Microeconomics

External effects and environmental economics

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Structure

Introduction

- Household theory
- Theory of the firm
- Perfect competition and welfare theory
- Types of markets
- External effects and public goods
  - **External effects and environmental economics**
  - Public goods

Pareto-optimal review

Robinson

- I plan an action (playing computer games in the evening):
  - Computer game A or B, both already bought
  - quiet, no neighbor is bothered.
- My decision does not concern other people.
- Social advantageousness = private advantageousness

External effects

Examples

positive	pleasure in a neighbor's garden
negative $\rightarrow$ **external cost**	smoking
unilateral	reduction of fish population due to waste water
mutual	mutual benefit of fruit growing and beekeeping
monetary	demand for one good increases price for that good and also for other goods
non-monetary	all other examples given so far

Overview "external effects"

- General model of external effects
- Monetary external effects versus theft
- Governmental solutions for non-monetary external effect
  - Regulation
  - Pigou tax or Pigou subsidy
  - Certificates
- Property rights and negotiations (Coase theorem)
- Applications
  - Cournot monopoly
  - Cournot duopoly
  - Pharmaceutical company versus fishermen

General model of external effects

Definition of external effects

Definition (external effects)

interference between economic subjects beyond market relations

- For individual A action a yields utility

$$U_A(a).$$

- Action a also influences the utility of B,

$$U_B(a).$$

General model of external effects

Definition of external effects

- Positive external effect:

