

Lecture 4 - Patents and Intellectual Property Rights

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Patents and Intellectual Property Rights

Where we left off: the innovation problem

Last week we established three facts about **private incentives to innovate**:

1. **Replacement effect** — an incumbent monopolist under-invests because innovation partly cannibalises its own rents ($\Delta\pi^m < \Delta\pi^{pc}$)
2. **Appropriability gap** — without protection, imitation dissipates rents and the innovator's WTP falls to zero
3. **Private vs social value** — the social planner values a cost reduction at $\Delta W > \Delta\pi$, so private incentives are generically too weak

These problems share a common root: innovators cannot capture enough of the surplus they create.

Today's question: can intellectual property rights close this gap — and at what cost?

IPRs: economic problem

i Object of analysis

IPRs make a non-rival good partially excludable, creating private incentives for costly innovation.

- ▶ Knowledge is (partly) **non-rival** and often **hard to exclude**
- ▶ Without protection, imitation can dissipate rents \Rightarrow weak private incentive to incur fixed R&D cost
- ▶ **Policy objective:** provide incentives for invention while limiting static distortions in product markets
- ▶ **Discussion:** Why can't we just rely on first-mover advantage?

Learning objectives

- ▶ Explain why non-rival ideas can lead to underinvestment without protection
- ▶ Use the ideas model to compare the private investment condition $\pi\nu T \geq F$ to the planner objective
- ▶ Understand how **length** and **breadth** jointly shape the incentive-distortion trade-off
- ▶ Explain why patent races can generate socially excessive duplication

i Today: roadmap

1. Patents as incentives: the central trade-off
2. Patent length in the ideas model (screening and welfare)
3. Breadth, endogenous R&D, and patent races

IPRs: instruments

- ▶ Main IPR types:
 - ▶ Patents
 - ▶ Trademarks
 - ▶ Copyrights
 - ▶ Design rights
- ▶ Key design dimensions (patents):
 - ▶ **Length** (duration)
 - ▶ **Breadth** (scope)
 - ▶ **Geographical coverage**
 - ▶ **Transferability** (sale, licensing)

IPRs: central trade-off

- ▶ Patents create temporary market power \Rightarrow static deadweight loss
- ▶ Stronger protection (longer/broader) typically:
 - ▶ increases expected private returns to R&D
 - ▶ increases the static distortion during protection
- ▶ Questions:
 - ▶ What is an optimal **length** and **breadth**?
 - ▶ How does competition in R&D (patent races) affect efficiency?

Application: Pharmaceuticals

- ▶ Fixed development cost F is large (clinical trials), while marginal cost is low
- ▶ Patent protection creates temporary market power, but expiry enables generic entry
- ▶ Breadth maps to how close a substitute can be without infringing; races map to multiple labs pursuing the same target

Scotchmer (2006): Ideas model

Ideas model: primitives

Following Scotchmer (2006)

- ▶ An “idea” is a pair (ν, F)
- ▶ ν : per-period consumer surplus under competitive supply (value parameter)
- ▶ F : fixed cost to develop the idea into an innovation (R&D cost)
- ▶ **Interpretation**
 - ▶ ν captures the size of social gains from making the idea usable
 - ▶ F is the up-front resource cost required for development

i Application: a new drug

Map (ν, F) to an innovation with large fixed R&D cost F and a flow of benefits ν that is partially appropriable during patent protection.

Ideas model (Scotchmer): social value under discounting

Assume social value lasts forever and the product is competitively supplied.

- ▶ Per-period social value: ν
- ▶ Discounted social value:

$$\sum_{t=1}^{\infty} \frac{1}{(1+r)^t} \nu = \frac{\nu}{r}$$

▶ Interpretation

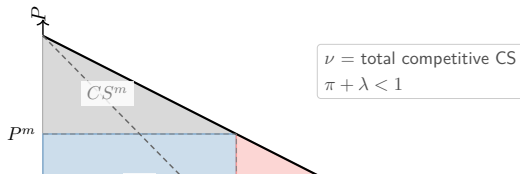
- ▶ Discount rate r reduces the present value of long-run benefits
- ▶ Longer-lived benefits (lower r) raise the social value of an idea

Ideas model (Scotchmer): private returns and deadweight loss

- ▶ Firm's per-period private profit under patent: $\pi\nu$ where $0 < \pi < 1$
- ▶ Patent profit for discounted length T :

$$\pi\nu T$$

- ▶ Per-period deadweight loss: $\lambda\nu \Rightarrow$ patent DWL: $\lambda\nu T$
- ▶ **Interpretation**
 - ▶ π is a reduced-form “appropriability” parameter
 - ▶ λ captures the static distortion created by protection



