# Licensing and Intellectual Property Rights

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January 7, 2014

# Intellectual property rights

- Patents give incentives to innovate but confer monopoly rights to the holder.
- How can one design IPR policies which simultaneously give incentives to innovate and prevent monopolization?
- One answer is to *promote licensing*: force firms to share the innovation with others
- Another possibility is to limit patent length or breadth – there is a trade-off between the two notions.

# Licensing

- Licensing : either the innovator license, or a firm licenses to competitors
- Licensing: either through fixed fees, royalties or two-part tariffs
- Katz Shapiro (1985) and Kamien Tauman (1986) study licensing

# Patent design

- Gilbert Shapiro (1990) points out a tradeoff between patent length and breadth
- Gallini (1992) discusses patent protection with imitators
- Green Scotchmer (1995): patent protection with sequential innovations

# Kamien and Tauman (1986)'s model of licensing

- An innovator sells a patent to firms in an industry
- The value of the patent to a firm depends on the number of firms who have bought the patent – negative externality
- In Kamien and Tauman's model, the bargaining power is in the hands of the innovator who chooses the price of the license
- There is no auction for the patent: prices are posted by the seller
- Kamien and Tauman compare profits and welfare when the license is sold as a fixed fee or as a royalty.

# The game

- A Cournot oligopoly of $n$ firms
- A three stage game
- *Stage 1.* The innovator chooses a vector of prices for the patent – fixed fee $(\alpha_1, \alpha_n)$ or royalties $(r_1, ..., r_n)$
- *Stage 2.* Firms simultaneously choose whether to license the innovator or not – a set $S$ chooses to license, $N \setminus S$ does not
- *Stage 3.* Firms choose the quantities on the market $q_i$ as a function of $\alpha$, $r$ and $S$.

# The innovation

- By using the innovation, the firm can reduce its constant marginal cost of production from $c$ to $c - \epsilon$
- Market demand is linear $P = a - Q$
- The profit of a firm using the innovation (with fixed fee) is

$$\pi_i = (p - c + \epsilon)q_i - \alpha_i,$$

- The profit of a firm which does not use the innovation is

$$\pi_i = (p - c)q_i,$$

  with $p = a - \sum q_i$.
- An innovation is *drastic* if the new monopoly price $p'^m$ after innovation is lower than the cost before the innovation, i.e. if $(a - c) \leq \epsilon$.

# The third stage: Market decisions

- The equilibrium quantities are given by

$$q_i^* = \frac{a-c+(n-k+1)\epsilon}{n+1} \text{ if } i \in S,$$
$$= \frac{a-c-k\epsilon}{n+1} \text{ if } i \notin S.$$

- If $k > \frac{a-c}{\epsilon}$, only the innovating firms produce
- If $k \leq \frac{a-c}{\epsilon}$, all firms produce

# The second stage: Licensing choices

- In equilibrium, the licensing fee will be the same for all firms $\alpha$
- In equilibrium, letting $\pi_i(k,n)$ and $\pi_j(k,n)$ denote the profit of an innovating (respectively not innovating) firm, we must have

$$\pi_i(k,n) - \alpha \geq \pi_j(k-1,n) \qquad \text{Firms in } S \text{ want to license}$$
$$\pi_i(k+1,n) - \alpha \leq \pi_j(k,n) \qquad \text{Firms not in } S \text{ do not want to license}$$

# The first stage: Choice of the number of licensees

- The innovator uses the second stage to compute a demand function $k(\alpha)$ , and chooses $k^*$ to maximize

$$\pi_{PH} = \alpha k(\alpha).$$

$$\begin{aligned} k^* &= n \text{ if } n \leq 2\frac{\frac{a-c}{\epsilon}+1}{3}, \\ &= \frac{a-c}{2\epsilon} + \frac{n+2}{4} \text{ if } 2\frac{\frac{a-c}{\epsilon}+1}{3} \leq n \leq 2\frac{a-c}{\epsilon-1}, \\ &= \frac{a-c}{\epsilon} \text{ if } 2\frac{a-c}{\epsilon-1} \leq n. \end{aligned}$$