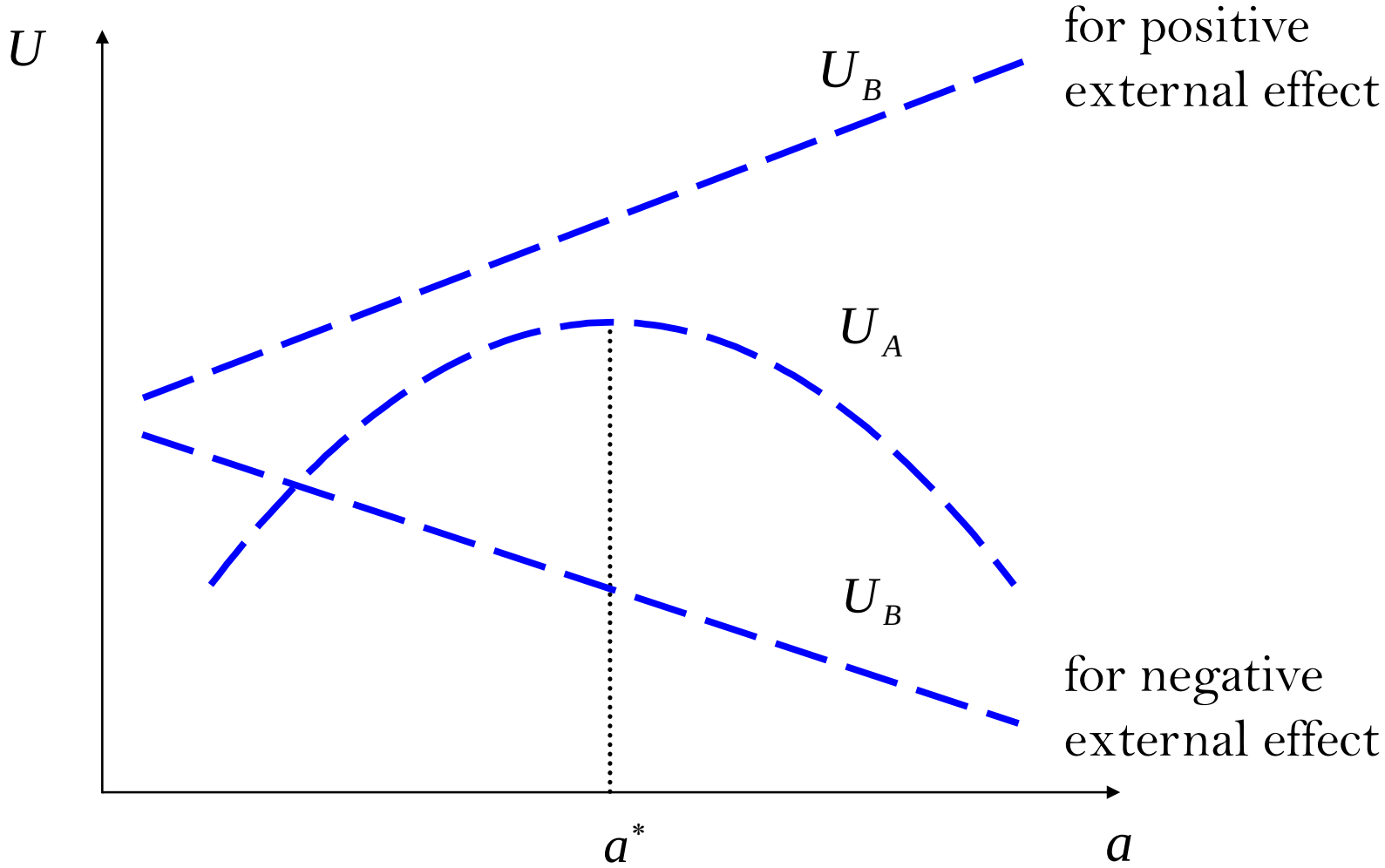
$$\frac{dU_B(a)}{da} > 0$$

- Negative external effect:

$$\frac{dU_B(a)}{da} < 0$$

General model of external effects

Definition of external effects



General model of external effects

Definition of external effects

- **Unilateral** external effect:
  - U_B depends on b and a, *but*
  - U_A does not depend on b
- **Mutual** external effect: U_A and U_B depend on a and b
- External effects may be **pecuniary** (e.g., demand that increases the price for others) or non-pecuniary

General model of external effects

Missing Pareto efficiency

- Individual A chooses action a without consideration of the other individual.
- Optimal action from A's point of view is a^*.
- For the optimal value

$$\left.\frac{dU_A(a)}{da}\right|_{a^*} = 0$$

holds.

$\Longrightarrow$ At a^* a small change of the action does not change A's utility.
$\Longrightarrow$ If the action exerts an external effect, a Pareto improvement is possible.

General model of external effects

Missing Pareto efficiency

	positive external effect of action a	negative external effect of action a
external effect is present if	$\frac{dU_B(a)}{da} > 0$	$\frac{dU_B(a)}{da} < 0$
Pareto optimality requires	$a^{opt} > a^*$	$a^{opt} < a^*$
remedy is provided by (e.g.)	negative tax (subsidy)	tax

Monetary external effects

Example house sale

- I (A) want to sell my house.
- As a consequence, my neighbor (B), who also wants to sell his house, suffers a loss of 5000 Euro.
  $\Rightarrow$ monetary external effect

But:

- on the one hand, my neighbor (B) looses 5000 Euro
- on the other hand, the buyer C gains 5000 Euro

Net profit of all three parties involved = my net profit

Monetary external effects

Generalization

On markets with monetary external effects, only, typically net profit of the individual decides on social advantageousness.

Competition is no crime and no reason for compensation

Monetary external effects

Theft

A thief (A) steals a hundred Euro from me (B).

- On the one hand, I loose 100 Euro
- On the other hand, the thief gains 100 Euro

Net profit equals zero $\Rightarrow$ no problem?

Why is theft still considered a crime?

Theft is no monetary effect!

Monetary external effect:
Action of A leads to a transfer from B to C
$\Rightarrow$ competition

Theft:
Action of A leads to a transfer from B to A

Theft versus newspaper delivery (perfect competition)

Theft does not pay

- If a good worth 100 Euro can be stolen with expenses of 50 Euro, theft is beneficial.
- The number of people delivering newspapers (e.g.!!) decreases, while the number of thieves increases.
- The number of objects that can easily be stolen decreases and
- the hourly gain of a thieve decreases as long as
- the thieve is indifferent between newspaper delivery and theft.

Hence, expenses for the most clumsy thieve equal his value of the object.

Theft versus newspaper delivery (perfect competition)

Theft is harmful for society

Additionally: In many cases the value of an object is higher for the former owner than for the thieve.

- Therefore, stolen goods are not uncommonly resold to the former owner.
- In particular, this concerns kidnapping.

Protection against theft:

- money in shoes (uncomfortable)
- locks (and key service!)

Rent seeking

Theft and ...

- Subsidies for farmers
- Lower revenue taxes for hoteliers
- New positions for faculty A at the expense of faculty B
- New computers for chair A instead of chair B
- BAFöG for students instead of free places in kindergartens

Non-monetary external effects

Problems

Hotel A is built near another hotel B and shades B's pool.

- Hotel A is built, because (long-run) revenue is larger than construction cost.
- But: Is long-run profit sufficient to compensate the loss of hotel B?

Cattle of farmer A trample on grain of farmer B.

- The cattle is kept because cost of keeping is smaller than revenue from milk and meat.
- But: Is profit sufficient to compensate the loss of farmer B?

