Research and Development

Introduction

- Technical progress is the source of rising living standards over time
- Introduces new concept of efficiency
  - Static efficiency—traditional allocation of resources to produce existing goods and services so as to maximize surplus and minimize deadweight loss
  - Dynamic efficiency—creation of new goods and services to raise potential surplus over time

Introduction 2

- Schumpeterian hypotheses (conflict between static and dynamic efficiency)
  - Concentrated industries do more research and development of new goods and services, i.e., are more dynamically efficient, than competitively structured industries
  - Large firms do more research & development than small firms

A Taxonomy of Innovations

Product versus Process Innovations

- Product Innovations refer to the creation of new goods and new services, e.g., DVD’s, PDA’s, and cell phones
- Process Innovations refer to the development of new technologies for producing goods or new ways of delivering services, e.g., robotics and CAD/CAM technology
- We mainly focus on process or cost-savings innovations but the lines of distinction are blurred—a new product can be the means of implementing a new process

A Taxonomy of Innovations 2

Drastic versus Non-Drastic Innovations

- Process innovations have two further categories
- Drastic innovations have such great cost savings that they permit the innovator to price as an unconstrained monopolist
- Non-drastic innovations give the innovator a cost advantage but not unconstrained monopoly power

Drastic versus Non-Drastic Innovations

- Suppose that demand is given by: $P = 120 - Q$ and all firms have constant marginal cost of c = \$80
- Let one firm have innovation that lowers cost to c_M = \$20
- This is a ***Drastic*** innovation. Why?
  - Marginal Revenue curve for monopolist is:

    $$\boldsymbol{MR} = 120 - 2\boldsymbol{Q}$$

  - If $\boldsymbol{c_M}$ = \$20, optimal monopoly output is:

    $$\boldsymbol{Q_M} = 70 \text{ and } \boldsymbol{P_M} = \$70$$

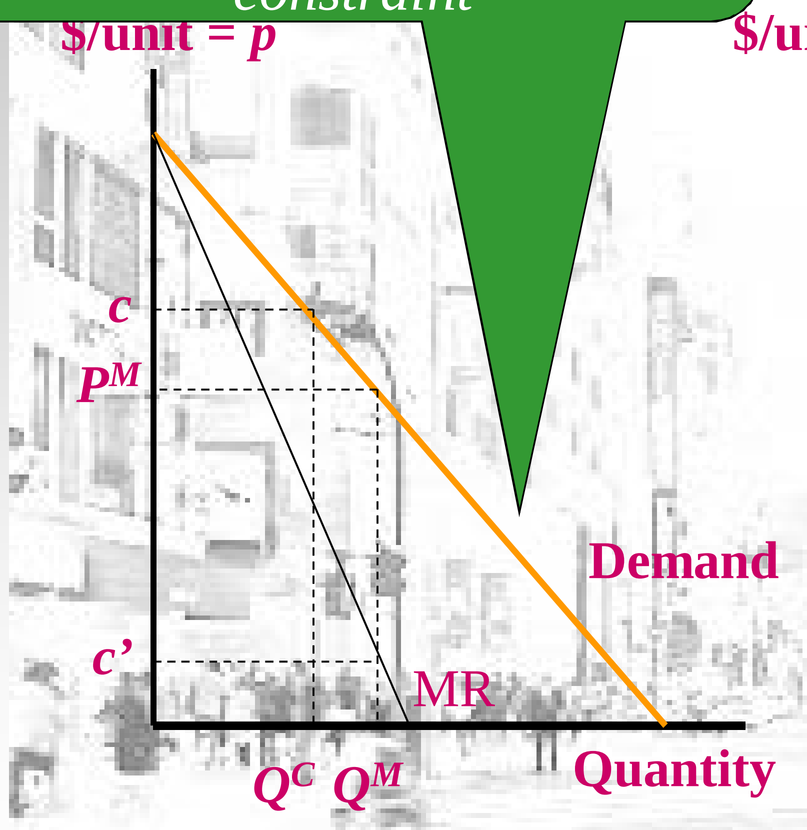
  - Innovator can charge optimal monopoly price (\$70) and still undercut rivals whose unit cost is \$80

