Module 11: Innovation & Patents

Market Organization & Public Policy (Ec 731)  ·  George Georgiadis

○ Technological progress is crucial for improving welfare, but (very) costly.
  - How to incentivize firms to innovate?

○ Suppose that a large number of firms engage in Cournot competition.
  - We have seen that the equilibrium price will be close to the marginal cost, and firms’ profits close to 0.
  - Consider a firm’s incentive to engage in costly R&D.
  - If other firms can imitate a new innovation, then the innovating firm will have little incentive to invest in the first place.
  - Therefore, a new firm must be guaranteed enough (expect) profits to recoup the R&D cost.

○ Enter: Patents (that provide the innovating firm with a temporary monopoly).

○ Schumpeter (1943): If one wants to induce firms to undertake R&D, then one must accept the creation of monopolies as a necessary evil.

The Value of Innovation

○ A simple model of process innovation:
  - Assume that innovation lowers the (constant) marginal production cost from \( \bar{c} \) to \( c < \bar{c} \).
  - How much would a firm be willing to pay to reduce its marginal cost, given that no other firm will (be allowed to) buy it?
Social Planner (First best):

- She sets price equal to marginal cost; i.e., $p = \bar{c}$ before the innovation, and $p = \underline{c}$ after.
- Additional net social surplus p.u of time: $v^s = \int_{\underline{c}}^{\bar{c}} D(c) dc$
- The social planner’s value from innovating is:
  $$V^s = \int_0^\infty e^{-rt} v^s dt = \frac{1}{r} \int_{\underline{c}}^{\bar{c}} D(c) dc$$

Monopoly:

- Suppose that a firm is in a monopoly situation.
- Let $\Pi^m$ denote monopoly profit p.u of time. Then:
  $$\frac{d\Pi^m}{dc} = \frac{d}{dc} [(p - c) D(p)]$$
  $$= \frac{\partial \Pi^m}{\partial p} \frac{dp^m}{dc} + \frac{\partial \Pi^m}{\partial c} = -D(p^m(c))$$
  - Application of the Envelope Theorem.
- The monopolist’s value from innovating is:
  $$V^m = \int_0^\infty e^{-rt} [\Pi^m(\underline{c}) - \Pi^m(\bar{c})] dt$$
  $$= \frac{1}{r} \int_{\underline{c}}^{\bar{c}} \left( -\frac{d\Pi^m}{dc} \right) dc$$
  $$= \frac{1}{r} \int_{\underline{c}}^{\bar{c}} D(p^m(c)) dc$$
  - Because $p^m(c) > c$ and $D' < 0$, we have $D(p^m(c)) < D(c)$ for all $c$, and hence $V^m < V^s$.
  - A monopolist has weaker incentives to innovate relative to a social planner.
    - Intuitively: Because he sets a higher price, the cost reduction pertains to a smaller number of units.

Competition:

- Suppose that 2 firms engage in Bertrand competition.
Then \( p = \bar{c}, \) and firms earn 0 profits.

- The firm that obtains new technology with cost \( c \) is awarded a patent.
- Let \( p^m(c) \) be the monopoly price when the cost is \( c \).
- **Case 1:** If \( p^m(c) \leq \bar{c} \), then we say that the innovation is *drastic*.
  - The innovator then charges \( p = p^m(c) \), and obtains the entire market.
  - His value from innovating is \( V^m \).
- **Case 2:** If \( p^m(c) > \bar{c} \), then we say that the innovation is *nondrastic*.
  - Both firms charge \( p = \bar{c} \), and the innovator’s profit p.u. of time is \( \Pi^c = (\bar{c} - c) D(\bar{c}) \).
  - The value from innovating is
    \[
    V^c = \frac{1}{r} (\bar{c} - c) D(\bar{c})
    \]
  - Because \( \bar{c} < p^m(c) < p^m(c) \), we have \( D(\bar{c}) > D(p^m(c)) \) for all \( c \geq \bar{c} \), so
    \[
    V^m = \frac{1}{r} \int_{\bar{c}}^{\infty} D(p^m(c)) \, dc < \frac{1}{r} \int_{\bar{c}}^{\infty} D(\bar{c}) \, dc = V^c
    \]
  - But \( D(\bar{c}) < D(c) \) for all \( c < \bar{c} \), so \( V^s = \frac{1}{r} \int_{\bar{c}}^{\infty} D(c) \, dc > \frac{1}{r} \int_{\bar{c}}^{\infty} D(\bar{c}) \, dc = V^c \).
  - Therefore, \( V^c \in (V^s, V^m) \).
- Take-aways:
  - Even with patents of infinite duration, the innovator does not internalize the entire social surplus from the innovation.
  - A monopolist has less to gain from innovating than does a competitive firm. Why?

