Patent Pools and Upstream R&D Investment

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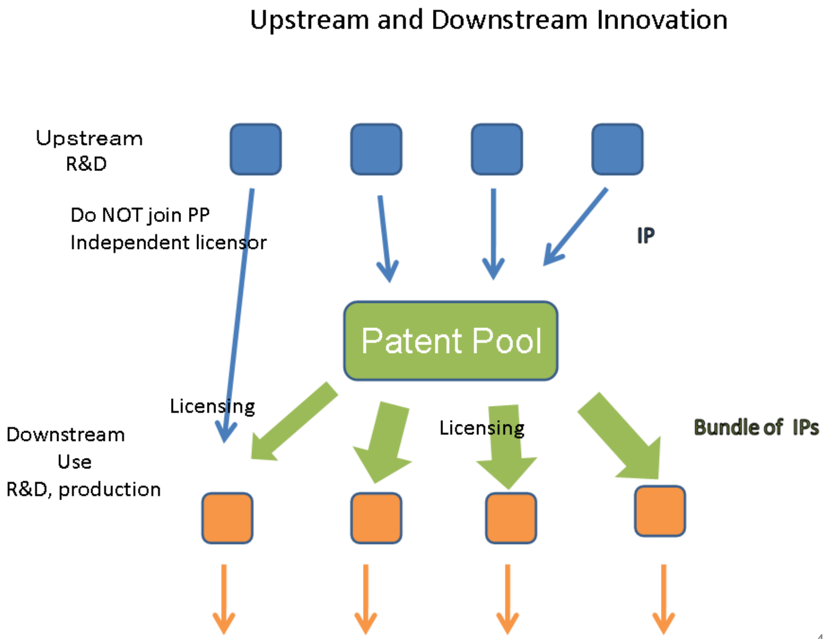
Introduction

- Problem:
  - Downstream innovation or product development may require licensing multiple upstream technologies with multiple owners $\Rightarrow$ high transaction costs and 'tragedy of the anticommons'.
  - Example: Standard implementing patents, Genetic diagnostic tests
- Possible solutions:
  - Cross-licensing
  - Compulsory licensing
  - Research exemptions
  - **Patent pools**, copyright collectives, clearinghouses
  - Open source

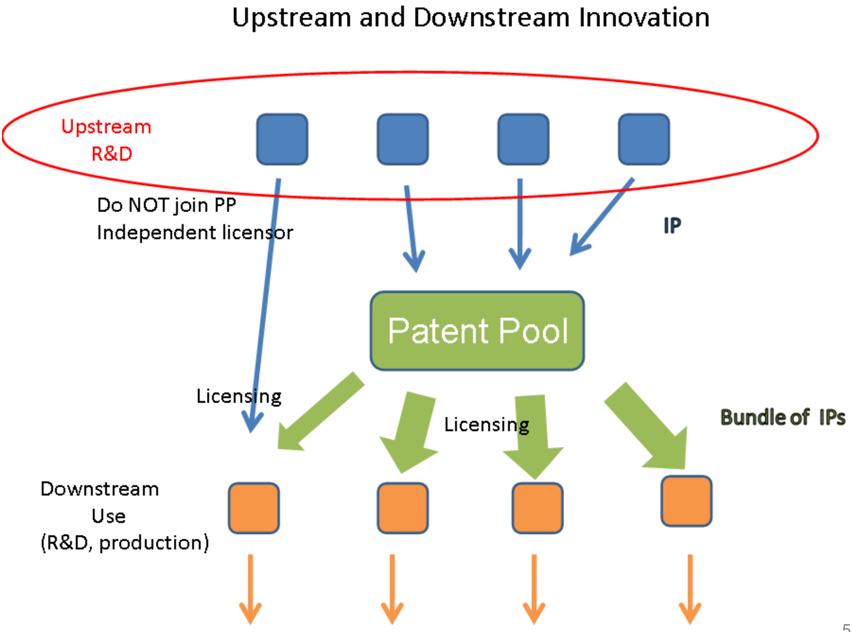
What is a Patent Pool?

