JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

Industrial Organization and Antitrust (Industrieökonomie)

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Course organization: excercise class, web site, other courses at VWL I

Topics and Lectures

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

J) Research & Development

Topics and Lectures

A) Introduction

B) Competition and Monopoly

C) Technology and Cost; Industry Structure

D) Price Discrimination and Monopoly
   1) Linear Pricing
   2) Nonlinear Pricing

E) Product Variety and Quality under Monopoly
   1) Product variety
   2) Product quality
   3) Bundling & complementary products

F) Static Games
   1) Cournot Competition
   2) Bertrand Price Competition

G) Dynamic Games, First and Second Movers
   1) Stackelberg Leadership
   2) Capacity Expansion and Entry Deterrence

H) Horizontal Product Differentiation
   1) Price Competition & Product Choice
   2) Entry & Optimum Product Variety
   3) Love of Variety Approach

I) Vertical Product Differentiation

J) Advertising

K) Research & Development

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A) Introduction

IO: the study of the structure of firms and markets and of their interaction

- How firms behave in markets
- Whole range of business issues
  - Pricing of goods and services
  - which new products to introduce
  - merger decisions
  - methods for attacking or defending markets
- ***Strategic view*** of how firms interact

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Industrial Organization is that branch of economics that is concerned with imperfect competition!

A) Introduction

- How should a firm price its product given the existence of rivals?
- How does a firm decide which markets to enter?
- Incredible richness of examples:
  - Microsoft/Netscape/Sun
  - Roche: Vitamin cartel (collusion)
  - Toys R Us (exclusive dealing)
  - American Airlines, Lufthansa, AUA (predatory pricing)
  - Telekom Austria TikTak-Tarif (Bundling?)
  - Merger wave
- At the heart of all of this is strategic interaction

Strategic interaction: Taking into account what my rival does and how my actions might affect my rival!

A) Introduction

- Rely on the tools of ***game theory***
  - focuses on strategy and interaction
- **Subject of the course:**

⇒ **strategic interactions between firms**

Not covered: Organization and goals of firms

  - Do not say much about the *internal organization* of firms

⇒ **“Theory of the firm”** (of the boundaries of the firm)

⇒ Transaction costs theory (O. Williamson), based on R. Coase

- Transactions Costs: the expenses of trading in excess of the price of the commodity

A) Introduction

- Transaction Costs Theory and the Theory of the Firm
  - Basic concepts:
    a. markets and firms are alternative means for completing transactions
    b. the relative costs of using these alternatives determine the choice
    c. transactions costs vary with the characteristics of the decision-makers involved and the characteristics of the market
    d. these human and environmental factors vary across markets and within firms.

A) Introduction

- Transaction Costs Theory and the Theory of the Firm
  - Basic goal:
    a. find which environmental and human factors explain firm and industrial organization.
    b. key factors:
       1. the number of firms
       2. Uncertainty
       3. bounded rationality: limited human capacity to solve complex problems
       4. opportunism

A) Introduction

- More on the *internal organization* of firms and the "Theory of the firm"
  - ⇒**Institutionenökonomik (Prof. Albert)**
  - ⇒**Economics of Regulation (Prinicipal agent models)**
- How to proceed in IO:

⇒ Construct models: abstractions

- well established tradition in all science
  - physics
  - engineering
    - are SUVs safe?
    - Do seat-belts/Volvos save lives?

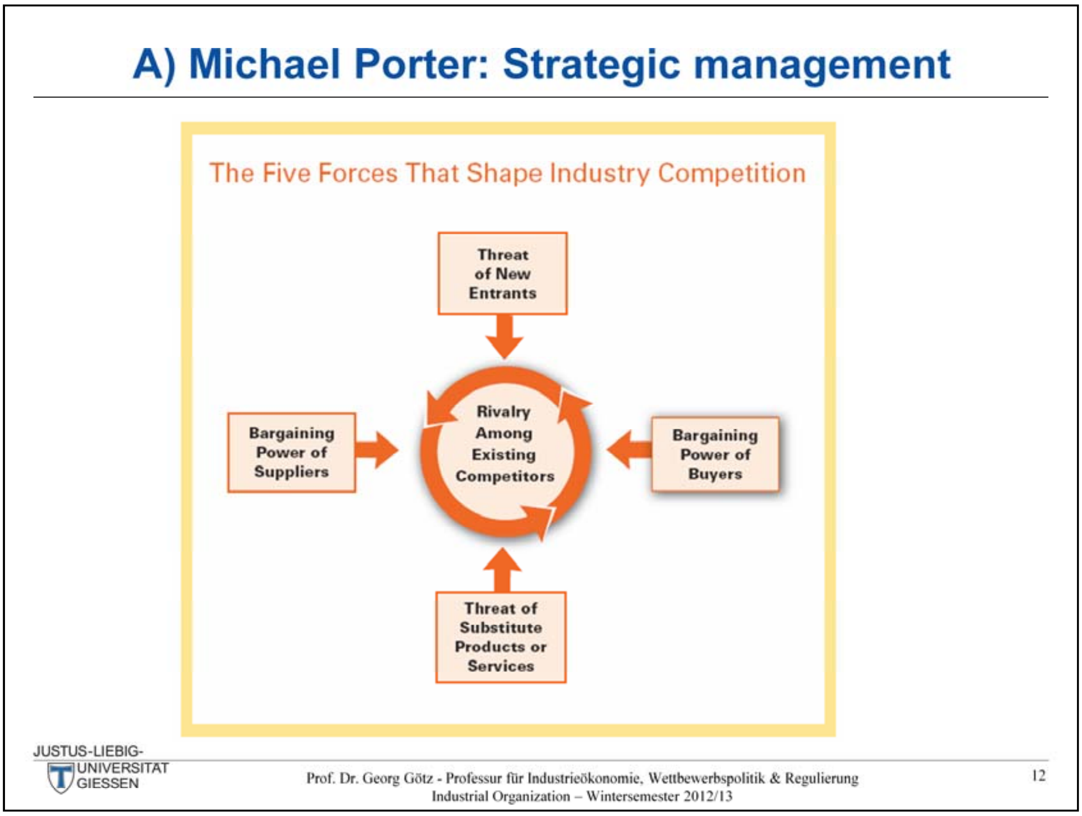
A) Introduction

IO and the analysis of strategic interactions: What for?

- Understanding strategic competition in different market contexts
  - ⇒Relation to marketing and industrial management
  - ⇒Porter: Five Forces that shape strategy
- Evaluating market outcomes from a social perspective: If results are not optimal, how can public policy improve matters

⇒ Antitrust (competition policy)

Example: Telekom Austria: Effect of regional discrimination of broadband internet access?



THE FIVE COMPETITIVE FORCES THAT SHAPE STRATEGY
by Michael E. Porter
hbr.org | **January 2008 | Harvard Business Review 79-93**

Understanding the forces that shape industry competition
is the starting point for developing strategy.

A) IO

Need for and importance of antitrust policy:

Adam Smith (1776): The Wealth of Nations

- "The monopolists, by keeping the market constantly understocked, by never fully supplying the effectual demand, sell their commodities much above the natural price."
- "People of the same trade seldom meet together, even for merriment or diversion, but the conversation ends in a conspiracy against the public, or in some contrivance to raise prices."

Adam Smith's view of industry associations?

