OI: pesquisa, desenvolvimento e patentes

Aula 4 – 1ª Parte

Baseado nos slides de Paul Belleflamme e Martin Peitz

Agenda

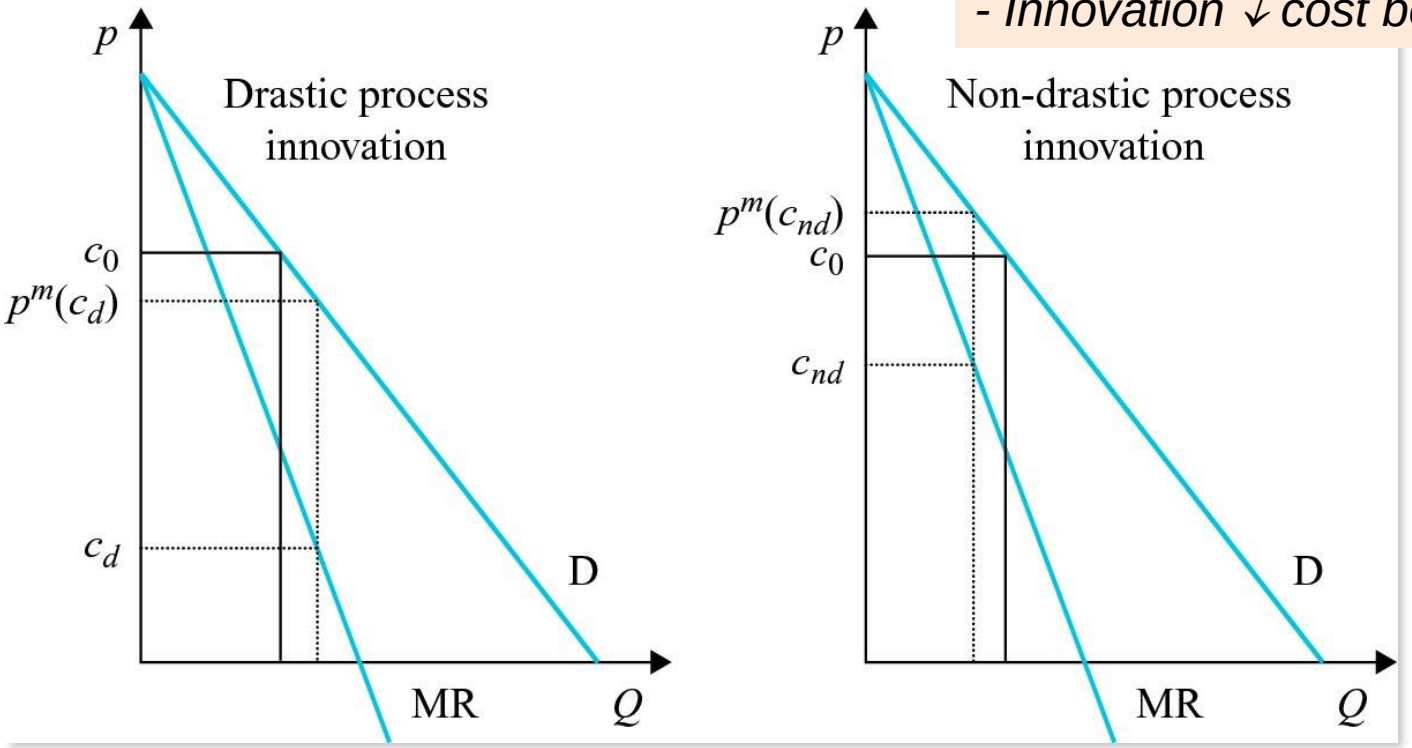
- Market structure and incentives to innovate
- R&D cooperation and spillovers
- Remedies to the appropriability problem
- Optimal patent design

Definitions

- Process vs. product innovation
  - **Process innovation**: generation, introduction and diffusion of a new production process (with the products remaining unchanged)
  - **Product innovation**: generation, introduction and diffusion of a new product (with the production process being unchanged)
- Major vs. minor process innovation
  - **Major innovation**: allows the innovator to behave as a monopolist without being constrained by price competition in the industry
  - **Minor innovation**: innovator may gain some cost advantage over its rivals but competition constrains the innovator

Major vs. minor innovation

- Homogeneous product market
- Firms produce at c_0 and compete in prices.
- Innovation ↓ cost below c_0



Major innovation if the monopoly price corresponding to the new cost falls below the cost of the non-innovating firms.