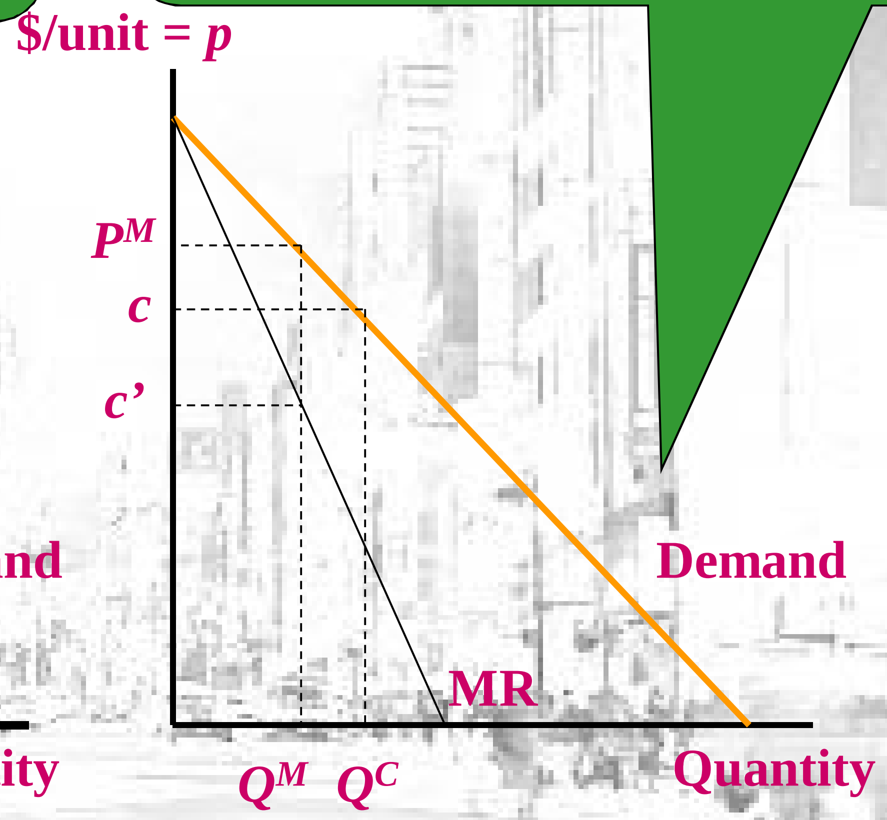
Drastic versus Non-Drastic Innovations 2

- Now consider the case if cost fell only to \$60, innovation is ***Non-drastic***
  - Marginal Revenue curve again is: $\boldsymbol{MR} = 120 = 2\boldsymbol{Q}$
  - Optimal Monopoly output and price: $\boldsymbol{Q_M} = 30$; $\boldsymbol{P_M} = \$90$
  - However, innovator cannot charge \$90 because rivals have unit cost of \$80 and could under price it
  - Innovator cannot act as an unconstrained monopolist
  - Best innovator can do is to set price of \$80 (or just under) and supply all 40 units demanded.

Drastic Innovation: $Q^M > Q^C$ *so innovator can charge monopoly price* P^M *without constraint*