A) IO History in a Heartbeat

- Mid-Late-1800s: Cournot, Bertrand, Edgeworth
- Early-Mid-1900s: Case Studies; Chamberlin, Hotelling
- 1950-60s: S-C-P (Bain)
- 1960-70s: Chicago School Critique
- 1970-80s: Modern Game Theory
- “New Industrial Organization”

A) The New Industrial Organization

- *Harvard-School* (J. Bain, E. Mason etc.) **Structure - Conduct - Performance** (e.g. concentration↑ ⇒ rate of profit↑)
- Dissatisfaction with the structure-conduct-performance approach
  - collect profit data on firms in an industry
  - explain differences using information on size, organization, R&D, financial leverage etc.
  - *but what is the direction of causation?*
- *Chicago-School* (A. Director, G. Stigler etc.)
- Since 1970-1980ies: Game theory inspired new interest in I.O.: strategic decision-making

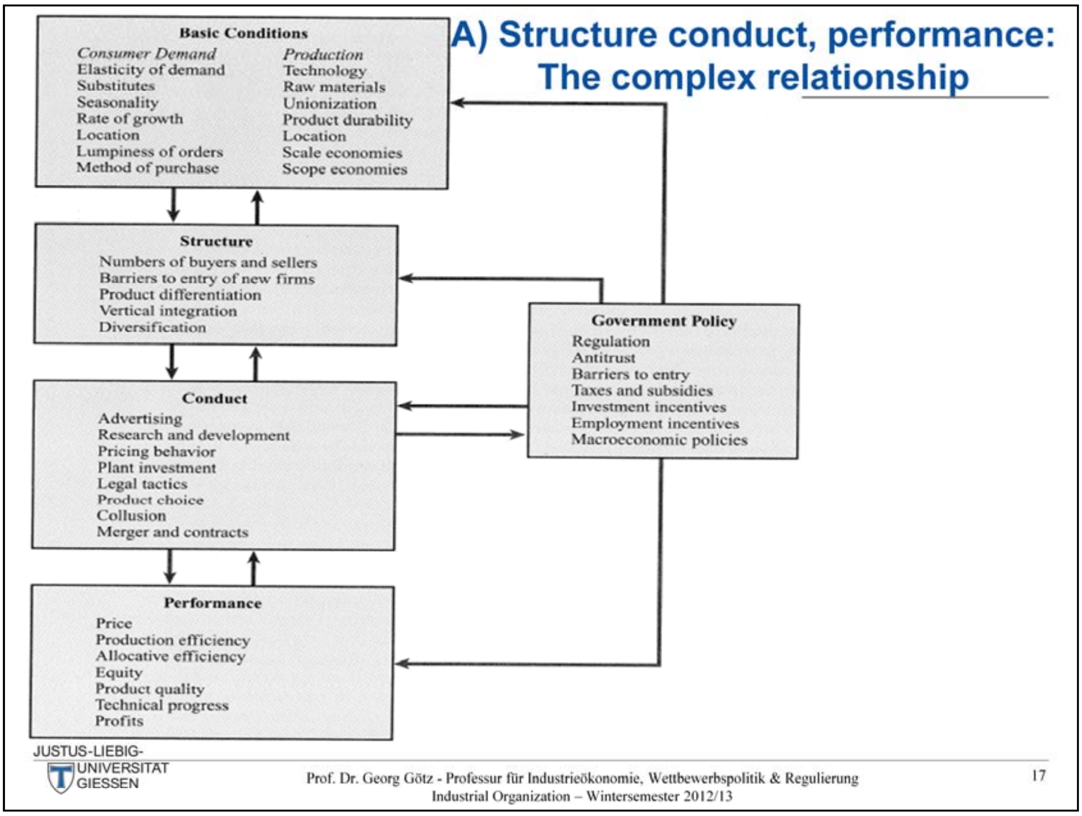
Chicago-school: high profits of a firm might well be due to superior efficiency => causation?

=> ‚Micro'-approach: detailed examination of industry

TABLE 1.1 **Some Basic Market Structures**

Market Structure	Sellers: Entry Barriers	Sellers: Number	Buyers: Entry Barriers	Buyers: Number
Competition	no	many	no	many
Monopoly	yes	one	no	many
Monopsony	no	many	yes	one
Oligopoly	yes	few	no	many
Oligopsony	no	many	yes	few
Monopolistic competition	no	many	no	many

Carlton, Perloff, p. 7



Taken from Carlton, Perloff, p. 4

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B) Perfect competition

- Firms and consumers are *price-takers*
- Firm can sell as much as it likes at the ruling market price
  - Firms potential supply (typically) “small” relative to the market

  ⇒Many firms!
  - do not necessarily need many firms
  - do need the idea that firms *believe* that their actions will not affect the market price
- Therefore, marginal revenue equals price
- To maximize profit a firm *of any type* must equate marginal revenue with marginal cost
- So in perfect competition price equals marginal cost

Review!

Examples: Farmers! Price elasticities of more than 5000% (Carlton/Perloff Example 3.1, p. 69)

Special cases in which a small number of firms behaves competitively: Perfectly elastic demand.

„L“-shaped marginal cost curves: (steel industry) (boom – bust)

Formal assumptions for perfect competition according to Carlton/Perloff:

-Homogeneous perfectly divisible product

-Perfect information

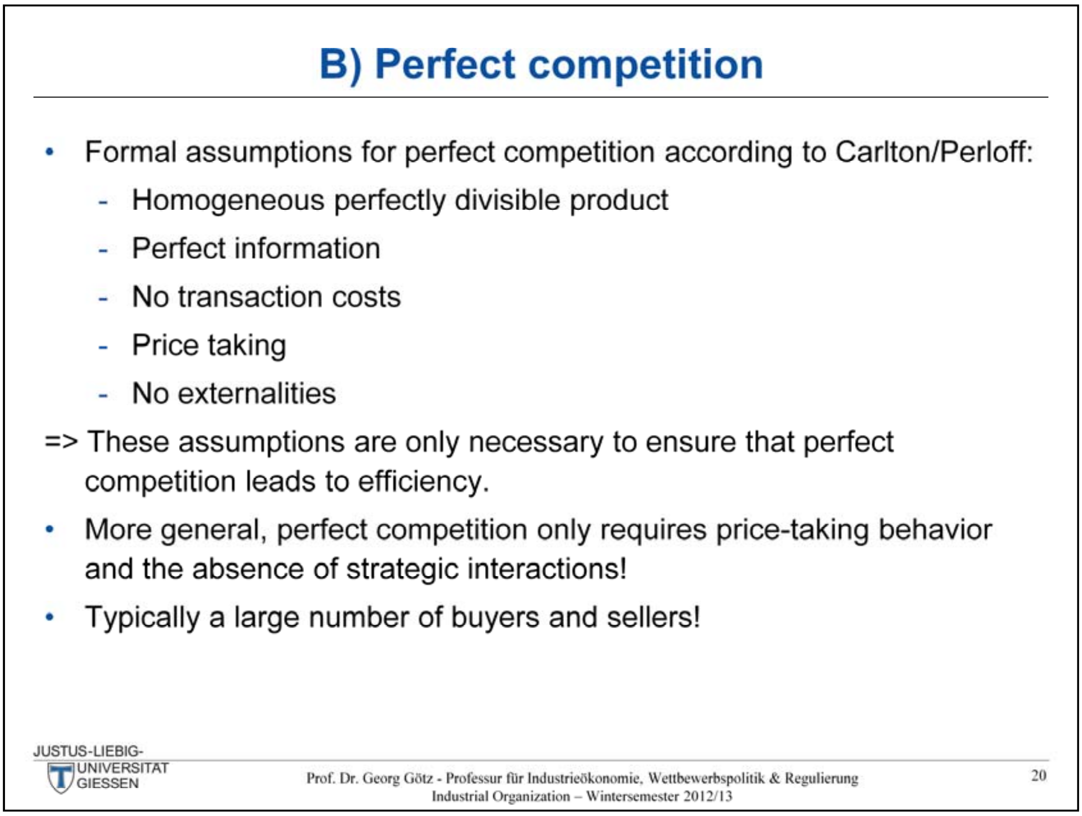
-No transaction costs

-Price taking

-No externalities

! These assumptions are only necessary if one wants to make sure that perfect competition leads to efficiency. More general, perfect competition only requires price-taking behavior and the absence of strategic interactions!

Typically a large number of buyers and sellers!



Review!

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Typically a large number of buyers and sellers!

