Consortium Standards and Patent Pooling

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Overview

- Lessons from Standard Consortiums
  - Free Riding
  - Bargaining Failure
- Patent Pools and Innovation
  - Upstream and downstream
  - Upstream = technology in the patent pools
  - Downstream = uses patent pools technology

Evidence from Standard Consortiums

- Members leaving
  - Rambus left JEDEC and now suing members
- Patent owner does not join the pool,licenses independently and charges “high” royalty
  - Forgent sues firms over JPEG patents
- DVD consortium split into 3 patent pools
- 3G platform
  - 5 standards
  - Qualcom, Nokia, Eriscson not a member of any

Why is a Pool Not Stable?

- Welfare is greater when there is one single patent pool
  - Competition authorities supportive
- Source of instability
  - Free riding by non-members
  - Bargaining failure due to heterogeneous membership

Example

- Demand for license depends on total royalty payment (licensing fee)
- Higher royalty means fewer demand for licenses
- $Q = 60 - r$
    - Q is number of licenses demanded
    - r is total royalty payment
        - If all patentees in one pool , then r is pool's rate
        - If there are multiple licensees, then r is sum of all rates

There are three firms, A, B and C

- Single licensor
  - All three firms form a pool
- Independent licensing
  - There are three licensor
- Firm C is an outsider
  - Only firms A and B form a pool
  - There are two licensors (pool and a firm)

Each licensor (pool or firm) sets royalty to maximize own revenue

- If there are 3 licensors
  - Firm A charges r_A
  - Total royalty payment is $r_A + r_B + r_C$
  - Firm A's revenue $(60 - r_A - r_B - r_C) \times r_A$
- If there is one licensor (pool)
  - Pool charges r
  - Total royalty payment is r
  - Pool's revenue $(60 - r) \times r$

Incentives

- Raising royalty reduces number of licenses
- A's revenue hurt by B and C's royalty rate
  - Better to have fewer rivals
- A does not take into account reduction of B and C's revenue
  - Each firm independently sets royalty too high

Optimal Royalty and Revenue

Regime	No. of Licensors	Each Licensor Royalty	Total Royalty	Each Licensor Revenue
One Patent Pool	1	30	30	30X30= 900
Firm C is Outsider	2	20	20 x 2= 40	20X20= 400
Independent Licensing	3	15	15 x 3= 45	15X15= 225

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Each Firm's Revenue

Regime	Each Licensor Revenue	Each Firm Revenue
One Patent Pool	900	900/3 = 300 > 225
Firm C is Outsider	400	400/2 = 200 pool member 400 outsider > 300
Independent Licensing	225	225

Each Firm's Revenue

Regime	Each Licensor Revenue	Each Firm Revenue
One Patent Pool	900	900/3 = 300 > 225
Firm C is Outsider	400	400/2 = 200 pool member 400 outsider > 300
Independent Licensing	225	225

Free Riding

- C is better off being an outsider than being a member of a pool
- Incentive to free ride
  - Good to have all other firms in a single pool
  - Better not to join
- Agree to a pool in principle and not join
- Leave the pool after formation
- Benefit increases with number of firms

Possible Solutions

- 400 + 200 + 200 < 900
- Pool members are better off having firm C join the pool
  - Pay 400 to firm C
- Independent licensing is bad for everyone – Use this as a threat to make members commit to the pool

Bargaining Failure

- Forgent and Rambus are not manufacturers
- Research only firms (R-firms) and vertically integrated (V-firms) have <u>different incentive</u>
  - V-firms both conduct research and manufacture
- But pool revenue distributed according to number of patents

Different Profit and Incentives

- R-firm
  - Profit (π_R) is only licensing revenue
- V-firm
  - Profit (π_V)

    = Licensing revenue + manufacturing profit
  - Manufacturing profit decreasing in royalty rate
  - Wants royalty lower than R-firm

Patent Pool Licensing Frontier

- Plot of V-firm and R-firm profits with different patent pool royalty rates (r)
- Pool revenue distributed according to number of patents (in this example equal number of patents)
- r=0 : no pool revenue, good for manufacturing
- Higher r decreases licenses and output

