Gliederung der Vorlesung

A) Introduction

B) Competition and Monopoly

C) Technology and Cost; Industry Structure

D) Price Discrimination and Monopoly

E) Product Variety and Quality under Monopoly

F) Static Games

G) Dynamic Games, First and Second Movers

H) Horizontal Product Differentiation

I) Vertical Product Differentiation

J) Advertising

K) Research & Development

K) Joseph Alois Schumpeter, Capitalism, Socialism and Democracy, 1943, p. 84f.

- "*Economists are at long last emerging from the stage in which price competition was all they saw.*"
  ⇒Perfect competition
- "*As soon as quality competition and sales effort are admitted into the sacred precincts of theory, the price variable is ousted from its dominant position. However, it is still competition within a rigid pattern of invariant conditions, methods of production and forms of industrial organization in particular, which monopolizes attention.*"
  ⇒'Traditional' IO

„Old fashioned" IO, foundation of our study of R&D activities

But: How does competition look like? Drastic vs. gradual innovation

Note that the Schumpeter quotation is one long single quote.

K) Joseph Alois Schumpeter, Capitalism, Socialism and Democracy, 1943, p. 84f. cont.

- *"But in capitalist reality as distinguished from its textbook picture , it is not that kind of competition which counts but the competition from the new commodity, the new technology, the new source of supply, the new type of organization (…) – competition which commands a decisive cost or quality advantage and which strikes not at the margins of the profits but at their foundations and their very lives."*

  ⇒ ***The Process of Creative Destruction***

Evaluation of R&D competition from a social point of view!

K) Joseph Alois Schumpeter, Capitalism, Socialism and Democracy, 1943, p. 84f. cont.

- "*This kind of competition is as much more effective than the other as a bombardment is in comparison with forcing a door, and so much more important that it becomes a matter of comparative indifference whether competition in the ordinary sense functions more or less promptly; the powerful lever that in the long run expands output and brings down prices is in any case made of other stuff.*"

⇒ ***Static vs. dynamic efficiency***

Evaluation of R&D competition from a social point of view!

K) Research questions

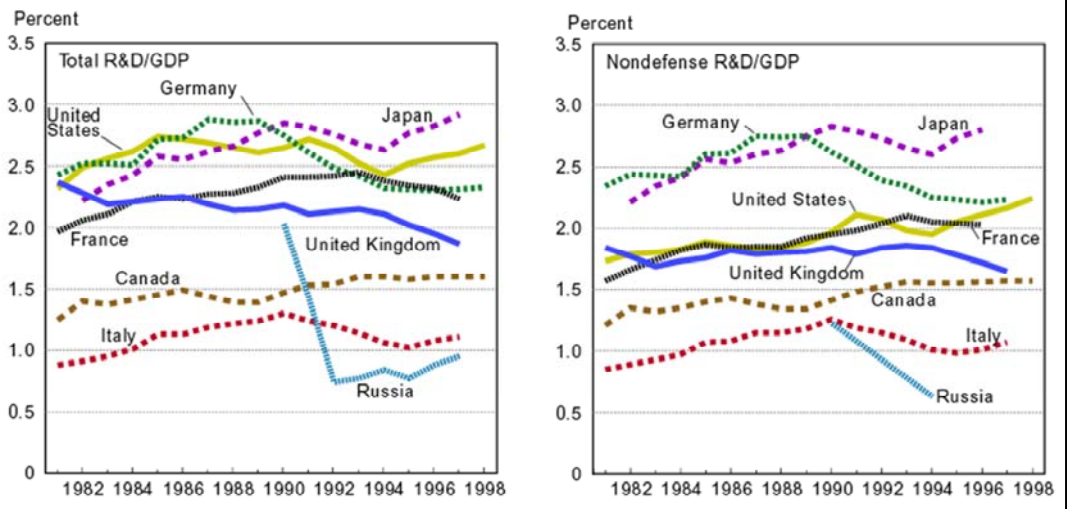
- Who invests in R&D, who are the drivers of innovation? New, entrepreneurial firms or large, established corporations (Schumpeter Mark I or Schumpeter Mark II)?
- Which market structure is most conducive to R&D? Is market power a prerequisite for innovation?
- Is the level of R&D activities optimal from the perspective of the society as a whole? Do firms spend too much or insufficiently on R&D compared to the social optimum? Duplication of efforts vs. spillovers
- What is the effect of R&D on aggregate long run growth?

We will address these questions in the course.

