Today
R&D, Innovation & Patents
BM 1: The case against Patent
About next classes
About the mid-term and exams

R&D and Innovation
PRN: chs. 20-21???
CW ch 18 VFS
Exercises from Garavaglia or CW or PRN + past exams
Innovation

• Definition
• Measures
• Innovation and growth
• Incentives
  – Market incentives (firms)
  – Innovation policy
Innovation

• “a new combination of factors of production” (Schumpeter)

• “successful production, assimilation and exploitation of novelty in the economic and social spheres” (European Commission)
How to measure innovation

- Researchers
- Researchers as a share of labour force
- Research spending (enterprise and government)
- Research spending as share of GDP
- Patents
- Share of Patents
## Researchers and Research Spending, 2005

*(Table 8.1)*

<table>
<thead>
<tr>
<th>Country</th>
<th>Number of Researchers</th>
<th>Researchers as a Percentage of the Labor Force</th>
<th>Research Spending ($ billions)</th>
<th>Research Spending as a Percentage of GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>1,334,628</td>
<td>0.89%</td>
<td>312.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Japan</td>
<td>677,206</td>
<td>1.02%</td>
<td>118.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Germany</td>
<td>268,100</td>
<td>0.61%</td>
<td>61.7</td>
<td>2.4</td>
</tr>
<tr>
<td>France</td>
<td>200,064</td>
<td>0.72%</td>
<td>40.4</td>
<td>2.1</td>
</tr>
<tr>
<td>Korea</td>
<td>179,812</td>
<td>0.76%</td>
<td>31.6</td>
<td>2.9</td>
</tr>
<tr>
<td>OECD Total</td>
<td>3,707,255</td>
<td>0.66%</td>
<td>740.5</td>
<td>2.1</td>
</tr>
</tbody>
</table>

*Source:* OECD Main Science and Technology Indicators database.
### Spesa per ricerca e sviluppo totale e sostenuta dalle imprese nei paesi UE

**Anno 2010 (in percentuale del Pil)**

<table>
<thead>
<tr>
<th>Paesi</th>
<th>Spesa totale</th>
<th>Spesa delle imprese</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finlandia</td>
<td>3,90</td>
<td>2,72</td>
</tr>
<tr>
<td>Svezia</td>
<td>3,39</td>
<td>2,33</td>
</tr>
<tr>
<td>Danimarca</td>
<td>3,07</td>
<td>2,09</td>
</tr>
<tr>
<td>Germania</td>
<td>2,80</td>
<td>1,88</td>
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<td>Austria</td>
<td>2,79</td>
<td>1,90</td>
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<tr>
<td>Francia</td>
<td>2,24</td>
<td>1,41</td>
</tr>
<tr>
<td>Slovenia</td>
<td>2,09</td>
<td>1,42</td>
</tr>
<tr>
<td>Belgio</td>
<td>2,01</td>
<td>1,33</td>
</tr>
<tr>
<td>Paesi Bassi</td>
<td>1,85</td>
<td>0,89</td>
</tr>
<tr>
<td>Regno Unito</td>
<td>1,80</td>
<td>1,10</td>
</tr>
<tr>
<td>Irlanda</td>
<td>1,71</td>
<td>1,17</td>
</tr>
<tr>
<td>Estonia</td>
<td>1,63</td>
<td>0,82</td>
</tr>
<tr>
<td>Portogallo</td>
<td>1,59</td>
<td>0,73</td>
</tr>
<tr>
<td>Repubblica Ceca</td>
<td>1,55</td>
<td>0,96</td>
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<tr>
<td>Lussemburgo</td>
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<td>1,00</td>
</tr>
<tr>
<td>Spagna</td>
<td>1,39</td>
<td>0,72</td>
</tr>
<tr>
<td>Italia</td>
<td>1,26</td>
<td>0,68</td>
</tr>
<tr>
<td>Ungheria</td>
<td>1,17</td>
<td>0,70</td>
</tr>
<tr>
<td>Lituania</td>
<td>0,80</td>
<td>0,23</td>
</tr>
<tr>
<td>Polonia</td>
<td>0,74</td>
<td>0,20</td>
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<tr>
<td>Maltà</td>
<td>0,67</td>
<td>0,42</td>
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<tr>
<td>Slovacchia</td>
<td>0,63</td>
<td>0,27</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>0,60</td>
<td>0,30</td>
</tr>
<tr>
<td>Lettonia</td>
<td>0,60</td>
<td>0,22</td>
</tr>
<tr>
<td>Grecia (a)</td>
<td>0,60</td>
<td>0,17</td>
</tr>
<tr>
<td>Cipro</td>
<td>0,50</td>
<td>0,09</td>
</tr>
<tr>
<td>Romania</td>
<td>0,46</td>
<td>0,18</td>
</tr>
<tr>
<td>Ue27 (b)</td>
<td>2,01</td>
<td>1,24</td>
</tr>
</tbody>
</table>