B) Perfect competition cont.

- Profit is $\pi(q) = R(q) - C(q)$
- Revenue $R(q) = p\ q$
- Profit maximization: $Max_q\ \pi(q) = R(q) - C(q)$

$\Rightarrow$ $d\pi/dq = dR(q)/dq - dC(q)/dq = 0$

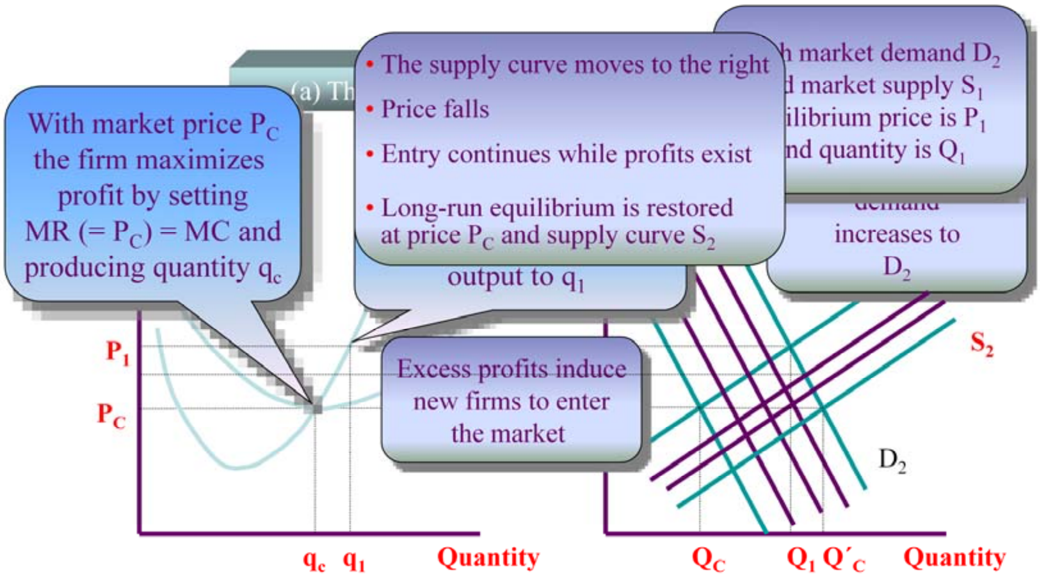
- But $dR(q)/dq$ = marginal revenue = p and $dC(q)/dq$ = MC
- profit maximization implies MR = p = MC

$\Rightarrow$ Inverse supply function: $p = C'(q)$

$\Rightarrow$ Supply function $q = s(p)$

- SOC: $d^2\pi/(dq)^2 < 0 \Rightarrow C''(q) > 0$

B) Perfect competition: an illustration



B) Perfect competition

- Short run: Given number of firms *n*

⇒ Industry supply curve $S(p,n) = \sum_{i=1}^{n} s_i(p)$

⇒ Short run market equilibrium $D(p) = S(p,n)$

- Long run: Free entry and exit

⇒ No excess profits: π(q) = R(q) - C(q) = 0

⇒ (R(q) - C(q)) / q = 0 ⇔ p = AC

⇒ Firms need to be “small” for this to hold with equality

- The number of firms on a market is not a perfect indication of competitiveness of the market
  - MES large (wrt demand): few firms
  - MES small: many firms

Definition of ***normal profit***

Often also called “zero” profit, does not imply zero “accounting profits”, but that a firm is making the market return on the assets employed in the business

For the “marginal firm” only; if firms have different costs of production, infra-marginal firms make positive profits.

B) MES in selected industries

Industry	Minimum Efficient Scale	% of 1967 Demand	% by which unit cost rises at 0.33 MES
Beer brewing	4.5 million barrels (31 gallon) per year	3.4	5.0
Cotton and synthetic fabrics	37.5 million sq. yards per year; 600 employees in modern integrated plants	0.2	7.6
Paints	10 million gallons per year; 450 employees	1.4	4.4
Petroleum refining	200,000 barrels (42 gallon) per day crude oil processing	1.9	4.8
Nonrubber shoes	1 million pairs per year; 250 employees per shift	0.2	1.5
Integrated Steel	4 million tons per year	2.6	11.0
Refrigerators	800,000 units per year	14.1	6.5
Automobile batteries	1 million units per year; 300 employees	1.9	4.6

[1] Source: F.M. Scherer, Alan Beckenstein, Erich Kaufer, and R.D. Murphy, *The Economics of Multi-Plant Operation: An International Comparisons Study*, Harvard University Press, Cambridge, MA, 1975.

B) MES in selected industries

Industry	MES as % of US demand	% increase in unit cost at 0.25 MES
Flour mills	0.7	3
Soybean mills	2.4	2
Bread baking	0.3	7.5
Tufted rugs	0.7	10
Printing paper	4.4	9
Sulphuric acid	3.7	1
Synthetic rubber	4.7	15
Cellulosic synthetic fibers	11.1	5
Nylon, acrylic, and polyester fabrics	6.0	7–11
Detergents	2.4	2.5
Passenger auto tires	3.8	5
Bricks	0.3	25
Iron foundries: lg. castings	0.3	10
Turbogenerators	23.0	NA
Machine tools	0.3	5
Electronic computers	15.0	8
Electric motors	15.0	15
Transformers (mix of types)	4.9	8
Integrated passenger auto production	11.0	6
Commercial transport aircraft	10.0	20
Bicycles	2.1	NA
Diesel engines, up to 100 hp	21-30	4-28

[2]Source: Leonard W. Weiss, "Optimal Plant Size and the Extent of Suboptimal Capacity," in Robert T. Masson and P.D. Qualls, eds., *Essays on Industrial Organization in Honor of Joe S. Bain*, Ballinger, Cambridge, MA, 1975.

In industries with large MES it is (more) likely that we find imperfect rather than perfect competition.

B) Pure Monopoly

- Single supplier,
- negatively sloped demand function,
- no potential market entry.
- *Notation:*
- q: Quantity of the good,
- $c(q)$: cost function,
- $p(q)$: inverse demand function,
- $\Pi(q)$: Profit.
- Assumption: $c'(q) \geq 0 \geq p'(q)$.

B) Pure Monopoly cont.

- Objective function: Profit maximization
- $\max_q \Pi(q) = q\, p(q) - c(q)$

$\Rightarrow$ First order condition: (MR =) $p + q\, p'(q) = c'(q)$

- **Price elasticity of demand** $\varepsilon = -(dq/dp)(p/q)$
- **Amoroso-Robinson** Relation:
- $$p\left[1-\frac{1}{\varepsilon}\right] = c'(q)$$
- Optimum: $\varepsilon > 1$ must hold.
- **Lerner index:** $$\frac{p(q)-c'(q)}{p(q)} = \frac{1}{\varepsilon}$$

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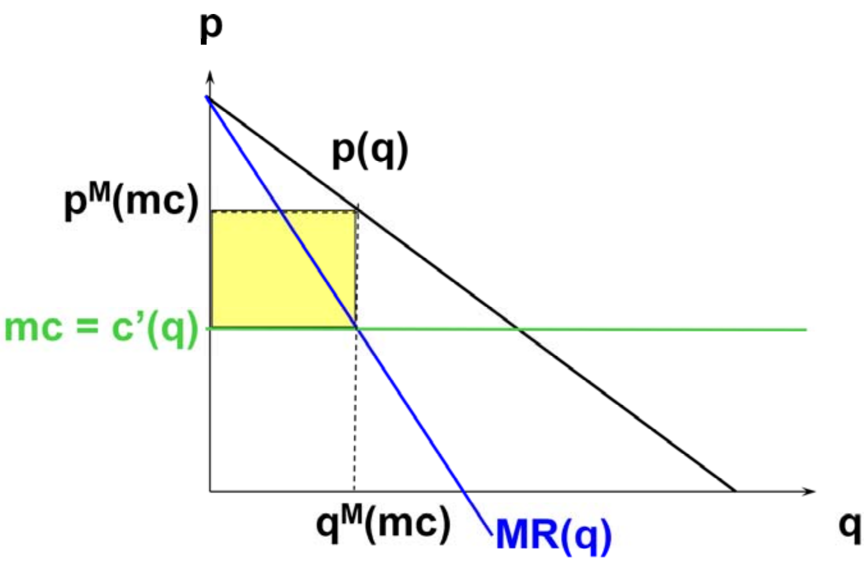
Elasticity defined in absolute (=positive) terms!

