# Industrial Organization 09
# Innovation and intellectual property

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# The purpose and the role of innovation

The principal goal of innovation: strong improvement of living standards.

- Spread of consumption goods to households (fridge, washing machine, microwave oven...)
- Security improvement (automobiles, substitutes for toxic products)
- ... within a framework of sustained productivity gains (especially through the development of ICT)

# The purpose and the role of innovation

## Product or service innovation

The creation of a product or a service that did not exist before. Along with it, a new market is created in which the first entrepreneur that enters makes a monopoly profit.

## Process innovation

Producing a product or a service that already existed at a lower cost. The diffusion of the good is accelerated as it becomes more affordable to a broader public. The innovator increases its profit compared to its competitors.

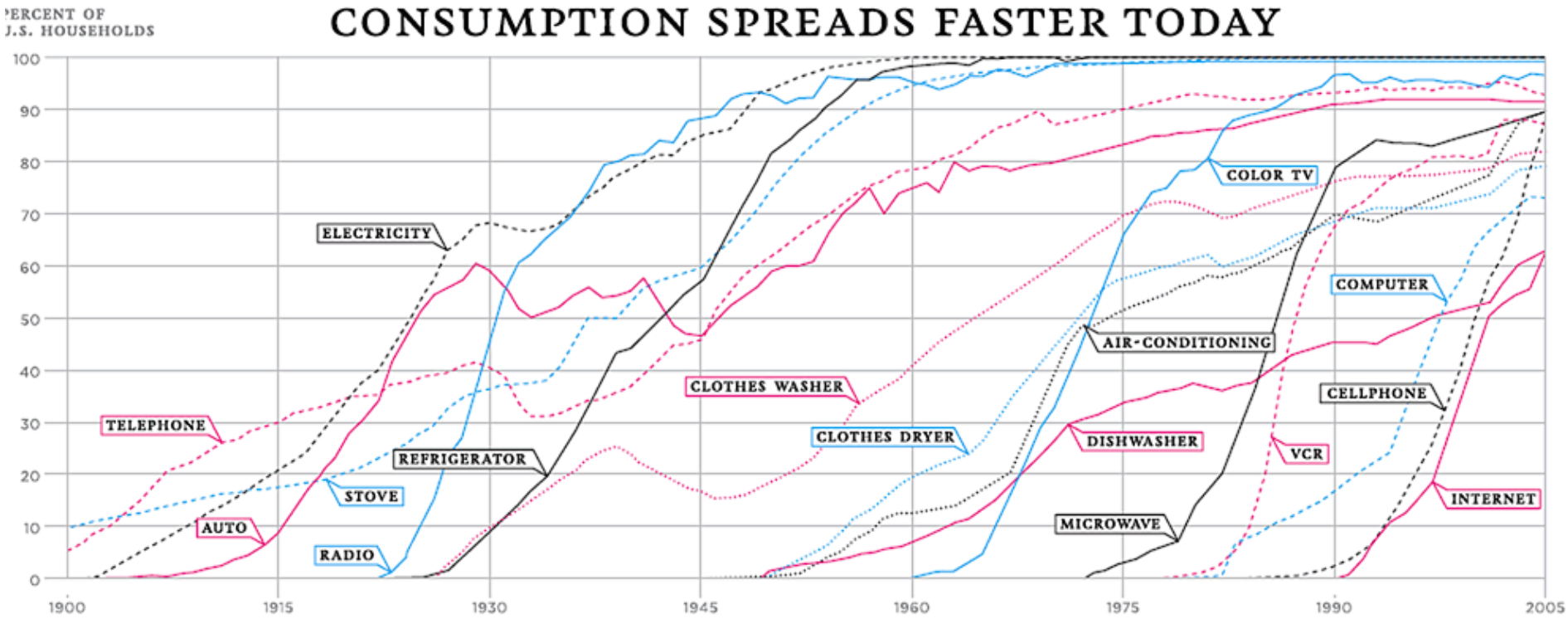
In both cases innovation constitutes a competitive advantage in the meaning used by Porter.

