

# Effect of Patent Pools on Innovation

Reiko Aoki    Aaron Schiff

Hitotsubashi University    Covec Ltd

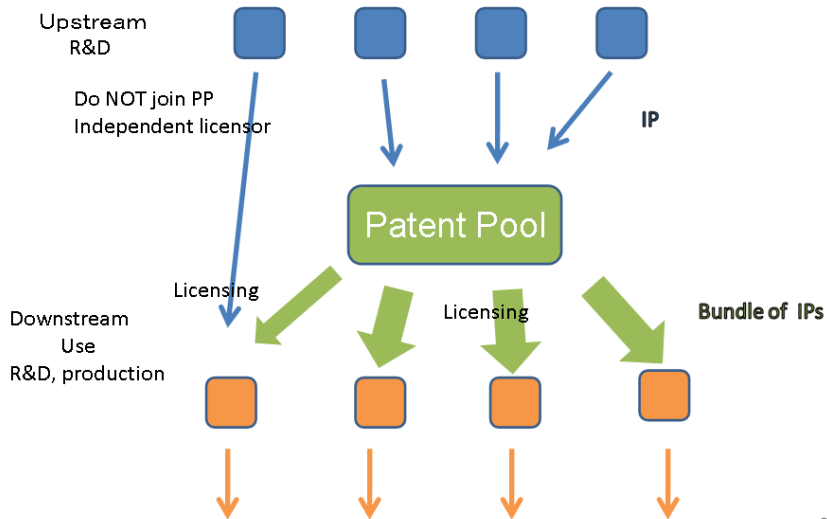
IPRIA Pacific Rim Innovation Conference  
University of Melbourne  
22 January 2010

# Function of Patent Pools

- ▶ Patent pools (collective rights organizations)
  - ▶ Standard implementing technologies - DVD, MPEG item  
DNA sequences for DNA microarrays (DNA-on-a-chip)
  - ▶ (ASCAP)
- ▶ Centralized licensing of multiple patents (IP rights)
  - ▶ Economies of scale in negotiations and royalty collection.
  - ▶ Overcome 'tragedy of anticommons' (complementary patents) problem by collective licensing.
- ▶ Promotes **downstream use (production, cumulative innovation)** of complementary IP
- ▶ Feeds back into **upstream incentives to innovate.**