B) Pure Monopoly cont.



Yellow area: producer surplus (if there are fixed costs)! = profit + fixed costs

B) Efficiency

- What is *efficiency?*

  no reallocation of the available resources makes one economic agent better off without making some other economic agent worse off
- Need a measure of well-being
  - ***consumer surplus:*** difference between the maximum amount a consumer is willing to pay for a unit of a good and the amount actually paid for that unit
  - aggregate consumer surplus is the sum over all units consumed and all consumers
  - ***producer surplus:*** difference between the amount a producer receives from the sale of a unit and the amount that unit costs to produce
  - aggregate producer surplus is the sum over all units produced and all producers
  - ***total surplus*** = consumer surplus + producer surplus

Can we reallocate resources to make some individuals better off without making others worse off?

B) Consumers surplus

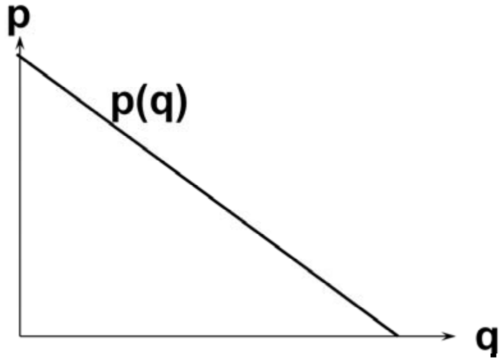
- Demand and inverse demand function

$$q = D(p) = q(p); \quad p = D^{-1}(q) = p(q)$$

- Consumers Surplus

$$S(p_0, \bar{p}) = \int_{p_0}^{\bar{p}} q(c)dc =$$

$$= \int_0^{q(p_0)} p(c)dc - p_0 q(p_0)$$



Calculate example with linear demand!

B) Canonical partial equilibrium model

- Optimization problem of representative consumer with quasilinear utility

  max $W(q_0,q) = q_0 + U(q)$

  s. t. $q_0 + pq \leq I$
- U increasing and concave in $q = (q_1,\ldots,q_n)$
- q_0 Numeraire good, I income, assumed to be large enough ($q_0 \geq 0$)

⇒ Optimization problem:

⇒ Lagrangean: Lagrange multiplier: $\lambda = 1$!

⇒ $\text{argmax}_q\ W(I,q) = I + U(q) - pq = \text{argmax}_q\ U(q) - pq$

⇒ $CS(q) = W(I,q) - I = U(q) - pq$

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λ: Marginal utility of income

CS: monetary measure of utility. With quasi-linear utility this coincides with (indirect) utility function (see next page).

CS: extra utility from existence of products q

Example for U(q1): a q1 – 0.5 b q1^2

Alternative: linear-quadratic with differentiated products:

U(q1,q2)=a q1 – 0.5 b q1^2+a q2 – 0.5 b q2^2 - s q1 q2

B) Canonical partial equilibrium model

- max $U(q) - pq$

$\Rightarrow \quad \dfrac{\partial U}{\partial q_i} = p_i$

$\Rightarrow \quad \partial p_i / \partial q_j = \partial p_j / \partial q_i \qquad \partial p_i / \partial q_i < 0$

$\Rightarrow$ Symmetric cross effects and downward sloping demand follow from negative definite Hessian of *U*

$\Rightarrow$ Maximum value function (indirect utility) $\Rightarrow$ CS

$\Rightarrow$ $CS(p) = U(D(p)) - pD(p)$

$\Rightarrow$ Envelope theorem:

$$\partial CS / \partial p_i = \sum_{j=1}^{n} \left(\frac{\partial U}{\partial q_j} - p_j \right) \frac{\partial q_j}{\partial p_i} - D_i(p) = -D_i(p)$$

$\Rightarrow$ Quasilinear utility: no income effects

Individual consumer surplus can be aggregated to representative consumers (Vives, p. 77)

Share of goods in question in terms of total income needs to be small in order to justify assumption!

Imortant point from envelope theorem: How does welfare (utility increase) if the price changes marginally!

B) Canonical partial equilibrium model

- Consequences and special cases
  - consumers can be aggregated to representative consumer

$$CS(p) + I = \sum_{h=1}^{H} CS^h(p) + \sum_{h=1}^{H} I^h$$

  - Special case: Additively separable utility function across products

$$U(q) = \sum_{i=1}^{n} u_i(q_i)$$

$\Rightarrow$ $\partial u_i / \partial q_i = p_i$ No cross price effects

$\Rightarrow$Consumer surplus = sum of area under independent demand functions

$$CS(p_1,\ldots,p_n) = \sum_{i=1}^{n} \int_{p_i}^{\bar{p}_i} q_i(t)\,dt$$

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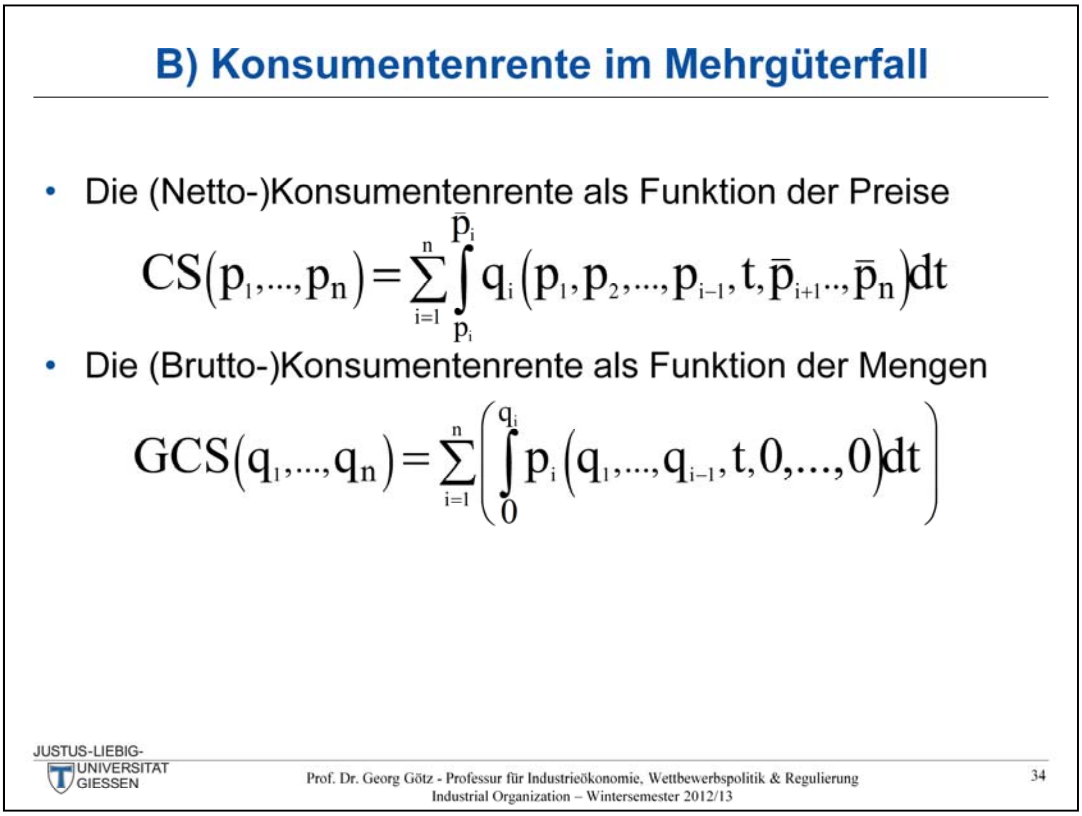
Separable functions often assumed when analysing Ramsey prices. Different user groups or user times; local vs. long-distance calls.

