Chapter 23: Patents and Patent Policy

Learning Objectives

The students will learn to

1. Discuss the issues involved in determining the optimal breadth of a patent.
2. Use data on market demand, marginal production costs and the probability of research success to set up the payoff matrix for a patent race game. The student will also be able to determine the Nash equilibria for various patent race games.
3. Discuss reasons for over or under investment in R&D based on market structure, patent office policy, and alternative parameterizations of demand and technology (cost).
4. Use the models developed in Chapter 6 to analyze when patents can be used to protect a monopoly position or to engage in predation. Students will be able to explain why monopolists may be more likely to engage in research than potential entrants.
5. Explain the intuition behind “sleeping” patents and numerically solve a model where there is an incentive to patent a product and then not use the patent.
6. Explain the incentives for technology licensing. The student will also be able to discuss the advantages and disadvantages of straight royalties as compared to fixed fees or two-part tariffs, and to compare revenues from alternative licensing strategies.
7. Understand how innovation builds on innovation so that strong patent laws can result in a “patent thicket” in which a firm must obtain multiple licenses to offer any new product.
8. Understand the basics of a Poisson relationship.

Suggested Lecture Outline:

Spend one fifty-minute long lecture on this chapter.

Lecture 1:

1. Models of optimal patent length
    - Benefits to the firms
    - Benefits to society
2. Patent breadth
3. Patent races
    - Computing expected profits
    - Finding the Nash equilibria
4. Welfare implications of patent races
5. Preclusion by existing firms
6. Sleeping patents and preclusion
7. Technology licensing
    - Cournot versus Bertrand models of technology licensing
    - licensing with drastic innovations and the value of a monopoly
    - social benefits of licensing and incentives for firms to license
8. Hall and Ziedonis (2001) study of semiconductor patenting

Suggestions for the Instructor:

1. Motivate the students with a number of good examples.
2. Discuss when patents are appropriate and when they might not be. Class discussion of whether software patents make sense can raise many interesting issues.
3. A project that investigates the patent process of a popular product may be interesting.
4. A project that involves searching the Patent Office database would also be interesting.

Solutions to End of the Chapter Problems:

Problem 1

(a) We need to find profits as a function of K and ρ for the different possible situations: neither firm has the innovation, only one firm has the innovation, and both firms have the innovation. If neither firm has the innovation, competition is Cournot with symmetric costs of 100 each. So, we find quantities, price and profits as follows:

$$q_1 = 50, q_2 = 50, \pi_1 = 2500, \pi_2 = 2500$$

If only one firm has the innovation, say it is firm 1, then firm 2's response function is unchanged, and the innovator's response function reflects its lower costs. The new quantities, prices and profits are as follows:

$$q_1 = 70, q_2 = 40, \pi_1 = 4900, \pi_2 = 1600$$

If both firms succeed at innovating, we again have Cournot with symmetric costs. With both firms' costs reduced to $70, the new quantities, prices and profits are as follows:

$$q_1 = 60, q_2 = 60, \pi_1 = 3600, \pi_2 = 3600$$

If only one firm establishes a research facility, expected profit to that firm is

$$E(\pi_{owner} \mid 1\_firm\_establishes) = \rho(4900) + (1-\rho)(2500) - K = 2500 + 2400\rho - K$$

If only one firm establishes a research facility, expected profit to its competitor is

$$E(\pi_{non\_owner} \mid 1\_firm\_establishes) = \rho(1600) + (1-\rho)(2500) = 2500 - 900\rho$$

If both firms establish research facilities, expected profit to each firm is

$$\begin{aligned} &E(\pi_i \mid 2\_firm\_establishes) \\ &= \rho^2(3600) + \rho(1-\rho)(4900) + \rho(1-\rho)(1600) + (1-\rho)^2(2500) - K \\ &= 2500 - 400\rho^2 + 1500\rho - K \end{aligned}$$

Now, write down the payoff matrix and identify conditions for three different types of equilibria. Neither firm will establish a research facility if No Facility is the best response to No Facility for both firms. This will be true for the following conditions:

$$K > 2400\rho$$

Only one firm will establish a research facility if No Facility is the best response to Establish Facility and Establish Facility is the best response to No Facility. This will be true for the following conditions

$$2400\rho - 400\rho^2 < K < 2400\rho$$

Both firms establish a facility if Establish Facility is a best response to Establish Facility for both firms:

$$2400\rho - 400\rho^2 > K$$

(b) "Too much" R&D means that it is an equilibrium for both firms to establish research facilities, but aggregate profits to joint establishment are less than the aggregate payoffs to (No Facility, Establish Facility) or (Establish Facility, No Facility). It is a Nash equilibrium for both to innovate if

