Patents and Technological Change

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ECON 2216: Industrial Organization

Outline

1. Innovation
   - Innovations and Patents
     - Patents, Copyrights, and Trademarks
   - Research Effort
     - Research Effort
     - Incentives for Innovation

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Patents

- A **patent** grants exclusive rights for an invention
- Requirements: useful, novel, nonobvious, public description, working model (if applicable)
- U.S. Patent and Trademark Office issues:
  1. **Utility patents**: common, cover various inventions (devices, software, methods...)
  2. **Design patents**: ornamental appearance of products
  3. **Plant patents**: specific plant types (flowers, fruits, shrubs, vines)

Copyrights

- **Copyrights**: exclusive rights for artistic, dramatic, literary, or musical works
  - Examples: articles, books, drawings, maps, compositions, designs, photos
- Covers "works of authorship" fixed in a "tangible medium"
  - Examples: books, computer hard drives, web posts
- **Difference**: Patents protect function and purpose, copyrights protect artistic expression

Trademarks

- **Trademarks**: words, symbols, marks to distinguish goods/services from competitors
  - Examples: Kodak film, Exxon gasoline, Apple computers
- No fixed term, but protection can be lost
- Trademarks that became generic names:
  - Aspirin, Cellophane, Nylon

Distinctions between Patents, Copyrights, and Trademarks

- Key distinction between patents and copyrights:
  - Copyrights: protect expression of an idea
  - Patents: protect tangible embodiment of the idea
- Patents: **greater exclusivity** and **more monopoly power**
- Patents: **more difficult** to obtain than copyrights

Incentives for Inventions, Imitation Challenges, and Spreading Information (1)

- Inventions: new information, public good, need incentives
- Without patents: legal imitations, low invention incentives
  - Example: Ford's assembly line innovation copied
- Inventor's return may be less than societal value
  - Example: Xerox copier and similar products
- Information spread through employees, communication, reports, and reverse engineering

Imitation Challenges and Patent Strategies (2)

- Competitors can "invent around" patents, lowering value
- **Reverse engineering** for compatibility or imitation
- Patents increase imitation costs and delay imitator entry
- Despite revealing information, many firms obtain patents

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Patents Encourage Research

Patent Encourage Research

- By imposing costs on potential imitators, patents can give market power to patent holders
  - The resulting profits can be a strong inducement to be the first to invent a new product
- If the inventor's return is less than society's, the inventor tends to underinvest in research
- Patents may permit inventors to capture a large share of the benefits (internalize the externality) associated with the production of knowledge by insulating them from competition
  - By granting these exclusive rights through patents, society encourages more inventions in some industries
- However, even when patents protect the inventor from imitation, the patent holder's monopoly profit is less than the full social benefit
  - Although patents encourage additional research, they may induce less than the optimal level

Patents Encourage Disclosure

- Policies increasing invention diffusion are desirable
  - Faster adoption benefits society, ideas lead to others
- Patent requirements: novel, nonobvious
  - Results: increased R&D incentives, accelerated innovation through disclosure
- Some firms avoid patents, use trade secrets instead
  - Greater disclosure with patent system than trade secrets
- Novelty rule stringency affects R&D incentives, profits, and disclosure
  - More extreme novelty requirement: harder to obtain patents, longer monopolistic profits
  - Less frequent patents: lower research incentive, less disclosure

