

Lecture 4 - Patents and Intellectual Property Rights

Gerhard Riener

Patents and IPRs

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

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?

Scotchmer: ideas model

Ideas model (Scotchmer): 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

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: $\ell\nu \Rightarrow$ patent DWL: $\ell\nu T$
- ▶ **Interpretation**

- ▶ π is a reduced-form “appropriability” parameter
- ▶ ℓ 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):

$$\frac{\nu}{r} - \ell\nu T$$

- ▶ **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 ℓ
 \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 $T = 20$, $\pi = \frac{1}{2}$, $\ell = \frac{1}{4}$, $r = \frac{1}{3}$.

- ▶ Tasks:
 - ▶ Which ideas are privately profitable ($\pi\nu T \geq F$)?
 - ▶ Which ideas have positive discounted net social value $(\frac{\nu}{r} - \ell\nu T - F \geq 0)$?
- ▶ 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

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)

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

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

i 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

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:

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

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
- ▶ 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: Nash equilibrium condition



Duplication incentive

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

- ▶ Firms choose I or NI simultaneously
- ▶ (I, I) is a Nash equilibrium if:

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

- ▶ **Interpretation**
 - ▶ Private incentives include the probability of being the unique winner and the case where both succeed

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

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 $\frac{\nu}{r}$ and the DWL term $\ell\nu T$
- ▶ 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

- Scotchmer, Suzanne. 2006. *Innovation and Incentives*. MIT Press.
- Shy, Oz. 1995. *Industrial Organization: Theory and Applications*. MIT Press.