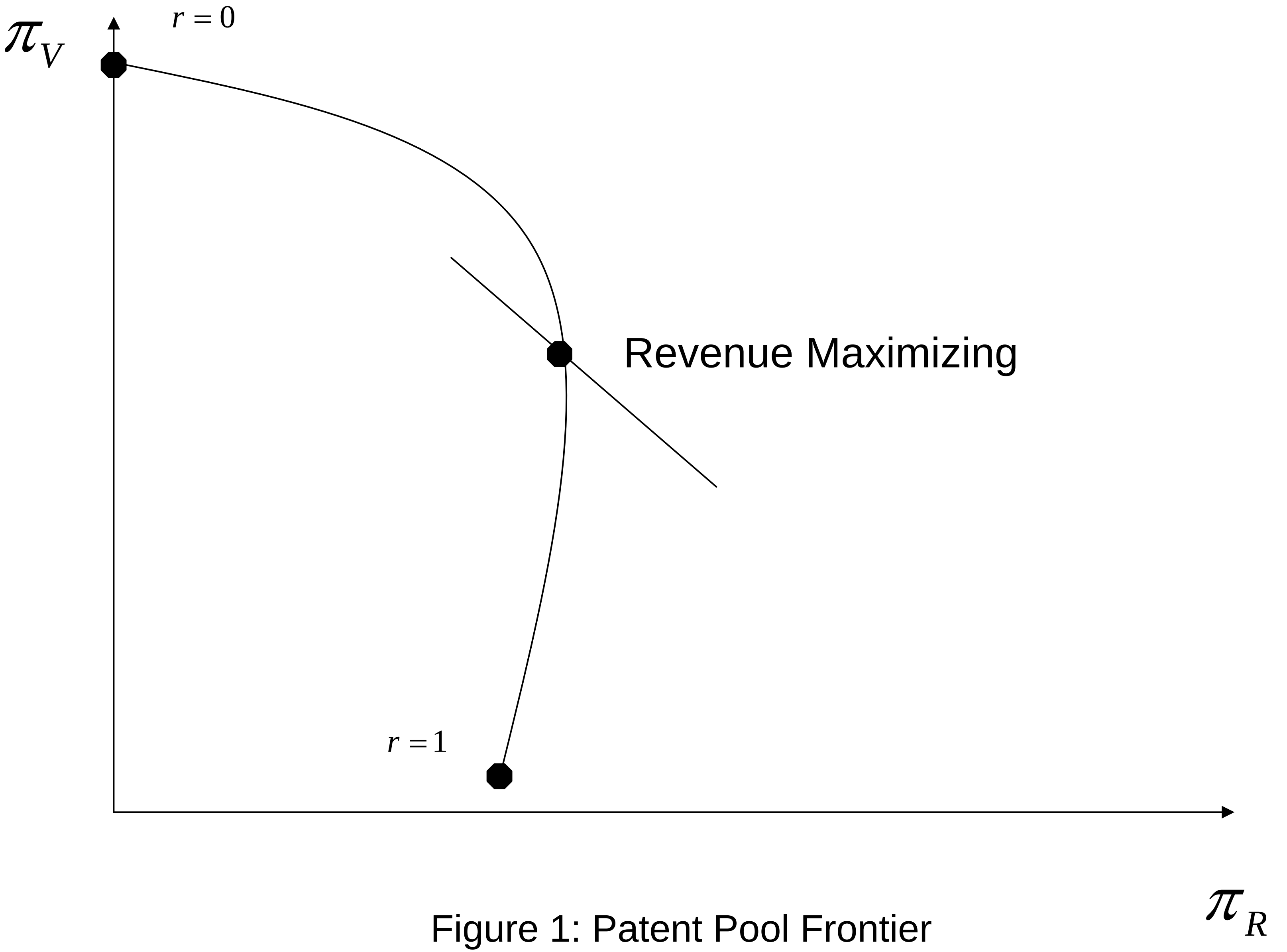

Figure 1: Patent Pool Frontier

Possible Profit Allocations

- **Revenue Maximizing Point** = pool revenue maximized
- Profit Maximizing Point = total firm profits maximized (r lower than Revenue Max)
- Independent Licensing Point = Firms license independently

