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

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

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

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

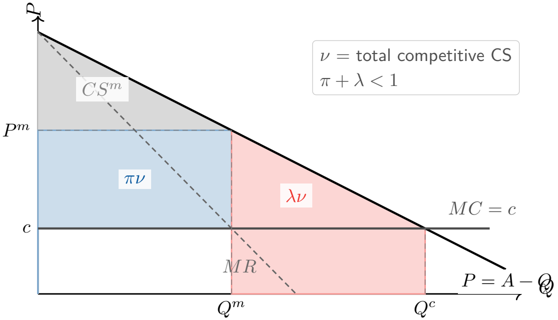
- Firm's per-period private profit under patent: $\pi\nu$ where $0 < \pi < 1$
- Patent profit for discounted length T:

$$\pi\nu T$$

- Per-period deadweight loss: $\lambda\nu \Rightarrow$ patent DWL: $\lambda\nu T$

Interpretation of π and λ

- 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 $\tau \to \infty$ 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

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

Firm's choice of x given τ

Firm solves:

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

$$\text{where } \rho = \frac{1}{1+r}$$

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

Assume:

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

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

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:

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

- 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 gamess

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

Case Study: COVID-19 vaccine patent race

History: mRNA as a platform (**storzIntellectualPropertyRaces2022?**)

- mRNA vaccines look modular, but rely on *layers* of upstream patents
  (modified nucleosides, delivery/LNPs, manufacturing, formulations)
- Race was not only **time-to-market**, but also **time-to-priority**:
  - who files first on enabling technologies vs. product-specific
  - how broad claims interact with follow-on entrants and variants
- Post-success phase: fast diffusion of know-how → **ex post disputes** over who owns key enabling steps
  (licensing demands, litigation threats, bargaining over royalties)

IO lens

Treat the vaccine as an *innovation stack*: competition happens across layers (upstream enablement) and across products (downstream vaccines).

Problem 1: patent-race incentives interact with safety (**kimOptimalPatentDesign2020?**)

- Standard patent-race logic: **winner-takes-most rents** → strong incentives to accelerate R&D effort
- With vaccines, firms choose **two margins**:
  1) investment in *speed* (inventing first)
  2) investment in *safety* (reducing side-effect risk)
- Liability regime matters:
  - If the first inventor captures rents but also bears liability, **private incentives can tilt** toward *too much* investment in both speed and safety under strict liability (relative to the social optimum in the model)
- Empirical complication:
  - "Race outcomes" depend on *legal institutions* (liability, indemnification, compensation schemes), not only patent length/breadth

Problem 2 public funding → private appropriation (Florio 2022) + pooling (Billette de Villemeur et al. 2023)

- mRNA COVID vaccines built on substantial **public-sector science + funding**, but patent ownership is largely private → distributional conflict: *who should capture returns?* (Florio 2022)
- This creates at wedge:
  - ex ante: strong incentives to race
  - ex post: fragmented rights → bargaining, "hold-up" risk, and politically salient access constraints
- Proposed "third way": **patent pooling** to expand access while preserving incentives (Billette de Villemeur et al., SSRN 2023)
  - pool aggregates relevant rights and offers standardized licences (reducing transaction costs)
  - goal: **maximize access** subject to participation/incentive constraints
  - positioned as an alternative to: (i) full waiver, (ii) fully fragmented bilateral licensing

Problem: fragmented IP after the innovation race

- COVID-19 vaccines are not single inventions but **bundles of complementary technologies**:
  - platform patents (e.g. mRNA chemistry, delivery systems)
  - formulation and manufacturing patents
  - downstream production know-how
- Result: multiple entities hold indispensable rights
  $\Rightarrow$ downstream producers must negotiate **many licenses** to manufacture at scale.
- IO interpretation:
  - complements create **multiple marginalization**
  - bargaining frictions and legal uncertainty raise effective marginal costs

Key tension

The patent race may solve innovation speed ex ante, but can generate coordination failures ex post.

Proposed solution: a non-profit patent pool ("third way")

- The paper proposes a **non-profit patent pool** that bundles all required licenses into a single contract (a "one-stop shop").
- Pool objective:
  - **maximize access / quantities**
  - while ensuring patent holders are *not worse off* than under separate licensing (participation constraint).
- Compared regimes in the model:
  1. separate, non-cooperative licensing (multiple margins)
  2. for-profit pool (joint profit maximization)
  3. **non-profit pool** (access maximization)
- Economic mechanism:
  - internalizes complementarities
  - lowers royalty stack
  - reduces transaction costs and hold-up risk.

IO insight

How the solution fits — and what it does *not* solve

What it addresses well

- **Fragmented ownership** $\rightarrow$ bundling reduces bargaining frictions
- **Access problem** $\rightarrow$ lower final prices, higher quantities
- Welfare gains increase with the number of patent holders.

What remains unresolved

- Does **not** model the *ex ante patent race*:
  - incentives for speed vs safety
  - duplication of R&D effort
- Does not resolve manufacturing capacity or tacit know-how constraints by itself

Lecture takeaway

- Patent races solve the **innovation problem**.
- Patent pools address the **coordination problem after innovation**.
- Policy design must separate:
  - incentives to invent (dynamic efficiency)
  - mechanisms for diffusion and global access (static +

References

Scotchmer, Suzanne. 2006. *Innovation and Incentives*. MIT Press.

Shy, Oz. 1995. *Industrial Organization: Theory and Applications*. MIT Press.