**Monopoly Threatened By Entry**

- Simple setting with two firms. Initially:
  - Firm 1 is a monopolist, produces at marginal cost \( \bar{c} \), and earns profit \( \Pi^m(\bar{c}) \).
  - Firm 2 does not currently produce, but is a potential entrant.
○ If only one of the firms has the opportunity to acquire the technology to reduce marginal cost to $c$, then we have the same situation as before:

- $V^c > V^m$, so innovation is more valuable for the entrant than for the monopolist.

○ Now suppose that a 3$^{rd}$ party generates the innovation, and auctions it to the two firms.
○ We will see that in this case, the innovation is more valuable for the monopolist than for the entrant.

○ If firm 1 obtains the innovation, then it remains a monopolist, and earns profit $\Pi^m (c)$.
○ If firm 2 obtains the innovation, then both firms become duopolists.
  - Denote the profits of firm 1 and 2 by $\Pi^d (\bar{c}, c)$ and $\Pi^d (c, \bar{c})$, respectively.
○ The value of innovation for firm 1 is:

$$V^m = \frac{\Pi^m (c) - \Pi^d (\bar{c}, c)}{r}$$

○ The value of innovation for firm 2 is:

$$V^c = \frac{\Pi^d (c, \bar{c})}{r}$$

○ Assume that: $\Pi^m (c) \geq \Pi^d (\bar{c}, c) + \Pi^d (c, \bar{c})$.
  - A monopolist earns greater profit than two non-colluding duopolists.
○ Then: $V^m > V^c$. (Opposite from before!)
○ Because competition reduces profits, the monopolist’s incentive to remain a monopolist is greater than the entrant’s incentive to become a duopolist.

○ A monopolist may have incentives to obtain property rights on an innovation, even though he will make no use of it (often referred to as patent shelving).
  - The only purpose is to prevent an entrant from competing.
– Subject of many antitrust cases; generally considered anti-competitive behavior.
– In many countries, the patent law includes a compulsory licensing provision (i.e., patent holder is forced to license if he does not utilize the innovation within a specified length of time).

**Patent Races**

○ Insofar, we have considered

1. the value of innovation in a situation where one firm has monopoly over R&D activities; and
2. the value of innovation when monopoly power is auctioned to a monopolist and a potential entrant.

○ In practice, R&D competition can be likened to a “race” for a patent.

– Multiple firms invest in R&D simultaneously, and whichever firm innovates first, obtains a patent.

○ We will study the so-called “Poisson” patent race.

– Initially, there is a monopolist with cost $\bar{c}$, and a potential entrant.
– The two firms compete in R&D activities, and the firm first to innovate (i.e., obtain a technology with cost $c$) obtains a patent.

○ At every moment $t$, each firm $i$ invests in R&D at rate $x_{i,t}$, and its innovation rate is $h(x_{i,t})dt$, where $h' > 0 > h''$.

– If firm $i$ invests $x_i$ during $(t, t + dt)$, then it incurs cost $x_idt$ and its probability of innovating is $h(x_{i,t})dt$.
– This is called a “Poisson” race, because the probability of innovating during $(t, t + dt)$ is independent of investments at $t' < t$.
– It follows that each firm’s investment rate will be independent of $t$.

○ If firm 1 obtains the patent, then the firms earn profits $\Pi^m (c)$ and 0, respectively.
If firm 2 obtains the patent, then the firms earn profits $\Pi^d(\bar{c}, \bar{c})$ and $\Pi^d(\bar{c}, \bar{c})$, respectively.

Assume that: $\Pi^m(\bar{c}) \geq \Pi^d(\bar{c}, \bar{c}) + \Pi^d(\bar{c}, \bar{c})$.

During an arbitrary interval $(t, t + dt)$, firms 1 and 2 earn profit $[\Pi^m(\bar{c}) - x_1]dt$ and $-x_2 dt$, respectively.

- With probability $h(x_1)dt$, firm 1 is first to innovate, and the firms will earn discounted profits $\frac{\Pi^m(\bar{c}) - x_1}{r}$ and 0, respectively.
- With probability $h(x_2)dt$, firm 2 is first to innovate, and the firms will earn discounted profits $\frac{\Pi^d(\bar{c}, \bar{c})}{r}$ and $\frac{\Pi^d(\bar{c}, \bar{c})}{r}$, respectively.
- With probability $1 - h(x_1)dt - h(x_2)dt$, neither firm innovates during $(t, t + dt)$.

