Lecture 4 - Patents and Intellectual Property Rights

Gerhard Riener

Patents and IPRs

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

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 $\tau \to \infty$ 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):

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

- **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.

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.