Non-monetary external effects

What is the problem?

The problem is not that

- shadow
- environmental pollution

is bad.
Of course, costs are bad, but we are willing to pay them if utility is accordingly high.

The problem of external cost is that decision makers do not consider them.

Consideration of external effects = internalization

Regulation

Examples

- Sachsenspiegel (second book, Art. 52):

  Jeder soll auch seinen Backhofen und seine Esse beschirmen, auf daß die Funken nicht in eines andern Mannes Hof fahren, ihm zu Schaden.

- Today: respect "state of the art":
  - often as general clause, but also
  - put in more concrete terms for certain applications in attachments of laws, in legislative decrees, or in administrative regulations

  Examples
  - Bundes-Immissionsschutzgesetz - BImSchG
  - Wasserhaushaltsgesetz - WHG

Sachsenspiegel

- most important and, together with the Mühlhäuser Reichsrechtsbuch, the oldest book of law in the German Middle Ages
- was created between 1220 and 1235
- Eike von Repgow compilated the Sachsenspiegel from common law that was orally passed down.
- First large document of law in Germany that, instead of Latin, was written in German language.
- No law, but soon still considered an official book of law.

Regulation

Problems

1. Does the regulatory authority want to find the efficient solution?
   - Politicians with influence receive campaign donations.
   - Public agency staff is bribed.
   - Budgetary problems (runtime of nuclear power plants 2010)

2. Even with a good will:
   The regulatory authority cannot necessarily know how to determine the optimal technology.
   - Cost of different technologies
   - Utility of products for consumers

Pigou tax

Abwasserabgabengesetz

§ 1
Grundsatz
Für das Einleiten von Abwasser in ein Gewässer ... ist eine Abgabe zu entrichten (Abwasserabgabe).

Anlage
(zu § 3)
... Einer Schadeinheit entsprechen jeweils folgende volle Messeinheiten

- 25 Kilogramm Stickstoff
- 500 Gramm Blei

§ 9
Abgabepflicht, Abgabesatz
(4) ... Der Abgabesatz beträgt für jede Schadeinheit ... 35,79 Euro

Pigou tax

Basic idea

Environmental taxes give possibilities to polluters:

- pollute and pay
- cease activity
- install retention devices (filter)

Polluters choose the cheapest alternative for the given

- technologies
- environmental taxes
- market chances of products

Pigou tax

Problems

Similar to regulation:

1. Campaign donations, bribes, budgetary problems
2. Fewer informational problems:
   - only determine cost of environmental pollution, but
   - not the cheapest technology for prevention.
3. Possibly also fewer political problems, because laws are
   - related to the pollutants and
   - not related to firms.

Pigou tax

Further applications

Fines for

- parking in no-parking zones
- exceeding speed limits

Jail and death sentence for

- Theft, murder (price in years) $\longrightarrow$ criminal law
- ...

= Pigou theory of criminal law

Certificates

Pigou:
Prices $\rightarrow$ environmental pollution (factor demand)

Certificate:
Pollution rights $\rightarrow$ prices (inverse factor demand)

- sale to highest bidder with
- possibility of resale

- Kyoto protocol: trade of emission rights between countries
- Chicago Climate Exchange (CCX) = trade system from the USA functioning on a voluntary basis since 2003;
  350 firms, universities, and associations have committed to decrease their joint greenhouse emissions by 6%.

Property rights and negotiations (Coase theorem)

- Coase: The Problem of Social Cost (1960)
- Coase versus Pigou
  - Reciprocity
  - Coase theorem
- Why is there environmental pollution?
- Coase + Pigou: two is not better than one!

Coase versus Pigou

Pigou:

- Externalities lead to inefficient results.
- Pigou taxes lead to efficient results.

Coase:

- No,
  not necessarily.
- No,
  in general not.

The problem is not externalities, but transaction cost.

Pigou taxes do not always lead to efficient results

Steel factory versus summerhouse owner

A steel producer causes negative external cost for the owner of summerhouses. The damage does not occur if

- a filter is installed or
- if wood is planted instead of renting summerhouses.

steel production with environmental production	200.000
filter installation	100.000
wood instead of summerhouses	50.000

Pigou tax $\rightarrow$ filter installation (damage/cost: 100.000)
no Pigou tax $\rightarrow$ wood instead of summerhouses (damage: 50.000)

Pigou taxes do not always lead to efficient results

Leipzig-Halle airport versus local residents

- Noise reduction with quieter airplains or quieter runways
- Noise protection for houses
- Change of use: houses $\rightarrow$ loud factories

A priori it is not clear which solution is best.