**Fonte:** Eurostat, *Research and development statistics*

(a) Dato riferito al 2007.

(b) Stima Eurostat.
European patent applications per country of origin

This graph shows the geographic origin of the European patent applications\(^1\) determined by the country of residence of the first applicant listed on the application form (first-named applicant principle\(^2\)).

![Pie chart showing the distribution of European patent applications per country of origin. The largest portion is from the US (25%), followed by DE (15%), JP (13%), and CN (5%). Other countries and regions make up the remaining 25% of the applications.](image-url)
<table>
<thead>
<tr>
<th>Country</th>
<th>2018</th>
<th>2017</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>43,612</td>
<td>42,463</td>
<td>2.7%</td>
</tr>
<tr>
<td>Germany</td>
<td>26,734</td>
<td>25,539</td>
<td>4.7%</td>
</tr>
<tr>
<td>Japan</td>
<td>22,615</td>
<td>21,774</td>
<td>3.9%</td>
</tr>
<tr>
<td>France</td>
<td>10,317</td>
<td>10,619</td>
<td>-2.8%</td>
</tr>
<tr>
<td>China, People’s Republic of</td>
<td>9,401</td>
<td>8,641</td>
<td>8.8%</td>
</tr>
<tr>
<td>Switzerland</td>
<td>7,927</td>
<td>7,354</td>
<td>7.8%</td>
</tr>
<tr>
<td>Korea, Republic of</td>
<td>7,296</td>
<td>6,457</td>
<td>13.0%</td>
</tr>
<tr>
<td>Netherlands</td>
<td>7,140</td>
<td>7,043</td>
<td>1.4%</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>5,736</td>
<td>5,321</td>
<td>7.8%</td>
</tr>
<tr>
<td>Italy</td>
<td>4,399</td>
<td>4,360</td>
<td>0.9%</td>
</tr>
</tbody>
</table>
Innovation and Growth

• Innovation is a source of economic growth
• Firms’ incentive to innovate → technological progress is endogenous

• Innovation is the result of R&D
  – basic and applied Research + Development
  – firms decide investments in R&D
  – risky investment (prob. success/failure)
  – Governments contribute to R&D in several ways (innovation policies)
Firms’ incentives to Innovation

• The incentive to innovate is the difference in profit that a firm can earn if it invests in research and development compared to what it would earn if it did not invest.

• Innovation and market structure: Competition or monopoly?
  – The replacement effect: Firms with market power have less incentive to innovate because profit after innovation REPLACE profit before innovation

• Innovation and market structure: Incumbent or new entrant?
  – The efficiency effect: An Incumbent has greater incentive to innovate than a potential entrant. Market profits are maximised (Efficiency effect). Monopoly tend to persist
Schumpeter’s view

• It is not [price] competition which counts, but competition from the new commodity, the new technology, the new source of supply, the new type of organization … [Schumpeter, 1942]

• Competition is dynamic and evolving... Competition is a constantly changing landscape in which new products, new ways of marketing, new production processes emerge [M.Porter, 1990]

• Creative destruction is the essence of capitalism [Schumpeter]
Schumpeterian hypotheses
(conflict between static and dynamic efficiency)

- **Static efficiency**: 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

Schumpeterian hypotheses

- 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 Innovations** refer to the creation of new goods and new services [e.g., DVD’s, cell phones]

• **Process Innovations** refer to the development of new technologies for producing goods or new ways of delivering services [robotics and CAD/CAM technology] → cost savings innovation
A Taxonomy of (process) Innovations

- **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: 
    $$MR = 120 - 2Q$$
  – If $c_M = $20, optimal monopoly output is: 
    $$Q_M = 50$$ and $$P_M = $70$$
  – 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: \( MR = 120 - 2Q \)
  – Optimal Monopoly output and price:
    \[ Q_M = 30; \quad P_M = $90 \]
  – 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.