[Table 16.4]Costs and Benefits of Research Programs

Number of Projects, n	Expected Marginal Social Benefit	Expected Payoff with a Prize = B	Probability of Success, $\rho(n)$	Expected Social Benefit, $B\rho(n)$	Social Cost, $C(n)$	Net Social Benefit, $B\rho(n) - C(n)$
1	4.14	4.60	0.18	4.60	1.00	3.60
2	3.38	4.17	0.33	8.35	2.00	6.35
3	2.76	3.80	0.46	11.41	3.00	8.41
4	2.25	3.48	0.56	13.91	4.00	9.91
5	1.84	3.19	0.64	15.94	5.00	10.94
6	1.50	2.93	0.70	17.61	6.00	11.61
7	1.23	2.71	0.76	18.97	7.00	11.97
8	**1.00**	**2.51**	**0.80**	**20.08**	**8.00**	**12.08**
9	0.82	2.33	0.84	20.98	9.00	11.98
10	0.67	2.17	0.87	21.72	10.00	11.72
11	0.54	2.03	0.89	22.32	11.00	11.32
12	0.44	1.90	0.91	22.81	12.00	10.81
13	0.36	1.79	0.93	23.22	13.00	10.22
14	0.30	1.68	0.94	23.54	14.00	9.54
15	0.24	1.59	0.95	23.81	15.00	8.81
16	0.20	1.50	0.96	24.03	16.00	8.03
17	0.16	1.42	0.97	24.21	17.00	7.21
18	0.13	1.35	0.97	24.35	18.00	6.35
19	0.11	1.29	0.98	24.47	19.00	5.47
20	0.09	1.23	0.98	24.57	20.00	4.57
21	0.07	1.17	0.99	24.65	21.00	3.65
22	0.06	1.12	0.99	24.71	22.00	2.71
23	0.05	1.08	0.99	24.77	23.00	1.77
24	0.04	1.03	0.99	24.81	24.00	0.81
24.84	0.03	1.00	0.99	24.84	24.84	0.00
25	0.03	0.99	0.99	24.84	25.00	−0.16

$m = 1$, per-firm cost of a research project

$B = \$25$

- Example illustrating effects on research effort
- Industry properties (Table 16.4):
  - Unlimited identical firms, each with one project; n firms in the industry
  - Constant marginal and average research cost: $m = 1$, total cost: $C(n) = nm = n$
  - Success probability $\rho(n)$ increases with n
- Research timing and benefits:
  - Research in period $t = 0$, benefits in subsequent periods $(t = 1, 2, ...)$
  - Successful research allows new product production at constant marginal cost
  - Present value of potential societal benefit: $B = \$25$, expected social benefit: $B\rho(n)$

Determining the Optimal Number of Firms

- Society should choose the number of firms racing to make discoveries that maximizes expected net social benefit
  - As more firms join the race, the probability of success approaches 1 (certainty), so that adding more firms to the race has little effect on expected benefits
- In Figure 16.1a,
  - The gap between social benefits and costs and the height of the net social benefits curve is maximized at 8 firms
  - The gap between expected benefits and costs is greatest at where the slope of the benefit and cost curves are equal
- The marginal benefit curve in Figure 16.1b equals the slope of the expected benefit curve in Figure 16.1a

[Figure 16.1]

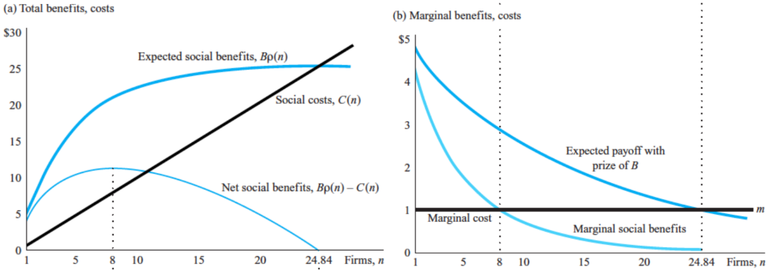


Figure: Costs, Expected Benefits, and Net Social Benefits from R&D

No Government Incentives

- In the absence of patents and other incentives to invent, few inventions may be produced
  - If once a discovery is made everyone can copy it, then the new product is sold at a competitive price, and the inventor makes no economic profits
  - If inventors bear the full private and social cost of research $(m = 1)$ but receive no private financial benefits from their inventions, the profit-maximizing solution for inventors is to engage in no research

Government-Financed Research

- Government can encourage research by:
  - Subsidizing research costs (e.g., R&D tax deductions, duty-free export zones)
  - Paying firms to conduct research (e.g., research contracts, retaining product rights)
- Optimal number of firms depends on true research costs and expected benefits
  - Efficient if government has adequate information and funds research effectively

Prizes and Optimal Prize

- Government can induce research by offering prizes for success
  - No cost if no discovery; large enough prize can encourage research
- Optimal prize induces n^* firms to compete, equalizing expected earnings and research costs
  - Probability of at least one discovery: $\rho(n)$
  - Each firm's expected gain: $\frac{\rho(n)}{n}$ times the prize
  - Example (Table 16.4): optimal prize $\frac{\$1}{(0.80304/8)} = \$9.96$
    - Expected winnings equal expected marginal social benefits for $n = 8$
    - Each firm's expected winnings: $\$1.00$, equal to costs
- Prizes can efficiently induce innovation if:
  - Government has necessary information to set prize optimally
  - Prize financed without distortions

