Chapter 22: Research and Development

Learning Objectives

Students should learn to:

1. Explain why technological progress is so important for society.
2. Explain the Schumpeterian hypothesis. Ideas include:
    a) Price competition is secondary to competition for the new commodity, the new technology, the new supply source, etc.
    b) Large firms are more likely to undertake R&D.
    c) Monopolistic firms (ones with market power) are more likely to aggressively pursue innovations.
3. Define the following terms and use them in economic analysis:
    a) Creative destruction
    b) Basic research
    c) Applied research
    d) Product development
    e) Process development
    f) Drastic innovations
    g) Non-drastic innovations
4. Cite evidence supporting and discrediting the Schumpeterian hypothesis.
5. Find the equilibrium in a competitive R&D model with research spillover of R&D on production costs.
6. Find the equilibrium in an R&D model, where there is joint research cooperation.
7. Summarize the results from the various models on research spillovers and
8. Discuss which types of industries are more likely to see research joint ventures.
9. Appreciate how formal econometric analysis can illuminate the topic of technical spillovers and how data on technology flows between countries may shed light on spillovers between firms.

Suggested Lecture Outline:

Spend two fifty-minute long lectures on this chapter.

Lecture 1:

1. Introduction, types of innovations, market structure, and competition in R&D
2. The Schumpeterian hypothesis
    a. trade-offs between incentives for innovation and promotion of competition
    b. creative destruction
    c. basic research, applied research, and product development
    d. process and product innovations
    e. drastic and nondrastic innovations
    f. innovation with a social planner, with competition, and with monopoly

3. simple models of R&D competition
4. empirical data—Keller (2002) study on international spillovers

Lecture 2:

1. Competition via innovation
2. Non-cooperative solutions in a Cournot duopoly
3. Cooperative joint ventures with incomplete spillovers and competition in the product market
4. Cooperative joint ventures with perfect R&D spillover
5. Comparison of results
6. Summary

Suggestions for the Instructor:

1. This chapter is highly relevant for students interested in the business world and in business strategy.
2. Play up these factors as you discuss the incentives to develop new products and processes.
3. A discussion of the Schumpeterian hypothesis is an excellent way to engage the students in a debate about the advantages and disadvantages of large and small firms, the need for patent protection, abuses of the patent system, and reasons why some monopoly power may be good for society. One could also discuss the issues involved when universities seek to patent research.
4. An in-class activity might be to have students write down in one minute, the number of products they currently use that were not on the market when they were born. Alternatively, one might ask them to list products with which they are familiar that have been modified in the last two years (Burger King fries, Nintendo video games, Nike basketball shoes, Goodyear all-season tires, Crest toothpaste, MP3 players etc.).
5. In discussing creative destruction, stress that there are few new products that perform a new service or create a new type of consumer satisfaction. Microwaves are to heat food, just like ranges, and ovens, and coal stoves, and open fires. Surge is made to quench thirst and provide a pick-me-up just like Mello Yellow, and Coke, and mineral water, and tap water. Gore-tex outerwear is designed to shed water like coated nylon, and rubber, and plastic, and large leaves. The point is that most products will replace something else in the consumption bundle. There are exceptions, such as the telephone or the airplane, but even here one might make a case that the pony express and hot air balloons were creatively destroyed even though the product is quite different.
6. In support of university research, one could put in a serious plug for basic research as the foundation for applied research and industrial product development.
7. To help the students distinguish product from process innovations, have them make a list of ten new products they can think of that have been developed in the last five years. Then have them identify discoveries or ideas that have led to lower production costs for standard products. They will usually have more trouble identifying process innovations since they are primarily consumers and not technicians (unless you have a bunch of engineers or molecular biologists). Help them understand that reducing production costs is very important for economic growth. One might also point out how concerns for the

environment may actually raise production costs and process innovations may be ways to reduce environmental damage without raising costs. Good examples of process innovations include robotics, computer assisted design, more efficient valves in pumps, internal combustion engines with less weight and more horsepower, just-in-time inventory systems, pelleted as compared to ground feed, etc.

8. Students often are confused about the difference between drastic and non-drastic innovations. The key point to make is that a drastic innovation gives the adopting firm an absolute cost advantage that effectively precludes any competition in the market. For the adopting firm, the marginal cost that is equal to its marginal revenue assuming no other firms in the market is lower than the lowest marginal cost of any potential rival. The way to check this out is to assume the adopting firm is a monopolist, compute the equilibrium in this case, and compare the resulting marginal cost to that of competitors.
9. One of the more interesting sections is the one on technology cooperation and spillovers. This can lead to an excellent discussion on positive externalities and growth. Again, it is important to point out that the level of innovation (x) is also the cost reduction.
10. In discussing the inset on optimal non-cooperative R&D, be sure to point out that this is a two-step optimization (or a two-stage game), where the choice of x is dependent on already finding the second stage Cournot solution.
11. In discussing the difference between non-cooperative and cooperative R&D effort, the insets make clear that the first order conditions for the cooperative case allow the firms to choose the optimal level of the other firm's research as compared to just responding to it. One way to make this clear would be to write the profit equations in the two cases one above the other and then discuss what the first order conditions for each will be.