Reciprocity

A harms B.

But only if B is there.
It takes two to tango.

If A is obligated to compensation, B harms A if she does not move.

Reciprocity II

A runs a factory on his property for 20 years, no complaint from neighbors.

B builds his sensitive sound studio nearby.

B requires that A closes the factory or pays compensation.

What is the best arrangement?

Coase theorem

Two theses

- **Efficiency thesis**: The social optimum is realized if property rights are defined and if there are no transaction cost.
- **Invariance thesis**: The extent of external effects (environmental pollution) is independent of the distribution of property rights.
- **But**: The distribution of profit depends on the distribution of property rights.

Coase theorem

Steel factory versus summerhouse owner

steel production with environmental pollution	200.000
filter installation	100.000
wood instead of summer houses	50.000

- legal regime: pollution allowed
  $\rightarrow$ efficient change of use (wood)
- legal regime: pollution disallowed
  $\rightarrow$ steel factory buys right to pollute from the summerhouse owner for 75.000 Euro.
  $\rightarrow$ efficient change of use (wood)

Coase theorem

Cattle breeder versus grain farmer

- Two agents: cattle breeder and grain farmer
- Cattle tramples grain
  $\Longrightarrow$ negative external effect.
- Loss of the grain farmer depends on the number of cows owned by the cattle breeder.

Coase theorem

Property rights

- **Legal regime: damage disallowed**
  the cattle breeder may damage the grain farmer only with her permission
- **Legal regime: damage allowed**
  the grain farmer can only defend against damage by negotiations; there is no obligation to compensation

Coase theorem

Illustration

herd size	marginal profit of one cow	grain loss	marginal grain loss
1	4	1	1
2	3	3	2
3	2	6	3
4	1	10	4

- marginal grain loss
  = additional loss due to one additional cow
- marginal profit = additional profit of one additional cow

Coase theorem

Review

1. Free trade leads to Pareto efficiency (exchange Edgeworth box).
2. External effects cause efficiency problems.
3. Coase's negotiations solve those problems.
4. For high transaction cost efficiency problems remain.

but

but

but

Why is there environmental pollution?

- efficient environmental pollution because
  cost of prevention are higher than utility
- inefficient environmental pollution because
  high transaction cost prevent reduction:
  100 or 1000 or 10 million victims cannot get together
  to force the steel factory to cease production or install filters

Coase + Pigou

two is not better than one!

steel production with environmental pollution	60.000
filter installation	80.000
wood instead of summerhouses	100.000

Damage allowed or Pigou tax (60.000)
yield (efficient!) environmental pollution

Pigou tax (fine for pollution)
+ Coase (payment for no pollution):

Summerhouse owner pays 30.000 for filter installation
$\rightarrow 80.000 - 30.000 = 50.000 < 60.000$
$\rightarrow$ inefficient prevention of environmental pollution