Schumpeter Mark I: The theory of economic development

Schumpeter Mark II: Capitalism, Socialism and democracy

K) Facts: R&D as a percentage of GDP, G-8 countries

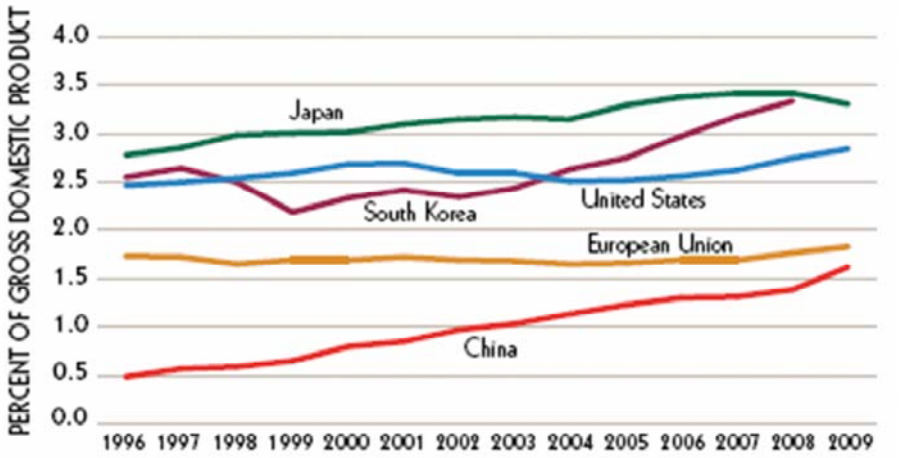


Starting with facts about R&D behavior. These facts demonstrate also the importance of R&D.

For detailed figures about the EU see http://ec.europa.eu/invest-in-research/monitoring/statistical01_en.htm

K) Facts: R&D as a percentage of GDP, G-8 countries

R&D expenditures as share of economic output for selected countries: 1996–2009



SEI 2012: Comparison of Country R&D Intensities, Chapter 4.

Source: National Science Board

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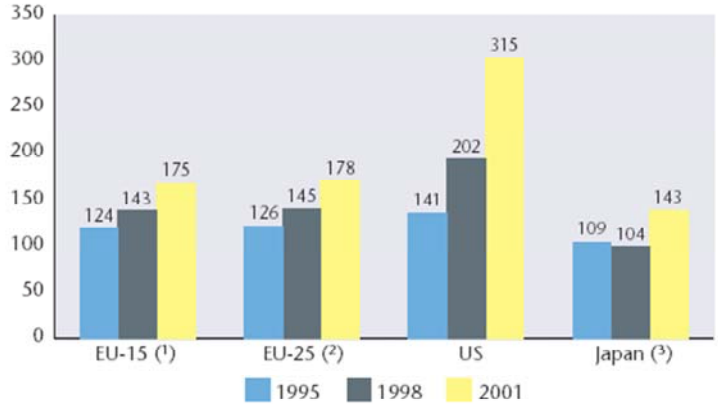
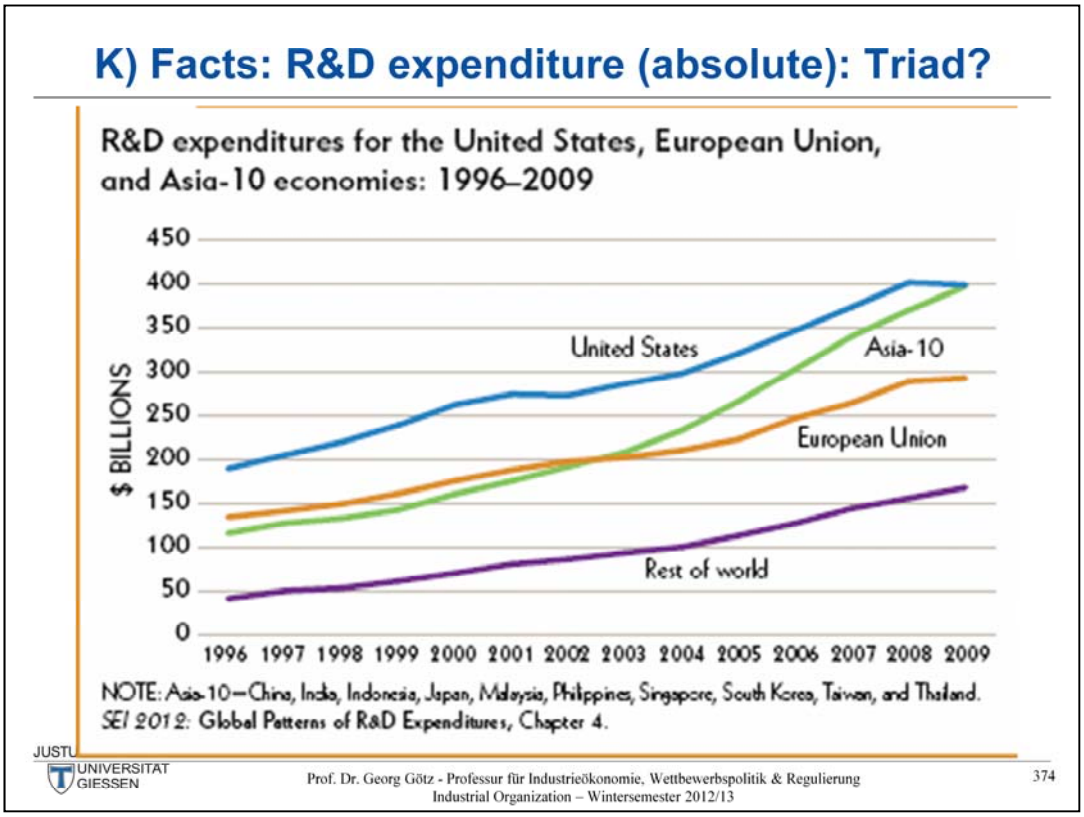
K) Facts: R&D expenditure (absolute) : Triad