- Examples of Patent Pools: MPEG LA, DVD, 3G, SARS Working Group
- Functions
  - Centralized licensing of multiple IP rights
    - Economies of scale in negotiations and royalty collection.
    - Overcome ‘tragedy of anticommons’ (complementary IP) problem by collective licensing.
  - Promotes downstream use (production, cumulative innovation) of complementary IP
  - Feeds back into upstream incentives to innovate.

Upstream vs Downstream



Upstream vs Downstream



Focus of This Paper

- Examine effects of PP upstream incentives to innovate
- PP of complementary intellectual property
  - Standard implementing patent pools
  - DNA microarrays
- Specifically, we examine how PPs effect
  - Ex-post (after upstream innovation) licensing
  - Ex-ante incentives to invest in upstream research.
- Compare different PP licensing revenue (royalty) distribution rules.
- Incorporate the effect of simple antitrust rules.

Analysis - Factors to Consider

- Licensing by the PP must be optimal ex-post (after upstream innovation) given the ex-post outcome of innovation (market structure)
  - Maximize joint profit
  - Induce IP owners to rationally 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 incentives ex-ante
  - Expected profit depends on number of firms investing (ex-ante market structure)
  - Firms differ: Some firms are competitors (substitute technologies) and some are partners (complementary technologies)

Main Conclusions

- In general, PPs stimulate upstream R&D investment
  - But PPs may hurt the incentive of an inventor with unique ability (ex-ante monopoly, firms ex-ante asymmetric)
    - PP dilutes rent
  - And incentives to invest may be socially excessive
- PP that distributes licensing revenue unequally among its members is less likely to lead to welfare loss
  - Unequal distribution helps form PP
  - Even if inventors are symmetric ex-ante, ex-post asymmetries may emerge
- Firm's profit ranking over different PP rules differs ex-ante or ex-post and by firm (monopolist or not) $\Rightarrow$ likely to lead to disagreement over PP rules and formation
- Implication: Determination of PP rules (revenue distribution, antitrust) should take into account R&D technology

Related Literature (1)

- Collective licensing
  - Shapiro (2001) discusses various types of PPs to mitigate anticommons problems
  - van Zimmeren et al 2006, Aoki & Schiff 2008 , Heller, & Eisenberg 1998 (anticommons) , Merges 1996 (PP)
- Patent pools
  - Lerner & Tirole (2004) examine ex post efficiency
  - Lerner et al (2007) empirical examination of licensing rules
  - Layne-Farrar & Lerner (2008) and Aoki & Nagaoka (2005) examine royalty distribution rules and incentives of patent owners to join pools (SSOs)
- Hoppe and Ozdenoren (2005) examine PPs as intermediaries to reduce informational problems in licensing markets
- These papers take technologies (IP) in PPs as given

Related Literature (2)

- We focus on innovation of technologies in the PP
- Related to work on innovation of complementary technologies
- Gilbert & Katz (2007) examine division of profits among innovators racing to develop complementary components
- Meniere (2008) examines effect of the novelty requirement on innovation of complementary technologies
- We consider division of profits via collective licensing

Framework

- New downstream product needs two complementary upstream innovations: A and B.
- 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 firm either independently succeeds or fails (probabilistic) .
- All successful projects (= patent) of a single component result in perfect substitutes.
- Patent Pool
  - Licenses on behalf of successful inventors who choose to join.
  - Objective is to maximize joint royalty revenues of its members.