Too High a Prize and the Common-Pool Problem

- Setting prize equal to social value ($B = \$25$) may cause too much research
- Example: $\$9.96$ prize, 8 firms compete, 80
- Example: $\$25$ prize, 24 firms compete, 99
  - Social cost of research rises from $\$8$ to $\$24$ (300
- Net social benefit maximized at $\$12.08$ with $\$9.96$ prize
- Net social benefits nearly eliminated with $\$25$ prize

Relaxing Antitrust Laws: Joint Ventures

- Externality problem can be avoided with research joint ventures
- Government may suspect price collusion for a new product
- Patent pools can help overcome barriers from multiple patent owners
- Unclear whether joint ventures finance optimal number of research projects
  - May avoid duplication, reducing research costs
  - May undertake too little research if not capturing full social value
- Joint ventures typically capture less than full social value (including consumer surplus)
- In easily copied research, joint ventures may capture little social value
  - Unlikely to generate substantial research in such markets

Patents and Their Value

- Patents lead to distortions due to monopoly pricing
  - Less efficient than optimal prizes or research contracts if the government has sufficient information
- Patent race: several firms compete to be the first to make the discovery and be granted the patent
- Example assumptions:
  - Linear demand: $p = 6 - 5Q$
  - Marginal (and average) cost of production is 1
  - Patent rights split if two firms make a discovery simultaneously
  - Interest rate r is 10 percent
- Monopoly pricing with a patent:
  - Price $p_m = \$3.50$, quantity $q_m = 0.5$, annual profits $\pi_m = \$1.25$
  - Annual consumer surplus $\$0.65$, one-fourth of competitive industry
- Two cases to consider:
  1. A patent that lasts forever
  2. A patent that lasts for only a few years

Permanent Patent

- Permanent patent leads to monopoly profits forever
- May result in excessive research effort
- Present value of a permanent patent: $\frac{\pi_m}{r} = \$12.50$
  - 50% of net social value if the product were sold at competitive prices
- Expected return for a firm: $\$12.50$ times the probability of being first, $\frac{\rho(n)}{n}$
- Firm joins race if research costs $m = 1$ are less than expected benefits
- Example: 11.22 research projects for permanent patent rights
  - 40% more research projects than the optimal number 8

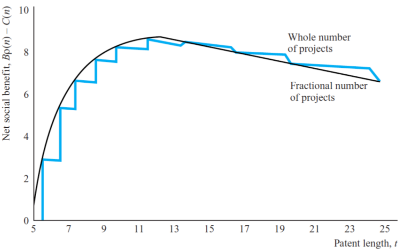
Finite Patent Length and Government Uncertainty

- Shorter patent length reduces excessive research, but longer patents induce more research with increased monopoly costs
- Optimal patent length maximizes net social benefit
- Fixed patent length may not suit all product types; rapid invention pace can make it irrelevant
- Government uncertainty affects desirability of patents, prizes, and research contracts
- Patents and joint ventures can be superior when inventors have more information than government officials
- Predicting the value of an invention is challenging, affecting the choice of incentives

TABLE 16.5 Optimal Patent Length

Length of Patent, t	Fractional Firms Possible: Number of Projects, n	Fractional Firms Possible: Net Social Benefit	Fractional Firms Impossible: Number of Projects, n	Fractional Firms Impossible: Net Social Benefit
5.35	0.50	$1.66	0.00	$0.00
5.71	1.00	3.10	1.00	3.20
6.53	2.00	5.35	2.00	5.35
7.47	3.00	6.91	3.00	6.91
8.56	4.00	7.91	4.00	7.91
9.00	4.35	8.14	4.00	7.84
9.87	5.00	8.44	5.00	8.44
10.00	5.09	8.47	5.00	8.42
11.00	5.74	8.60	5.00	8.29
11.4408	**6.00**	**8.608906**	**6.00**	**8.60891**
11.4475	**6.004**	**8.608908**	**6.00**	**8.60793**
12.00	6.31	8.59	6.00	8.53
13.00	6.82	8.51	6.00	8.41
13.40	7.00	8.47	7.00	8.47
14.00	7.26	8.39	7.00	8.39
15.94	**8.00**	**8.08**	**8.00**	**8.08**
19.51	9.00	7.48	9.00	7.48
25.36	10.00	6.72	10.00	6.72