Figure I-1a R&D investment (€ billion, in current terms), 1995, 1998 and 2001



Source: DG Research
Data: OECD, Eurostat
Key Figures 2003-2004
Notes: (1) EU-15: 1998, 2001: data estimated by DG Research and do not include LU. (2) EU-25 values were estimated by DG Research and do not include LU and MT. (3) JP: 1995: data adjusted by OECD.



Source: National Science Board

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K) Facts: Returns to R&D

Private and Social Rates of Return to Private R&D

Author (year)	Estimated Rates of Return	
	Private	Social
Nadiri (1993)	20 - 30	50
Mansfield (1977)	25	56
Terleckyj (1974)	29	28 - 78
Sveikauskas (1981)	7 - 25	50
Goto-Suzuki (1989)	26	80
Bernstein-Nadiri (1988)	10 - 27	11 - 111
Scherer (1982,1984)	29 - 43	64 - 147
Bernstein-Nadiri (1991)	15 - 28	20 - 110

This numbers indicate that R&D expenditures by firms are likely to be insufficient from a social point of view.

But: Patent races

K) Importance of R&D

- Estimation of Total Factor Productivity (TFP):
  - What percentage of GDP growth is due to technological progress?

  ⇒Very different results from .1 to .9%. These small numbers would imply that up to 50% of the increase in output per worker is due to technological progress.
- Countries where R&D expenditure by the business sector in relation to GDP has increased most from the 1980s to the 1990s have typically experienced the largest increase in the growth of multifactor productivity (MFP) (OECD, 2001).

Relation between R&D expenditures and growth not straightforward due to a number of problems

K) Importance of R&D: Policy

- EU: Lisbon strategy (Lisbon Summit 2000): Transforming the European Union by 2010 into “the most competitive and dynamic knowledge based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion”.
- European Council of Barcelona (March 2002): the goal of increasing the level of expenditure in research and development to 3% of GDP by 2010.

The European Council of Barcelona (March 2002) emphasised the importance of research and innovation by setting the goal of increasing the level of expenditure in research and development to 3% of GDP by 2010. While investing more in R&D is one part of the equation, another is better co-ordination of European research.

See respective page of EU Commission at http://ec.europa.eu/invest-in-research/index_en.htm

K) R&D: Definition and Concepts

- Definition: Activities aiming at cheaper production of known products (**process innovation**) or production of new products (**product innovation**) - (or at the improvement of the organisation).
- **Stages:** Basic Research - **invention - innovation - imitation**/diffusion.
  - Definitions: Freeman/Soete, p. 6:
  - **Invention** is an idea, a sketch or a model for a new or improved device, product, process or system. May be patented, in the majority of cases is not.
  - **Innovation** (in the economic sense) is accomplished only with the first commercial transaction involving the new product, process system or device, although the word is also used to describe the whole process.

Freeman/Soete, The economics of industrial innovation, p. 6:

Invention is an idea, a sketch or a model for a new or improved device, product, process or system. May be patented, in the majority of cases is not.

Innovation (in the economic sense) is accomplished only with the first commercial transaction involving the new product, process system or device, although the word is also used to describe the whole process.

K) 2. The Basic Model
(Social vs. private returns of innovations)

Questions:

1. What is the relation between market structure and innovation? Is a monopoly more conducive to R&D than competition?
2. Do the private and the social returns of innovation coincide? Is there a market structure which provides the 'right' (socially optimal) level of innovative activity?
3. Who will invest more in R&D, a potential entrant or an incumbent (monopolist)? What is the effect of the threat of entry on the monopolist's willingness to pay for an innovation? Will monopoly persist?