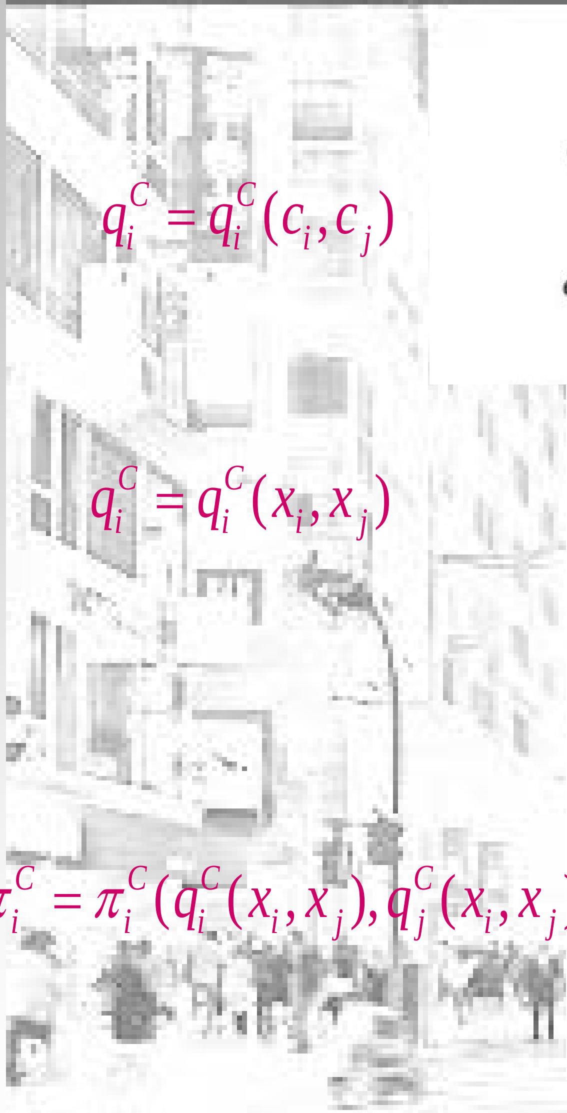
NonDrastic Innovation: $Q^M < Q^C$ *so innovator cannot charge monopoly price* P^M *because rivals can undercut that price*





R&D Spillovers and Cooperative R&D

- Technological break-throughs by one firm often "spill over' to other firms
  - Spillover is unlikely to be complete but likely to arise to some extent
  - We can model this by writing a firm's unit cost as a function of both its own and its rival's R&D
    - $c_1 = c - x_1 - \beta x_2$
    - $c_2 = c - x_2 - \beta x_1$
- To obtain solution, need also to assume that R&D is subject to diminishing returns, e.g., $r(x) = x^2/2$.



$$q_i^C = q_i^C(c_i, c_j)$$

$$q_1^C = \frac{(A - 2c_1 + c_2)}{3B}$$

$$q_2^C = \frac{(A - 2c_2 + c_1)}{3B}$$

$$q_i^C = q_i^C(x_i, x_j)$$

$$q_1^C = \frac{(A - c + x_1(2 - \beta) + x_2(2\beta - 1))}{3B}$$

$$q_2^C = \frac{(A - c + x_2(2 - \beta) + x_1(2\beta - 1))}{3B}$$

and their profits are

$$\pi_i^C = \pi_i^C(q_i^C(x_i, x_j), q_j^C(x_i, x_j), x_i, x_j)$$

$$\pi_1^C = \frac{(A - c + x_1(2 - \beta) + x_2(2\beta - 1))^2}{9B} - \frac{x_1^2}{2}$$

$$\pi_2^C = \frac{(A - c + x_2(2 - \beta) + x_1(2\beta - 1))^2}{9B} - \frac{x_2^2}{2}$$

$$\frac{\partial \pi_i^C}{\partial x_i} = \frac{2(2-\beta)[A - c + x_i(2-\beta) + x_j(2\beta - 1)]}{9B} - x_i = 0 \qquad (15.36)$$

Solving this for x_i gives the following best-response curves R_1 and R_2 for Firm 1 and Firm 2:

$$\begin{aligned} R_1\colon x_1 &= \frac{2(2-\beta)[A - c + x_2(2\beta - 1)]}{[9B - 2(2-\beta)^2]} \\ R_2\colon x_2 &= \frac{2(2-\beta)[A - c + x_1(2\beta - 1)]}{[9B - 2(2-\beta)^2]} \end{aligned} \qquad (15.37)$$