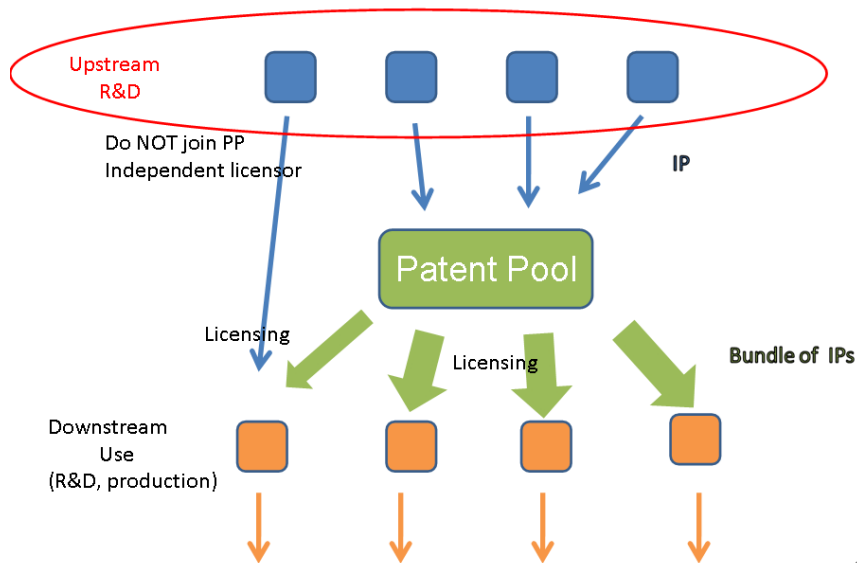
# Upstream vs Downstream

## Upstream and Downstream Innovation



# Upstream vs Downstream

## Upstream and Downstream Innovation



# Focus of Our Work

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

# Focus of Our Work

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

# Focus of Our Work

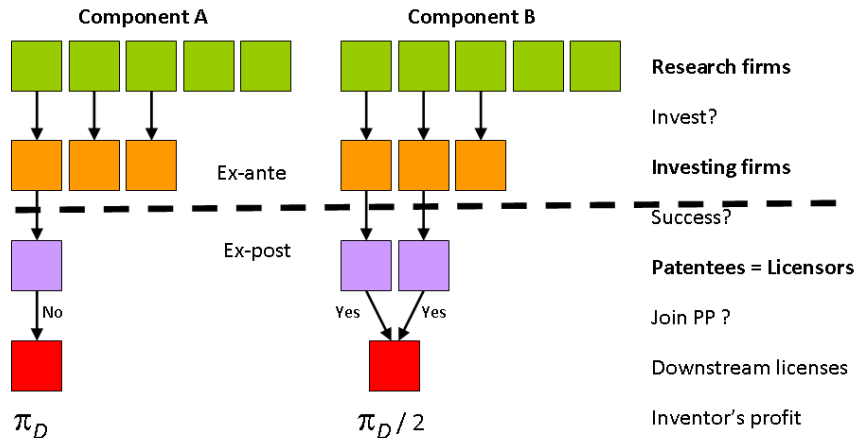
- ▶ Examine effects of patent pools on **upstream** incentives to innovate
- ▶ Patent pools of complementary intellectual property
- ▶ Specifically, we examine how patent pools effect
  - ▶ Ex-post (after upstream innovation) licensing
  - ▶ Ex-ante incentives to invest in upstream research.
- ▶ Compare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

# Focus of Our Work

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

# Model Summary (for given antitrust and patent pool distribution rules)

## Framework of Upstream R&D Analysis : Sequence of Events



# Analysis - Factors to Consider

- ▶ Licensing by the patent pool must be optimal **ex-post** (after upstream innovation) given the ex-post outcome of innovation (market structure)
  - ▶ Maximize joint profit
  - ▶ Induce patent 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)

# Analysis - Factors to Consider

- ▶ Licensing by the patent pool must be optimal **ex-post** (after upstream innovation) given the ex-post outcome of innovation (market structure)
  - ▶ Maximize joint profit
  - ▶ Induce patent 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)

# Analysis - Factors to Consider

- ▶ Licensing by the patent pool must be optimal **ex-post** (after upstream innovation) given the ex-post outcome of innovation (market structure)
  - ▶ Maximize joint profit
  - ▶ Induce patent 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, patent pools **stimulate upstream R&D investment**
  - ▶ But patent pools may **hurt** the incentive of an inventor with **unique** ability (ex-ante monopoly, firms ex-ante asymmetric)
    - ▶ patent pool dilutes rent
    - ▶ And incentives to invest may be socially excessive
- ▶ Patent pools that distributes licensing revenue **unequally** among its members is **less likely** to lead to welfare **loss**
  - ▶ Unequal distribution helps form patent pool
  - ▶ Even if inventors are symmetric ex-ante, ex-post asymmetries may emerge
- ▶ Firm's profit ranking over different patent pool rules differs **ex-ante or ex-post** and **by firm** (monopolist or not) ⇒ likely to lead to **disagreement** over patent pool rules and formation
- ▶ Implication: Determination of **patent pool rules** (revenue distribution, antitrust) should take into account **R&D technology**

# Main Conclusions

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

# Main Conclusions

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

# Main Conclusions

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

# Related Literature (1)

- ▶ Collective licensing
  - ▶ Shapiro (2001) discusses various types of patent pools 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 patent pools as intermediaries to reduce informational problems in licensing markets
- ▶ These papers take **technologies (IP) in PPs as given**

