# On the Division of Profit in Sequential Innovation
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# Purpose

▶ We investigate the policy that is most effective at ensuring the first innovator earns a large share of profit from the second-generation products it facilitates.

▶ That is; to determine patent breadth and length to encourage R&D thereby increasing social welfare.

# Model

▶ We call the quality of the first product x, and the quality of the second-generation product x + y, so that y represents the size of the improvement

▶ We assume that if the first product alone is marketed as a monopoly, the monopolist earns revenue $-\pi_x(T)$ when the patent lasts a period T

▶ If the improved product is marketed by a monopolist, the revenue is $\pi_{x+y}(T)$

▶ If the two products compete, the revenues are respectively $\pi_x^c(T)$ and $\pi_y^c(T)$, where $\pi_x^c(T) \leq \pi_x(T)$ and $\pi_{x+y}(T) \geq \pi_x^c(T) + \pi_y^c(T)$

For simplicity we will assume that little time elapses between the innovations, so that both patents begin and end at the same time. Relaxing this assumption would complicate the model without yielding substantially different conclusion

# Model

- Although both y and $c_2$ are unknown at the time of the first investment, some of the uncertainty will typically be resolved prior to the second investment.

- Below we consider two possibilities:

1. all the uncertainty is resolved, so that the prospective second innovator knows both the value and cost of the improvement when he makes his investment decision

2. only the cost is resolved, but the value is still uncertain.

# Patent Breadth

- The patent breadth is a value y* with the interpretation that if the subsequent innovator discovers a product of quality x + y, with y ≥ y*, then this product is deemed not to infringe the patent.

- If y < y*, then this product will infringe.

In U.S. patent law, patent claims will be upheld by the examiners and the courts only if the applicant invented the claimed technologies, and if they satisfy "novelty" and "nonobviousness." Although these tests refer to scientific and technical considerations, and not to economic values, our model uses the latter as a proxy
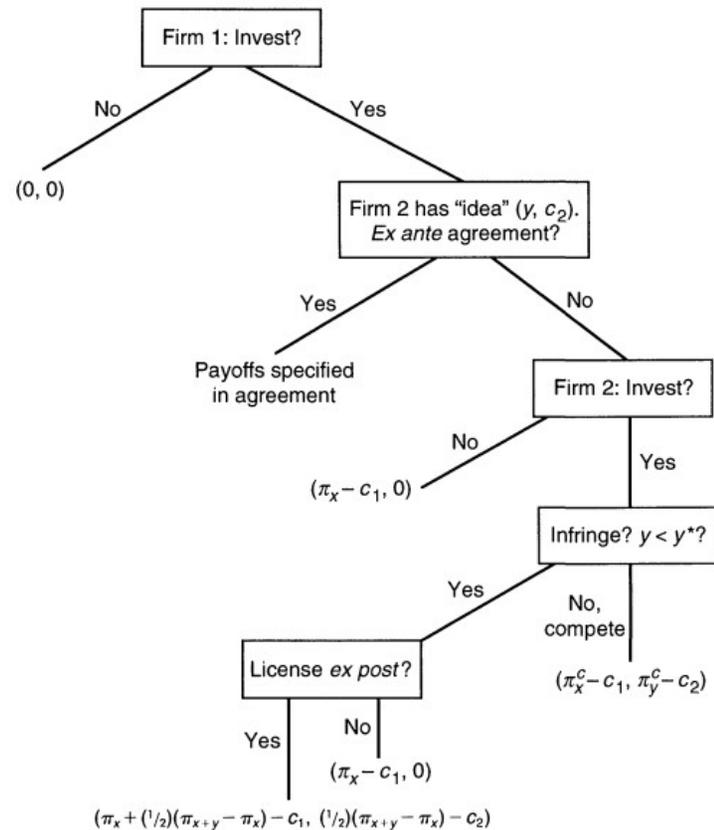
# Antitrust Rules

▶ There are two stages in our model at which an agreement between the sequential innovators could be reached.

1. When the second innovator gets his idea for the improved product but before he has sunk costs. We call this an ex ante license or ex ante agreement.

2. After the costs of the improved product have been sunk and the resulting product infringes. We call this an ex post license.

We do not permit agreements between firms prior to the first innovation.

Although such agreements could achieve first-best incentives for research in our model, they would be difficult to negotiate; prior to invention of the first technology, it is difficult for the first innovator to identify the firms that will think of second-generation products.

# Division of Profit

- Splitting the surplus, their profits in the ex ante agreement are

- $(\pi_x^c - c_1 + 1/2(\pi_{x+y} - (\pi_x^c + \pi_y^c)),$
  $\pi_y^c - c_2 + 1/2(\pi_{x+y} - (\pi_x^c + \pi_y^c)))$

- Assuming ex post is allowed



Firm 1: Invest?

No → $(0, 0)$

Yes → Firm 2 has "idea" $(y, c_2)$. Ex ante agreement?

Yes → Payoffs specified in agreement

No → Firm 2: Invest?

No → $(\pi_x - c_1, 0)$

Yes → Infringe? $y < y^*$?

Yes → License ex post?