R&D Spillovers and Cooperative R&D 2

- In this setting, response of firm 1's R&D to firm 2's R&D depends on size of spillover term β.
  - When β is small, R&D expenditures are strategic substitutes—the more firm 1 does the less firm 2 will do
  - When β is large, R&D expenditures are strategic complements—the more firm 1 does the more firm 2 will do
- However, determination of whether R&D efforts are strategic substitutes or strategic complements is not sufficient to determine what happens when there are spillovers

R&D Spillovers and Cooperative R&D 3

- Let Demand be given by: $P = A - BQ$
  - Let $c_i = c - x_i - \beta x_j$;
  - Each firm now chooses both production q_i and research intensity x_i
- General Solution is:

$$x_1^C = x_2^C = \frac{2(A-c)(2-\beta)}{9B - 2(2-\beta)(1+\beta)}$$

- To illustrate, consider two cases
  - First case: Low Spillovers; $\beta = 0.25$
  - Second case: High Spillovers; $\beta = 0.75$

Nash Equilibrium is for both firms to choose the high level of research intensity (x = 10). Why? When degree of spillovers β is small, firm know that its rival can do R&D knowing that it will get most of the benefits. Since this would advantage the rival, each firm tries to avoid being left behind by doing lots of R&D itself.

...operative R&D 4

for $\beta = 0.25$

		Firm 1	
		...search Intensity	High Research Intensity
Firm 2	Low Research Intensity	$107.31, $1[illegible]	$100.54, $110.50
	High Research Intensity	$110.50, $100.54	$103.13, $103.13

Nash Equilibrium is for both firms to choose the low level of research intensity (x = 7.5). Why? When degree of spillovers β is large, a firm knows that it will benefit from technical advance of its rival even if it doesn't do any R&D itself. So, each firm tries to free-ride off its rival and each does little R&D itself.

...operative R&D 5

...or β = 0.75

		Firm 1	
		...arch ...sity	High Research Intensity
Firm 2	Low Research Intensity	$128.67, ...128.671,	$136.13, $125.78
	High Research Intensity	$125.78, $136.13	$133.68, $133.68

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- MORAL of the foregoing analysis is that the Outcome of non-cooperative R&D spending depends critically on the extent of spillovers.
- What if R&D spending is cooperative?
- R&D cooperation can take two forms:
  - 1. Do R&D independently but choose x_1 and x_2 jointly to maximize combined profits, ***given*** competition in product market is maintained.
  - 2. Do R&D together as one firm, e.g, form a Research Joint Venture. That is, effectively operate as though the degree of spillovers is $\beta = 1$, again though, continue to maintain product market competition.
- The two types have very different implications.

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- Consider first the case of coordinated but not centralized R&D using our generalized demand and cost equations
  - Total R&D spending now rises unambiguously as β increases.
  - To see this note that given our earlier demand and cost assumptions, and given the fact that $\boldsymbol{x_1}$ and $\boldsymbol{x_2}$ are chosen to maximize joint profits, the optimal values for $\boldsymbol{x_1}$ and $\boldsymbol{x_2}$ are:

$$x_1 = x_2 = \frac{2(A-c)(1+\beta)}{9\beta - 2(1+\beta)^2}$$

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- This solution for the profit-maximizing research level under cooperation is unambiguously increasing in β but this is a good news/bad news story.
- The good news is that for the high spillover case (β >0.5), the free- riding problem is no longer an issue and firms now do more R&D
- The bad news is that for the low spillover case (β < 0.5), there is no longer a fear of being left behind by one's rival. So in this case firms do less R&D which means costs (and consumer prices) are higher than without cooperation.

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- What about a Research Joint Venture?
  - As noted, this effectively changes β to 1.
  - For our demand and cost equations, it can be shown that:

$$x_1 = x_2 = \frac{4(A-c)}{9B-8}$$

– This is clearly more R&D than occurred with simple coordination for any given value of β

– As a result, it leads to lower costs and more output to the benefit of consumers

$$q_1 = q_2 = \frac{3(A-c)}{9B-8}$$

– Profits are also higher. Thus, in the presence of spillovers, Research Joint Ventures are unambiguously beneficial.

– The only trick is to make sure that cooperation is limited to research and does not extend to other dimensions of competition