# Related Literature (1)

- ▶ Collective licensing
  - ▶ Shapiro (2001) discusses various types of patent pools 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 patent pools 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 patent pool
- ▶ 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**

## Related Literature (2)

- ▶ We focus on **innovation** of technologies in the patent pool
- ▶ 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**

## Related Literature (2)

- ▶ We focus on **innovation** of technologies in the patent pool
- ▶ 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**

# Work in Progress

- ▶ In the current paper, there is no patent pool when innovation takes place - only prospect of patent pool
- ▶ What is the incentive of patent pool members and outsiders when a patent pool already exists ?
  - ▶ How did DVD patent pool influence speed of development of Blu-ray ?
- ▶ Competition within pool (inside) and outside
- ▶ Replacement effect for pool members
- ▶ Empirical evidence
  - ▶ Lampe and Moser (2008): US sewing machine PP
    - ▶ Innovation increased before PP formation and after PP resolved
    - ▶ Innovation by members and outsiders slowed while PP existed
  - ▶ Nicol et al.: Australian bio=technology ( to come !)

# 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.

# Framework

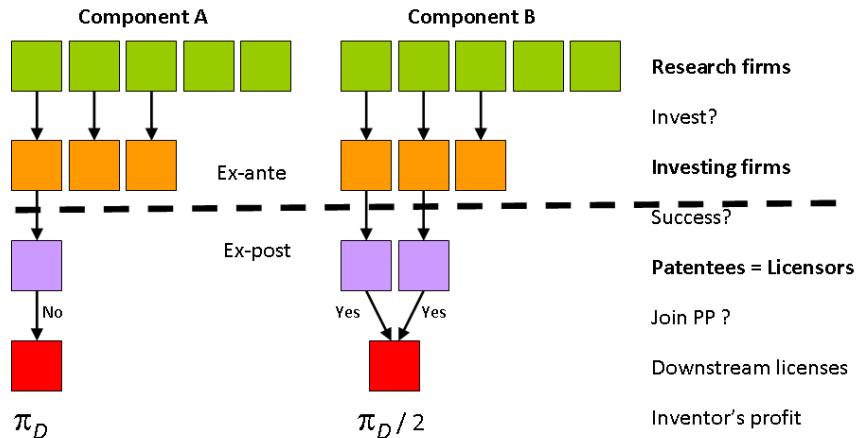
- ▶ New **downstream product** needs two complementary upstream innovations: A and B.
- ▶ Large number of competitive **upstream research firms**:
  - ▶ Each has capacity for one research 'project' at cost  $c$
  - ▶ Specialized in development of A or B
  - ▶ Revenues only from licensing
- ▶ Each **firm** 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.

# 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.

# Model Summary (for given antitrust and patent pool distribution rules)

## Framework of Upstream R&D Analysis : Sequence of Events



# Assumptions

- ▶ Tragedy of Anticommons:

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

- ▶  $\pi_M$  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 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):

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

Probability that  $k$  firms succeed when  $N$  firms invest

# Assumptions

- ▶ Tragedy of Anticommons:

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

- ▶  $\pi_M$  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 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):

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

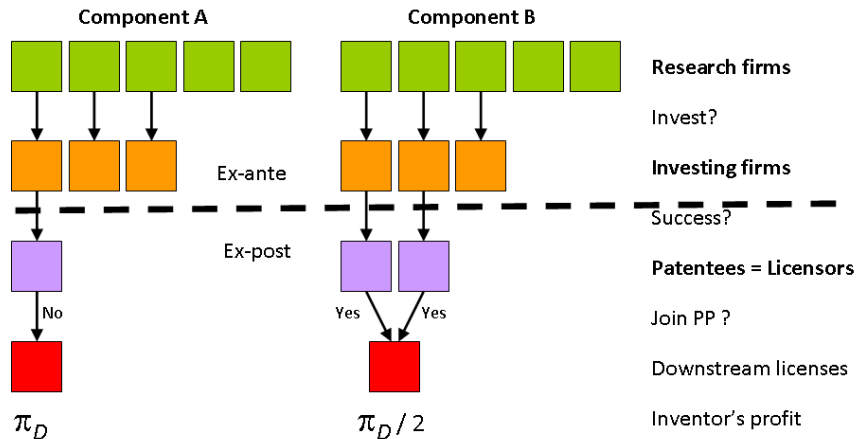
Probability that  $k$  firms succeed when  $N$  firms invest