Discounted patent length: T

- ▶ Let τ be the undiscounted duration (in periods)
- ▶ Define discounted duration:

$$T = \int_0^{\tau} e^{-rt} dt = \frac{1 - e^{-r\tau}}{r}$$

- ▶ Discrete-time approximation used in many models:

$$T \approx \sum_{t=1}^{\tau} \frac{1}{(1+r)^t}$$

- ▶ **Interpretation**

- ▶ T is increasing in τ but bounded as $\tau \rightarrow \infty$ when $r > 0$

Optimal patent length: innovating firm

- ▶ Patent gives discounted net profit:

$$\pi\nu T - F$$

- ▶ Firm invests if $\pi\nu T \geq F$

- ▶ **Interpretation**

- ▶ Higher ν or larger π reduces the minimum protection needed for investment
- ▶ Higher F requires longer (or stronger) protection to break even

Optimal patent length: social planner

- ▶ Discounted net social value (invention made):

$$\frac{\nu}{r} - \lambda \nu T - F$$

- ▶ **Interpretation**

- ▶ Planner values the full flow benefit ν , but counts DWL during protection
- ▶ Optimal design trades off inducing investment against static costs

Optimal length: heterogeneity and screening (intuition)

- ▶ If inventions differ in (ν, F) , “one-size-fits-all” length is not generally optimal
- ▶ Comparative statics (holding other parameters fixed):
 - ▶ more elastic demand / stronger substitution \Rightarrow higher DWL λ
 \Rightarrow shorter protection
 - ▶ higher development cost $F \Rightarrow$ longer protection to ensure investment

Example: ideas A and B

▶ Idea A: ($\nu_A = 5, F_A = 10$)

▶ Idea B: ($\nu_B = 2, F_B = 20$)

Let $T = 20, \pi = \frac{1}{2}, \lambda = \frac{1}{4}, r = \frac{1}{3}$.

▶ Tasks:

▶ Which ideas are privately profitable ($\pi\nu T \geq F$)?

▶ Which ideas have positive discounted net social value ($\nu/r - \lambda\nu T - F \geq 0$)?

▶ **Interpretation**

▶ With these parameter values, private profitability need not coincide with positive net social value: patent protection can induce investment even when net welfare is negative

Breadth: product space

Patent breadth: product space (definition)

- ▶ Breadth determines how close a substitute can be without infringing
- ▶ Reduced-form implication:
 - ▶ Narrower breadth \Rightarrow more close substitutes enter
 - ▶ Broader breadth \Rightarrow fewer close substitutes enter
- ▶ **Interpretation**
 - ▶ Allowing close substitutes increases the elasticity of demand faced by the patent holder

i Application: close substitutes

In pharmaceuticals, breadth maps to whether a close substitute can launch during protection without infringing.

Breadth and demand elasticity (intuition)

- ▶ If close substitutes are allowed:
 - ▶ residual demand becomes **more elastic**
 - ▶ equilibrium price is lower (all else equal)
- ▶ If substitutes are excluded (broader patent):
 - ▶ residual demand is **less elastic**
 - ▶ equilibrium price is higher (all else equal)
- ▶ **Discussion:** If you were a patent holder, would you prefer broad–short or narrow–long protection?

Breadth–length trade-off (given a target value)

Assume the “correct” expected private value of protection is fixed.

- ▶ **Regimes** (product space):
 - ▶ Broad–short: $(\hat{T}, \hat{\pi}_1 + \hat{\pi}_2)$
 - ▶ Narrow–long: $(\tilde{T}, \tilde{\pi}_1)$
- ▶ Broad patent yields higher per-period profit (includes infringing market):

$$\hat{T}(\hat{\pi}_1 + \hat{\pi}_2) = \tilde{T}\tilde{\pi}_1$$

Breadth–length trade-off (continued)

► Therefore:

$$\hat{T} < \tilde{T}$$

► **Interpretation**

- Broad protection can be paired with shorter duration to deliver the same incentive level

Which regime is better?

- ▶ The best regime depends on substitution patterns:
 - ▶ substitution between the patented good and an infringing substitute
 - ▶ substitution between these goods and the rest of consumption
- ▶ **Interpretation**
 - ▶ Broad–short: more sensitive to outside substitution (pricing alignment across many goods)
 - ▶ Narrow–long: more sensitive to within-category substitution

Optimal patent length with endogenous R&D
(Shy)

Shy (1995) model: setup

- ▶ Demand: $P(Q) = a - Q$
- ▶ Process innovation reduces marginal cost from c to $c - x$
- ▶ R&D effort x costs $R(x)$
- ▶ Two-stage game:
 1. Regulator chooses patent duration τ
 2. Firm chooses x to maximise discounted profit
- ▶ **Objects**
 - ▶ Choice variables: x (firm), τ (regulator)
 - ▶ Parameters: a, c, r

Shy model: firm's choice of x given τ

Firm solves:

$$\max_x \Pi(x; \tau) = \sum_{t=1}^{\tau} \rho^{t-1} \pi(x) - R(x),$$
$$\rho = \frac{1}{1+r}$$

Assume:

- ▶ per-period profit: $\pi(x) = (a - c)x$
- ▶ cost: $R(x) = \frac{x^2}{2}$
- ▶ Lemma:

$$\sum_{t=1}^{\tau} \rho^{t-1} = \frac{1 - \rho^{\tau}}{1 - \rho}$$

Shy model: induced innovation level

FOC implies:

$$x^I(\tau) = \frac{1 - \rho^\tau}{1 - \rho}(a - c)$$

► **Comparative statics:**

- x^I increases with τ
- x^I increases with a and decreases with c
- x^I increases with ρ (decreases with r)

► **Interpretation**

- Longer protection raises the marginal benefit of R&D because profits are earned for more discounted periods

Shy model: planner's choice of patent duration (statement)

Planner chooses τ trading off: - higher induced innovation $x^I(\tau)$ - static deadweight loss under monopoly pricing during protection

▶ Result (as in Shy): optimal duration is finite, $T^* < \infty$

▶ Interpretation

▶ Marginal benefit of longer protection (higher induced $x^I(\tau)$) eventually falls below the marginal cost (additional monopoly distortion during protection)

Patent races

Symmetric patent race: Setup

- ▶ Two symmetric firms may incur a fixed cost f to establish a research division
- ▶ Success probability: p (per firm)
- ▶ Payoffs:
 - ▶ monopoly profit if sole innovator: π^m
 - ▶ duopoly profit if both succeed: π^d

i Application: parallel R&D programs

Think of multiple labs racing to develop the same drug/vaccine: each pays a fixed setup cost and succeeds with some probability.

Symmetric patent race: Welfare benchmarks

- ▶ Welfare benchmarks (post-innovation welfare):
 - ▶ one research division: $W^m = \pi^m + CS^m$
 - ▶ two research divisions: $W^d = 2\pi^d + CS^d$
- ▶ Assumption (for the comparison):
 - ▶ $CS^d > CS^m$ (more competition in the product market raises consumer surplus)

Patent race: game structure

Duplication incentive

“Winner-takes-all” payoffs can create privately excessive entry into R&D when firms ignore duplication costs.

- ▶ Two firms simultaneously choose **Invest** (I) or **Not Invest** (NI)
- ▶ Each firm succeeds independently with probability p
- ▶ Payoffs depend on market structure:
 - ▶ Unique success \Rightarrow monopoly profit π^m
 - ▶ Both succeed \Rightarrow duopoly profit $\pi^d < \pi^m$

Patent race: Nash equilibrium condition

- ▶ If rival invests, my expected payoff from I :

$$p(1-p)\pi^m + p^2\pi^d - f$$

- ▶ (I, I) is a Nash equilibrium if:

$$f \leq p(1-p)\pi^m + p^2\pi^d \equiv f_2^{priv}$$

- ▶ **Interpretation**

- ▶ First term: I succeed, rival fails \Rightarrow monopoly
- ▶ Second term: both succeed \Rightarrow duopoly

Patent race: social optimum condition

- ▶ It is socially optimal to have one research division rather than two if:

$$f \geq p(1 - 2p)W^m + p^2W^d \equiv f_2^{publ}$$

- ▶ **Interpretation**

- ▶ The planner compares expected welfare under one vs two research divisions, counting duplication cost f

Socially excessive R&D (region)

- ▶ Socially excessive duplication occurs when:

$$f_2^{publ} < f < f_2^{priv}$$

- ▶ Interpretation:
 - ▶ Firms overinvest when the negative externality on rivals' profits outweighs the consumer-surplus gain from having two innovators

Numerical check: duplication region

Let $p = 0.8$, $\pi^m = 10$, $\pi^d = 3$, $W^m = 15$, $W^d = 16$.

► Private two-division threshold:

$$\begin{aligned}f_2^{priv} &= p(1-p)\pi^m + p^2\pi^d \\&= 0.8(0.2)(10) + 0.64(3) = 3.52\end{aligned}$$

► Social two-division threshold:

$$\begin{aligned}f_2^{publ} &= p(1-2p)W^m + p^2W^d \\&= 0.8(-0.6)(15) + 0.64(16) = 3.04\end{aligned}$$

► If $f = 3.2$, then $f_2^{publ} < f < f_2^{priv}$: two research divisions are privately viable but socially excessive.

► **Discussion:** What happens to this region as p increases?

Summary and next week

Summary

- ▶ Patents trade off dynamic incentives against static distortions (deadweight loss during protection)
- ▶ In the ideas model, investment requires $\pi\nu T \geq F$, while welfare accounts for ν/r and the DWL term $\lambda\nu T$
- ▶ Breadth and length can be substitutes in delivering a given private incentive level (broad–short vs narrow–long)
- ▶ Patent races can generate socially excessive duplication when private entry incentives exceed social benefits

Next week: Multi stage games

- ▶ Commitment and first-mover advantage (Stackelberg)
- ▶ Subgame perfect equilibrium and backward induction
- ▶ Strategic delegation (Vickers)

References

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