# The number of licensees

## Proposition

*If the innovation is not drastic,*

- *The number of licensees $k^*$ does not exceed $\frac{a-c}{\epsilon}$ regardless of the number of firms,*
- *The number $k^*$ is non increasing in $\epsilon$*
- *For $n$ sufficiently large, only the $\frac{a-c}{\epsilon}$ licensees produce*
- *The profit of the patent holder increases with $\epsilon$. When $n \to \infty$, the profit goes to $\epsilon(a-c)$*
- *The most profitable industry size for the patent holder depends on $\epsilon$*

# Analysis

- If instead of posted prices, firms bid for the license, the marginal benefit of the license is

$$\pi_i(k,n) - \pi_j(k,n) > \pi_i(k,n) - \pi_j(k-1,n),$$

  so that a PH obtains a higher profit by running an auction than a posted price.
- If PH uses the patent rather than licenses it, he would become a unique $(c-\epsilon)$ firm in a $n+1$ industry. He is better off licensing
- If the innovation is drastic, only the licensee produces. The best for the PH is to auction off the license to a single firm.

# Welfare results

**Proposition**

*Each firm is worse off relative to its profit level prior to the innovation, unless the innovation is drastic, and then the resulting monopoly breaks even. However, in both cases total production increases, the market price falls, and the consumers are better off.*

**Proposition**

*The market price under the auction strategy is at least as high as the market price resulting from the fixed fee strategy.*

# Royalties

- If the PH sets a royalty $r$, the profit of an innovative firm is given by

$$\pi_i = (p - c + \epsilon - r)q_i,$$

  so that the royalty $r$ reduces the advantage of the innovation.
- For the patent holder, the profit is $\pi_{PH} = r \sum_{i \in S} q_i$, so the profit is increasing in the quantities sold by the licensees.

# Equilibrium with royalties

## Proposition

*In an equilibrium with royalties ,*

- *All firms purchase the license to the innovation. The royalty in the non drastic case is* $\epsilon$ *and in the drastic case* $\frac{a-c+\epsilon}{2}$
- *For each finite n, the licensor realizes a lower profit using a royalty than a fixed fee*
- *If* $n \to \infty$*, the PH's profit under fixed fee and royalties coincide*
- *Consumers are better off with a fee than with a royalty*

# The licensing game in Katz and Shapiro

- In Katz and Shapiro, there are only two compeititors
- One of the firms obtains the innovation form a researcher (through an auction) and must decide whether to license it or not to the other firm
- The main question is: does the possibility of licensing increase the incentives to innovate or not?
- The possibility of licensing increases the payoff of the winner of the initial auction with the researcher, but also the payoff of the loser.
- The net effect on the profit of the innovator is unclear.

# The three stages

- The game has three stages:
  - The development stage: the two firms bid to obtain the innovation from a researcher. This is a first price auction with a minimum bid $\underline{B}$. Each firm submits a bid $B^i$
  - The licensing stage: the winning bidder chooses whether to license the innovation to the other firm. They bargain over a fee, the exact fee is unspecified. Bargaining will be successful if and only if the sum of payoffs is higher with licensing than without
  - The market stage: the two firms compete on the market

# Costs and output

- The initial costs of the firms are $a_1, a_2$, the cost after innovation $m_1, m_2$
- Market profits are given by $V^i(c_1, c_2)$ and market outputs given by $x^i(c_1, c_2)$, with classical assumptions:
  - $\frac{\partial V^i}{\partial c_i} \leq 0$, $\frac{\partial x^i}{\partial c_i} \leq 0$
  - $\frac{\partial V^i}{\partial c_j} \geq 0$, $\frac{\partial x^i}{\partial c_j} \geq 0$
  - Monopoly profits $V^m(c_i)$, prices and quantities $p^m(c_i), x^m(c_i)$
  - Firm 1 is an effective monopoly if $c_2 \geq p^m(c_1)$, in that case $V_1(c_1, c_2) = V^m(c_1)$.