Solutions to End of the Chapter Problems:

Problem 1

(a) We first want to solve for the pre-innovation output under competition. Given a marginal cost of c, we can obtain this by setting inverse demand equal to marginal cost as follows

$$P = A - BQ \Rightarrow c = A - BQ \Rightarrow BQ = A - c \Rightarrow Q = \frac{A-c}{B}$$

The monopolist's marginal revenue at $Q = \frac{A-c}{B}$ is given by

$$MR = A - 2BQ = A - 2B\left(\frac{A-c}{B}\right) = 2c - A$$

Thus, marginal cost must fall below *(2c -A)* for the innovation to be drastic.

(b) A drastic innovation is only feasible if the monopolist's marginal revenue at the pre-innovation output level is positive. $MR = 2c - A > 0 \Rightarrow A < 2c$

Problem 2

(a) With monopoly the firm will set marginal revenue equal to marginal cost. This requires that $MR = 240 - 2Q = MC = 120$, from which $Q = 60$ so $P = 240 - 60 = \$180$. Profit is $(180 - 120)*60 = \$3600$.

(b) In a Bertrand duopoly each will set price equal to marginal cost. In this case with a marginal cost of \$120 this will give

$$P = 240 - Q = 120 \Rightarrow Q = 120 \Rightarrow q_i = \frac{120}{2} = 60.$$

Each firm will have zero profits.

(c) The profit of each firm is given by

$$\pi_1 = (240 - q_1 - q_2)q_1 - 120q_1$$

$$\pi_2 = (240 - q_1 - q_2)q_2 - 120q_2$$

Maximizing profits for the first firm will give its response function as follows

$$q_1 = 60 - \frac{q_2}{2}$$

Similarly, we can find the best response function for firm 2 as

$$q_2 = 60 - \frac{q_1}{2}$$

Solving for the optimal levels of q_1 and q_2 we obtain $q_1 = q_2 = 40$.

Aggregate output is 80 and price and profits are given by $P = 160, \pi_1 = \pi_2 = 1600$. So total profits are $3,200.

Problem 3

(a) The monopolist in the market with a marginal cost of $60 would produce an output of 90, which sells at a price of $150. This is higher than the original marginal cost of $120 and so the innovation is not drastic.

(b) First consider the monopoly case. If the marginal cost falls to $60 the monopoly output is 90, monopoly price = $150 and monopoly profit is $8100.

In the Bertrand case the firm with the innovation can set a price of (just less than) $120 and drive its rival from the market. As a monopolist with price $120 it sells 120 units and has profit (120 – 60)*120 = $7200. The firm without the innovation has zero profit.

Now consider the Cournot case where one firm has the innovation and the other does not. The response function for the non-innovator is as in question 2 part c and is given by

$$q_{NI} = 60 - \frac{q_I}{2}$$

where NI denotes no innovation and I denotes innovation. For the innovator firm the response function is derived by maximizing profit with the new marginal cost as follows

$$q_I = 90 - \frac{q_{NI}}{2}$$

Using the two best response functions, we obtain $q_{NI} = 20$ and $q_I = 80$

The aggregate quantity is 100 and price and profits are given by $. P = 140, \pi_1 = 6400, \pi_2 = 400$

So total profits are $6800.

(c) With a discount rate of 0.9 and a perpetuity factor of 1/0.1 = 10 the amounts the firms would be willing to pay are given by the net present value of the profit change.

$$NPV(\Delta\pi^{Monopoly}) = \frac{4500}{0.1} = 45{,}000$$

$$NPV(\Delta\pi^{Bertrantd}) = \frac{7200}{0.1} = 72{,}000$$

$$NPV(\Delta\pi^{Cournot}) = \frac{4800}{0.1} = 48{,}000$$

Problem 4

If the entrant firm purchases the technology and enters the market as a Cournot competitor, the market equilibrium would be the Cournot one in part c. If the monopolist does not purchase the technology, it will end up as the high cost firm in the industry and have profits of only $400. Thus, if it purchases the technology it will have profits of $8,100, while if it doesn't it will have profits of $400 for a net difference of $7,700. This has present value of $77,000. Thus, the monopolist will pay more than the entrant firm for the technology if only one firm can purchase the technology. If both firms are allowed to purchase the technology and implement it, then the equilibrium will be a Cournot one with equal costs. Substituting 60 for 120 in question 2 part c, this implies profits of $3,600 to each firm as compared to $1,600 in the base case. The research institute will still get more money by only selling to the monopolist.

Problem 5

(a) Since neither firm makes profits when both have the innovation, neither will pay anything for it if they know that the other will also buy it. If the innovation were offered to only one of the Bertrand competitors, its profits with the innovation would be $7,200, so it would be willing to pay up to $72,000.

Clearly, the research institute would prefer to offer it to one rather than both.