Hwo does utility function look like for independent linear demand?



Advanced topic which won‘t be covered

Message of this part: Consumer surplus in multi-product case is not a simple sum of integrals over demand curves.

see Vives, Appendix, pp. 85.

Achtung: Konsumentenrente unter Vorbehalt! Der spezifizierte Preisänderungspfad sollte funktionieren.

Zur Konsumentenrente im Mehrproduktfall siehe: Crew, Kleindorfer, Public utility economics, Chapt. 2.

Siehe auch Vives, Review of Economic studies, 1987

Überprüfen bei linear-quadratischer Nutzenfunktion!

B) Konsumentenrente im Mehrgüterfall

- Zentrale Eigenschaft: Die Ableitung nach dem Preis (der Menge) eines Gutes i ergibt die Nachfrage (den Preis = Zahlungsbereitschaft) in Bezug auf dieses Gut

$$\frac{\partial CS(p_1,\dots,p_n)}{\partial p_i} = -\,q_i\left(p_1,p_2,\dots,p_{i-1},p_i,p_{i+1}\dots,p_n\right)$$

$$\frac{\partial GCS(q_1,\dots,q_n)}{\partial q_i} = p_i\left(q_1,\dots,q_{i-1},q_i,q_{i+1},\dots,q_n\right)$$

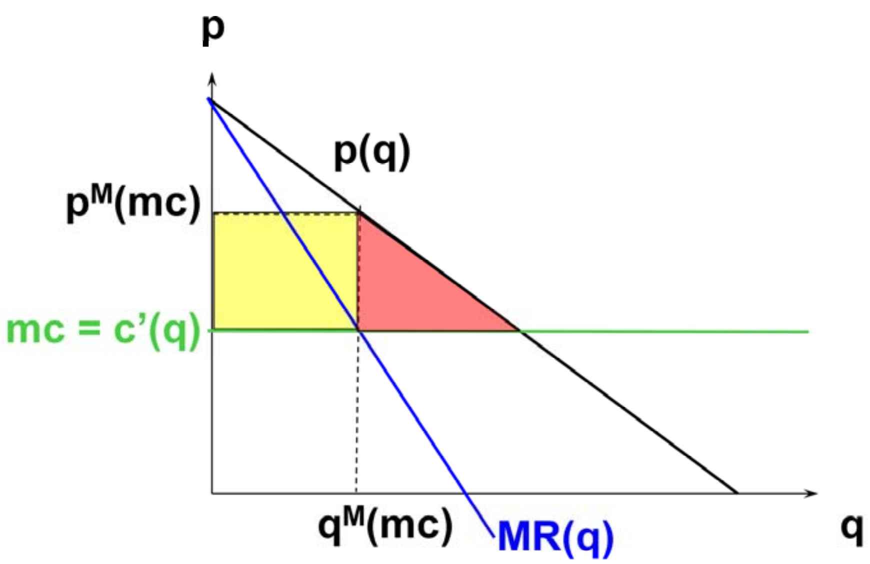
Beweisskizze: Die Ableitungen der ersten i-1 Integrale

B) Properties of market equilibrium under perfect competition

- Technical Efficiency
  - ⇒ Total social cost of production is minimized
  - ⇒ Production at MES in LRE

⇒ Allocative Efficiency
  - ⇒ Each consumer who is willing to pay the marginal social cost of production obtains the good
  - ⇒ total surplus is maximum.

B) Deadweight loss of Monopoly



Yellow area: producer surplus (if there are fixed costs)! = profit + fixed costs

Red area: dead weight loss (DWL)

B) Deadweight loss of Monopoly (cont.)

- Why can the monopolist not appropriate the deadweight loss?
  - Increasing output requires a reduction in price
  - *this assumes that the same price is charged to everyone.*
- The monopolist bases her decisions purely on the surplus she gets, *not* on consumer surplus (nevertheless some surplus goes to consumers)
- The monopolist undersupplies relative to the competitive outcome

  $\Rightarrow$ Allocative inefficiency: some consumers have a willingness to pay greater than the social cost of production but are not served by the monopoly.
- Distributional concerns: market power shifts surplus from consumers to firm owners
- The primary problem: ***the monopolist is large relative to the market***

Durable Goods and the Coase Conjecture

- Durability may reduce the monopolists ability to set prices above the current level
- Consider 2 periods and a monopolists with 2 units of a durable good
- One consumer values it at $50 per period the other at $30
- The ***discount factor*** is defined as R = 1/(1 + r)
- Buying in the first period yields (1+R) times their valuation
- Can either sell 2 in the first, one in the first and one in the second, or 2 in the second
  - (selling only 1 in the second yields $50, but selling 2 yields 2*30)
  - So price in the second period will always be $30

Famous 1945 US Supreme Court case concerning Alcoa, which had 90 percent market share (see Tirole, p. 79) (Aluminium recycling)

Discussion could also be put under the headline of intertemporal price discrimination

Note first that it would pay in the example to have intertemporal price discrimination if selling to the high value consumer at her valuation in period 1 and to the low value consumer in period 2.

Durable Goods and the Coase Conjecture

- If a monopolists tries to extract surplus by selling one at (1+R)50 in the first period, the high-value consumer is better off waiting and getting 50 - 30 in the second period
- At an in between price:
  - At the price $(1+R)(30+\varepsilon)$ the high-value consumer gets $(1+R)(20 - \varepsilon)$, but if she waits, she gets a surplus of R (50 - 30)
  - For her to buy in the first period it must be that $(1+R)(20-\varepsilon) > R\ 20$ or $\varepsilon < 20/(1+R)$

Durable Goods 3

- If a monopolist sells just 1 good in the first period she makes
  $(1+R)(30+20/(1+R)) +R *30=50+60*R$
  which is less than if she sells both in the 1st period $2* (1+R)30$
- So the market is efficient and there is no deadweight loss
- Durable goods do not always take away monopoly power:
  - If the low value consumer valued it at 20, then even with two goods remaining in the 2nd period the monopolist would prefer to sell just 1 ($50>2*20$)
  - So the high value consumer has no incentive to wait and the monopolist can extract all the consumer surplus

Note: leasing often helps if monopolist faces this problem (but not in the example here): Leasing can assure the high value type that he gets the bargain in later periods.

A Non-Surplus Approach

- Working off the previous example (low value consumer values at 20)

$\Rightarrow$ Inefficiency as one unit is not sold in first period

- Monopolist still owns two units of a valuable good
- What if there were 2 high-value consumers?
- Both units would be sold at (1+R)50; no deadweight loss
- Why not? **Monopolist is *small* relative to the market.**

Example: Capacity constraints in the Bayreuth festival or at a football stadium such as Old Trafford (ManU)

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C) The Neoclassical View of the Firm

- Concentrate upon a neoclassical view of the firm
  - the firm *transforms* inputs into outputs

- There is an alternative approach (Coase)
  - What happens *inside* firms?
  - How are firms structured? What determines size?
  - How are individuals organized/motivated?

Black box view of the firm.

Transaction cost literature: Coase, Williamson, Hart, Moore.

Agency literature: Milgrom Roberts, 1992

Institutionenökonomik (Albert)

We abstract from these problems, and assume simply that firms maximize profits and have no problems to produce along the efficiency frontier (= production function).