# The licensing decision

- To analyze whether licensing emerges, we need to compute how industry output ($X$) and profits ($V$) are affected by a change in the cost of one of the two firms, $c_2$
- Change in industry cost $c_1 x_1 + c_2 x_2$:

$$\begin{aligned}\Delta &= c_1 \frac{dx_1}{dc_2} + c_2 \frac{dx_2}{dc_2} + x_2, \\ &= c_1 \frac{dX}{dc_2} + (c_2 - c_1) \frac{dx_2}{dc_2} + x_2\end{aligned}$$

- Change in industry profits

$$\frac{\partial V}{\partial c_2} = (P + XP' - c_1) \frac{dX}{dc_2} + (c_1 - c_2) \frac{dx_2}{dc_2} - x_2.$$

# Licensing

- There are three effects of an increase in $c_2$:
  1. an aggregate output effect (negative if $\frac{dX}{dc_2} < 0$)
  2. an output mix effect (negative if $c_1 > c_2$, positive otherwise) and
  3. a direct cost effect (negative)

# Results on licensing

**Proposition**

*Suppose that the firms behave as Cournot competitors in the product market. If the equilibrium is stable and the firms are equally efficient before the innovation (i.e., $a_{,1} = a_2$), then an arbitrarily small innovation will (will not) be licensed if the industry marginal revenue curve is downward (upward) sloping at the equilibrium level of total output.*

- The condition for licensing is always satisfied if the demand is linear.

# Results on exclusion

## Proposition

*If $m_2 > m_1$ then there exists $\delta > 0$ such that it is privately optimal for firm 1 to exclude firm 2 from the innovation if $a_2 > p^m(m1) - \delta$.*

# Welfare effects of licensing

## Proposition

*Privately profitable fixed-fee licensing agreements are socially beneficial, so long as industry output increases as a single firm's costs fall. For some innovations, socially desirable licensing will not be privately profitable.*

## Proposition

*If $p^m(m_1) < a2$, then there exists a positive constant, $\delta$, such that for all $m_2$ satisfying $p^m(m_1) > m_2 > p^m(m_1) - \delta$, welfare is strictly greater when firm 1 excludes firm 2 rather than licenses to it.*

# Richer licensing contracts

## Proposition

*Suppose that the firms are Cournot duopolists and that the owner of the patent can implement two-part tariff licensing contracts in which the licensee pays both a fixed fee and a per-unit charge for products manufactured by using the patented technology. Then there always exists a licensing agreement that Pareto-dominates the "no-licensing" alternative from the firms' point of view. This dominance is strict if the licensee produces positive output in the absence of the license.*

- Choose as a royalty $a_2 - m_2$, and produce at cost $m_1$, this results in the same output as without licensing
- However, the saved costs can be redistributed through a fixed fee.

# The development stage

- Let $\pi_i^j$ denote the profit of firm $j$ when $i$ acquires the license, and $\pi_0^j$ the profit of no license is attributed to any of the two firms
- Let $\sigma$ denote the share obtained by the licensor in the bargaining agreement, $0 \leq \sigma \leq 1$
- Suppose that $\pi_1^1 + \pi_1^2 \geq \pi_2^1 + \pi_2^2$, ie $V(m_1, a_2) \geq V(a_1, m_2)$
- (If a firm excludes another at the licensing stage, it must be firm 1 excluding firm 2)

# Analysis of the development stage

- Let $\tilde{B}^i = \pi_i^i - \pi_j^i$ denote the incentive of firm $i$ to acquire the license when firm $j$ also competes
- Let $\hat{B}^i = \pi_1^1 - \pi_0^i$ denote the incentive of firm $i$ to acquire the license when firm $j$ does not compete
- *Lemma 1.* $\tilde{B}^1 \geq \tilde{B}^2$ if and only if $\pi_1 \geq p_2$
- *Lemma 2.* If firms have symmetric costs $\pi_1 = \pi_2$ and $\tilde{B}^1 = \tilde{B}^2$