Timing

- Innovation and licensing takes place in four stages:

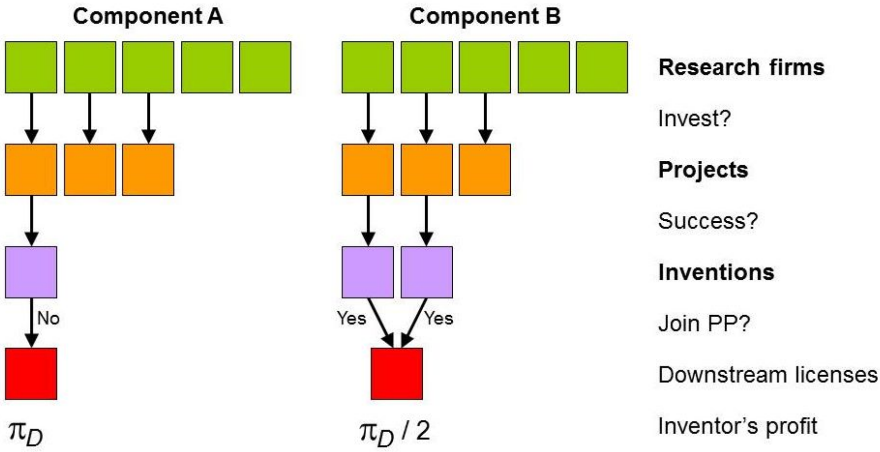
I. The antitrust rule is set and announced: Is the PP allowed to jointly license substitute innovations or not?

II. The PP 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 with given probability.

IV. Successful inventors simultaneously decideto join or not to join the PP or license independently, and then innovations are licensed by the PP and/or any independent inventors and royalties are paid by licensees.

Model Summary (for given antitrust and PP distribution rules)



Assumptions

- Tragedy of Anticommons:

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

  - π_M and W_M: Monopoly licensing profit and welfare.
  - π_D and W_D: Duopoly licensing profit and welfare.
  - W_0: Welfare when both components are licensed at zero price
- $P(k, N)$: Probability that k substitute versions of a component are invented when N projects are undertaken for that component (probability of k success from N trials):

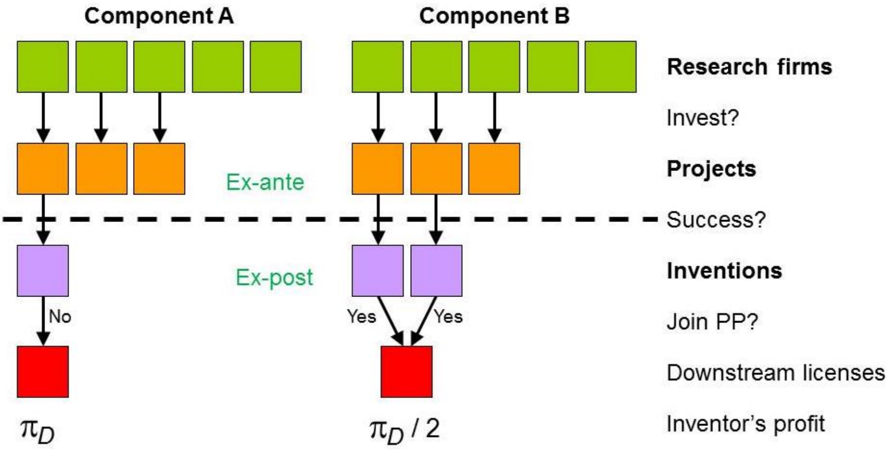
$$\sum_{k=0}^{N} P(k, N) = 1 \text{ and } lim_{N\to\infty} P(k, N) = 0.$$

  Probability that k firms succeed when N firms invest

Licensing Revenue and Antitrust Rules

- ($\pi =$ total PP licensing revenues)
- Joint licensing of substitutes is not allowed:
  - Strict Antitrust Rule: PP randomly chooses at most one member of each component to license; royalties are shared equally between the chosen.
- Joint licensing of substitutes by the PP is allowed:
  - 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.
- Compare to No PP

Ex-ante and Ex-post



Ex-post Outcomes and PP Membership

- Possible ex-post 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)
Case CC:	2 or more	2 or more

- Who will join the PP ex-post?
  - Competitive component inventors (**cases MC & CC**) join any kind of PP.
    - Competition among perfect substitutes drives royalties down to zero $\Rightarrow$ joining is a weakly dominant strategy for them.
  - **Case MM:** Both inventors join any kind of PP.
    - Avoid tragedy of anticommons .
  - **Case MC**: Monopoly inventor joins a strict PP. (Assumption) Monopoly inventor does not join an equal PP but does join an unequal PP (z).