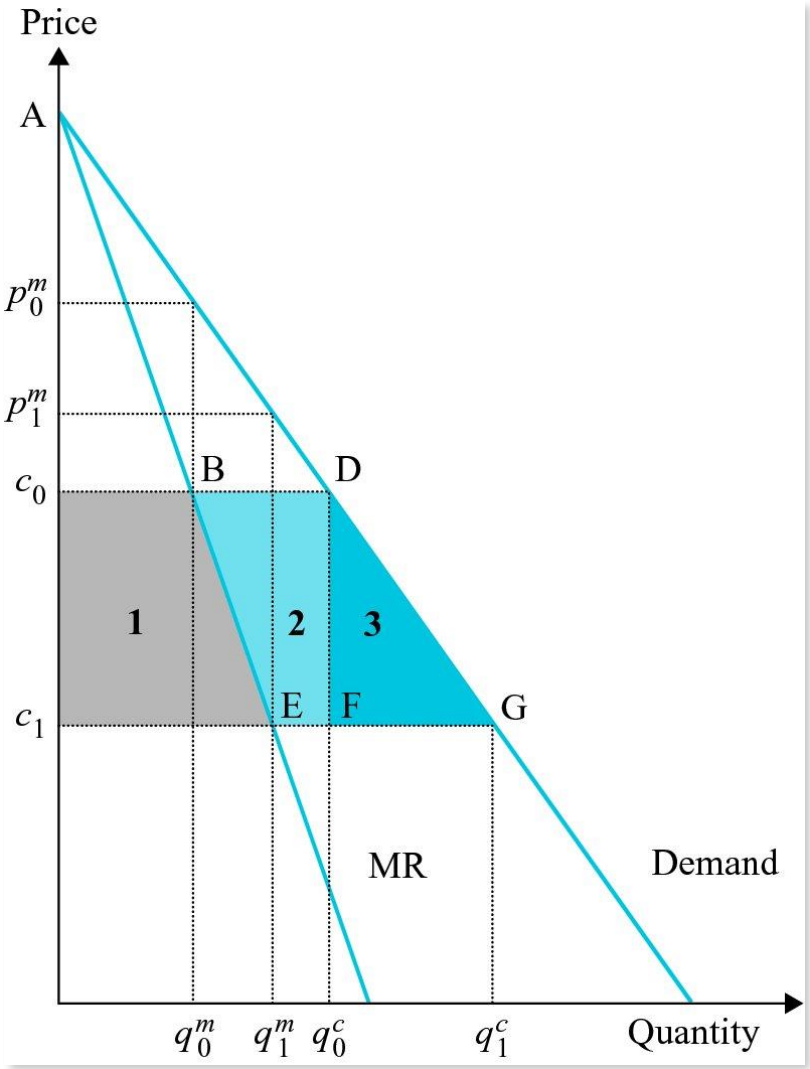
Market structure and incentives to innovate

- **Schumpeter** (*Capitalism, Socialism, and Democracy*, 1943)
  - Stresses **link** between market structure and R&D
  - Necessity of tolerating the creation of **monopolies** as a way to encourage the innovation process
    - Economic rationale behind protection of IP
  - R&D efforts are more likely to be undertaken by **large** firms
    - Large firms have a **larger capacity** to undertake R&D
      $\rightarrow$ deal better with market failures on innovating without IP
- Do large firms have larger **incentives** to R&D?
  - **Profit incentive** to innovate: which market structure, monopoly, oligopoly or perfect competition, provides firms with the highest incentives to undertake R&D?
  - What about **strategic incentives**?

Monopoly/perfect competition: replacement effect

- How much is a firm willing to pay for an innovation that it would be the **only one** to use?
- Model
  - Homogeneous product, constant marginal cost of production
  - Minor innovation ↓ cost from c_0 to $c_1 < c_0$
  - Profit incentive: willingness to pay for the innovation measured by the increase in profit that the innovation generates
  - Comparison between
    - Competitive situation (n firms competing *à la* Bertrand)
    - Monopoly situation
    - Social planner (benchmark)
- **Lesson**: A competitive firm places a larger value on a minor process innovation than a monopoly does

Replacement effect



Per-period value of the innovation

- *for competitive firm: sum of areas 1 and 2*
- *for monopolist: area 1*
- *for social planner: sum of areas 1, 2 and 3*

Competitive firm willing to pay more than monopolist. Why? ***Replacement effect***
→ prior to the innovation, the monopolist already earns a positive profit, whereas the competitive firm just recoups its costs.