Reference: Pepall, Richards, and Norman: Industrial Organization. Contemporary Theory and Practice. 2nd edition. South Western. 2002. Chapter 11.2.1

K) Market structure and the incentive to innovate (Arrow 1962)

- Assumption: New technology discovered which reduces unit costs from k to $\underline{k}$ (process innovation)
- What is the gain from this innovation to a firm that is the **only** one to undertake R&D?

Two cases:

- Monopoly
- Bertrand and perfect competition, resp.

Definition:

Drastic (or large or major) **innovation**: $p_M(\underline{k}) \leq k$

Gradual (or small or **non-drastic) innovation**: $p_M(\underline{k}) > k$

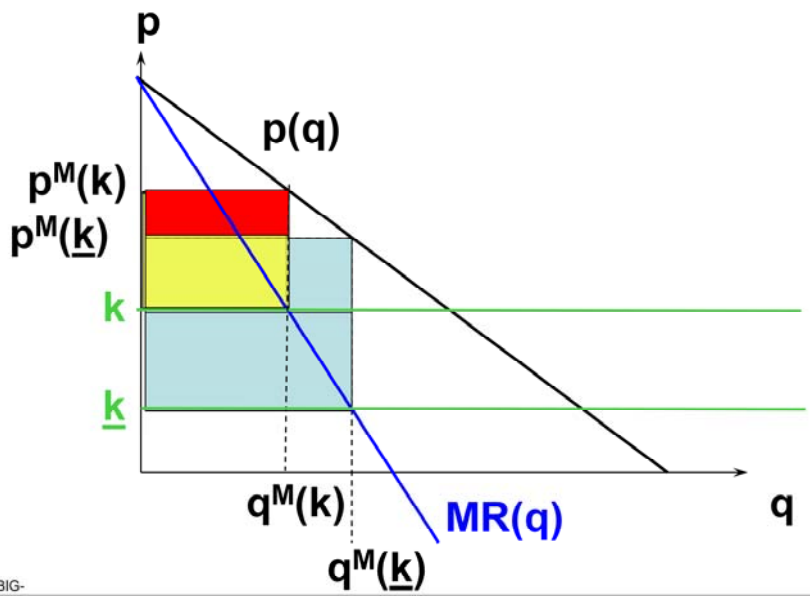
Arrow, K., 1962, Economic Welfare and the Allocation of Resources for Inventions. In: Nelson, R. (ed.): The Rate and Direction of Inventive Activity. NBER. Princeton University Press.

Monopoly: no threat of entry. If the monopolist does not invest, nobody else can in the respective market.

Bertrand competition equivalent to perfect competition if one assumes that – under perfect competition – an outside innovator holds the patent for the innovation and licenses the innovation to all firms in the industry charging a royalty (either k – $\underline{k}$ (non-drastic innovation) or p_Monopoly($\underline{k}$) – $\underline{k}$ (drastic innovation)).

Drastic innovation: Innovator not constrained by competitors

K) Incentive to innovate under monopoly: A graphical analysis



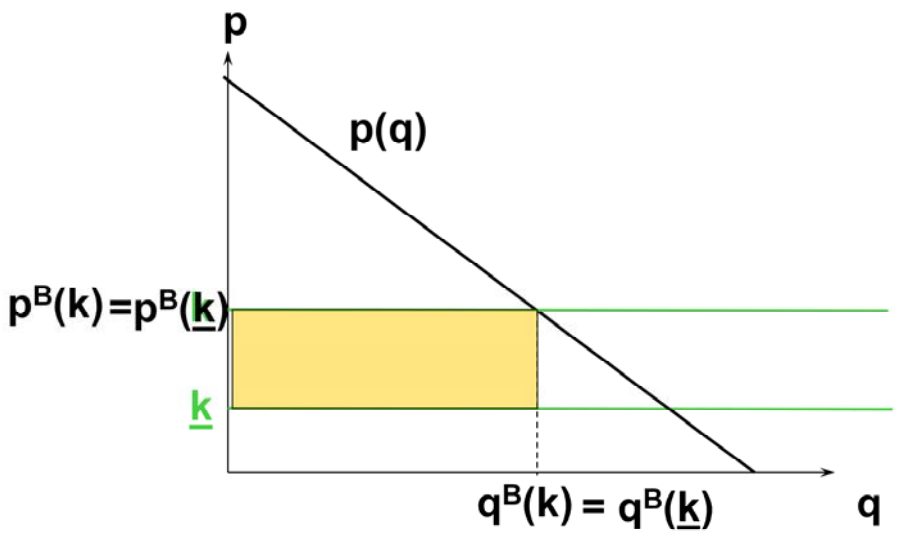
Non-drastic innovation!