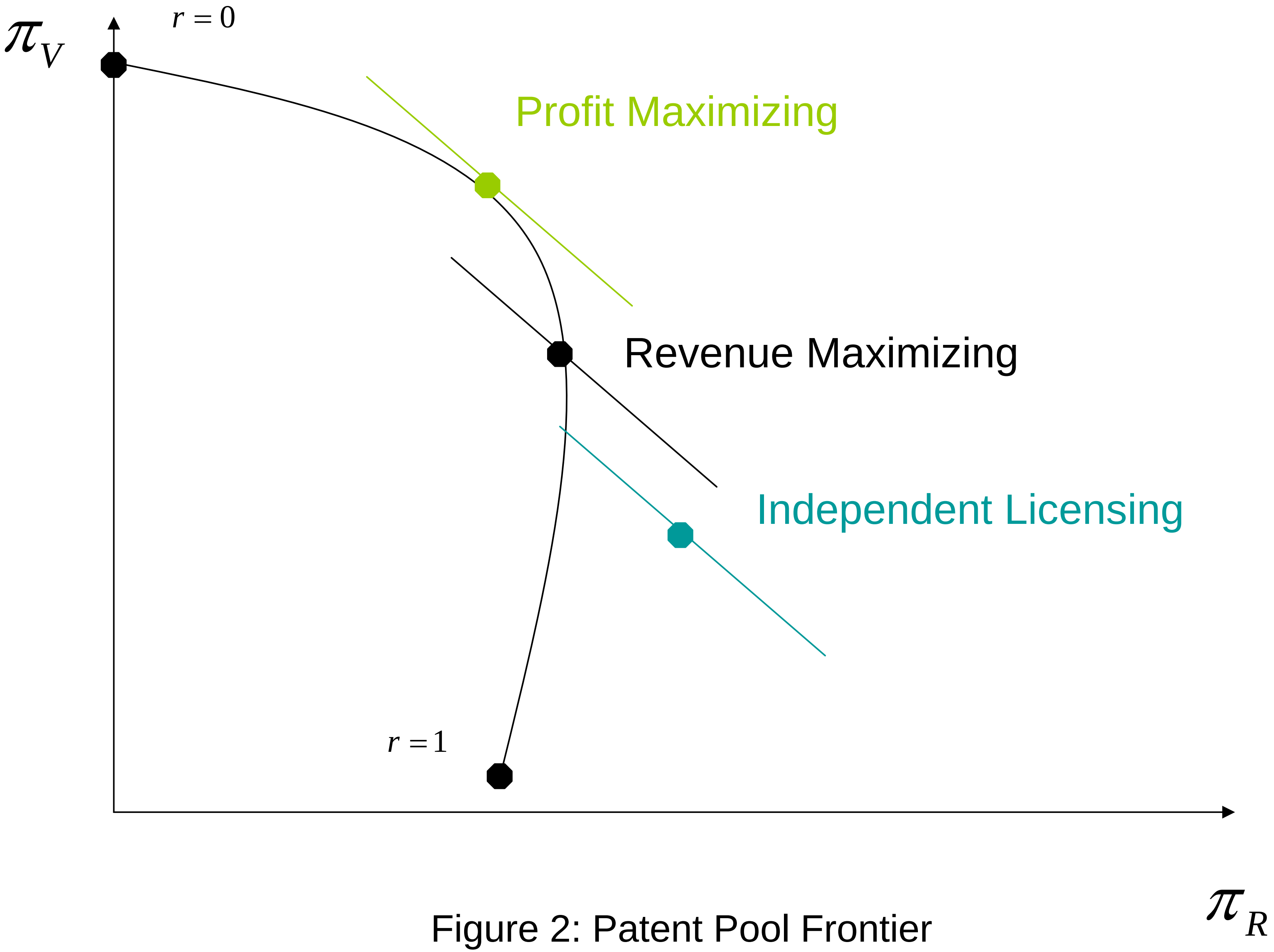

Figure 2: Patent Pool Frontier

Bargaining Failure

- Independent Licensing is <u>outside</u> the frontier
- <u>Not achievable</u> by current pool revenue sharing rule
- Pool revenue sharing rule must incorporate Independent Licensing into account
- <u>Benefit</u> from Independent Licensing is <u>different</u> between R and V firms.