# Licensing Revenue and Antitrust Rules

- (1) ( $\pi$  = total PP licensing revenues)
- (2) 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.
- (3) Joint licensing of substitutes by the PP is allowed:
  - ▶ **Equal**: With  $n$  members, each receives  $\pi/n$ .
  - ▶ **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  $(1 - z)\pi/n$  with  $z \in [0, 1]$ . Otherwise, equal shares.
- (4) Compare to **No PP**

# Ex-ante and Ex-post

## Framework of Upstream R&D Analysis : Sequence of Events



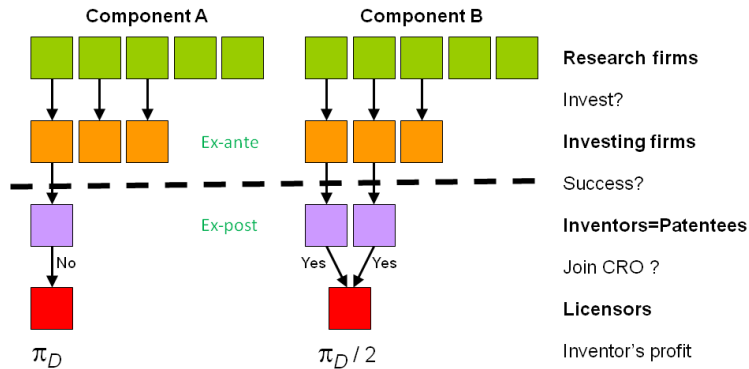
# Ex-post Profits

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

PP Type \ Profit	$\pi_{MM}$	$\pi_{MC}^M$	$\pi_{MC}^C(n)$	$\pi_{CC}(n_A, n_B)$
None	$\pi_D$	$\pi_M$	0	0
Equal	$\pi_M/2$	$\pi_D$	$\pi_D/n$	$\pi_M/(n_A + n_B)$
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-ante, firms don't know which outcome (which role in MC)

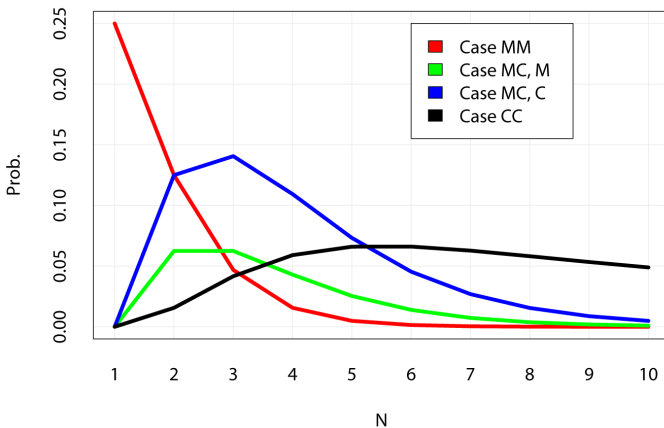
# From Ex-post to Ex-ante



# 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

Binomial, success prob. = 0.5



# Firm A only firm that can invest in component A

- ▶ Firm A's share of patent pool revenue is  $z$
- ▶ Firm A better off with smaller  $z$  to give component B innovators incentive
- ▶ Firm A needs component B