Ex-post Profits

- Ex-post equilibrium payoffs of successful inventors (Gains, Losses relative to no PP):

PP 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	$\pi_M/2$	$\pi_M/2$	$\frac{1}{n}\pi_M/2$	$\frac{1}{n_i}\pi_M/2;\ i=A,B$

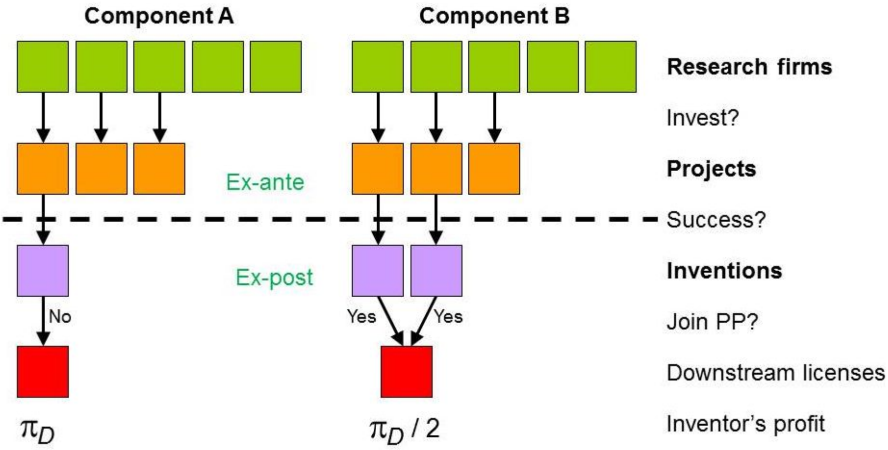
Ex-post Welfare

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

PP Type \ Welfare	$\mathbf{W_{MM}}$	$\mathbf{W_{MC}}$	$\mathbf{W_{CC}}$
None	W_D	W_M	W_0
Equal	W_M	W_D	W_M
Unequal	W_M	W_M	W_M
Strict	W_M	W_M	W_M

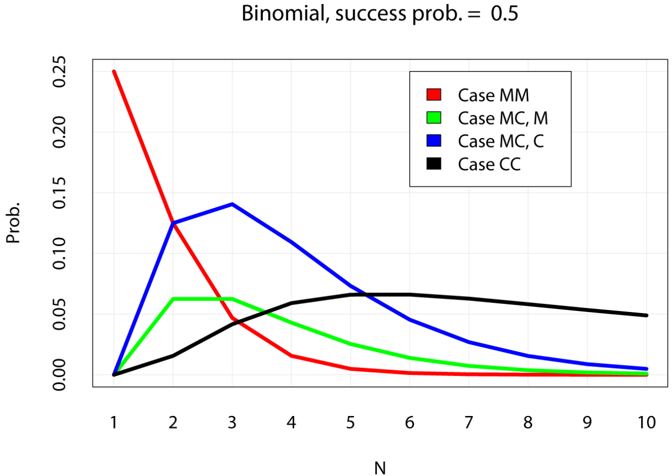
- Ex-ante only probability of outcomes (*MM*, *MC*, or *CC*) known

From Ex-post to Ex-ante



R&D Technology

- Probability that a given research firm becomes a successful inventor depends on the number of firms that invest.
- There are N firms engaged in R&D for each component



Upstream Innovation

- Ex-ante expected profit depends on ex-post profit and distribution of outcomes
- We consider two different upstream market structures.
- **Symmetric Market**: There are $N \geq 2$ firms that can invest in A and $N \geq 2$ firms that can invest in B.
  - Potential ex-ante competition for both components.
  - Symmetric
- **Asymmetric Market**: There is only one firm that invests in A. $N \geq 2$ firms can invest in B.
  - Ex-ante monopoly for innovation of component A. Competitive for component B.
  - Asymmetric

