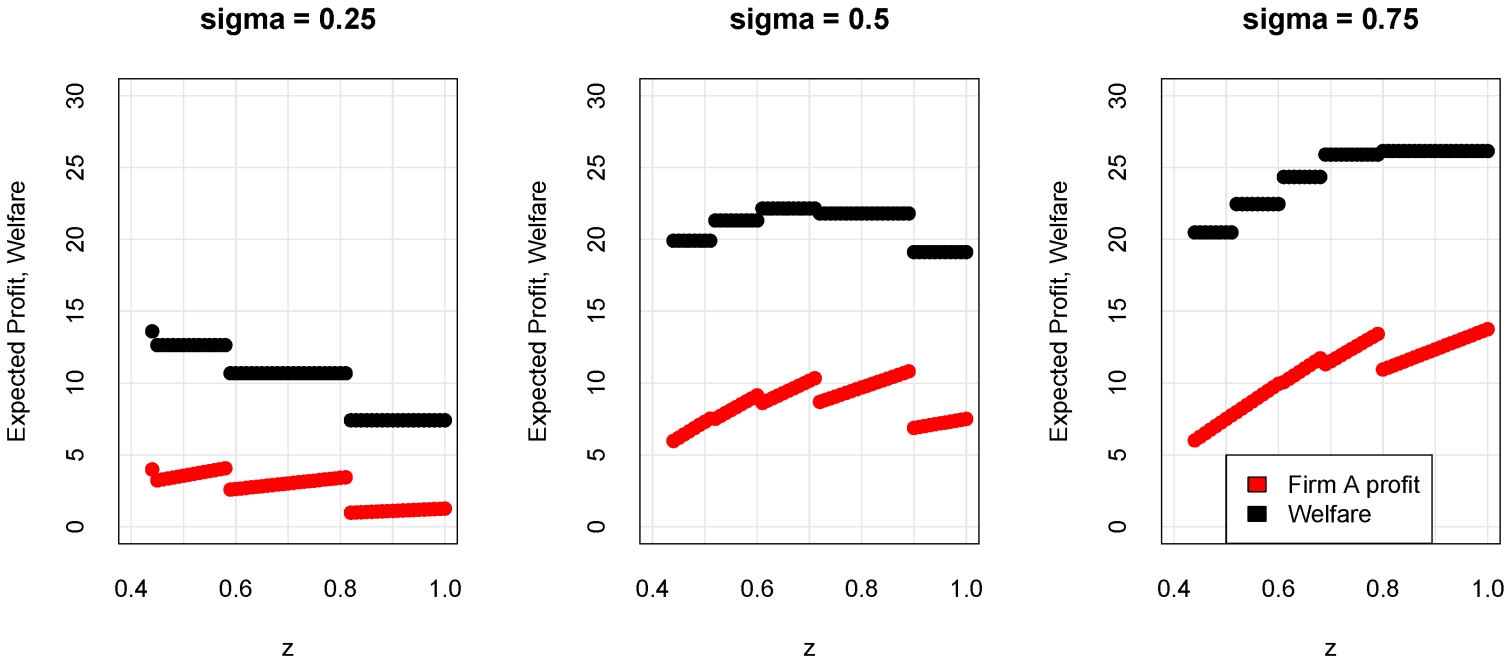

- Level of z affects equilibrium investment level of component B firms.
- CRO licensing revenue **distribution policies** need to be related to the innovation environment.