Possible Solutions

- Total profit is larger with Revenue Maximizing than Independent Licensing
- R-firm must be guaranteed at least Independent Licensing profit
  - Bargaining than per patent distribution rule
- Total profit is larger even larger with Profit Maximizing
  - Form pool, Profit Maximize and bargain

Nash Bargaining Solution

- Profit maximizing line is bargaining frontier
  - Best possible profits by firms cooperating
  - Best achievable only by forming a pool
- Disagreement point (threat point) is Independent Licensing
- Nash Bargaining Solution splits the surplus from cooperating (difference between frontier and disagreement point)

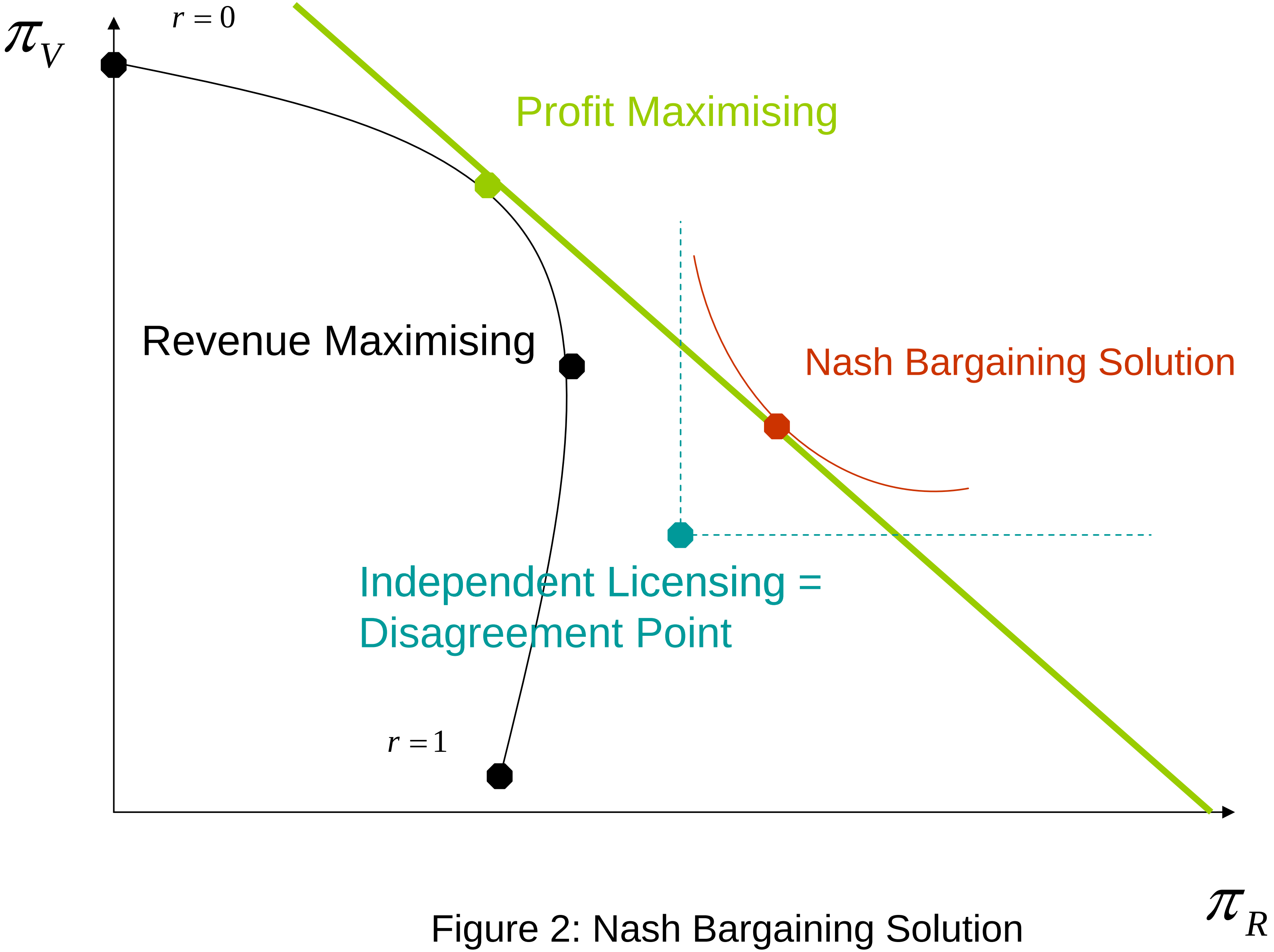

Figure 2: Nash Bargaining Solution

Conclusion

- Patent pool is appealing in theory
- Problems in implementation (also theoretically sound !)
  - Free riding
    - Incentive to not join or leave the pool
    - Wants everyone else to form a pool
  - Bargaining failure
    - Heterogeneous membership
    - Revenues sharing should be negotiable