FIGURE 16.2 Net Social Benefit Varies with Patent Length



Disney's Mickey Mouse Copyright Case

- Original Mickey Mouse copyright set to expire on January 1, 2024 [1]
- Disney to lose claim to "Steamboat Willie" version of Mickey Mouse [1]
- Complicated legal questions surrounding modern character licensing practices [1]
- Involvement of trademark law and association with Disney [2]

[1] arstechnica.com
[2] nytimes.com

Disney's History of Lobbying for Copyright Extension

- Successful lobbying in 1976: Copyright Act [3]
- Copyright Term Extension Act of 1998: 20-year copyright term extension [4]
- "The Mickey Mouse Protection Act" nickname [4]
- Influence on transference of intellectual property rights [5]

[3] theiplawblog.com
[4] wikipedia.org
[5] harvard.edu

Patent Holders May Manufacture or License

- A patent gives the inventor the monopoly on an idea for a fixed period of time. The patent holder may produce the product or **license** others to produce it in exchange for a payment called a **royalty**
- A profit-maximizing inventor is indifferent between being the only seller of the product and licensing others to produce and sell it, so long as the product market was competitive prior to the invention

Licensing

- Market originally competitive: constant cost m, price m, quantity Q
- New process allows lower cost $\underline{m}$, creating a low-cost dominant firm
- Optimal price just below m, profits (royalties) equal cost difference times units sold
- Licensing possibility: charge royalty per unit of output sold by other firms
- Profit-maximizing royalty where MR from selling a license equals zero marginal cost
- Occurs at quantity Q, royalty rate $r = m - \underline{m} = p - \underline{m}$
- Profit-maximizing royalty equals total per-unit savings from the new process
- Earnings equal if firm sells product itself without licensing

[Figure 16.3]

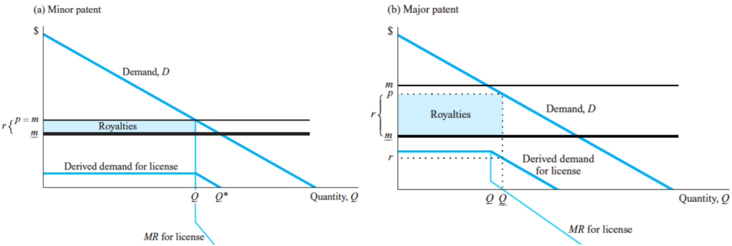


Figure: License Royalties

- Figure 16.3b uses the same types of curves to examine the case of a major new process that produces a dramatic fall in costs. The marginal revenue for the derived demand for licenses equals zero at $\underline{Q}$
- The profit-maximizing price p lies between m and $\underline{m}$
  - As a result, the royalty rate ($r = p - \underline{m}$) is less than the cost reduction ($m - \underline{m}$), but $\underline{Q} > Q$ licenses are sold

Licensing: Conclusion

- Inventor indifferent between selling and licensing if they can produce as efficiently as others
  - Competitive fringe restricts monopoly equally in both cases
  - Licensing likely when licensees have lower manufacturing costs
- Inventor captures all gains of minor discoveries, but not major discoveries
  - Minor: consumers buy same quantity at same prices, unaffected by discovery
  - Major: price falls, quantity rises, consumer surplus rises; inventor's gain less than total social gain

Examples of Royalties

- IBM: extensive patents on computing
  - Licensed patents for over 30 years
  - Collected 1-3
  - Cross-license agreements to avoid royalties
- Record companies: royalties on tape recorders and blank cassettes
  - Pushed for royalties on digital audio tape and compact cassettes in 1991
  - Agreement to equip recorders with "serial copy management system" chip
  - 3
  - Congress ratified in Audio Home Recording Act of 1992

For Further Reading I

- Carlton, Dennis W., and Jeffrey M. Perloff. Modern Industrial Organization. Fourth edition. Harlow, Essex, England: Pearson, 2015. Print.
- Belleflamme, Paul., and Martin. Peitz. Industrial Organization : Markets and Strategies. Cambridge, UK ;: Cambridge University Press, 2010. Print.