ECO 650: Firms' Strategies and Markets

Innovation

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To innovate enables firm to acquire a competitive advantage towards its rival.

- Lowering its production cost.
- Improving its quality.
- Create a new product (completely new, new variety, new packaging,...)

Protection-Patent

- The story of Robert Kearns and its “intermittent windshield wiper"
- If an innovation is not protected $\Rightarrow$ The innovator fails to appropriate the rent of its innovation
  - Uncertainty: Proba for a new medecine to be approved for patient use is about 1/10 000, Proba to be published for a book, ...
  - Imitation +Large fixed cost difficult to recover for the innovator
- How to protect an innovation ?
  - Patents : In the US and EU the term of a patent is 20 years.
  - Copyright: Longer period $\backsimeq$ 50 years
  - Secret: Coca-Cola

$https://www.uspto.gov/web/offices/ac/ido/oeip/taf/us_stat.htm$

Table: Patents in the US

Year	**Patent applications**	**Patents granted**	Share
1973	110 000	79 000	71%
1983	112000	62000	55%
1993	189 000	110 000	58%
2003	366 000	187 000	49%
2015	630 000	325 000	51%

The patent dilemma

- A patent grants a “temporary" monopoly power to the innovator to protect the innovator and favor innovation
- The monopoly position creates a dead weight loss

Two key variables to control this balance:

- The lenght of the patent
- The breadth of the patent

The optimal lenght of a patent

Assumptions

- Assume an innovation creates a social surplus W at each period.
- The discount factor is δ.
- The innovation cost is C and is paid in $t = 0$.

The social value of Innovation is:

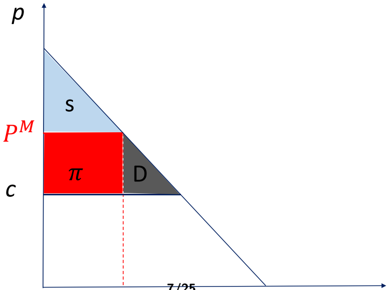
$$V = -C + W[\delta + \delta^2 + ...\delta^T]$$

When $T \to \infty, V \to W\frac{\delta}{1-\delta} - C$ V is increasing with δ. No reason to consider a limited time for the value of innovation.

The optimal lenght of a patent

Assumptions

- This innovation is protected by a patent for a lenght T.
- From $T+1$ and on, there is Bertand competition.
- We denote $\pi = \alpha W$ with $\alpha \in [0,1]$ the profit of the monopolist innovator. We have $W = S + \pi + D$. We denote $D = \beta W$.



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The social value of an Innovation protected by a brevet for T periods is:

$$V_B = \underbrace{W\frac{\delta}{1-\delta} - C}_{\texttt{Social Value of innovation}} - \underbrace{\beta W \overbrace{\delta[1+\delta+...+\delta^{T-1}]}^{\texttt{L=Lenght of the patent}}}_{\texttt{Social cost of patent protection}}$$

The innovator's incentive to innovate is:

$$V_I = \alpha WL - C$$

Comparing V_I and V_B, we obtain :

$$V_I < V_B$$

$$(\alpha+\beta)L < \frac{\delta}{1-\delta}$$

$$\alpha+\beta < \frac{\delta}{1-\delta}\frac{1-\delta}{\delta(1-\delta^T)} = \frac{1}{(1-\delta^T)}$$

- A single innovator protected by a patent innovates less than what would be socially optimal.
- The social value of an innovation protected by a patent decreases with L which increases with T.
- What happens with competition?

Innovation-Patent and competition

Assumptions

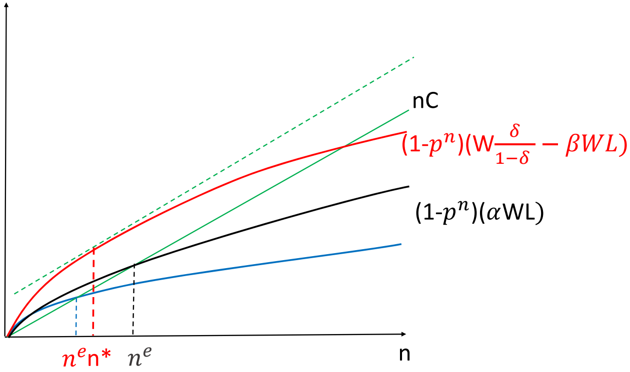
- Assume that there is free entry
- n firm can spend the cost C and each of them has a probability p to fail.
- Even if several firms innovates at the same time, only one gets the patent.

The probability that all firms fail is p^n.

The probability that at least one succeeds is $1 - p^n$.

Each firm has a probability $\frac{1}{n}$ to get the patent in case there is at least one inovation, i.e. $\frac{1}{n}(1 - p^n)$.