C) The Single-Product Firm

- Constraint of the firm: Technology
  - ⇒ ***production function***: how inputs are transformed into output
  - ⇒ n inputs at levels $x_1, x_2, \ldots, x_n$. The production function, assuming a single output q, is written:
  - ⇒ $q = f(x_1, x_2, x_3, \ldots, x_n)$
- Profit-maximization in one stage (assume perfect competition)

$$\underset{x_i}{\text{Maximize}} \quad pq - \sum_{i=1}^{n} w_i x_i \qquad \text{subject to } q = f(x_1, x_2, x_3, \ldots, x_n)$$

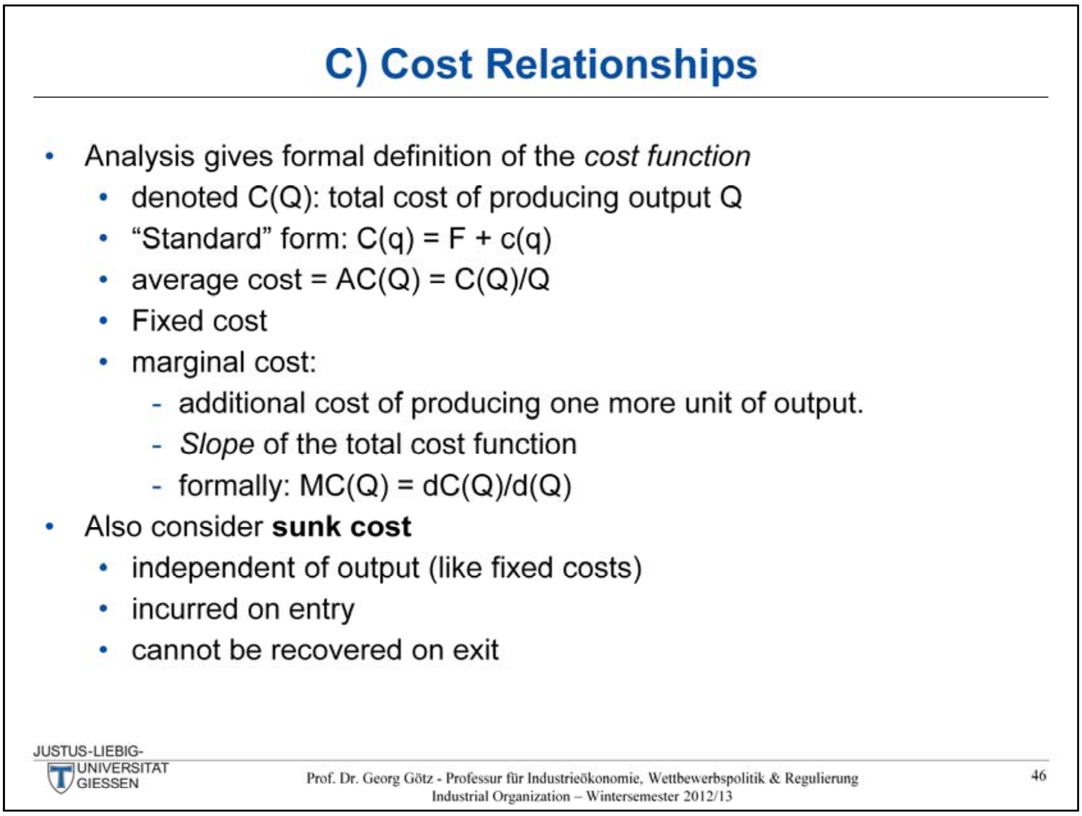
- Profit-maximization in two stages
  - minimize the cost of producing a given level of output
  - ⇒ cost function: relationship between output choice and production costs. Find input combination that minimizes cost, given output q_1

$$\underset{x_i}{\text{Minimize}} \quad \sum_{i=1}^{n} w_i x_i \quad \text{subject to } f(x_1, x_2, x_3, \ldots, x_n) = q_1$$

⇒Maximize profit by output choice s.t. cost function

Review!

Profit maximization in one stage is only simple under perfect competition, with monopoly and even more oligopoly two stage procedure is much simpler.



Marginal costs: often we assume constant marginal cost.

Fixed cost: Rent of office building

Sunk costs: digging the Eurotunnel, advertisements expenditures at product introduction. Important for asymmetry between incumbents and potential entrants

This analysis has interesting implications
different input mix across
time: as capital becomes relatively cheaper
space: difference in factor costs across countries

C) Cost Relationships 2

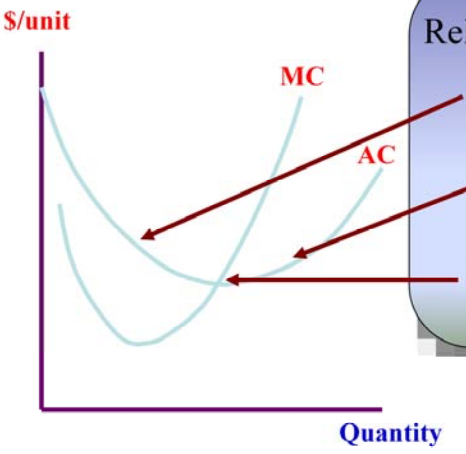
- The relationship between average and marginal cost is

$$\frac{dAC(q)}{dq} = \frac{d[C(q)/q]}{dq} = \frac{qC'(q) - C(q)}{q^2} = \frac{q[MC(q) - AC(q)]}{q^2}$$

- So average cost is increasing whenever it is less than marginal cost.
- Average costs are at a minimum, when MC = AC

C) Cost curves: an illustration

Typical average and marginal cost curves



Relationship between AC and MC
If MC < AC then AC is falling
If MC > AC then AC is rising
MC = AC at the minimum of the AC curve

C) Cobb Douglas Cost Minimization

- A common production function is Cobb-Douglas

$$q = x_1^\alpha x_2^\beta$$

- The associated Lagrangian function is:

$$L = w_1 x_1 + w_2 x_2 - \lambda \left(q - x_1^\alpha x_2^\beta \right) + F$$

Which gives the first-order conditions

$$\frac{\partial L}{\partial x_1} = w_1 - \lambda \alpha x_1^{\alpha-1} x_2^\beta \quad \Rightarrow \quad w_1 x_1 = \lambda \alpha q$$

$$\frac{\partial L}{\partial x_2} = w_2 - \lambda \beta x_1^\alpha x_2^{\beta-1} \quad \Rightarrow \quad w_2 x_2 = \lambda \beta q$$

$$\frac{\partial L}{\partial \lambda} = q - x_1^\alpha x_2^\beta$$

Refresher of intermediate Micro! You should be familiar with the Lagrange approach and how to derive cost functions.

C) Cost Minimization 2

- These equations give

  $w_1x_1 + w_2x_2 = \lambda(\alpha+\beta)q$ for total costs and

$$\left(\frac{w_1x_1}{\alpha}\right)^{\alpha} = \lambda^{\alpha}q^{\alpha}$$

$$\left(\frac{w_2x_2}{\beta}\right)^{\beta} = \lambda^{\beta}q^{\beta}$$

$$\lambda = \left(\frac{w_1}{\alpha}\right)^{\frac{\alpha}{\alpha+\beta}}\left(\frac{w_2}{\beta}\right)^{\frac{\beta}{\alpha+\beta}} q^{\frac{1}{\alpha+\beta}-1}$$

Which gives total costs:

$$C(w_1, w_2, q) = \left(\frac{w_1}{\alpha}\right)^{\frac{\alpha}{\alpha+\beta}}\left(\frac{w_2}{\beta}\right)^{\frac{\beta}{\alpha+\beta}}(\alpha+\beta)q^{\frac{1}{\alpha+\beta}} + F$$