Incentive to innovate: Profit after innovation – profit before innnovation = Green – red area

Consumers gain from innovation: price falls.

Important for welfare analysis (see below): consumer surplus effect one of the reasons for insufficient incentive to invest in R&D. Firms cannot appropriate all returns from R&D.

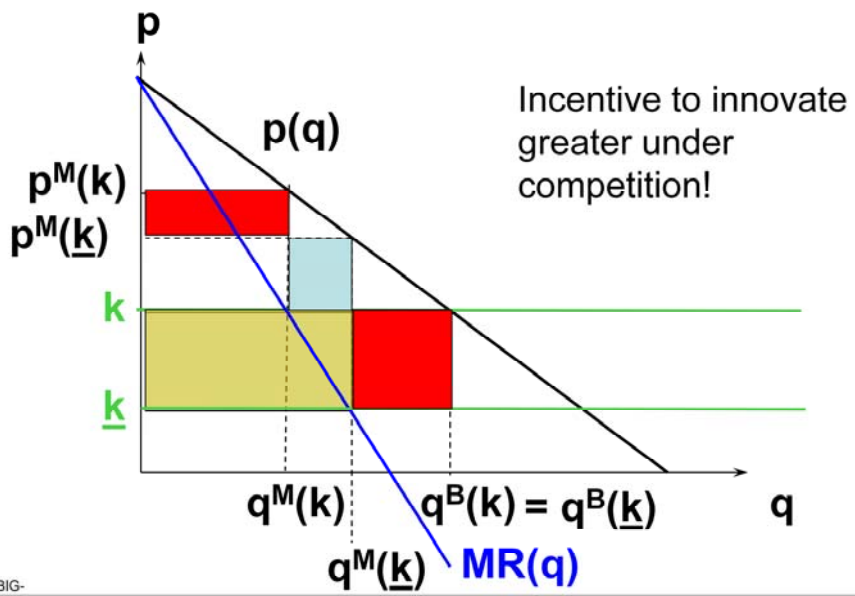
K) Incentive to innovate under Bertrand competition (one firm innovates)



Would it be possible under Bertrand competition that more than one firm invests in R&D (if the success of the the R&D activity is certain)? No! Both (in the the two firm case) firms would make losses!

Limit-pricing: $p^B = k$

K) Incentive to innovate: Monopoly vs. (Bertrand) competition



Incentive to innovate clearly smaller under monopoly: sum of red areas greater than green area.

K) Incentive to innovate: Monopoly vs. (Bertrand) competition

Formal analysis: the linear case

- Linear demand function: $q = s(a - p)$
- The monopolist's profit as a function of marginal costs k:

$$\Pi(k) = \frac{s}{4}(a-k)^2$$

- Gain from innovation: $\Delta\Pi = \Pi(\underline{k}) - \Pi(k)$
- Monopolist: $\Delta\Pi^M = \frac{s}{4}(2a - \underline{k} - k)(k - \underline{k})$
- Competition: $\Delta\Pi^B = s(a-k)(k-\underline{k})$

- Gain from innovation increases in market size s

(Per-period) Gain from nondrastic innovation. To obtain total gain take the discounted sum of the per-period gain over the relevant time horizon. In the case of an infinite horizon the gain is the per-period gain divided by the interest rate r.

K) Incentive to innovate: Monopoly vs. (Bertrand) competition cont.

$$\Delta\Pi^B > \Delta\Pi^M \Leftrightarrow a > 2k - (\underline{k} + k)/2$$

- Nondrastic innovation requires (Why): $a > 2k - \underline{k}$

⇒ Incentive to innovate greater under (Bertrand) competition than under monopoly. (Check that this is also true for a drastic innovation.)

⇒ **Replacement effect**: „monopolist's disincentive created by his preinvention monopoly profits"

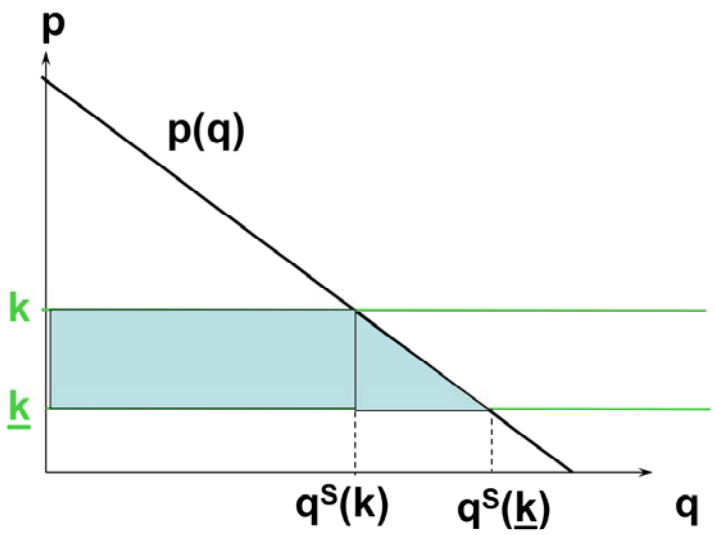
⇒ Result also obtained for more general demand functions (see Tirole, chapter 10).