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

\[
\text{Demand:} \quad P^M \quad \text{at} \quad Q^C \\
\text{Demand:} \quad P^M \quad \text{at} \quad Q^M
\]

\[
\text{Cost:} \quad c \quad \text{at} \quad Q^C \\
\text{Cost:} \quad c' \quad \text{at} \quad Q^M
\]
The social value of innovation: $V^s$

- net increase in surplus that would occur if pricing were efficient both before and after the innovation, i.e., at marginal cost
Innovation and Market Structure

• Arrow’s (1962) analysis—
  – Innovative activity likely to be too little because innovators consider only monopoly profit that the innovation brings and not the additional consumer surplus
  – Monopoly provides less incentive to innovate that competitive industry because of the Replacement Effect

• Assume demand is: \( P = 120 - Q \);

Innovator lowers cost to $60 and can sell all 40 units at \( P = 80 \).

• Profit Gain is $800—Less than Social Gain

\[
\begin{align*}
\text{Quantity} & \quad 80 & \quad 120 \\
\$/\text{unit} & \quad 120 & \quad 80 & \quad 60
\end{align*}
\]

\[
\text{Initial Surplus is Yellow Triangle--Social Gains from Innovation are Areas A ($800) and B ($200)}
\]

\[
\text{But Innovator Only Considers Profit Area A ($800)}
\]
Innovation and Market Structure 2

• Now consider innovation when market structure is monopoly
  – Initially, the monopolist produces where $MC = MR = $80$ at $Q = 20$ and $P = $100$, and earns profit (Area $C$) of $400$
  – Innovation allows monopolist to produce where $MC = MR = $60$ at $Q = 30$ and $P = $90$ and earn profit of $900$
  – But this is a gain of only $500$ over initial profit due to Replacement Effect—new profits destroy old profits

\[
\begin{array}{c|c|c|c}
\text{Quantity} & \text{60} & \text{90} & \text{120} \\
\hline
\text{MR} & \text{120} & \text{100} & \text{80} \\
\text{$/unit} & \text{90} & \text{80} & \text{60} \\
\end{array}
\]

Monopolist Initially Earns Profit $C$—With Innovation it Earns Profit $A$—Net Profit Gain is Area $A – Area C$
Which is Less than the Gain to a Competitive Firm
Replacement effect (Arrow)

- Firms with market power have less incentive to innovate
  - The reason is that the monopolists is already earning profits and the innovation allows to replace one profitable monopoly with another
  - A competitive firm increases profits from zero
  - It can be shown (see exercise below) that
    \[ V^M < V^C < V^S \]
Empirically, the relationship is not so clear-cut

• Aghion et al. (2005) collect a robust empirical evidence about the relationship between product market concentration and the intensity of innovative activity. They show that such relationship follows an inverted-U shape pattern with respect to market concentration as measured by an appropriately defined Lerner index.
Exercise

Suppose that demand is given by: \( P = 120 - Q \) and all firms have constant marginal cost of \( c = $80 \)

The innovation reduces the marginal cost to \( c' = $60 \)

- Compute the incentive to innovate for a monopoly firm.
- Compute the incentive to innovate for a firm competing in prices as in the Bertrand model.
- Compute the incentive to innovate for a firm competing in the level of production, as in the Cournot model.
- Compute the social value of the innovation.
The efficiency effect

• What if monopolist had to worry about Entrant using innovation

• Assume Entrant can only enter if it has lower cost, i.e. if it uses the innovation and assume Cournot competition
  – If Monopolist uses innovation, Entrant cannot enter and monopolist earns $900
  – If Monopolist does not use innovation, Entrant can enter as low-cost firm in a Cournot duopoly
    • *Entrant earns profit of $711*
    • *Incumbent earns profit of $44*
  – Gain from innovation now is $900 - $44 = $856