Pigou tax is correctly applied if

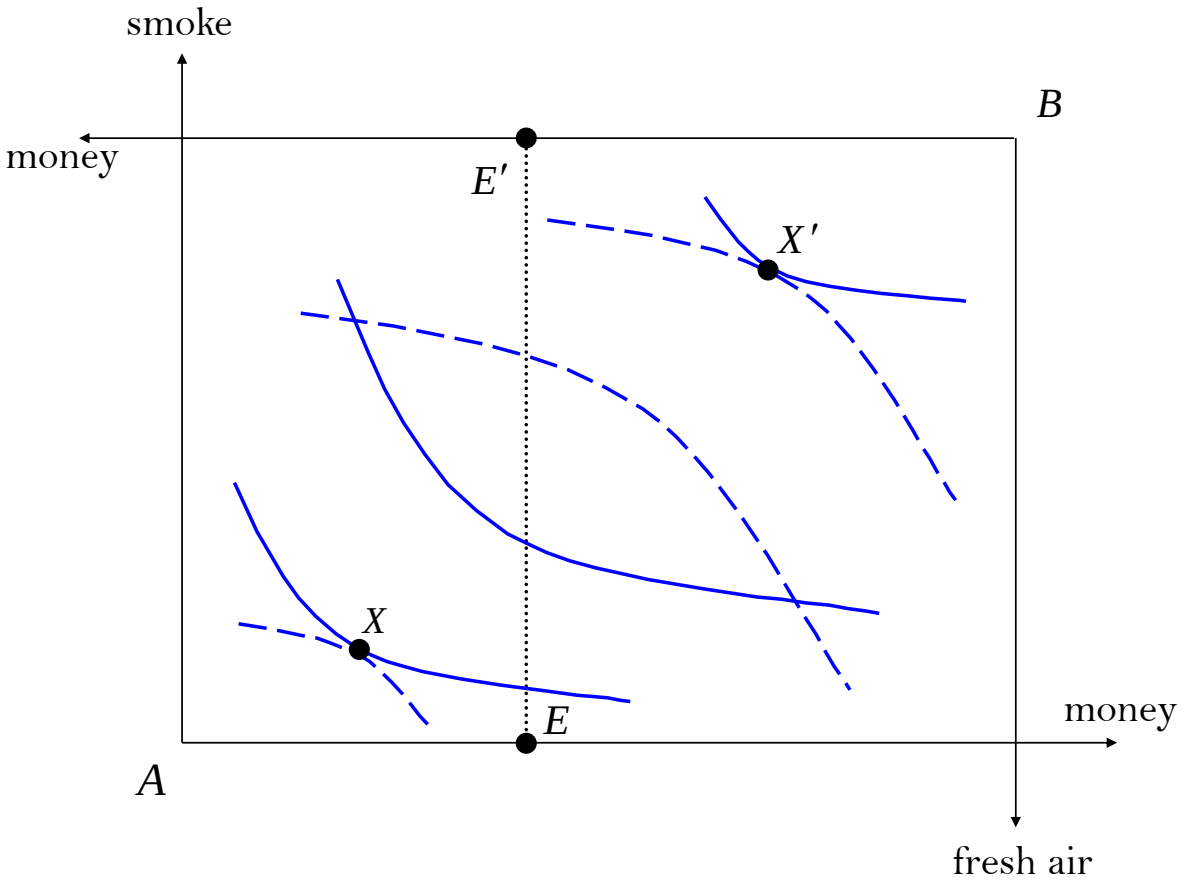
- there are high transaction cost
- it is clear who can solve the problem with lowest cost

$\rightarrow$ air pollution in cities

Smokers versus non-smokers

Two persons live in one room:

- A (smoker)
- B (non-smoker)



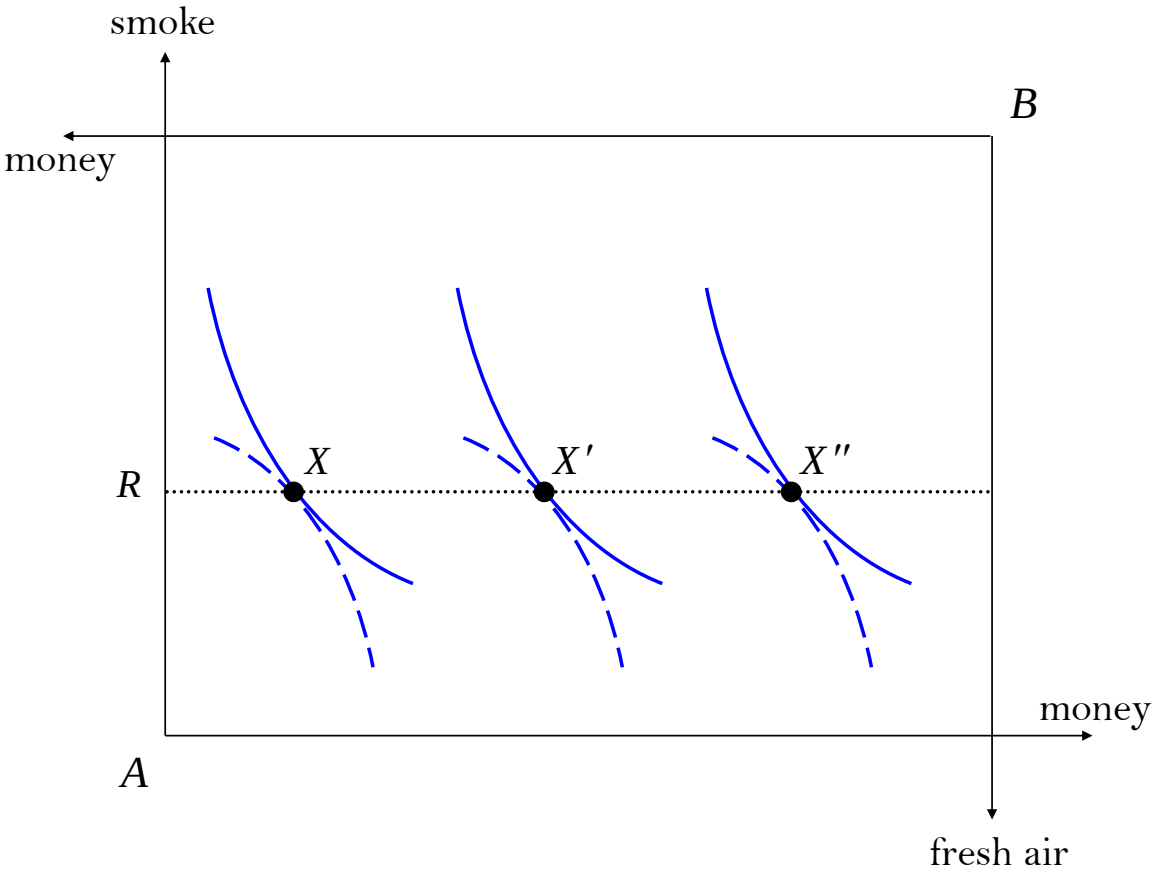
- Efficiency thesis correct?
- Invariance thesis correct?