$$2400\rho - 400\rho^2 > K$$

Joint establishment is excessive if

$$1500\rho - 800\rho^2 < K$$

So, there is excess R&D if both conditions prevail

$$2400\rho - 400\rho^2 > K > 1500\rho - 800\rho^2$$

(c) We need to find profits as a function of K and ρ for the different possible situations: neither firm has the innovation, only one firm has the innovation, and both firms have the innovation. If neither firm has the innovation, competition is Cournot with symmetric costs of 100 each. So, we find quantities, price and profits as follows:

$$q_1 = 50, q_2 = 50, \pi_1 = 2500, \pi_2 = 2500$$

If only one firm has the innovation, say it is firm 1, then firm 2's response function is unchanged, and the innovator's response function reflects its lower costs. The new quantities, prices and profits are as follows:

$$q_1 = 90, q_2 = 30, \pi_1 = 8100, \pi_2 = 900$$

If both firms succeed at innovating, we again have Cournot with symmetric costs. The new quantities, prices and profits are as follows:

$$q_1 = 70, q_2 = 70, \pi_1 = 4900, \pi_2 = 4900$$

If only one firm establishes a research facility, expected profit to that firm is

$$E(\pi_{owner} \mid 1\_firm\_establishes) = \rho(8100) + (1-\rho)(2500) - K = 2500 + 5600\rho - K$$

If only one firm establishes a research facility, expected profit to its competitor is

$$E(\pi_{non\_owner} \mid 1\_firm\_establishes) = \rho(900) + (1-\rho)(2500) = 2500 - 1600\rho$$

If both firms establish research facilities, expected profit to each firm is

$$\begin{aligned} &E(\pi_i \mid 2\_firm\_establishes) \\ &= 2500 - 1600\rho^2 + 4000\rho - K \end{aligned}$$

Now, write down the payoff matrix and identify conditions for three different types of equilibria. Neither firm will establish a research facility if No Facility is the best response to No Facility for both firms. This will be true for the following conditions:

$$K > 5600\rho$$

Only one firm will establish a research facility if No Facility is the best response to Establish Facility and Establish Facility is the best response to No Facility. This will be true for the following conditions

$$5600\rho - 1600\rho^2 < K < 5600\rho$$

Both firms establish a facility if Establish Facility is a best response to Establish Facility for both firms:

$$5600\rho - 1600\rho^2 > K$$

Problem 2

(a) This is an application of the location model. Here the reservation price V = 100. The distance is given by t = 10. The number of consumers is given by N = 100. The monopolist with only black suits is located at one end of the market. All consumers who have a reservation price more than the price charged plus the transportation will buy one suit. Denote the location of a consumer by x where $0 \leq x \leq 1$ and assume that black is at location x = 0. So a consumer at location x will buy a suit if

$$p + tx \leq V \Rightarrow p + 10x \leq 100$$

The furthest consumer is at point 1, and so at any price of \$90 or less the entire market will be served. We can also find the consumer who is just indifferent about buying a suit at price p by solving the equation for x. This gives

$$p + 10x = 100 \Rightarrow x = 10 - 0.1p$$

For example, at a price of \$95, the consumer at .5 will be indifferent to buying a suit. Since there are 100 consumers, at prices between 90 and 100, some fraction of them will buy a suit. In particular

$$Q(p) = 1000 - 10p$$

The demand function then looks as follows

$$Q(p) = \begin{cases} 0 & if \quad p > 100 \\ 1000 - 10p & if \quad 90 \leq p \leq 100 \\ 100 & if \quad p \leq 90 \end{cases}$$

Maximizing profit, we obtain $p = 90$ and $Q = 100$. *Profit* = 6500.

(b) The monopolist is now in effect operating two stores, black at 0 and yellow at 1. The monopolist will be able to serve the entire market. The marginal consumer is the one in the middle of the market. Consumers to the left will buy black, consumers to the right will buy yellow. The price is identified by

$$p + \frac{t}{2} = V \Rightarrow p = 95$$

The firm sells to all 100 consumers but can reach them with a price of 95 as compared to 90 in the initial situation. Profits are now given by *Profit* = 7000. Thus, profits are higher by \$500.

