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
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> 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

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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:

$$\sum_{t=1}^{\infty} \frac{1}{(1+r)^t} \nu = \frac{\nu}{r}$$
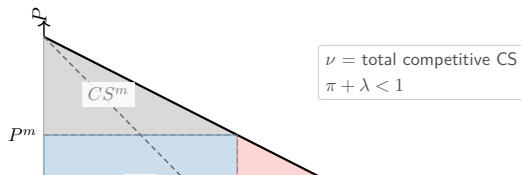
▶ **Interpretation**
  ▶ Discount rate r reduces the present value of long-run benefits
  ▶ Longer-lived benefits (lower r) raise the social value of an idea

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

$\nu =$ total competitive CS
$\pi + \lambda < 1$

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 $\tau \to \infty$ 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

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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):

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

▶ 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

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:

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

▶ **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:

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

▶ Social two-division threshold:

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

▶ 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 gamess

▶ Commitment and first-mover advantage (Stackelberg)

▶ Subgame perfect equilibrium and backward induction

▶ Strategic delegation (Vickers)

References

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