(b) If both firms obtain the technology, the new equilibrium will be given by

$$P = 120, \pi_1 = 3600, \pi_2 = 3600$$

Without the innovation, each firm has profit of $1,600 for a net benefit to each firm of $2,000. Thus, each firm will pay $20,000 or a total of $40,000 for the innovation. The research institute will make more by selling to only one firm since one firm would pay $48,000.

Problem 6

(a) The initial equilibrium is such that $q_i = 20, Q = 40, P = 80, \pi_i = 400$

(b) Assume firm 1 has the technology. Then $q_1 = 40, q_2 = 10, P = 70, \pi^1 = 1600, \pi^2 = 100$

(c) Output of the firm with the technology is $q_1 = 30 + r/3$ and of the firm without the technology is $q_2 = 30 - 2r/3$. Price is $P = 60 + r/3$. Aggregate profit of the firm with the technology is $\Pi_1 = \left(30 + \frac{r}{3}\right)^2 + r\left(30 - \frac{2r}{3}\right)$. Maximize with respect to r to give $r = 45$. The licensee would be unwilling to pay this fee since it raises its costs above its current cost of $30. In the absence of the license the licensee's profit is $100 (part b). With the license its profit is $\left(30 - \frac{2r}{3}\right)^2 - r\left(30 - \frac{2r}{3}\right)$. The maximum license fee that the licensee will pay is such that $\left(30 - \frac{2r}{3}\right)^2 - r\left(30 - \frac{2r}{3}\right) \geq 100 \Rightarrow r \leq 15$. Output of firm 1 is 35 and of firm 2 is 20. Profit of firm 1 is 1525 and of firm 2 is 100.

Problem 7

With a fixed fee both firms have marginal costs of $30. Profit per period to the licensor is $\pi_1 = 900 + L$ and to the licensee is $\pi_2 = 900 - L$. Is in part c, the maximum license fee that can be charged must satisfy $\pi_2 = 900 - L \geq 100 \Rightarrow L \leq 800$. This gives a fixed fee of $800 per period, with the total increase of the licensor's profit being:

$$NPV(\pi\_gained) = \frac{800}{1-R}$$

The licensor's per period profit from the fixed license fee is 1600 but is only 1525 with the per unit fee. The former is preferable.

Problem 8

(a) Without the innovation, the firm sells 20 units at a price of $80 per unit and earns profit of $400. If only one firm gets the license for the innovation, its unit cost is 30 + *r* while the other firm's unit cost is 60. The firm with the license produces 40 – 2*r*/3 units, the other firm produces 10 + r/3 units and the research firm's profit from the license is *r*(40 – 2*r*/3). This is maximized with *r* = 30 but this fee would be refused. The maximum fee that can be charged to firm 1 satisfies $\left(40-\frac{2r}{3}\right)^2 - r\left(40-\frac{2r}{3}\right) \geq 400 \Rightarrow r \leq 15.84$. Profit to the research firm is $466.33.

(b) Unit cost for both firms is 30 + *r* so each produces 45 – *r*/3. The maximum fee that can be charged to each firm satisfies $\left(45-\frac{r}{3}\right)^2 - r\left(45-\frac{r}{3}\right) \geq 400 \Rightarrow r \leq 25.52$ The research firm earns a total of $1862.62.

(c) If only one firm has the license and pays a fixed fee, its per unit cost falls to $30, so it sells 40 units of output at $70 per unit for profit of $1600. Therefore, the license permits a profit increase of $1600 - $400, so the research firm can charge up to $1200 for its fee.

If both firms have licenses, both have lower per-unit costs. The new quantities, prices and profits are as follows:

$$q_1 = 30, q_2 = 30, \pi^1 = 900, \pi^2 = 900$$

So, both firms have a net profit increase of $900 - $400 = $500 before the research firm's fee. The research firm can charge each firm up to $500, for a total of $1,000 in fees.

Problem 9

(a) From equation (22.15) profit to each firm is $\pi_i = \frac{(60 + x_1(2-\beta) + x_2(2\beta - 1))^2}{9} - \frac{x_i^2}{2}$.

Suppose β = 1/3. $x_1 = x_2 = 30$ gives profit to each firm of 661.11 while $x_1 = x_2 = 15$ gives profit to each firm of 598.61.

Suppose β = 2/3. $x_1 = x_2 = 30$ gives profit to each firm of 894.44 while $x_1 = x_2 = 15$ gives profit to each firm of 690.28.

(b) From the derivation checkpoint the equilibrium R&D intensity is $x^{RC} = \frac{120(1+\beta)}{9-2(1+\beta)^2}$. With β = 1/3 this gives $x^{RC} = 22.15$ and with β = 2/3 it gives $x^{RC} = 32.14$. Consumers lose with low spillovers and gain with high spillovers.

(c) From the derivation checkpoint R&D intensity would $x^{RJV} = 240$ which is impossible. The limit would be $x^{RJV} = 60$. Consumers gain from the research joint venture.