Patent Pools and Innovation

- 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:
  - Patent Pools
  - Cross-licensing
  - Compulsory licensing
  - Research exemptions
  - Open source

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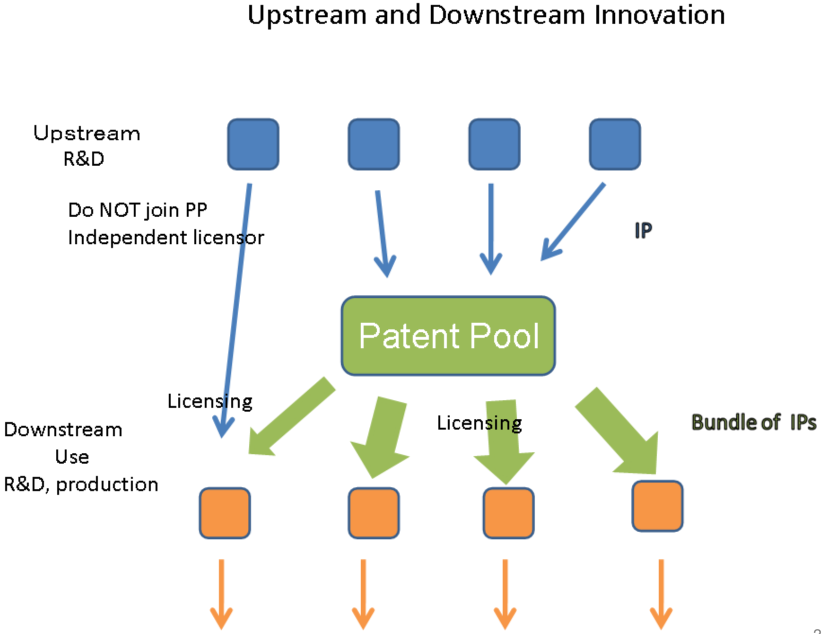
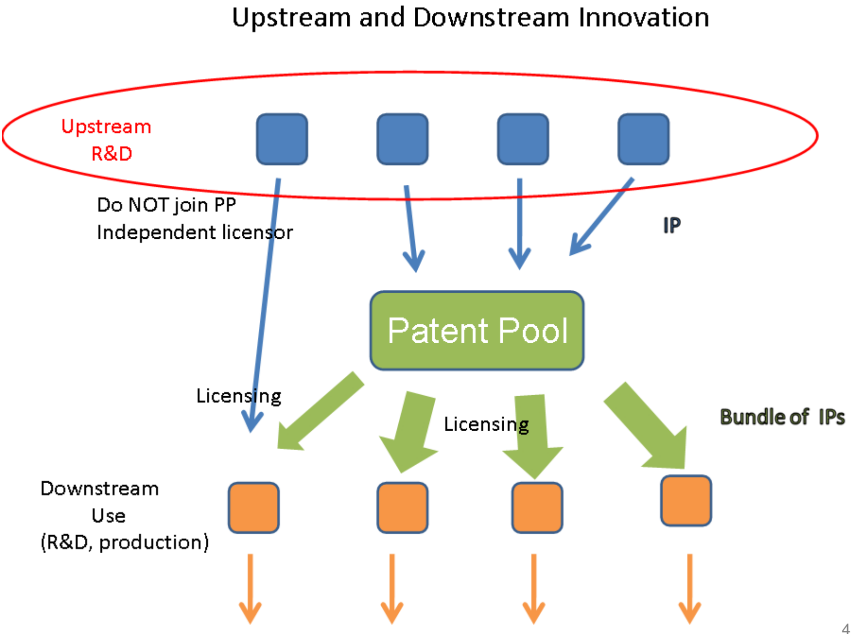
Upstream vs Downstream Innovation



Upstream vs Downstream



Focus

- Examine effects of PP on 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.