Symmetric Market Upstream Innovation

- **Symmetric Market**: N projects are undertaken for each component
- Ex-ante competitive, symmetric
- Ex-ante expected profit and welfare:

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

Symmetric Market Result: Ex-ante Expected Profit and Welfare (Given N)

- Ex-ante, the **expected profit gains always outweigh any losses**:
  - $\pi^{UC}(N) = \pi^{SC}(N) \geq \pi^{EC}(N) \geq \pi^{NC}(N)$ for all $N \geq 1$.
- PP increases incentive to invest in upstream R&D.
- Welfare
  - When N is large, case CC likely and W_0 achieved.
  - When N is small, case MM likely and PP beneficial.
- Expected welfare with **no PP** 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.
- Unequal or strict PP always outperforms equal: Unequal or strict are better able to get all successful inventors on board.

Simulation with Binomial Upstream R&D Technology (Determination of N)

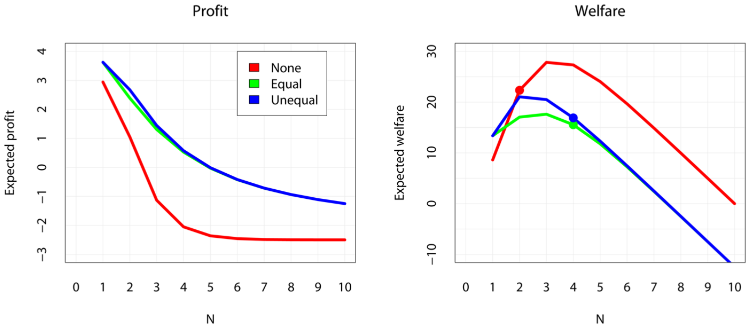
- Linear demand for licenses: $Q = 100 - \rho$ gives parameter values:

Parameter	π_M	π_D	W_0	W_M	W_D
Value	$\frac{100}{4}$	$\frac{100}{9}$	50	$\frac{75}{2}$	$\frac{250}{9}$

- Assume $P(k, N)$ is binomial; σ is success prob. of each project.
- Other parameters: z, c (market 1), c_A and c_B (market 2).
- Given parameter values, use numerical search to find equilibrium value of N under each PP type.
  - Equilibrium condition: Highest N where $\pi(N) \geq 0$ and $\pi(N+1) < 0$.

Symmetric Market Ex-ante Profit & Welfare and Equilibrium Investment by Simulation

- Simulation for $c = 2.5$ and $\sigma = 0.7$ (symmetry makes value of z irrelevant):



- PP stimulates investment but may reduce welfare.
  - Equilibrium investment may increase too much once R&D costs are taken into account.

Asymmetric Market of Upstream Innovation

- Asymmetric Market: Firm A has the unique ability to develop component A ; Development of component B is as before
- Asymmetric firms, Firm A is a monopolist
- Case CC is no longer possible.
- Firm profits when N projects undertaken for component B:

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

$$\pi_B(N) = \frac{1}{N}P(1,N)\,\pi_{MM} + \sum_{k=2}^{N} \frac{n}{N}P(k,N)\,\pi_{MC}^{C}(n) - c_B$$

Asymmetric Market Results: Ex-ante Expected Profits and Welfare (Given N)

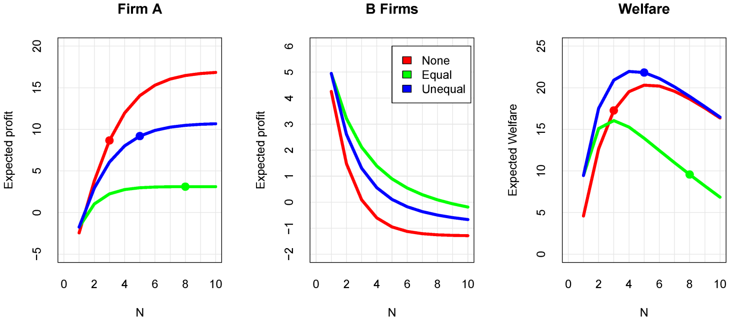
- Firm A prefers
  - No PP when N is large
  - Unequal PP when N is small.
- Component B firm , for any given N,
  - Always better off under either an equal or unequal PP compared to no PP.
  - Such a firm is better off under an unequal PP compared to an equal PP if $z \leq 1 - \pi_D/\pi_M$.
- Welfare: Unequal or strict PP best for all N. Equal PP performs better than no PP for sufficiently low N.