- At the social level, the optimal number of firm n maximizes $(1-p^n)(W\frac{\delta}{1-\delta}-\beta WL)-nC$
- FOC $\frac{(1-p^n)(W\frac{\delta}{1-\delta}-\beta WL)}{\partial n}=\frac{\partial(nC)}{\partial n}$
- Because of free entry, the number of firms that innovates in equilibrium is such that $(1-p^n)\alpha WL = nC$.



Remember

- When the lenght of the patent is too short, there is less firm that innovate compared to the social optimum.
- When the lenght of the patent is too long, there is too much entry. Race for patents leads to an overinvestment!
- The breadth of a patent defines how similar a product must be to infringe a patent. If the patent breadth is large it reduces the social value of the innovation and increases the profit of the innovator.
  $\Rightarrow$ Patent breadth and lenght are substitutable tools.

Alternative incentive mechanisms: Prizes or Subsidies

- A reward $R = \alpha WL$ to the innovator: same incentive to innovate as with a patent of lenght L but no deadweight loss.
- Offering a reward $R = C + \epsilon$ works also. The innovator is paid back for its inovation cost. But impossible when success is random
- Prizes require information about, W, α and C + government funding $\Rightarrow$ taxes?
- Prices are often announced in advance : Lépine awards
- Numerous examples of targeted prizes:
  - **1795** : Napoleon 1st had organized a competition to reward the best food preservation process for army! Nicolas Appert invented “tinned food".
  - **1996** : The X prize (10 millions) to transport humans in space (100 km height)
  - **2006**: The H prize technical challenges (hydrogen production and storage, hydrogen vehicles, etc...)

The Arrow replacement effect

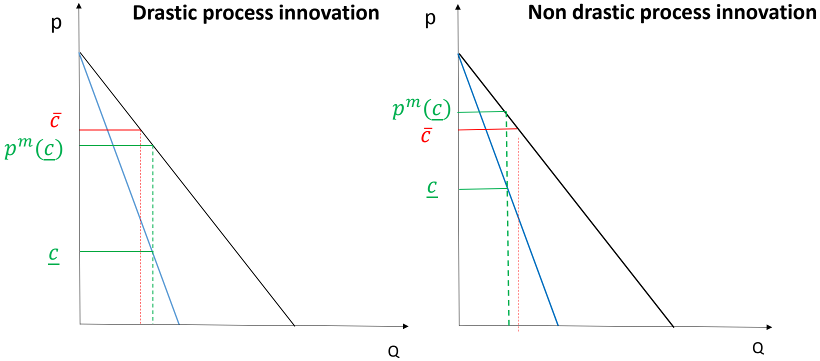
This effect highlighted by Arrow (1962) show that paradoxically the innovation incentives of a monopoly might be lower than that of competing firms.

Assumptions

- Initially a firms' marginal cost is $\overline{c}$.
- In case of innovation the marginal cost is $\underline{c} < \overline{c}$.
- The monopoly price is denoted $p^M(c)$. In case of competition, firms compete a la Bertrand.
- Innovation can either be drastic or non drastric.

Innovation level

- Drastic competition: $p^M(\underline{c}) < \overline{c}$
- Non drastic competition: $p^M(\underline{c}) > \overline{c}$.



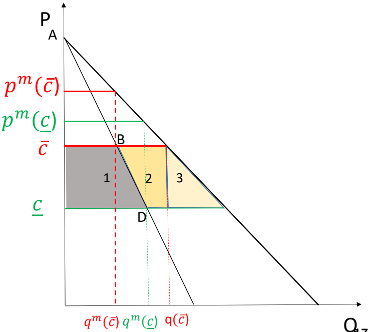
Competition vs Monopoly with drastic competition

- Competitive situation [*ex post*-*ex ante*]
  - *ex ante*: 0
  - *ex post*:$(p^M(\underline{c}) - \underline{c})q^M(\underline{c})$
- Monopoly :[*ex post*-*ex ante*]
  - *ex ante*: $(p^M(\overline{c}) - \overline{c})q^M(\overline{c})$
  - *ex post*: $(p^M(\underline{c}) - \underline{c})q^M(\underline{c})$

It is immediate that incentives to innovate are lower in the monopoly case! This is because the monopoly replaces itself.

Competition vs Monopoly with non drastic competition

- Competitive situation [*ex post*-*ex ante*= (1)+(2)]
  - *ex ante*: 0
  - *ex post*: $q(\overline{c})(\overline{c} - \underline{c})$
- Monopoly :[*ex post*-*ex ante*= (1)]
  - *ex ante*: $(p^M(\overline{c}) - \overline{c})q^M(\overline{c})$
  - *ex post*: $(p^M(\underline{c}) - \underline{c})q^M(\underline{c})$



Exercice 1:

Assumptions:

- Demand is linear, $p = a - q$
- Without innovation, the cost is $\overline{c}$.
- If one firm innovates, she has a unit cost $\underline{c}$.
- N firms compete a la Cournot.
- We denote $\phi = \frac{\overline{c}-\underline{c}}{a-\underline{c}}$.