(c) Assume that the firms will engage in Bertrand competition if the new one enters the market. It is clear that the entire market will be served. Thus, the marginal consumer (the one who is indifferent between buying a black suit at price p_b and a yellow suit at price p_y) is given by

$$x^m(p_b, p_y) = \frac{p_y - p_b + t}{2t}$$

Since there are N consumers, we can find the demand for black suits and the demand for yellow suits as follows

$$D^b(p_b, p_y) = \left(\frac{p_y - p_b + t}{2t}\right)N$$

$$D^y(p_b, p_y) = \left(\frac{p_b - p_y + t}{2t}\right)N$$

Now, get the profit functions. Maximization of profits yields

$$p_b = p_y = t + c$$

For the problem at hand, this will imply a price for both black and yellow suits of

$$p_b = p_y = 35$$

Profits are given by

$$\pi^b = \pi^y = 1000$$

Thus both firms have very low profits compared to the $6,500 or $7,000 earned by the original firm.

Problem 3

(a) The most the entrant has to gain is $1,000 (profits in the Bertrand duopoly) while the initial firm stands to lose $5,500 by letting the entrant develop the yellow suits.

(b) The value to the monopolist of keeping the entrant out is the value of $5,500 forever. Once the yellow swimming suits are producible, the value of adding them to the selection is $500 forever. Suppose that the discount factor is *F*. The monopolist will develop the suits but not market them if

$$R \le \frac{5500}{1-F}, D \ge \frac{500}{1-F} .$$

Problem 4

In a Bertrand duopoly each firm will set price equal to marginal cost. In this case with a marginal cost of $75 this will give P = 75. Each firm will have zero profits. Consumer surplus is given by 2812.5. So, total surplus is $2812.5.

Problem 5

(a) During the period of patent protection, the firm conducting R&D will be able to charge just less than $75 and capture the entire market since the other firm will not match a price below $75. The firm conducting R&D will be able to sell 75 units at this slightly lower price. The cost per unit will be 75 - 10. So the innovator will have profits per year (ignoring the one-off R&D costs) of $750.00. The firm, which made no profit before now, has profit equal to the cost savings on each of the 75 units sold.

(b) After the patent expires the other firm will be able use the innovation and the market price will fall to (75 - 10) = $65. This will give a market quantity of 85. There will be no per-period profits since competition is Bertrand. Consumer surplus will be given by $3612.5.

Problem 6

With the innovation consumer surplus will be 2,812.5 for *T* years and then be 3,612.5 for the remainder of time. Profits will be 750 per year for *T* years and zero thereafter. So total surplus per year during the patent period is 2,812.5 + 750 and is 3,612.5 during the rest of time since there are no profits. The present value of the surplus during the patent protection is then

$$PV(\,surplus\_during\_protection\,) = \frac{(2812.5 + 750)(1 - (0.9)^T)}{0.1}$$

The value during the remainder of time is given by finding the value of the perpetuity and then discounting it back to the present. The adjustment factor for this is given by $\frac{R^T}{1-R}$. This then gives

$$PV(\,surplus\_after\_protection\,) = \frac{(TS)(R^T)}{1-R} = \frac{(3612.5)(0.9)^T}{0.1}$$

Combining terms and subtracting the cost of the research to get the net benefit we obtain

$$PV(\,surplus\,) = 34625 + 500(\,0.9\,)^T$$

This is decreasing in *T*. Since the firm had already chosen its level of R&D, we find that social surplus is maximized by giving no patent protection or setting *T* = 0.

Problem 7

Price remains \$75. Now the profit per unit is the reduction in cost of \$15, giving aggregate profit per period of \$1,125 and consumer surplus as before of \$2812.5 per period. After the patent expires price falls to \$60, giving consumer surplus of \$4050 per period.

Problem 8

Total surplus is now

$$PV(\,surplus\,) = 37125 + 1125(\,0.9\,)^T\ .$$

Problem 9

During the period of patent protection profit per unit is *x* and sales are 75. Present value of profit is then:

$$PV(profit) = \frac{(1 - 0.9^T)}{0.1}75x - 10x^2$$

Maximizing with respect to R&D intensity gives

$$x^*(T) = 37.5(1 - 0.9^T)$$

Substituting into the profit equation gives the present value of the profit from patent protection

$$V(\,x^*(\,T\,),T\,) - r(\,x^*(\,T\,)) = 14062.5(1 - 0.9^T)^2\ .$$

During the patent protection consumer surplus is CS_0 2812.5 per period. After the patent expires, price falls to 75 – $x^*(T)$ and consumer surplus becomes $CS_1 = (75 - x^*(T))^2/2$. The present value of the increase in consumer surplus is

$$CS(x^*(\,T\,),T) = \frac{0.9^T}{0.1}(CS_1 - CS_0) = 7031.25(5 - 0.9^T)(1 - 0.9^T)0.9^T$$

Maximizing $V(X^*(\,T\,),T) + CS(X^*(\,T\,),T)$ with respect to *T* gives $T^* \cong 19$.