Monopolist has more to gain from innovation than Entrant

Monopoly tend to persist
Summing up

• In case of non-drastic innovation, Incumbent has greater incentives to innovate than Entrant.
• If innovation is drastic, or if there is uncertainty, then $E$ might have greater incentives to innovate.
• →
  – Market leaders/established firms: non-drastic innovations
  – Small firms/new entrants: drastic innovations
Innovation as a public good

• Innovation has positive externalities: it is a public good (non-excludable and non-rival)
• Sub-optimal «production» → need for public intervention
  – R&D agreements are granted exemption from art. 101 of TFEU
  – Intellectual property rights (patents)
  – Tax and subsidies
  – Public research funding
  – Public procurement/demand driven innovation
PATENTS

• A patent grants its holder a temporary monopoly on the exploitation of an invention. The patent-holders acquires the exclusive right to prevent other parties from using, commercialising or importing the patented product or process.

• To obtain a patent, the inventor must file an application to the PTO.

• Patentability requirements:
  – subject-matter eligibility
  – novelty
  – non-obviousness
  – uselfuness
PATENTS

• Patent protection grants a monopoly position for twenty years, but at the same time induces firms to invest in R&D.

• The traditional view is that absent patent protection firms would not invest in R&D; in fact, imitation by competitors would reduce the profits the inventor is able to appropriate (see Boldrin and Levine, 2008, for a view «Against Intellectual Monopoly» cfr. CM 7.2)

• ‘Optimal’ patent protection must trade-off static vs dynamic efficiency

• Optimal design of patent along two dimensions:
  – length
  – breadth
OPTIMAL LENGTH
(Nordhaus, 1969)

Drastic Process Innovation; Cost of Innovation $= x$
Social value of innovation $(A+B) = \nu$  Firm’s profit: $A-x$
Life cycle of the product $= N$ years
$SW = TA - x + (N-T)(A+B)$

Optimal value $T^*$ s.t $TA - x = 0$ i.e. $T^* = x/A$
• Optimal length is positive but finite
  – If $T = 0$, firms do not invest in R&D
  – As $T$ increases
    ▪ Firms invest more in R&D
    ▪ But society must wait longer to get B.
OPTIMAL BREADTH

- Optimal length may depend on patent’s breadth
  - Long length and small breadth or
  - Short length and ample breadth
- Best: ensure minimum profit to induce firm to invest
Strategic patenting

• Since the 80’s there has been a remarkable growth in the number of patents.
• In high-tech markets, firms must negotiate licensing agreements → a large patent portfolio is an important asset to increase bargaining power in (cross-licensing) negotiations.
• Lower quality of patents (VFS p. 82)?
• Need to revise patenting system?
**Open innovation (CM 7.1)**

- Various high-tech sectors have experimented striking innovation despite low propensity to patenting.

- Open innovation: research in collaboration with partners allows to share risks and rewards
  - Open source: source code is available and released under a licence allowing third party to study, modify and improve the code

- Avoid duplication of effort and expenses

- Speeds up innovation.

- But risk of dissipate competitive advantage
Against intellectual monopoly
(Boldrin_Levine; CM 7.2)

• They argue that
• IP laws provide inventors with an excessive strong protection. Intellectual monopoly (i.e. the control of the use of innovation) guarantees excessively large profits.
• The ‘right to sell the first copy’ is sufficient to compensate the inventor for R&D efforts and investments.
• The price of the ‘first copy’ is not driven to the MC because in the short run productive capacity is limited → positive profits [graphic]
Next …

• 15
  – Erasmus: Price discrimination … (10 min)
  – The model by Aquisti and Varian
  – Assignment 5
  – Network (1 hour)
• 20 Network + Assignment 6
• 22 Two-sided + Assignment 7
• 29 and/or another date (24?):
  – Written exam simulation
  – Ecomi 1: Network effects …
  – Epos 1 and 2: Big Data
  – other BMs: Digital platforms
• 29 and 3 June
  - recap