# The purpose and the role of innovation

Innovation in 2005 in OCDE countries is:

- 771.5 billion of dollars, meaning 2.25 % of the global GDP, with:
  - 42 % from the United States
  - 30 % from Europe
  - 17 % from Japan
- employing a total of 3.15 millions of people

# The purpose and the role of innovation




Source: The New York Times, February 2008

# The purpose and the role of innovation

The Austrian economist J. Schumpeter (1946) defines innovation as a process of *creative destruction*.

- An innovation does not improve the current status, it replaces it. Ex: the LCD technology does not improve the cathode tube, it renders it obsolete.
- Incumbent firms and jobs disappear in favor of new actors. Ex: the first distributor of MP3 music, Apple, is a software company and hardware manufacturer that did not have any experience in music industry.

With the concept of *cumulative* innovation, the product or the process improves little by little. Ex: the automobile industry since its creation. Ford, which has invented the T model, was the better placed to improve it.

# Protection of intellectual property

In the public debate about innovation, intellectual property takes a central place. Why protect innovations?

- Innovation takes the form of knowledge, which is a public good: non-rival and non-exclusive, it is subject to free-riding problem and can be produced in a suboptimal quantity.
- Intellectual *property* increases the appropriation of innovation gains by the innovator.

Other possible incentive mechanisms: *rewards* (ex: Netflix Prize of $1M). A reward orientates the research toward a precise goal but there is no room for unexpected innovations.

# Protection of intellectual property

## Patents

Patents grant the holder a legal monopoly over the commercial exploitation of an innovation. It is an *intellectual property right*.

## Criteria of patentability:

1. It must be new. It should not be already applied or published.
2. It must be useful. It should have an applied or industrial utility.
3. It must be non-obvious. It should not be obvious to a person having ordinary skill in the type of technology used in the innovation.

The usefulness requirement underlines that a patent does not protect the idea but its realization.

# Protection of intellectual property

Patenting an innovation or keeping it secret? Comparison of costs vs. benefits

- Cost of a patent:
  - monetary. Legal fees, translation costs, filling and renewal expenses: 25,000 euros for an European patent, 10,000 euros for its maintenance during 10 years.
  - *monitoring* and legal procedures. A patent does not alert the owner when it is transgressed.
  - diffusion of the patent content after 18 months.
- Cost of a secret: organization cost for confidentiality.
- Risk of secret: (almost) no protection possible when the secret is disclosed.
- Risk of a patent: invalidation by a court. Patents are *probabilistic property rights* (Lemley and Shapiro, 2005).

# Strategic use of patent

According to Lemley and Shapiro, 2005 :

- More than half of the applicable patents in the US are not renewed.
- The value of patents is estimated to be distributed very asymmetrically, with a high concentration of the value owned by the best 1%

Why do companies apply for a patent that does not have any value for themselves?

# Strategic use of patent

Strategic element of holding a patent:

- Uncertainty of commercial success of the innovation
- Patents can bring funding, increase the market value of the firm, can also be a signaling effect; *Patent-pending*.
- A defensive mean to discourage legal procedures; mass-licensing

Metaphor of a lottery ticket: increase the chance of earnings

Results of this approach: *patents thickets*, or patent portfolios.

# Example of a patent litigation: RIM vs. NTP

- Research In Motion is the inventor of Blackberry, quoted in Toronto Stock Exchange, a turnover of $10B (2009), of which 14% in R&D (2000)
- NTP, Inc. has as a principal asset a portfolio of 50 patents
- In 2000, NTP proposes a license of its patents to several hightech firms including RIM. Facing the refusal of RIM, they filed a complaint.
- From 2002 to 2005, RIM contested to the US Patent Office the validity of the patents used against them.
- RIM is sentenced to pay 53 M$ of damages and legal fees, and to stop the infringement without delay (ie. shut the Blackberry OS).
- RIM appealed. The procedure takes its course.
- In March 2006, they find an agreement. RIM paid 612 M$ of damages to end the litigation
- Several of the patents in question were invalidated since then.