Effect of Sharing Rule by Simulation

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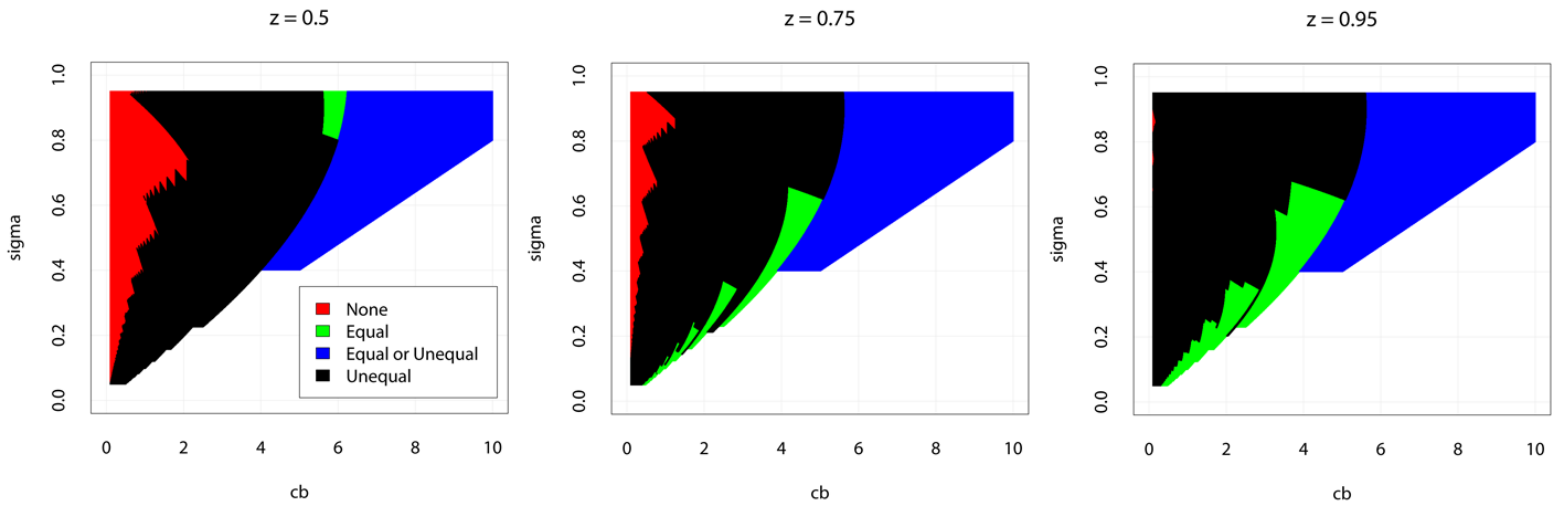
- Simulated CRO equilibrium expected welfare performance across parameter values (fixed $c_A = 5$):



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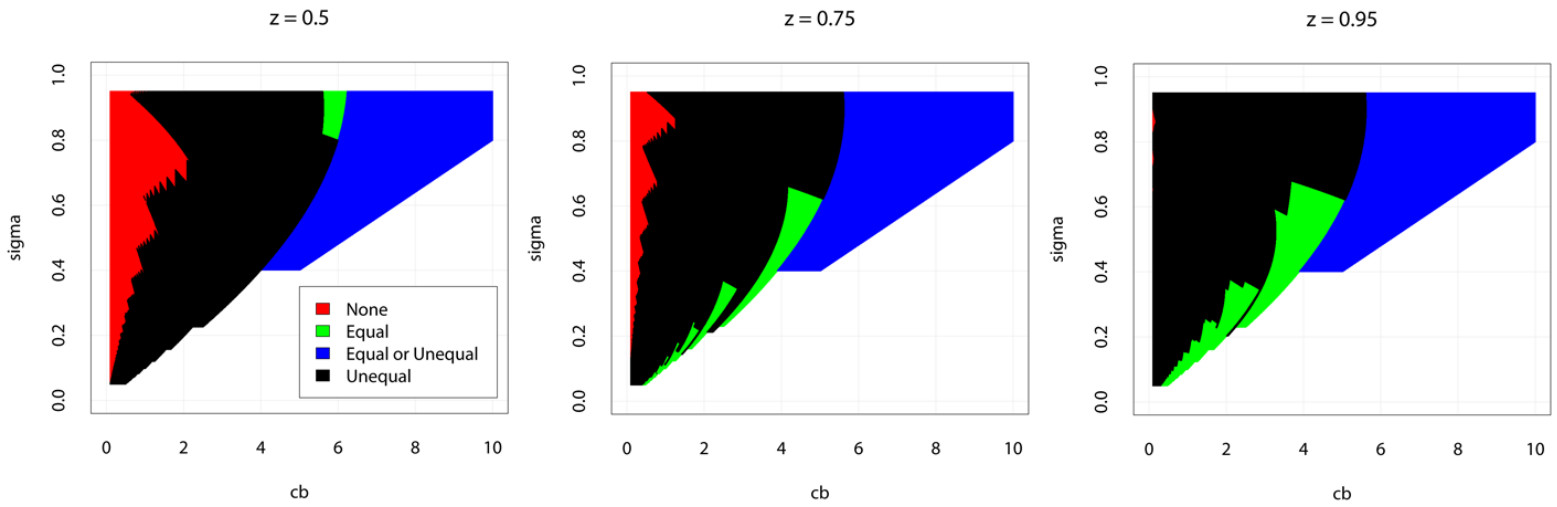

- High z makes **unequal CRO** generate **similar** outcomes to **no CRO**, but the CRO performs better when both components have a single successful inventor.
- However, an **equal CRO may outperform an unequal CRO** with high z as the equal CRO gives greater incentives to component B firms to invest.

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