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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)

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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) ⇒ 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

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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.
- PP
  - Licenses on behalf of successful inventors who choose to join.
  - Objective is to maximize joint royalty revenues of its members.

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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.

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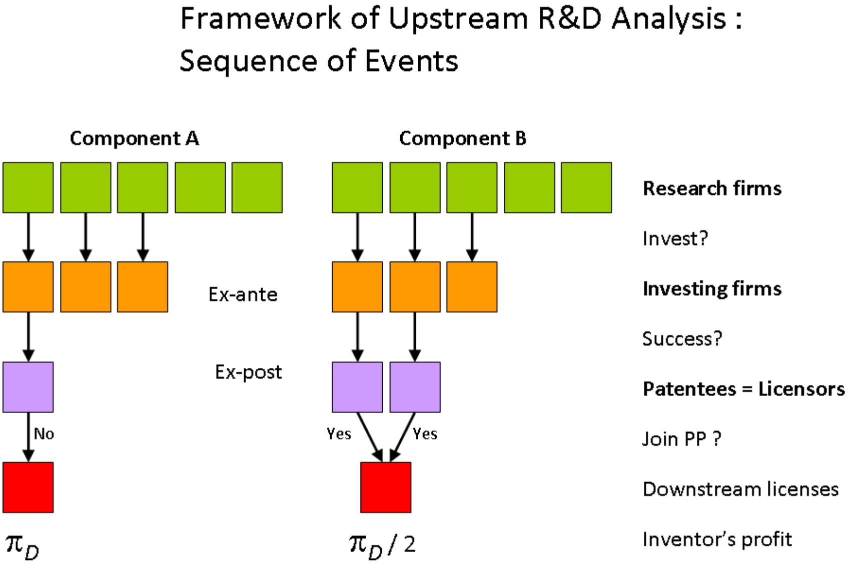
Model Summary (for given antitrust and PP distribution rules)



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

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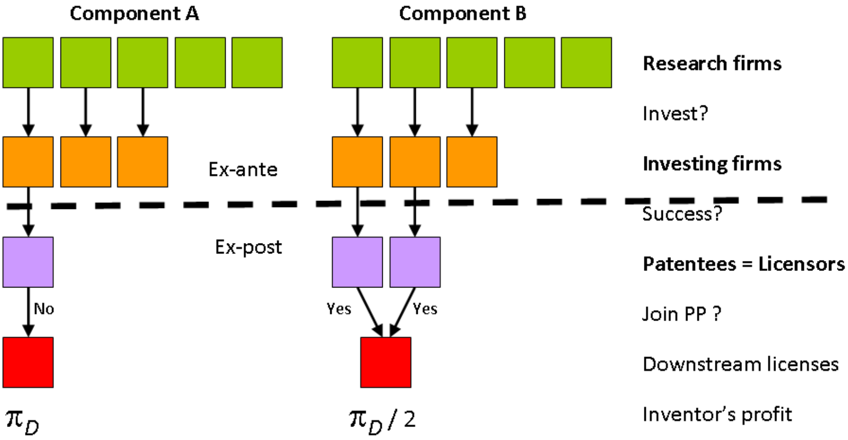
Licensing Revenue and Antitrust Rules

- ($\pi =$ 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

Framework of Upstream R&D Analysis :
Sequence of Events



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 ⇒ 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).

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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

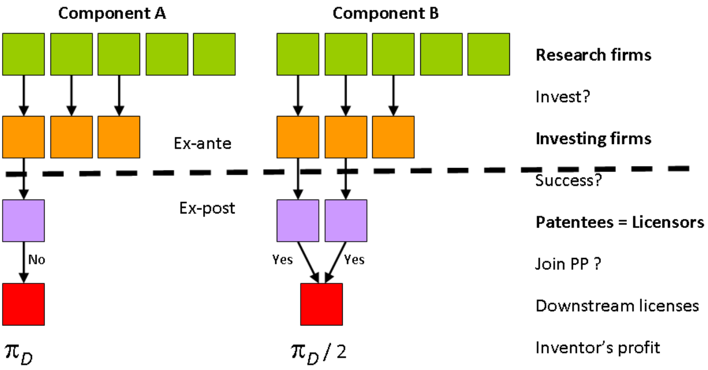
- Ex-post equilibrium welfare:
  (Gains, Losses)