C) Average Costs

Average cost *AC*, Average variable cost *AVC*, and average fixed costs *AFC*

$$AC(q) = \frac{(w_1 x_1 + w_2 x_2) + F}{q} = \left(\frac{w_1}{\alpha}\right)^{\frac{\alpha}{\alpha+\beta}} \left(\frac{w_2}{\beta}\right)^{\frac{\beta}{\alpha+\beta}} (\alpha+\beta) q^{\frac{1}{\alpha+\beta}-1} + \frac{F}{q}$$

$$AVC(q) = \frac{(w_1 x_1 + w_2 x_2)}{q} = \left(\frac{w_1}{\alpha}\right)^{\frac{\alpha}{\alpha+\beta}} \left(\frac{w_2}{\beta}\right)^{\frac{\beta}{\alpha+\beta}} (\alpha+\beta) q^{\frac{1}{\alpha+\beta}-1}$$

$$AFC(q) = \frac{F}{q}$$

C) Marginal Cost

- Marginal cost is the increase in cost resulting from a small change in output
  - ***MC(q) = dC(q)/dq.***
- In Cobb-Douglas, we have:

$$MC(q) = \frac{dC(q)}{dq} = \left(\frac{w_1}{\alpha}\right)^{\frac{\alpha}{\alpha+\beta}} \left(\frac{w_2}{\beta}\right)^{\frac{\beta}{\alpha+\beta}} q^{\frac{1}{\alpha+\beta}-1}$$

Note: MC = λ

C) Cost and Output Decisions

- Marginal costs
  - ⇒Determine (together with MR) how much output the firm produces
- Average costs
  - ⇒Determines whether firm produces positive amount
  - ⇒*shut-down decision*
- Sunk costs
  - ⇒Determines whether firm enters the market
  - ⇒Enter if price is greater than average total cost
    - must expect to cover sunk costs of entry

Role of and importance of various categories of costs!

Potential source of sunk costs:

Indivisibilities which are highly specialized with little value in other uses

market research expenditures

rail track between two destinations

The latter are *sunk costs*: nonrecoverable if production stops

Sunk costs affect market structure by affecting entry

C) Economies of scale (EOS)

- Definition: average costs fall with an increase in output
- Represented by the *scale economy index*

$$S = \frac{AC(Q)}{MC(Q)}$$

- $S > 1$: economies of scale
- $S < 1$: diseconomies of scale
- S is the inverse of the elasticity of cost with respect to output

$$\eta_C = \frac{dC(Q)}{C(Q)} \Big/ \frac{dQ}{Q} = \frac{dC(Q)}{dQ} \Big/ \frac{C(Q)}{Q} = \frac{MC(Q)}{AC(Q)} = \frac{1}{S}$$

C) Economies of scale

- Note: Different from: Returns to scale (RTS)
  - RTS defined w.r.t. production function
  - RTS => EOS but reverse does not hold in general
- Sources of economies of scale
  - "the 60% rule": capacity related to volume while cost is related to surface area (Pipeline)
  - product specialization and the division of labor
  - "economies of mass reserves": economize on inventory, maintenance, repair
  - indivisibilities

Question (to students): Which of the sources of EOS are due to RTS?

Indivisibilities make *scale of entry* an important strategic decision:

enter large with large-scale indivisibilities: heavy overhead

enter small with smaller-scale cheaper equipment: low overhead

Some indivisible inputs can be redeployed

Aircraft: movie "The terminal": Filmed at the assembly hangar of former aircraft production site. => not sunk

C) Natural Monopoly and sub-additivity

- Sub-additivity of the cost function

$$c(q) < \sum_{i=1}^{n} c(q_i) \qquad \text{where} \qquad q = \sum_{i=1}^{n} q_i$$

  - Sub-additivity => “Natural monopoly”

    ⇒Industry output *q* can be supplied cheaper by one firm than by two or more firms
  - Sub-additivity does not (necessarily) imply falling average costs!

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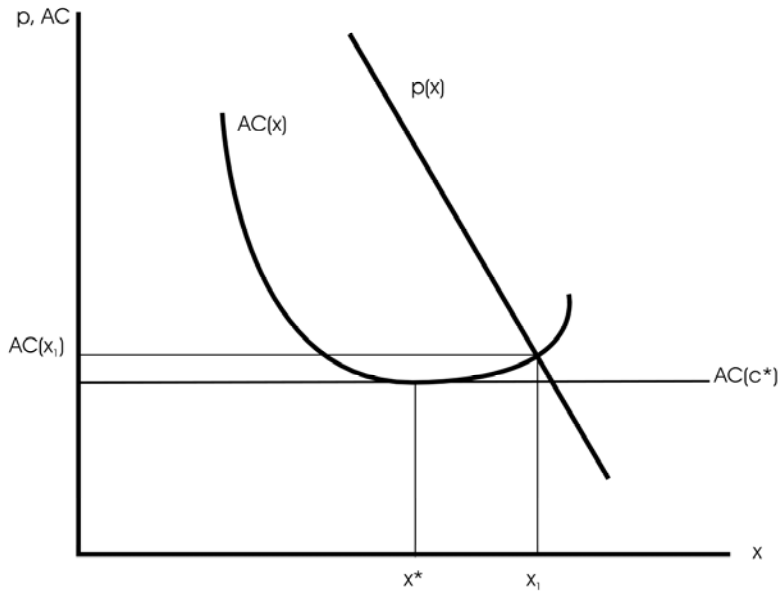
This and next slide from Clemenz, Mueller, p. 12 f.

C) Natural Monopoly and subadditivity cont.



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Example for: Subadditivity does not (necessarily) imply falling average costs

Another point: Importance of EOS: If they are large (compared to market size measured by demand!), market tends to be concentrated!

C) Sunk Costs and Market Structure

- The greater are sunk costs the more concentrated is market structure
- An example:

Suppose that elasticity of demand $\eta = 1$

Then total expenditure $E = P.Q$

If firms are identical then $Q = Nq_i$

Suppose that $LI = (P - c)/P = A/N^{\alpha}$

Lerner Index is inversely related to the number of firms

Suppose firms operate in only on period: then $(P - c)q_i = K$

As a result: $$N^e = \left[\frac{AE}{K}\right]^{\frac{1}{1+\alpha}}$$

N: number of firms, K: sunk costs, A and α: Parameters
Sunk costs similar to EOS, but accrue only at entry. After the inititial stage firms make positive operating profits, but these are necessary to cover sunk entry costs. Firms need to make higher operating profits and therefore to charge higher prices if sunk costs are higher. Higher market power is inevitable with higher sunk costs!

Discussion of alpha: As soon as alpha > 0, LI decreases with increase in N and equilibrium number of firms is increasing at a decreasing rate with market size (=total expenditure) (=concave in E).

Under monopolistic competition with a continuum of firms, alpha is 0 and N proportional to E.

C) Multi-Product Firms

- Many firms make multiple products
  - Ford, General Motors, 3M, ÖBB, Telekom Austria etc.
- What do we mean by costs and output in these cases?
- How do we define *average costs* for these firms?
  - total cost for a two-product firm is $C(Q_1, Q_2)$
  - marginal cost for product 1 is $MC_1 = \partial C(Q_1,Q_2)/\partial Q_1$
  - but average cost cannot be defined fully generally
  - need a more restricted definition: ***ray average cost***

  => See Economics of Regulation course for further discussion

C) Economies of Scope (EoScope)

- Definition: EoScope exist if it is less costly to produce a set of products in one firm than in two or more firms
- Formal definition (for the two goods case):
- EoScope exist if $C(Q_1, 0) + C(0, Q_2) - C(Q_1, Q_2) > 0$

$$S_C = \frac{C(Q_1, 0) + C(0, Q_2) - C(Q_1, Q_2)}{C(Q_1, Q_2)}$$

- The critical value in this case is $S_C = 0$
  - $S_C < 0$: no economies of scope; $S_C > 0$: economies of scope.

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In the context of multiproduct firms, EoScope are the more interesting concept!

C) Economies of Scope (cont.)

- Sources of economies of scope
- shared inputs
  - same equipment for various products
  - shared advertising creating a *brand name*
  - marketing and R&D expenditures that are generic
- cost complementarities
  - producing one good reduces the cost of producing another
  - oil and natural gas
  - oil and benzene
  - computer software and computer support
  - retailing and product promotion

Examples: cow, sheeps, etc.

marketing and R&D expenditures that are generic: generic hier im Sinne einer übergeordneten Kategorie : Mercedes (Stern);

-Player Shared inputs: Handy inkl. Photoapparat und MP3.