## Proposition

*The researcher can earn* $M = \max\{\tilde{B}^1, \hat{B}^1, \hat{B}^2\}$ *by choosing the minimum bid optimally. If* $\hat{B}^i$ *is the maximal value, then he sets a minimum bid* $\underline{B} = \hat{B}^i$ *, and firm i wins the auction at price . If the maximum is* $\tilde{B}^1$*, then the researcher sets* $B = 0$ *and firm* 1 *wins the auction at price* $\tilde{B}^1$*.*

# Licensing, exclusion and patent ownership

## Proposition

*(a) If at least one of the two producers would exclude, were he to own the innovation, exclusion will occur. (b) If each firm would license to the other, then either firm can obtain the patent.*

## Proposition

*If it is socially optimal for firm 1 to exclude, then firm 1 will obtain the patent and exclude firm 2. If it is socially optimal for firm 2 to exclude, then firm 1 will obtain the patent and exclude. If society prefers licensing to exclusion by either firm, then the right or wrong pattern of ownership and licensing can arise in equilibrium.*

# Licensing and development

- Does the possibility of licensing increase the payoff to the innovator?
- Let $\sigma^*$ be the solution to

$$\frac{\sigma}{1-\sigma} = \frac{V(m_1, m_2) - V(m_1, a_2)}{V(m_1, m_2) - V(a_1, m_2)}.$$

## Proposition

*Suppose that each firm would license were it to obtain the innovation. If $\sigma > \sigma^*$, the possibility of licensing increases the researcher's revenues. If $0 \leq \sigma \leq \sigma^*$, the researcher's revenues will be raised if and only if*

$$\max\{\hat{B}^1, \hat{B}^2\} > V^2(a_1, m_2) - V^2(m_1, a_2).$$

# Patent breadth and length

- The literature considers only the problem of *optimal patent length* as a tradeoff between incentives to innovate and deadweight loss due to monopoly pose
- Gilbert and Shapiro (1990) also parameterize patent breadth – measuring the probability that the pater is infringed – as an increase/decrease in the flow of profits
- They characterize the optimal policy using *both* instruments.

# The model

- Let $T$ be the patent life, $\pi$ the flow profit
- Let $w(\pi)$ denote the flow welfare corresponding to profit $\pi$, $w'(\pi) < 0$
- We define discounted welfare as

$$\Omega(T, \pi) = \int_0^T w(\pi) e^{-rt} dt + \int_T^\infty \overline{w} e^{-rt} dt.$$

- and discounted profit as

$$V(T, \pi) = \int_0^T \pi e^{-rt} dt + \int_T^\infty \overline{\pi} e^{-rt} dt.$$

- The problem is

$$\max_{T, \pi} \Omega(T, \pi) \text{ subject to } V(T, \pi) \geq V.$$

- = Ramsey pricing problem for natural monopoly.

# The result

**Proposition**

*Suppose that $w''(\pi) < 0$. Then the optimal patent policy calls for an infinitely lived patent.*

# Proof of the result

- Define $\Phi(T)$ as the flow of profit required to achieve $V$ with a patent life $T$,

$$V = \Phi(T)\frac{1-e^{-rT}}{r} + \overline{\pi}\frac{e^{-rT}}{r}.$$

- Differentiating that equation with respect to $T$:

$$0 = (\Phi(T) - \overline{\pi})e^{-rT} + \Phi'(T)\frac{1-e^{-rT}}{r}.$$

- Welfare is given by $W(T) = \Omega(T, \Phi(T))$ and

$$W'(T) = \frac{\partial \Omega}{\partial T} + \frac{\partial \Omega}{\partial \pi}\Phi'(T).$$

- Replacing

$$W'(T) = (w(\Phi(T)) - \overline{w})e^{-rT} + (\Phi(T) - \overline{\pi})w'(\Phi(T))e^{-rT}.$$

- Using the concavity of $w$, $W'(T) > 0$.

