

# 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  $(\nu, F)$
- ▶  $\nu$ : per-period consumer surplus under competitive supply (value parameter)
- ▶  $F$ : fixed cost to develop the idea into an innovation (R&D cost)
- ▶ **Interpretation**
  - ▶  $\nu$  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:  $\nu$
- ▶ 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**

- ▶  $\pi$  is a reduced-form “appropriability” parameter
- ▶  $\ell$  captures the static distortion created by protection

## Discounted patent length: $T$

- ▶ Let  $\tau$  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  $\tau$  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  $\nu$  or larger  $\pi$  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  $\nu$ , but counts DWL during protection
- ▶ Optimal design trades off inducing investment against static costs

## Optimal length: heterogeneity and screening (intuition)

- ▶ If inventions differ in  $(\nu, F)$ , “one-size-fits-all” length is not generally optimal
- ▶ Comparative statics (holding other parameters fixed):
  - ▶ more elastic demand / stronger substitution  $\Rightarrow$  higher DWL  $\ell$   
 $\Rightarrow$  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  $\tau$
  2. Firm chooses  $x$  to maximise discounted profit
- ▶ **Objects**
  - ▶ Choice variables:  $x$  (firm),  $\tau$  (regulator)
  - ▶ Parameters:  $a, c, r$

## Shy model: firm's choice of $x$ given $\tau$

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  $\tau$
  - ▶  $x^I$  increases with  $a$  and decreases with  $c$
  - ▶  $x^I$  increases with  $\rho$  (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  $\tau$  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:  $\pi^m$
  - ▶ duopoly profit if both succeed:  $\pi^d$
- ▶ 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.