Value for competitive firm < social value
Why? Competitive firm fails to appropriate the increase in consumer surplus (area 3).

Incentives to innovate in oligopolies (1)

- Conjecture
  - Oligopolies = **intermediate** market structure between monopoly and perfect competition $\Rightarrow$ incentives to innovate in oligopolies are **between** the low incentives in monopoly and the high incentives in perfect competition
- This conjecture is **wrong**!
- Intensity of competition depends on
  - Number of firms
  - Degree of product differentiation
  - Type of competition (price or quantity)
- **In general:** these 3 properties affect incentives to innovate in non-monotonic, different, and potentially opposite ways

Incentives to innovate in oligopolies (2)

- Impact of the **number** of firms
  - Simple linear Cournot model with n firms
  - Profit incentive may follow an inverse U-shape as $n \uparrow$
- In a Cournot industry with a homogeneous product, the market structure that gives the largest profit incentive to innovate is monopoly when the innovation **size** is not too large; it is oligopoly otherwise and the 'ideal' number of firms in the industry increases with the innovation size
- **Intuition**: 2 opposite effects when $n \uparrow$
  - **Competition effect**: profits for all firms $\downarrow$
  - **Competitive advantage**: cost advantage of innovator $\uparrow$ with n

Information and appropriability (1)

- Activities generating information (knowledge!) suffer from the 3 generic sources of market failure
  - **Indivisibilities**
    - R&D programmes involve high **fixed** set up costs, display economies of scale (extensive division of highly specialized labour)
    - Knowledge is inherently **discrete**
  - **Uncertainty**: 2 sources of uncertainty for R&D
    - **Technological uncertainty** $\rightarrow$ how to make a new product and how to make it work?
    - **Market uncertainty** $\rightarrow$ how to sell the new product and make it a commercial success?
    - + **moral hazard** problems $\rightarrow$ why does the product fail? inherent scientific difficulty or lack of effort?

Information and appropriability (2)

- 3 generic sources of market failure (cont'd)
  - **Public good nature**
    - Information is **nonrival**
      - Consumption by one doesn't prevent (rival) consumption by others
      - At any level of production of information, the **marginal cost** of **delivering** it to an extra consumer is zero (**!!!**)
    - Information is **nonexcludable**
      - One person cannot exclude another person from consuming information (once acquired!)
      - Excludability depends on the available technology for exclusion and on the **institutional** (legal) framework
- 3 market failures $\Rightarrow$ problem of **appropriability**
  - General presumption: markets provide **too little** incentive to introduce innovations (**!!**)

Intellectual property protection (1)

- **Intellectual property** (IP)
  - Legal rights resulting from intellectual activity in the industrial, scientific, literary and artistic fields
    - **Industrial property branch** $\rightarrow$ inventions, business methods, industrial processes, chemical formulae, unique names
    - **Copyright branch** $\rightarrow$ all information products that derive their intrinsic value from creative expression, literary creation, ideas, or presentations
- Main **objective** of IP law
  - To promote innovation and aesthetic creativity
  - How? By granting **exclusive use** of the protected knowledge or creative work to the creator

Intellectual property protection (2)

- **Incentives** versus **use**
  - Nonexcludability → hard to appropriate the returns from intellectual activities → **underproduction problem**
  - But exclusivity allows creators to set prices above (zero) marginal costs → **underutilization problem**
- IP law solves (?) the 2 problems sequentially
  - **Legal protection** makes the good excludable
    - Creators have incentives to produce new knowledge
  - Once protection is **over**, the good falls in public domain.
    - All users may access the good for free (i.e., at marginal cost).
- IP law strikes a **balance** between
  - **Incentives** to create and innovate
  - **Use** of the results of creation and innovation

Intellectual property protection (3)