The value of innovation to firm 1 is

$$V_1 = [\Pi^m(\bar{c}) - x_1] dt + e^{-r dt} \left[ h(x_1) dt \frac{\Pi^m(\bar{c})}{r} + h(x_2) dt \frac{\Pi^d(\bar{c}, \bar{c})}{r} + (1 - h(x_1)dt - h(x_2)dt) V_1 \right]$$

$$V_1 = \frac{\Pi^m(\bar{c}) - x_1 + h(x_1) \frac{\Pi^m(\bar{c})}{r} + h(x_2) \frac{\Pi^d(\bar{c}, \bar{c})}{r}}{r + h(x_1) + h(x_2)}$$

and for firm 2

$$V_2 = -x_2 dt + e^{-r dt} \left[ h(x_2) \frac{\Pi^d(\bar{c}, \bar{c})}{r} + (1 - h(x_1) dt - h(x_2) dt) V_2 \right]$$

$$V_2 = \frac{-x_2 + h(x_2) \frac{\Pi^d(\bar{c}, \bar{c})}{r}}{r + h(x_1) + h(x_2)}$$

- Note 1: $e^{-rdt} \approx 1 - r dt$ for “small” $dt$ (Taylor expansion)
- Note 2: $dt^2 \approx 0$

A Nash equilibrium is a pair $\{x^*_1, x^*_2\}$ such that $x^*_i$ maximizes $V_i$ given $x^*_{-i}$.

Which firm will have stronger incentives to invest in R&D?

Depends on which of two effects dominates.

1. **Efficiency effect**: $\Pi^m(\bar{c}) \geq \Pi^d(\bar{c}, \bar{c}) + \Pi^d(\bar{c}, \bar{c})$ suggests that the monopolist has stronger incentives, and therefore, spends more on R&D.
2. **Replacement effect:** By increasing \( x_1 \), the monopolist (on expectation) brings the discovery date forward, thus hastening his own replacement. In contrast, the entrant does not forgo a flow profit during the R&D phase, and therefore has stronger incentives.

- What if we consider the case of a drastic innovation?
  - \( i.e., \) whichever firm obtains the patent, becomes a monopolist, so \( \Pi^d (\bar{c}, \bar{c}) = \Pi^m (\bar{c}) \) and \( \Pi^d (\bar{c}, \bar{c}) = 0 \).

- Problems:
  - Excessive duplication of research
  - With multiple stages, as the gap between the firm widens, incentives weaken.

### Welfare Analysis of Patent Protection

- Overall, economic research in this area is still nascent.

- **Main issues:**
  - Optimal patent length?
  - Optimal degree of patent protection?
  - Subsidies? (\( e.g., \) in the US, tax credits for R&D investments)

- An example from *United States vs. Microsoft Corp*:

  - Microsoft was accused of becoming a monopoly and engaging in abusive practices, in violation of the Sherman Act.
  
  - **Central Issue:** Whether Microsoft was allowed to bundle its web browser (IE) with Windows. Allegedly, this restricted the market for competing web browsers.
  
  - Microsoft’s argument:
    
    - While it possesses a lot of static market power, this is merely the fuel for stimulating dynamic R&D competition.
    
    - Antitrust intervention would run the risk of reducing the rate of innovation and welfare.
Government’s argument:

* Microsoft’s practices prevented entry of new firms and products, thus raising prices and retarding innovation.

- Key trade-off:

  - Policies that protect new entrants (e.g., start-up) from incumbents (e.g., Microsoft) raise a successful innovator’s initial profits, and may thereby encourage innovation.
  
  - But entrants hope to become the next Microsoft, and will want to engage in similar entry-disadvantaging behaviors should they succeed. Thus by lowering the profits of incumbency, protective policies may actually retard innovation.

- Difficult problem to analyze, because it is inherently dynamic.
  
  - Need a model of successive patent races.
  
  - See Segal and Whinston, (AER, 2007).

Alternatives to Patents

- Patents incentivize R&D investments by conferring monopoly rights to an innovator.

- Can we (somehow) avoid the deadweight losses associated with monopoly?

- Yes:

  1. Award system
  2. Procurement or contractual mechanism

- Award system:

  - An entity (e.g., government or a firm) designates a (well-defined) project, and grants a fixed sum of money to the first firm that completes the project.
  
  - After the prize is awarded, the innovation falls into the public domain.
  
  - Examples: XPrize, Innocentive, etc...
  
  - Advantage: Does not produce a monopoly!
  
  - Disadvantage: Difficult to implement!
* Unlike with patents, the government must be highly knowledgeable about the demand for the project, which is crucial for determining the size of the award, which in turn, influences R&D incentives.

− In practice, the size of the award will often be determined after the innovation has occurred, which raises hold-up issues.

* Administrative authorities typically estimate the values of innovations conservatively.

○ Procurement or contractual mechanism:

− Similar to the award system, but the government controls access to the research market.

* i.e., chooses a certain number of firms and signs a contract with them.

− Contract may specify that certain portion of the R&D costs will be borne by the government.

* Raises incentives problems.

* Can limit duplication of research.

− As with the award system, the government must know the value of the innovation.

− Often used in connection with space and defense projects.

References