General case: Main point: Quantities are smaller under monopoly

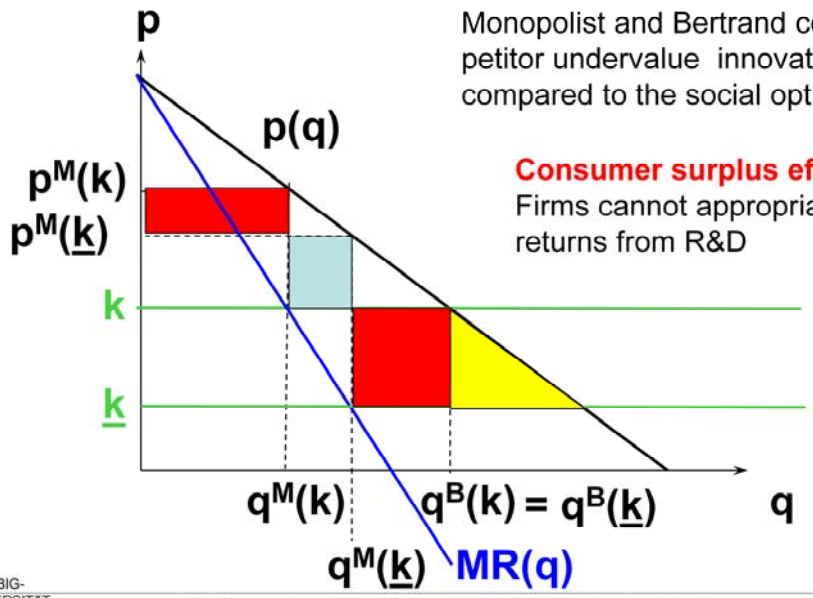
Result a contradiction to Schumpeter?

1. Small firms have a larger incentive to do R&D but do they also have the capacity to do so? Capital market imperfections and so on.
2. Monopolist we consider is also monopolist ex-post (legal or other barriers to entry). Does not capture the possibility of creative destruction. See later for what changes if we take that into account.

K) Incentive to innovate: A social planner



K) Incentive to innovate: Monopoly vs. (Bertrand) competition vs. social planner



Monopolist and Bertrand competitor undervalue innovation compared to the social optimum.

Consumer surplus effect: Firms cannot appropriate all returns from R&D

Consequence of welfare result: Firms would not introduce a new technology if the R&D costs are greater than their profit gain. If the costs are below the gain to the social planner, but above that of the firms, socially beneficial projects are not carried out.

K) Incentive to innovate in Cournot duopoly

- Important: Firms with different (marginal) costs may coexist. Inefficient firms may survive and have positive market share.
- Cournot duopoly: Marginal costs
- Firm 1: k_1, firm 2: k_2
- Linear demand function: $q = s(a - p)$
- Profits as a function of own and rival's costs

$$\Pi_i^C\left(k_i, k_j\right) = \frac{s}{9}\left(a - 2k_i + k_j\right)^2, \quad i, j = 1,2,\ i \neq j$$

Coexistence of firms with different costs is also possible under Bertrand competition if products are differentiated!

K) Incentive to innovate in Cournot duopoly cont.

- Incentive to innovate for firm 1:

$$\Delta\Pi_1^C = \Pi_1^C\left(\underline{k}_1, k_2\right) - \Pi_1^C\left(k_1, k_2\right)$$

$$= \frac{4s}{9}\left(a - \underline{k}_1 - k_1 + k_2\right)\left(k_1 - \underline{k}_1\right)$$

Assume: $k_1 = k_2$

$$\Rightarrow \qquad \Delta\Pi^B > \Delta\Pi_1^C$$

Proof: Use fact that innovation is nondrastic and

$$\Delta\Pi^B > \Delta\Pi_1^C \Leftrightarrow a - k > \frac{4}{9}\left(a - \underline{k}_1\right) \qquad \Delta\Pi_1^C = \frac{4s}{9}\left(a - \underline{k}_1\right)\left(k_1 - \underline{k}_1\right)$$

$$\frac{4}{9}\left(a - \underline{k}_1\right) \underset{\text{NI: } \underline{k}_1 > 2k - a}{<} \frac{4}{9}\left(a - \left(2k - a\right)\right) = \frac{8}{9}\left(a - k\right) < a - k$$

Cournot: Also replacement effect, but preinvention profit much smaller than that of the monopolist. Therefore incentive between that of the other two market structures

NI: Nondrastic innovation

K) Incentive to innovate in Cournot duopoly cont.