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

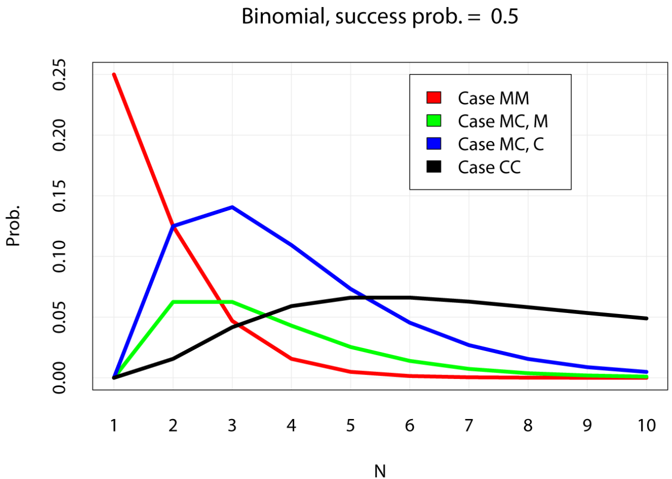
From Ex-post to Ex-ante

Framework of Upstream R&D Analysis :
Sequence of Events



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.
- **Market 1**: 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
- **Market 2**: 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

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Market 1 Upstream Innovation

- **Market 1**: N projects are undertaken for each component
- Ex-ante competitive, symmetric
- Ex-ante expected profit and welfare:

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

Market 1 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.
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  - 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,

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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.
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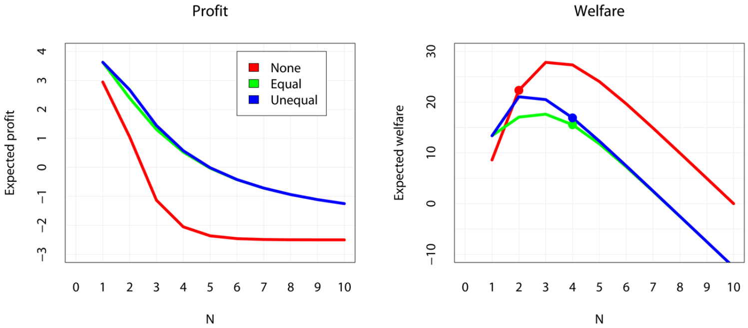
Market 1 Ex-ante Profit & Welfare and Equilibrium Investment by Simulation

- 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.

Market 2 of Upstream Innovation

- Market 2: 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:

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

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Market 2 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.

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Market 2 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.

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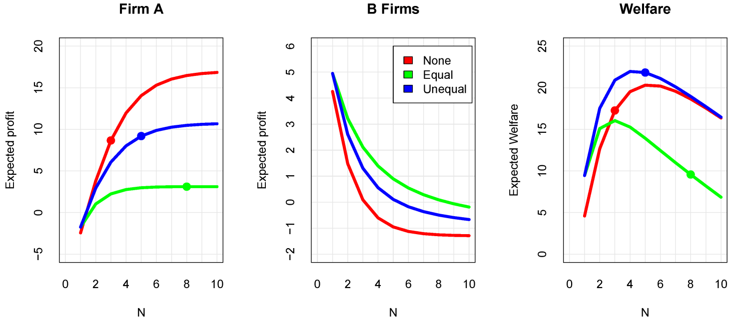
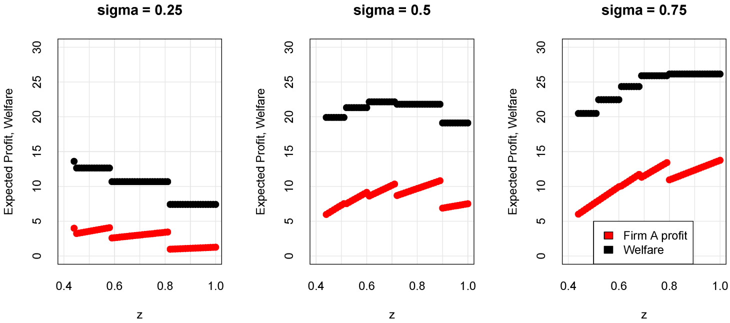
Market 2: Ex-ante Profit & Welfare and Equilibrium Investment

- 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.

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