Questions:

1. Determine the asymetric Cournot equilibrium when one firm innovates.
2. Determine the symmetric Cournot gain without innovation and the net gain to innovation.
3. How does this net gain vary with n?
4. What is the optimal market structure in terms of innovation incentive when $\phi = \frac{1}{4}$? when $\phi = \frac{1}{2}$? when $\phi = \frac{2}{3}$?

R&D diffusion and Cooperation

- Patent licensing
  - Incentive to sell the patent to other firms.
  - Patent pools : firms put in common their complementary patents often pro competitive (lower prices.)
- Firms voluntarily release their innovation : The open source software industry!
- R&D cooperation through “Research Joint Ventures" is often encouraged by antitrust legislation!
  - Obvious when research costs operate increasing returns to scale (e.g. high fix cost to build a lab)
  - More ambigous with decreasing return to scale.

Patent Licensing

Assumptions:

- An innovation reduces the marginal cost of an innovator from c to $c - x$.
- The innovator can choose a royalty rate r at which it licenses its new technology.
- We consider a 3-stage game :
  1. The innovator sets r,
  2. Other firms decide whether or not to become licensee,
  3. Firms compete à la Cournot.
- In a Cournot with n firms and an inverse demand $P = a - \sum_i^n q_i$, the optimal quantity is:

$$q_i^* = \frac{1}{n+1}(a - nc_i + \sum_{j \neq i} c_j)$$

Patent Licensing

- In stage 3), the innovator i has a cost $c - x$ and its $n-1$ competitors have a cost $c - x + r$.

$$q_i^* = \frac{1}{n+1}(a - (c-x) + (n-1)r)$$

$$q_l^* = \frac{1}{n+1}(a - 2r - (c-x)))$$

and

$$P^* = \frac{a + n(c-x) + (n-1)r}{n+1}$$

- It is straightforward that a licensee accepts any royalty $0 < r \leq x$.
- The innovator chooses r to maximize its profit:

$$\pi_i = (P - c + x)q_i^* + r(n-1)q_l^* = (q_i^*)^2 + r(n-1)q_l^*$$

- The FOC is:

$$\frac{\partial \pi_i}{\partial r} = 2q_i^* \frac{\partial q_i^*}{\partial r} + r(n-1)\frac{\partial q_l^*}{\partial r} = 0$$

- We obtain $\frac{\partial \pi_i}{\partial r} = \frac{(n-1)(n+3)(a-c-2r+x)}{(n+1)^2} > 0$. Therefore, the maximum is obtained for $r = x$.

- With licensing the innovator's profit is

$$\pi_i^* = \frac{(a-c)^2 + (2n+n^2-1)(a-c)x + x^2}{(n+1)^2}$$

.

- Without licensing, the profit of the innovator would be $\hat{\pi}_i = \frac{(a-c+nx)^2}{(n+1)^2}$.
- $\hat{\pi}_i < \pi_i^*$: Whether the innovator licenses its patent or not, the competitive situation is the same and the marginal cost of the innovator is $c - x$ whereas, at $r = x$, the licensee's cost is c. The innovator now gets the aditionnal profit of licenses.

Open source

- Firms who sell softwares use object code
- Recently many open source softwares making the “source code" available for free have grown.
    - The operating system Linux
    - Web server Apache,
    - Web browser Firefox;
- The main rationale are
    - The existence of spillovers: the innovator benefits from the feedback of developers who fix bugs but also add developments and extensions.
    - The existence of a specificity of the software for the innovator (unapropriable component).

Exercice 2: R&D Cooperation

Assumptions:

- Demand is linear, $p = 2 - Q$ and two firms two firms $i \in \{1, 2\}$ compete à la Cournot.
- The cost of firm i is a function $c_i(w_i, x_j) = 1 - x_i - \beta x_j$ with $0 < \beta < 1$ representing a spillover, i.e. benefit a firm obtains from its rival's discovery (public part).
- We denote $\phi(x_i) = \frac{x_i^2}{2}$ the innovation cost.
- The timing we consider is 1) an investment stage which can be either non cooperative or cooperative, and 2) a competition stage.

Questions:

1. Determine the Cournot equilibrium in stage 2
2. Non Cooperative $R\&D$: firms in stage 1 choose x_i and x_j. What is the equilibrium profit and quantity ?
3. Cooperative $R\&D$: firms in stage 1 choose x_i and x_j that maximizes their joint profit. What is the equilibrium profit and quantity ?
4. Compare the outcomes in the two cases.

References

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- Oz Shy, Industrial Oragnization, Theory and Applications, Chapter 9, *The MIT Press*, 1995.