- Incentive to innovate for firm 1:

$$\Delta\Pi_1^C = \Pi_1^C(\underline{k}_1, k_2) - \Pi_1^C(k_1, k_2)$$

$$= \frac{4s}{9}(a - \underline{k}_1 - k_1 + k_2)(k_1 - \underline{k}_1)$$

Assume: $k_1 = k_2$

$$\Rightarrow \quad \Delta\Pi_1^C \gtrless \Delta\Pi^M \quad \Leftrightarrow \quad k_1 - \underline{k}_1 \gtrless \frac{2}{7}(a - k_1)$$

Proof: Define: $\varepsilon \equiv k_1 - \underline{k}_1$

Solve $\Delta\Pi^M = \Delta\Pi_1^C$ for ε to obtain the above result!

To show that incentive for monopolist is smaller for large innovations substitute k=(a+$\underline{k}$)/2 in the monopoly gain.

Result: 4(a-$\underline{k}$)/9> 3(a-$\underline{k}$)/8.

Results are the same for the case of a drastic innovation. The derivation is much easier in this case: The post-innovation profit is equal to the monopoly profit under all three market structures, the preinnovation profits are – in increasing order – 0 for Bertrand, the Cournot duopoly profit and the monopoly profit.

Slides in previous version were wrong! See slides Preis und Wettbewerb, p. 62

Incentive to innovate is greater under Cournot compared to oligopoly if the innovation is large, ie. Close to a drastic innovation

⇒Leads to large post-innovation output and large gain of market share.

Incentive to innovate is smaller for small innovations

⇒large difference in output between monopoly and Cournot; smaller incentive to invest in process innovation

K) Incentive to innovate in Cournot duopoly cont.

- It is possible that an R&D investment is detrimental to social welfare!
- Welfare = consumers surplus + aggregate profits
- Welfare increase due to the innovation of firm 1:

$$\Delta W = W\left(\underline{k}_1, k_2\right) - W\left(k_1, k_2\right)$$

$$= \frac{s}{18}\left(8a - 11\underline{k}_1 - 11k_1 + 14k_2\right)\left(k_1 - \underline{k}_1\right)$$

$$\Delta W > \Delta\Pi_1^C \Leftrightarrow 2k_2 > k_1 + \underline{k}_1$$

⇒ If an inefficient firm invests in R&D, welfare may fall.

⇒ **Business stealing effect**: firm does not take into account that its rival's profit falls (externality)

Now slightly changed welfare question:

What is the change in (gross) social welfare if a Cournot competitor introduces a new technology?

Note that both $\Delta\Pi$ and ΔW are always greater than zero. But to calculate the total welfare costs we need to take into account the costs of the R&D project.

Consider the case: $\Delta\Pi > \Delta W$.

Welfare reduction if (per-period) costs f of the R&D project are such that $\Delta\Pi > f > \Delta W$

Business stealing effect is also called profit destruction effect. Note that mere shifting of profits from one firm to the other does not change social welfare, but makes a huge difference to firms. For a firm the losses of the rival are irrelevant, what counts is the change in one's own profits.

K) Will monopoly persist if innovative entry is possible? The effect of the patent system on market structure (Gilbert and Newbery, 1982)

Situation:

- Monopolist holds patent and produces with marginal costs *k*.
- Potential entrant: Entry only possible with new technology ('innovative entry')
- 'Outsider': R&D lab, which has discovered and patented a new technology allowing production with costs $\underline{k}$. Sells the new technology in an auction.

Gilbert, R.J., Newbery, D., 1982, Preemptive Patenting and the Persistence of Monopoly. American Economic Review, 72, 514-526.

See also Pepall, Richards, and Norman, Section 11.4.2

Instead of the outsider one could also think that the incumbent or the entrant invest in R&D. R&D technology such that earlier introduction of the innovation increases costs. The patent is awarded to the firm which innovates first.

K) Will monopoly persist... cont.

Questions:

- Who will invest more in R&D, i.e. who has the higher willingness to pay for the new technology, the potential entrant or the incumbent (monopolist)?
- What is the effect of the threat of entry on the monopolist‘s willingness to pay for an innovation? Are monopolists innovative? Comparison to the case of (legally) blockaded entry.
- Will monopoly persist?
- Does the patent system create opportunities for firms with monopoly power to maintain their monopoly power?