Asymmetric Market Upstream R&D Incentives

- PP's effect depends on firm (ex-ante market structure)
  - Increase the incentives of competitive research firms to invest, but
  - May reduce the incentive of monopolist (unique ability).
- PP's effect differ by firm and by ex-ante and ex-post.
  - Ex-post, firm A prefers a high value of z under an unequal PP, 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.
  - Or, ex-ante, firm A may prefer not to have a strict anti-trust rule even though this facilitates collusion among B firms, to give them an incentive to invest.

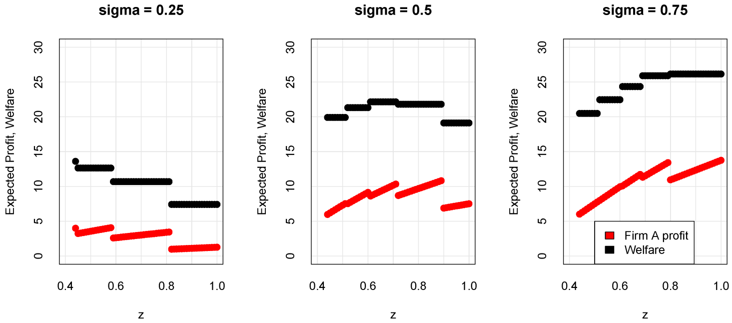
Asymmetric Market: Ex-ante Profit & Welfare and Equilibrium Investment

- Single simulation of market 2, for $c_A = 8$, $c_B = 1.3$, $\sigma = 0.5$ and $z = 0.75$:



Interaction between Technology and Distribution Rule by Simulation

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



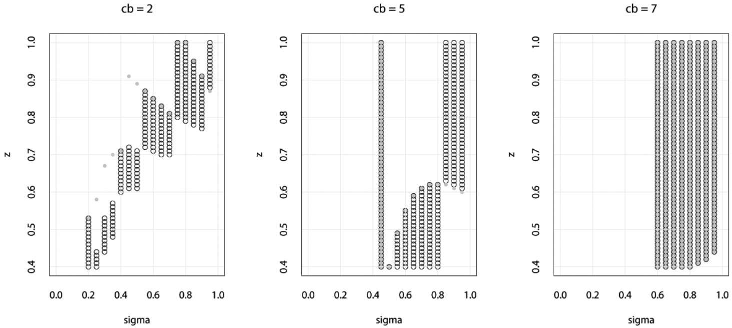
- Level of z affects equilibrium investment level of component B firms.
- PP licensing revenue distribution policies need to be related to the innovation environment.

Conclusion

- PP can generate both ex-post and ex-ante gains and losses to welfare and profits of research firms.
- PP generally stimulate investment in upstream R&D except possibly by inventors who have unique abilities.
- Unequal PP redistribution is less likely to lead to welfare losses but not always.
- Likely conflict between existing and potential inventors regarding PP support.
- PP design and royalty distribution rule needs to reflect conditions of the innovation environment.

Optimal z for Asymmetric Market by Simulation

- Find welfare maximizing z (circles)
- Grey dots indicate A's profit maximized $c_A = 5$



- z increases when σ increases (prevent over investment)
- z decreases when c_B increases (give B incentive)
- If c_B is very high, then $N = 1$ and unequal distribution never used. All values optimal.
- σ very high, then many firms invest in B. Low z necessary to give incentive.