C) Flexible Manufacturing

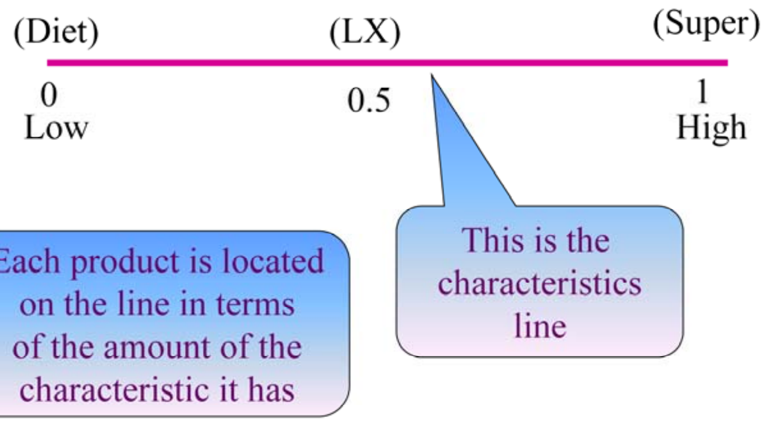
- Extreme version of economies of scope
- Changing the face of manufacturing
- "Production units capable of producing a range of discrete products with a minimum of manual intervention"
  - *Benetton*
  - *Custom Shoe*
  - *Levi's*
  - *Mitsubishi*
- Production units can be switched easily with little if any cost penalty
  - *requires close contact between design and manufacturing*

C) Flexible Manufacturing 2

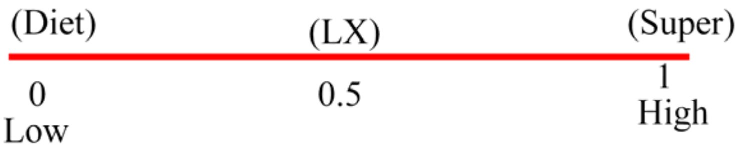
- Take a simple model based on a spatial analogue.
  - There is some characteristic that distinguishes different varieties of a product
    - sweetness or sugar content
    - color
    - texture
  - This can be measured and represented as a line
  - Individual products can be located on this line in terms of the quantity of the characteristic that they possess
  - One product is chosen by the firm as its base product
  - All other products are variants on the base product

C) Flexible Manufacturing 3

- An illustration: soft drinks that vary in sugar content



C) Flexible Manufacturing 4



- Assume that the process is centered on LX as base product.
- A switching cost *s* is incurred in changing the process to either of the other products.
- There are additional marginal costs of making Diet or Super - from adding or removing sugar. These are r per unit of “distance” between LX and the other product.
- There are shared costs F: design, packaging, equipment.

C) Determinants of Market Structure

- Economies of scale and scope affect market structure but *cannot be looked at in isolation*.
- They must be considered *relative to market size*.
- Should see concentration decline as market size increases
  - Entry to the medical profession is going to be more extensive in Chicago than in Oxford, Miss
  - Find more extensive range of financial service companies in Wall Street, New York than in Frankfurt

See Bresnahan/Reiss (1991)

Sutton! Important point: Sunk costs may change (ie. increase) with market size. Expenditure on advertising!

C) Network Externalities

- Market structure is also affected by the presence of network externalities
  - willingness to pay by a consumer increases as the number of current consumers increase
    - telephones, fax, Internet, Windows software
    - utility from consumption increases when there are more current consumers
- These markets are likely to contain a small number of firms
  - even if there are limited economies of scale and scope

⇒ demand-side economies of scale!

C) The Role of Policy

- Government can directly affect market structure
  - by limiting entry
    - taxi medallions in Boston and New York
    - airline regulation
  - through the patent system
  - by protecting *competition* e.g. through the Robinson-Patman Act

C) Empirical Application: Cost Minimization and Cost Function Estimates

Consider simple cost minimization problem:

- **Minimize: $C = wL + rK$;**
- **Subject to: $Q = K^{\alpha}L^{\beta}$**

From Production Constraint: $L= Q^{1/\beta}K^{\alpha/\beta}$

Substitution yields: $C = wQ^{1/\beta}K^{\alpha/\beta} + rK$

Minimizing for given Q with respect to K and then substituting into the cost equation yields:

$$C(r,w,Q) = \left(\frac{r}{\alpha}\right)^{\frac{\alpha}{\alpha+\beta}} \left(\frac{w}{\beta}\right)^{\frac{\beta}{\alpha+\beta}} (\alpha+\beta)Q^{\frac{1}{\alpha+\beta}}$$

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This is the solution of the cost minimization problem from page 48 by means of an alternative approach, the substitution method.

Empirical Application: Cost Minimization and Cost Function Estimates 2

In logs, we have:

$$\ln C = \text{Constant} + \frac{\alpha}{\alpha+\beta}\ln r + \frac{\beta}{\alpha+\beta}\ln w + \frac{1}{\alpha+\beta}\ln Q$$

In general, we have:

$$\ln C = \text{Constant} + \delta_1 \ln r + \delta_2 \ln w + \delta_3 \ln Q$$

A more flexible specification is the translog form

$$\ln C = \text{Constant} + \delta_1 \ln r + \delta_2 \ln w + 0.5[\delta_{11}(\ln r)^2 + \delta_{12}(\ln w)(\ln r) + \delta_{21}(\ln w)(\ln r) + \delta_{22}(\ln w)^2] + \delta_3 \ln Q + \delta_{31}(\ln Q)(\ln r) + \delta_{32}(\ln Q)(\ln w) + 0.5\delta_{33}(\ln Q)^2$$

Not part of the lecture! Particularly interessant for students also doing the Econometrics course. Not relevant for the final exam. However, you should know how to obtain the first equation. Just taking logs of the Cobb-Douglas production function.

Empirical Application: Cost Minimization and Cost Function Estimates 3

- **The translog function is more flexible because it does not restrict the underlying production technology to be Cobb-Douglas. Its general form is consistent with many other plausible technologies**
- **The scale economy index is now** $S = 1/\frac{\ln C}{\ln Q}$

  $= 1/(\delta_3 + \delta_{33}\ln Q + \delta_{31}\ln r + \delta_{32}\ln w)$

  So long as δ_{31}, δ_{32}, and δ_{33} do not all equal zero, S will depend on the level of output Q

This is one of the many restrictions on the data that can be tested empirically with the translog functional form

Not part of the lecture! Particularly interessant for students also doing the Econometrics course. Not relevant for the final exam.

Empirical Application: Cost Minimization and Cost Function Estimates 4

- A pioneering use of the translog approach was the study by Christensen and Greene (1976) on scale economies in electric power generation
  - They assume three inputs: Labor (paid *w*); capital (paid *r*); and Fuel (paid *F*). So, they have five explanatory or right-hand-side variables
    - a pure output term
    - an interaction term of output and *r*
    - an interaction term of output and *w*
    - an interaction term of output and *F*
    - a pure output squared term
  - Results shown on next slide

Not part of the lecture! Particularly interessant for students also doing the Econometrics course. Not relevant for the final exam.

Empirical Application: Cost Minimization and Cost Function Estimates 5

Variable	Coefficient	t-statistic
(ln Q)	0.587	20.87
(ln Q)(ln r)	–0.003	–1.23
(ln Q)(ln w)	–0.018	–8.25
(ln Q)(ln F)	0.021	6.64
$(\ln Q)^2$	0.049	12.94

- All the variables are statistically significant indicating among other things that the scale economies depend on the output level and disappear after some threshold is reached
- Christensen and Greene (1976) find that very few firms operate below this threshold

Not part of the lecture! Particularly interessant for students also doing the Econometrics course. Not relevant for the final exam.