	Patent	***Copyright***
Requirements for protection	*Novelty, inventive step, practical use*	*Originality, authorship, form of expression*
Ownership	*First to file* *First to invent*	*Author/creator*
Rights	*Bundle of rights extending to the idea: exclusive rights against all commercial uses (make, use, sell the innovation)*	*Economic and moral rights on the form of expression: exclusive rights against copying (rights of performance, display, reproduction, derivative works)*
Scope of protection	*Wide*	*Narrow*
Duration	*20 years from filing*	*Life of author + 70 years*
Costs of protection	*Filing, issue, and maintenance fees; litigation costs*	*No filing necessary; suit requires registration; litigation costs*

Patent licensing (1)

- Patents are transferable rights (through licenses)
- Importance of **transferability**
  - Ensures that innovations and artistic creations are used by the agents who **value** them most
  - **Additional** source of profit to the innovator
- **Mode** of patent licensing
  - **Royalty** per unit produced with technology (influences price)
  - **Fixed fee** (influences the division of profits)
  - **Combination** of the previous two options
- **Terms**
  - Any firm can buy one license?
  - Auction a limited number of licenses?

Patent licensing (2)

- **Social viewpoint**
  - Licenses **increase** diffusion and use of knowledge
- **Private viewpoint**
  - Do licenses increase incentives to innovate?
  - Additional source of profits for the innovators
    - Only effect if licensee operates in a totally different market
  - Potential negative effect if licensor and licensee are direct competitors
  - Net effect depends on
    - Size of innovation
    - Market structure

Licensing by an outside innovator (1)

- Patentee licenses innovation **outside** his own industry
  - No competition with his potential licensees
- **Model**
  - Inverse demand: $P(q) = a - q$
  - n firms, with pre-innovation constant marginal cost of c
  - Innovation ↓ cost from c to $c - x$
  - Major if $x > a - c$, minor if $x < a - c$
  - Outside innovator decides how to license (fixed-fee vs. royalty) and to whom, to maximize licensing revenues
  - 3-stage game
    1. Innovator sets a fixed licensing fee or a per unit royalty rate
    2. Firms decide simultaneously whether to accept the offer
    3. Bertrand or Cournot competition

Licensing by an outside innovator (2)

- **Bertrand competition**
  - No point in granting more than one license in case of fixed fee
  - Major innovation
    - Value of exclusive license: $\pi^m = (a - c + x)^2 / 4$
    - Patentee can capture this value by setting
      - Fixed fee $F = \pi^m$ or
      - Royalty = monopoly margin: $r = (a + c - x) / 2 - (c - x) = (a - c + x) / 2$
  - Minor innovation
    - Licensee sets its price just below *c* and make a profit of $\pi^{mc} = x\,(a - c)$.
    - Patentee can capture this value by setting $F = \pi^{mc}$ or $r = x$
- **Lesson**: if an outside innovator licenses his process innovation to an industry competing à la Bertrand, he chooses to grant **one** license at a fixed fee or to offer **several** licenses at a royalty rate

Licensing by an outside innovator (3)

- **Cournot competition**
  - 3rd stage (duopoly)

$$q_i^*(c_i,c_j) = \tfrac{1}{3}(a - 2c_i + c_j)$$
$$Q^*(c_i,c_j) = \tfrac{1}{3}(2a - c_i - c_j)$$
$$\pi_i^*(c_i,c_j) = \tfrac{1}{9}(a - 2c_i + c_j)^2$$

  - 2nd stage – Fixed fee
    - Maximum fee to be exclusive licensee (F_1) or one of two licensees (F_2)

$$F_1 = \begin{cases} \pi_i^*(c-x,c) - \pi_i^*(c,c) & \text{(nondrastic innovation),} \\ \pi^m(c-x) - \pi_i^*(c,c) & \text{(drastic innovation),} \end{cases}$$

$$F_2 = \begin{cases} \pi_i^*(c-x,c-x) - \pi_i^*(c,c-x) & \text{(nondrastic innovation),} \\ \pi_i^*(c-x,c-x) - 0 & \text{(drastic innovation).} \end{cases}$$

Licensing by an outside innovator (4)

- **Cournot competition** (cont'd)
  - 1st stage: Fixed fee: optimal to give an exclusive license iff
    $$F_1 > 2F_2 \Leftrightarrow x > a - c$$
  - 2nd stage: Royalty
    - Let r be the amount of royalty licensees have to pay
    - If licensee, cost becomes $c - x + r$
    - $\rightarrow$ if $r \leq x$, both firms choose to license and if $r > x$, no firm will license
  - 1st stage: Royalty
    - Set $r \leq x$, so that both firms choose to license
    - Problem: $\max_r r\frac{2}{3}(a - c + x - r)$ s.t. $r \leq x$
      - FOC:

Total quantity when both firms have cost $c - x + r$

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

$$\text{with } r^* \leq x \Leftrightarrow x \geq a - c$$

Licensing by an outside innovator (5)

- **Cournot competition** (cont'd)
  - 1st stage – Royalty
    - **Major innovations**
      - Optimal royalty is r^*
      - Licensing revenues: $R_d = \frac{1}{6}(a-c+x)^2$
    - **Minor innovations**
      - Optimal royalty is x
      - Licensing revenues: $R_n = \frac{2}{3}x(a-c)$
  - Fixed fee vs. royalty
    - **Major innovations**: fixed fee dominates if and only if

$$F_1 > R_d \Leftrightarrow \frac{1}{4}(a-c+x)^2 - \frac{1}{9}(a-c)^2 > \frac{1}{6}(a-c+x)^2 \quad \text{OK}$$

    - **Minor innovations**: fixed fee dominates if and only if

$$2F_2 > R_n \Leftrightarrow \frac{8}{9}x(a-c) > \frac{2}{3}x(a-c) \quad \text{OK}$$

Licensing by an outside innovator (6)

- **Lesson**: If an outside innovator licenses his process innovation to an industry competing à la Cournot, he always prefers fixed-fee licensing to royalty licensing. He licenses drastic innovations to only one firm and non-drastic innovations to more than one firm
- **Intuition**
  - Fixed-fee → licensing firm(s) become **more** efficient → innovator can **exploit** this efficiency gain by reaping a licensing revenue via fixed fee → This total revenue is **always** larger than that obtainable under royalty licensing when the firms are equally efficient
  - But, in reality, the 2 forms of licensing are equally prevalent
  - 2 ways to reconcile theory and facts
    - Stage 1: patentee also decides how many licensees he will accept
    - Licensees have asymmetric costs

Licensing by an inside innovator (1)

- **Major innovations**
  - **Cournot and Bertrand** competition $\rightarrow$ no incentive to license
    - No license: innovator becomes **monopolist**
    - License: **duopoly** at lower cost; innovator can reap total duopoly profit, but this is smaller than monopoly profit
- **Minor innovations**
  - **Bertrand** competition $\rightarrow$ no gain from licensing
    - Same setting as above
    - No license: $p = c - \varepsilon \rightarrow$ margin of $(x - \varepsilon)$ on each unit sold
    - Any license: only sensible royalty rate is $r = x - \varepsilon$
      - quantity sold doesn't change
      - Innovator secures a margin of $(x - \varepsilon)$ on the units she sells
      - Innovator collects a royalty of $r = x - \varepsilon$ on the units sold by the licensees.

Licensing by an inside innovator (2)

- **Minor innovations** (cont'd)
  - **Cournot** competition
    - Royalty licensing is now the preferred option
      - Innovator can secure licensing revenues without damaging his competitive advantage
    - 3-stage game
      - Incumbent innovator selects royalty rate r
        $\rightarrow$ it selects $r \leq x$
      - Other firms decide whether or not to become licensees
        $\rightarrow$ they all buy a license because this $\downarrow$ marginal cost from c to $c - x + r$
      - Cournot competition among all firms
        $\rightarrow$ i.e. 1 firm with cost $c - x$ and n - 1 firms with cost $c - x + r$

Licensing by an inside innovator (3)

- **Minor innovations** (cont'd)
  - **Cournot** competition $\rightarrow$ analysis
    - Equilibrium quantity and profit for typical firm k

$$q_k^* = \frac{1}{n+1}\left(a - nc_k + \sum_{j \neq k} c_j\right) \quad \pi_k^* = \left(q_k^*\right)^2$$

    - Apply to innovator and licensees

$$q_{inn}^* = \frac{a - c + x + r(n-1)}{n+1} \text{ and } q_{lic}^* = \frac{a - c + x - 2r}{n+1}$$

    - Innovator's profit

$$\pi_{inn} = \left(q_{inn}^*\right)^2 + r(n-1)q_{lic}^*$$

Licensing by an inside innovator (4)