# Incentives to innovate and market structure

- The value of innovation (or the incentive to innovate, the willingness to pay the innovation) for a firm is given by the comparison of its profit in case of an innovation and without the innovation.
- Is it better to establish a monopoly or a competitive situation to make more innovation? Is innovation going to come from firms already in the market or from *outsiders*?

# Incentives in monopoly and under competition

Let's compare the value of an innovation for a monopoly and for a firm under competition.

- The firm produces at cost $\bar{c}$, innovation allows to lower the cost to $\underline{c}$.
- Incentives for a monopoly: $V^m = \Pi^m(\underline{c}) - \Pi^m(\bar{c})$
- Incentives for a firm in competition: $V^c = (\bar{c} - \underline{c})D(\bar{c})$
- We can show that $V^m < V^c < V^s$, with $V^s$ the social optimum.

# Inventives in monopoly and in competition

$$V^m < V^c < V^s$$

## Appropriation of the surplus

There is an appropriation problem of the social surplus for a monopoly or for a competitive firm, even with a perfect patent (ex: green technologies reduces pollution; car security reduces accidents).

## *Replacement effect*

The monopoly has less incentives to innovate than a firm in competition because it replaces itself and measures the *extra* profit brought by the innovation, whereas a firm in competition begins with 0 profit.

# Incentives of a monopoly and a new entrant

Let's suppose now that each firm can make an innovation.

- Firm 1 is a monopoly in the market. She produces at a marginal cost of $\underline{c}$.
- If firm 1 does not innovate, firm 2 can innovate and enter the market.
- Value of the innovation for the entrant: $V^c = \Pi^d(\underline{c}, \overline{c})$
- For the monopoly: $V^m = \Pi^m(\underline{c}) - \Pi^d(\overline{c}, \underline{c})$
- We make the assumption of dissipation of monopoly profits: $\Pi^m(\underline{c}) \geq \Pi^d(\overline{c}, \underline{c}) + \Pi^d(\underline{c}, \overline{c})$

Then it becomes $V^m \geq V^c$.

## Efficiency effect

The incentives to remain a monopoly is greater than the incentives of the new entrants to become a duopolist.

# A model of patent race

- We eliminate the assumption of a monopoly on the research activity. The two firms are able to spend in R&D. The first firm that innovates becomes a monopoly on the innovation and the other firm does not obtain anything.
- The innovation process is uncertain: at the time $t$ firm $i$ spends $x_i dt$ in research and obtain a probability of $h(x_i)dt$ to innovate.
- This probability follows a Poisson law, without memory: the probability to make the innovation is between $t$ and $t + dt$ and does not depend on the previous spendings.
- Assumption on the hazard function $h$: $h'(x) > 0$, $h(0) = 0$, $h'(0) = \lim_{x\to\infty} h'(x) = 0$, and productivity increases then decreases.
- Let's calculate the present value of innovation for firm $i$, noted $V_i$. The probability that no firm succeed in innovating at $t$ is $e^{-[h(x_1)+h(x_2)]t}$
- The monopoly profit between $t$ and $t + dt$, knowing that no innovation was done before $t$, is: $[\Pi^m(\overline{c}) - x_1]dt$.
- With the probability $h(x_1)dt$ the monopoly innovates first and gets from this moment a (discounted) income stream of $\frac{1}{r}\Pi^m(\underline{c})$. If the new entrant innovates first he gets $\frac{1}{r}\Pi^d(\overline{c}, \underline{c})$

# A model of patent race

There are two types of competition in R&D:

## A model of returns to scale (Loury)

The R&D costs are spent at the beginning of the race: it is a sunk cost.

## A model of research intensity (Lee)

The R&D expenses are spent over time. What is spent is not recoverable, but ending the race stops also the expenses.