# Concavity of $w(\pi)$

- The result relies on the concavity of $w(\pi)$. When is this function concave?
- If profits and welfare are both concave in output, then the welfare is concave in the patentee's profit
- If For small values of the patentee's reward, the welfare is concave in the patentee's profit.

# Costly imitation

- The literature either assumes that patent protection is perfect, or that imitation can occur at no cost.
- In a study of the chemical industry, Levin et al. (1988) report: Patents raise imitation costs by about forty percentage points for both major and typical new drugs, but about thirty percentage points for major new chemical products, and by twenty-five percentage points for typical chemical products."
- If imitation is costly competitors endogenously choose whether to imitate or not
- If competitors endogenously choose whether to imitate, the results of Gilbert and Shapiro (1990) may be overturned.

# The model

- Innovation can be protected or kept secret
- If protected, the imitation is covered by a patent for $T$ periods.
- Competitors can invent around the patent at a cost $K$. If this is the case, there is free entry of competitors, and all rents are dissipated.
- The profit is a function of the number $m$ of competitors, $\pi(m)$ with $\pi'(m) < 0$.
- If the innovation is kept secret, it may be discovered by competitors at no cost with probability $p_D$.

# The sequence of decisions

- The innovator researches
- The innovator decides whether or not to patent
- If patented, rival firms make initiation decisions
- Production takes place

# Imitation decision

- Let $\beta(T) = \frac{1-e^{-rT}}{r}$.
- Let $T_I(K)$ be defined by $\beta(T)\pi(0) - K = 0$,
- If $T \geq T_I(K)$, competitors imitate and enter until rents are dissipated,
$$\beta(T)\pi(m) - K = 0.$$

# Patenting decision

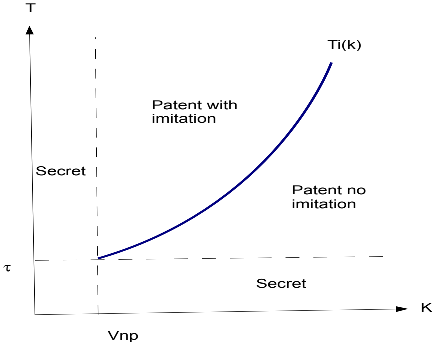
- We compute the value when patenting $V^P$ and not patenting $V^{NP}$

$$\begin{aligned} V^P(T) &= \beta(T)\pi(0) \text{ if } T < T_I(K), \\ &= K \text{ if } T \geq T_I(K), \end{aligned}$$

$$V^{NP} = (1 - p_D)\frac{\pi(0)}{r}$$

- If $K < V^{NP}$, secrecy is always preferred
- If $K \geq V^{NP}$, secrecy is preferred if $T \leq \tau$ where $\tau$ is implicitly defined by: $\beta(\tau) = \frac{1-p_D}{r}$.

# Patenting and imitation



# Interpretation

- Increasing $T$ beyond $T_l(K)$ is not profitable for the innovator.
- In fact, as $T$ increases, the profit of the innovator is given by $V^{NP}$ if $T < \tau$, $\beta(T)\pi(0)$ if $\tau \leq T \leq T_l(K)$ and $K$ if $T > T_l(K)$

# Optimal patent length

- Let $\epsilon_x^n$ be the elasticity of output with respect to the number of firms

**Proposition**

*For $K \geq V^{NP}$ and $\epsilon_x^n < 1$, the patent length that maximizes social surplus is no greater than $T_I(K)$; that is, no imitation takes place under the optimal patent policy.*

- If patent life is decreased below $T_I(k)$ imitation costs go down. The rate at which they go down is higher than the rate at which output goes up, so that it is profitable to decrease $T$ below $T_I(K)$.
- This result stands in contrast to Gilbert and Shapiro (1990)