- **Minor innovations** (cont'd)
  - **Cournot** competition $\rightarrow$ analysis
    - Optimal royalty rate

$$\frac{\partial \pi_{inn}}{\partial r} = \frac{(n-1)(n+3)}{(n+1)^2}(a-c+x-2r) > 0 \Rightarrow r^* = x$$

    - Equilibrium innovator's profit

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

    - Innovator's gain from licensing

$$\pi_{inn}^* - \pi_{inn}^{\text{no license}} = \frac{(n-1)(a-c-x)x}{n+1} > 0$$

    - Society also gains from licensing
      - Consumers and rivals are as well off but innovator is strictly better off.

Licensing by an inside innovator (5)

- **Lesson**: In the case of quantity competition on the product market, it is **always** profitable for an incumbent innovator to license a minor cost-reducing innovation to its industry rivals
  - Licensing also benefits society
- Intuition
  - Same competitive situation if license or not
    - Marginal costs: $c - x$ for innovator, c for rivals
    - $\rightarrow$ same (direct) profit for innovator in both situations
  - If licensing, innovator also collects royalties
    $\rightarrow$ higher total profit

Innovation affecting market structure

- What if ideas are **common** knowledge?
  - Several firms have the simultaneous opportunity to achieve competing innovations
  - Innovation becomes a **competitive** tool in itself
  - How does it affect market structure?
- Possible outcomes
  - Incentive to innovate for monopoly threatened by entry $\rightarrow$ does monopoly persist because of innovation?
    - **Low-risk innovation**: challenging entrant possible
    - **Uncertain innovation**: asymmetric patent races
  - Dynamic R&D competition between symmetric firms

Asymmetric patent race model (1)

- Incumbent and entrant can both acquire innovation (which ↓ marginal cost from c_0 to $c_1 < c_0$)
- Entrant can enter profitably only with innovation
- Objective of R&D: be the 1st to come up with an innovation → **patent race**
- Firms decide about
  - **Intensity** of R&D investments
  - **Timing** of of R&D investments
- Combined influence of
  - **Replacement effect**: monopoly power = disincentive to R&D for incumbent
  - **Efficiency effect**: threat of entry = incentive to R&D for incumbent

Asymmetric patent race model (2)

- **Lesson**: in a patent race, it is in general ambiguous whether the incumbent or the entrant has a stronger incentive to invest
- **Intuition**: outcome depends on balance between
  - **Efficiency effect** $\rightarrow$ higher incentives for incumbent
    - Net flow profit incumbent receives by preempting the entrant is larger than what the entrant gains by being first.
  - **Replacement effect** $\rightarrow$ lower incentives for incumbent
    - Marginal productivity of R&D expenditure for the incumbent $\downarrow$with its initial profits (by investing more, incumbent moves discovery date forward and hastens its own replacement).

R&D cooperation and spillovers

- **Innovative environment**
  - Ideas are common knowledge (e.g., automobile industry) (**!!**)
  - R&D investments result immediately and for sure into an innovation (no tournament, no uncertainty) (**!!!!**)
  - R&D investments are a form of strategic commitment
  - R&D leads to spillovers which benefit other firms
  - Firms may cooperate on R&D decisions to internalize spillovers
- **Issues**
  - Do firms invest more or less when they recognize the strategic nature of their R&D decisions?
  - Should firms be allowed to coordinate their decisions at the R&D stage?
  - Is it worthwhile modelling R&D as an certain process?

Effects of R&D cooperation

- R&D activities with **spillovers** create 2 externalities:
  - R&D affects **overall** industry profits
    - This externality increases with the level of spillovers
    - Ignored when firms choose R&D separately
    - Internalized when firms choose R&D cooperatively
  - R&D affects a firm's competitive **advantage** w.r.t. its rival
    - This externality reduces with the level of spillovers
    - Present when firms choose R&D separately
    - Internalized when firms choose R&D cooperatively
- **Lesson**: when firms behave strategically, R&D cooperation leads to more (less) R&D when spillovers are large (small)

Referências

- BELLEFLAMME, P.; PEITZ, M. Industrial Organization: Markets and Strategies, 2 ed. Cambridge (UK): Cambridge University, 2015.
- TIROLE, J. The Theory of Industrial Organization. Cambridge (MA): MIT, 1988.