# A model of patent race

We obtain the discounted profit for firm 1 and firm 2, with the model of returns to scale (Loury):

$$G_1(x_1, x_2) = \frac{\Pi^m(\overline{c}) + h(x_1) \cdot \frac{1}{r}\Pi^m(\underline{c}) + h(x_2) \cdot \frac{1}{r}\Pi^d(\overline{c}, \underline{c})}{r + h(x_1) + h(x_2)} - x_1$$

$$G_2(x_1, x_2) = \frac{h(x_2) \cdot \frac{1}{r}\Pi^d(\overline{c}, \underline{c})}{r + h(x_1) + h(x_2)} - x_2$$

# A model of patent race

- The efficiency effect implies that a monopoly has more incentives to innovate, i.e. more incentives to invest in R&D.
- The replacement effect means that the monopoly accelerates its own replacement by investing in R&D. This is expressed, in the research intensity model, through a decreasing marginal productivity of the R&D with respect to the initial profit: $\frac{\partial}{\partial[\Pi^m(\bar{c})]}\frac{\partial G_1}{\partial x_1} < 0$
- This quantity is 0 for the returns to scale model since investments are high. The closeness of the discovery date and the possibility of the entrant to succeed in innovation is crucial: there is only the efficiency effect.

# A model with $n$ firms

- We consider a race between $n$ identical firms
- Innovation has an identical value of $V$ for everyone
- In equilibrium $x_1^* = ... = x_n^* = x^*$
- Therefore the global hazard rate is $h_{-i}(x^*) = (n-1)h(x^*)$
- The optimal investment $x^*(n)$ verifies: $x^*(n) = \hat{x}[(n-1)h(x^*(n))]$
- We note $\hat{x}_i(h_{-i})$ the best response function of firm $i$
- The best response function is i) decreasing with respect to $r$ (investing means giving up the immediate gain and assured gain), ii) increasing the value of innovation $V$.
- Other properties depend on the type of the model (scale or intensity model).

# In a model with $n$ firms

## In the returns to scale model:

- R&D expenses are strategic substitutes.
- The amount of individual expenses $x^*(n)$ is decreasing with $n$. Schumpetarian property: monopoly supports innovation (but this property is not robust in modeling research).
- If $-h'(x^*)\frac{\partial \hat{x}}{\partial h_{-i}} < 1$, the global effort $nx^*(n)$ is increasing with $n$.

## In the research intensity model:

- R&D expenses are strategic complements.
- A sufficient condition for the individual effort $x^*(n)$ to increase with $n$ is $h'(x^*)\frac{\partial \hat{x}}{\partial h_{-i}} < 1$ (the same condition as previously) then the global effort increases with respect to $n$.

# Comparison with the social optimum

The equilibrium investments in a patent race do not correspond to the socially optimal. This is because:

1. Individual value < social value because of spillovers (negative effect on individual effort).
2. Business stealing effect: who is the winner does not matter for the society but matters to the firms (positive effect on individual efforts)
3. The number of participants increases as long as there are potential benefits, even when the date of discovery is close (wasteful efforts)

# Comparison with the social optimum

- We can show that the individual efforts and the number of entering firms in equilibrium for a non-cooperative game with free entry are both greater than social optimum: *overinvestment* in a patent race.
- But is duplication necessarily a bad thing? If the product of the innovation process can be reused, the wasteful efforts allow to accumulate experience.

# Take-aways (1)

- Innovation consists in introducing new products and services, or lowering production costs.
- As a process of creative destruction (Schumpeter, 1946) innovation renders whole segments of an industry obsolete. It is a disruption that favours the entry of new players.
- As knowledge is a public good, implementing intellectual property rights is necessary to maintain innovation incentives. The main IPR is the patent.
- In a static framework, a firm in monopoly has less incentives to innovate than under competition because of the *replacement effect*: the existing firm considers only the extra-profit brought by innovation.
- Within a static framework with strategic effect (of potential entry), the incentives to keep a monopoly position is greater than the incentives of a new entrant to become a duopolist.

# Take-aways (2)

- Patent race occurs when all the firms in the market are active in R&D.
- In a model with scale effects, R&D expenses are strategic substitutes and the amount of individual expenses decreases with the number of firms. The total expenses of all the firms do not always increase with the number of firms. In a model with research intensity, R&D expenses are strategic complements.
- The individual effect and the number of firms in equilibrium are greater than those at the social optimum. Patent races lead to over-investment.
- It is a waste, except if we consider that unsuccessful investments have positive externalities such as to provide experience gains to entrepreneurs and a knock-on effect on the economy.