# Optimal patent length

- Let $\Omega$ be the optimal patent length as in Nordhaus (1969) when $p_D = 1, K > \frac{\pi(0)}{r}$

## Proposition

*For $K \geq V^{NP}, \epsilon_x^n < 1$,*

- *If $\Omega < \tau$, $T^* = 0$*
- *If $\Omega \geq \tau$, $T^* = T_I(K)$ for $K \in [V^{NP}, \beta(\Omega)\pi(0)]$*
- *$T^* = \Omega$ for $K > \beta(\Omega)\pi(0)$*

# Optimal patent length and breadth

**Proposition**

*When both patent length and imitation costs are patent instruments and* $\epsilon_x^n < 1$*, then the optimal patent is broad (*$K$ *is set sufficiently high to discourage imitation) with patent length adjusted to achieve the desired reward for the innovator.*

# Sequential innovation

- Consider one innovation and an improvement (or application), or a first innovation which is a necessary step to another innovation
- The first innovator may have allow incentive to innovate because the second product competes with the first
- Even without competition, the social value of the initial innovation includes the application and is not internalized by the first innovator.
- The question of division of the value of the innovation among the two innovators becomes essential – through licensing or patents.

# The model

- Let $x$ be the quality of the first generation product, and $y$ the value of the improvement
- $x + y$ is the quality of the second generation product.
- For a patent length $T$, $\Pi_x(T)$ and $\Pi_{x+y}(T)$ denote the values of the patents for the two goods if produced by the same firm
- $\Pi_x^c(T)$ and $\Pi_y^c(T)$ denote the values if the patents are held by two competing firms.
- We suppose $\Pi_x^c(T) \leq \Pi_x(T)$ and $\Pi_{x+y}(T) \geq \Pi_x^c(T) + \Pi_y^c(T)$

# The second generation product

- After the first product is patented, firm 2 receives an idea $(y, c_2)$ – an improvement of size $y$ at a cost $c_2$ drawn from a distribution $(G, H)$
- The investment in the first product must be made before the idea and the identity of the second firm are known.
- The social value of the first generation product has two components: the value of product $x$ and the option value of product $x + y$
- In an ex ante agreement, the firms agree to share $\Pi_{x+y}(T) - \Pi_x(T) - c_2$
- Investment in the first period is efficient if

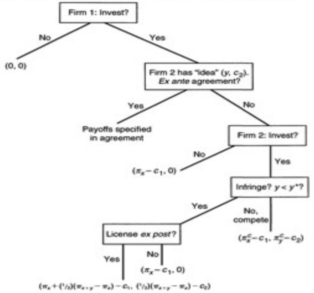
$$\Pi_x(T) - c_1 + E_{G,H} \max\{\Pi_{x+y}(T) - \Pi_x(T) - c_2, 0\} > 0.$$

# Patent breadth and antitrust

- The patent breadth determines a value $y^*$ such that the patent is infringed if $y \leq y^*$ and not infringed if $y > y^*$
- An ex ante agreement is made before the cost $c_2$ is sunk
- In an ex post agreement, after the cost $c_2$ is sunk, firms can only share $\Pi_{x+y}(T) - \Pi_x(T)$
- This means that, with ex post agreements, the second innovator may be unwilling to invest whereas he would have invested with an ex ante agreement.

# The sequence of decisions

FIGURE 1 ON THE DIVISION OF PROFIT BETWEEN SEQUENTIAL INNOVATORS



# Bargaining outcome

**Proposition**

*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.*

- The first innovator does not have all the bargaining power: the second innovator can threaten him with competition
- This implies that, in order to give incentives to the first innovator, $T$ must be higher than if both innovations were made in the same firm.

# Optimal patent breadth

**Proposition**

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

- This result does not necessarily hold if the second innovator learns about the size of the improvement $y$ after investing.

# Ex ante and ex post licensing

## Proposition

*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.*

## Proposition

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