No, compete → $(\pi_x^c - c_1, \pi_y^c - c_2)$

Yes → $(\pi_x + (1/2)(\pi_{x+y} - \pi_x) - c_1,\ (1/2)(\pi_{x+y} - \pi_x) - c_2)$

No → $(\pi_x - c_1, 0)$

# Proposition 1

▶ Given T, firm 1's profit is never more than $\pi_{x+y}(T) - (c_1 + c_2)$, and for some second-generation products it is less

▪ Easy to understand as this is monopoly profit.

# Second innovator has bargaining power

▶ First, if the second product will not infringe, the first innovator is threatened with profit-eroding ex post competition, as well as the inability to collect royalties on the new product.

▶ Second, if the product infringes but its incremental benefits are large relative to its costs, the second innovator may find it profitable to invest even though he must negotiate licensing fees ex post after his costs are sunk

▪ He will not give away more profit in the ex ante agreement than is available by declining the ex ante agreement in favor of ex post licensing

▶ Third, if the second innovator has an exclusive ability to develop the product, he might have a credible threat not to do so unless he gets a positive fraction of the incremental profit.

# Optimal Patent Breadth

▶ In the case of isolated inventions, it would be optimal for the patent life to be just long enough to cover the costs of R&D.

▶ But Proposition 1 shows that this principle does not apply when two stages of innovation are undertaken by different firms, because not all the profit can be transferred to the first innovator.

▶ If the patent life is just long enough to cover total R&D costs $(c_1 + c_2)$, the first innovator will in general not enter because he could anticipate negative profit.

▶ Nevertheless, the more profit we can transfer to the first innovator, the shorter is the patent life required to stimulate research.

▶ It is therefore of interest to investigate the policies regarding patent breadth and the antitrust policy toward licensing that contribute to the goal of transferring profit from the second innovator to the first.

# Proposition 2

- If all the uncertainty on y and $c_2$ is resolved prior to investment in the second product, the best patent breadth is y* = $\infty$

- It is intuitive that the best way to protect firm 1's profit is to give firm 1 a broad patent.

- But curiously, this is not necessarily true when only the uncertainty on $c_2$ has been resolved

# Proposition 3

- Suppose firm 2's "idea" is $(G, c_2)$.

- Suppose further that $E_G 1/2(\pi_{x+y}(T) - \pi_x(T)) - c_2 \leq 0$ for all $c_2$ in the support of H, and that $\pi_{x+y} = \pi_x + \pi_y^c = \pi_x^c + \pi_y^c$.

- Then the optimal patent breadth is finite, $y^* < \infty$

# Antitrust Policy

- ▶ Should ex ante agreement and/or ex post agreement be legal?
- ▶ Can you have one without the other?

# Proposition 4

► Assume ex ante licensing is legal. For any patent breadth, the first innovator earns greater profit if ex post licensing is permitted than if not

- When ex ante licensing is available, the only role of ex post licensing is to shift the threat points for the ex ante agreement.

- The possibility of ex post licensing does not affect the total profit that is available to the firms, but only the division of it.

- The possibility of ex post licensing favors the first innovator because it may take away firm 2's credible threat not to enter, which reduces his bargaining power in an ex ante agreement.

# Proposition 5

▶ Suppose that second-generation products are applications of the first technology, which has no value as a stand-alone product, that is, $\pi_{x+y}(T) = \pi_y^c(T)$. Then whatever the patent breadth, ex ante licensing improves social welfare

▪ The per-period monopoly distortions are the same whether the license is ex ante or ex post, or whether the second product is noninfringing and marketed with no license.

▪ In all these regimes, the second product is marketed by a monopolist, and the first product does not compete with it.

▪ Ex ante agreements increase social welfare because they can ensure that the second product is developed (which improves utility even though there are monopoly distortions), and they can increase the profit of the first innovator

# Conclusion

▶ Ex ante agreements have the potential to increase the expected profits of both parties without inhibiting later research, but even with ex ante agreements, the first innovator cannot collect all the profit from second-generation improvement

▶ This derives primarily from the fact that the second innovator has bargaining power has a clear consequence for patent length: in order to give sufficient incentive for basic research, patents must last longer when cumulative research is undertaken by different firms than when both generations of research are concentrated in the same firm.

# Conclusion

▶ In the model presented here, the sequential innovators will always form ex ante agreements, and the roles of ex post licensing and patent breadth are to set "threat points" for such agreements.

▶ We concluded that the possibility of ex post licensing has a salutary effect on the first innovator's profit in ex ante agreement

▶ As to the breadth of patent protection, we have shown circumstances in which the first patent should be broad, but other circumstances in which a broad patent reduces the first innovator's profit because it increases the later innovator's bargaining power. It does this by giving the later innovator a credible threat not to undertake a profitable investment unless the first innovator is willing to share the costs. Counterintuitively, the first innovator can be better off with a narrower patent when the patent's life is fixed

# Conclusion

▶ For completeness, it is worth noting that our main result on patent life would follow if we were concerned with rates of R&D investment as well as with minimizing monopoly distortions.

▶ To take the extreme case, let T* be the patent life that elicits efficient rates of investment in the first stage of innovation with a fixed number of firms, possibly one, when each first-stage firm is capable also of developing the second product.

▪ Compare this with what happens if the two stages take place in different firms. By our argument in Section 2, the second-stage firms will collect some of the joint profit, and therefore each firm at the first stage races for a smaller reward. The firms will therefore reduce their rates of investment.

▪ To restore the efficient rates of investment, the patent life must be increased.