K) Will monopoly persist... cont.
Incentives to acquire the new technology

- Entrant's willingness to pay (WTP) for a nondrastic innovation: Duopoly profit of a low-cost firm:

  => $\Pi^D(\underline{k},k)$
- Monopolist's WTP: monopoly profit with the new technology – duopoly profit of a high-cost firm

  => $\Pi^M(\underline{k}) - \Pi^D(k,\underline{k})$
- Monopolist innovates! To see this note that

  $\Pi^D(\underline{k},k) < \Pi^M(\underline{k}) - \Pi^D(k,\underline{k}) \Leftrightarrow$

  $\Pi^D(\underline{k},k) + \Pi^D(k,\underline{k}) < \Pi^M(\underline{k})$ q.e.d.
- Monopoly profit in homogeneous good industry always higher than profit of two – non-colluding – duopolists

  $\Rightarrow$ **efficiency effect**! Industry structure moves in the direction of higher total industry profits

The profit here should be interpreted as the presented discounted value of the the profit flow over the relevant time horizon.

Efficiency effect: Monopolist could always duplicate the situation of the noncolluding duopolists. Therefore, his profit must be at least as high as that of the duopolists.

K) Will monopoly persist... cont.

Answers:

- The monopolist will invest more in R&D due to the incentive to defend his monopoly. He has more to lose from **not** winning the bid than the entrant has to gain from winning it.
- Monopolists are more innovative than firms acting under competition!
- The monopolist's WTP for a new technology is greater under the threat of entry. Difference in innovativeness of monopoly due to patents and monopoly due to regulation (e.g. postal service).
- Persistence of monopoly! Patent system may allow to expand life span of the monopoly.
- Examples: Xerox, Eli Lilly

Second point: Schumpeter!

Examples (s. Cabral, p. 296):

Xerox, spend more on R&D than rival IBM. „Patent thicket“: Xerox sued IBM. 25% of IBM‘s budget was devoted to patent counsel.

Eli Lilly: Market leader for insulin. With the advent of biotechnology the development of synthetic human insulin was likely. In 1978 Genentech was successful (ahead of three other rival labs! Patent race! See later) in completing all steps to synthesize human insulin. One day after the Genentech‘s last experiment, Eli Lilly signed an agreement with the company.

Drastic innovations: WTP of entrant and incumbent identical.

With uncertainty of the R&D process the results change! See later.

K) Will monopoly persist... cont.
Sleeping patents

- Sleeping patents or patent shelving: Monopolist may obtain property rights of an innovation even though he makes no use of it.
- Firms often hold large numbers of patents relating to the same process or product, only part of them used.
- Economic rationale: Preventing imitation and therefore competition by making it hard to "invent around"
- Formal proof: Assume a new technology becomes available allowing production of the product with marginal costs $\underline{k} > k$. The monopolist has a higher WTP for this innovation $\Pi^D(\underline{k},k) < \Pi^M(k) - \Pi^D(k,\underline{k})$, even though he will never use it!

Formal result holds for both Bertrand and Cournot competition (see also exercises in the question set): Bertrand WTP of entrant 0, for monopolist positive. Cournot: WTP of entrant but higher for monopolist.

The argument holds also for product innovations for close substitutes!

Examples:

Xerox: Patent thicket. FTC ordered in the seventies that Xerox must license its technology to all entrants (at nominal costs). Xerox shares dropped by 50 % between 1972 and 1977.

(s. Pepall et. al., p. 624)

Electronic ballasts to be used in fluorescents lamps (Elektronische Vorschaltgeräte für Leuchtstofflampen). Patented late 1970s by C. Stevens and B. Alling: 50% (recent estimation: at least 30) percent improvement in energy efficiency over inductive/magnetic ballast (induktive Vorschaltgeräte). In 1981, Universal Manufacturing Corporation, which owned one of the major magnetic ballast manufacturers, Magnetek, acquired the technology for a share(!) of the royalties which should be earned from licensing the product. By 1984 nothing happened, 1997 a jury awarded $96 million in damages to the inventors. Meanwhile Motorola had invented around the patent. Motorola had originally approached the inventors before Magnetek did!

Alcoa (Bradley patents, developed fifteen years after the introduction of C.M.Hall's electrolytic process) , DuPont: Hundreds of patents on variants of the molecules used in synthetic fiber nylon.

Hollywood: film rights to books.

Solutions to the problem of sleeping patents:

- Compulsory licensing provisions if the patent is not used within a certain time
- Patent renewal fees which are increasing over time