Smokers versus non-smokers

no income effects

Problem

Invariance thesis for $U(m, s) = m + V(s)$?



Application: Cournot monopoly

- A monopolist maximizes profit, where y denotes output:

$$\max_y \left(p(y)y - C(y)\right).$$

- Optimality condition:

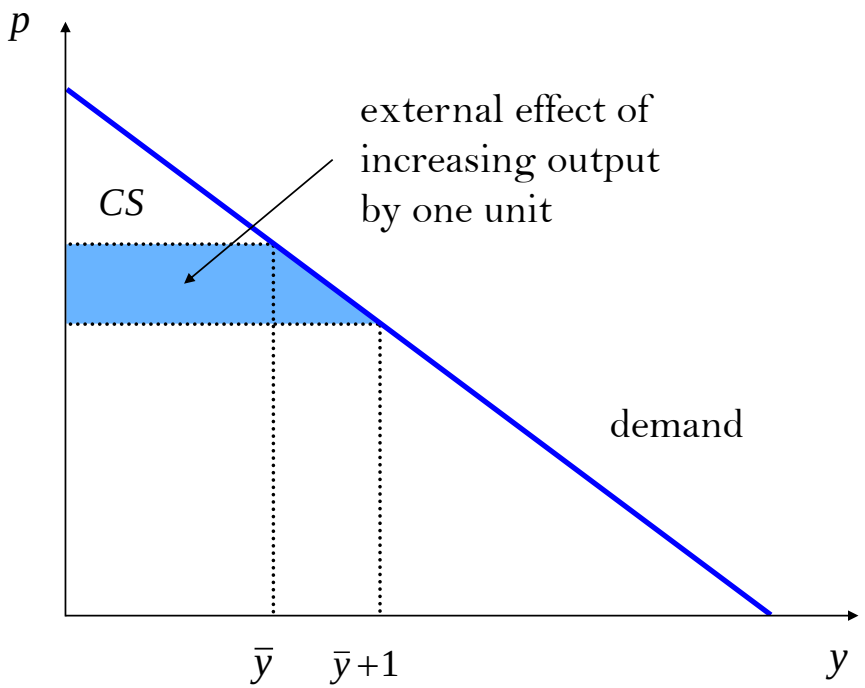
$$p + \frac{dp}{dy}y = MR \stackrel{!}{=} \frac{dC}{dy}.$$

- Consumer surplus:

$$\begin{aligned} CS\left(y\right) &= \int_0^y \left(p\left(q\right) - p\left(y\right)\right) dq \\ &= \int_0^y p\left(q\right) dq - \int_0^y p\left(y\right) dq \\ &= \int_0^y p\left(q\right) dq - yp\left(y\right). \end{aligned}$$

Application: Cournot monopoly

$$\begin{aligned}\frac{dCS(y)}{dy} &= \frac{d\left(\int_0^y p(q)\,dq\right)}{dy} - \frac{d\left(yp(y)\right)}{dy} \\ &= p(y) - \left(p(y) + \frac{dp}{dy}y\right) = -\frac{dp}{dy}y > 0.\end{aligned}$$



Application: Cournot monopoly

- If the monopolist takes the positive external effect into account, she maximizes

$$p(y)y - C(y) + KR(y),$$

- First-order condition

$$p + \frac{dp}{dy}y - \frac{dC}{dy} - \frac{dp}{dy}y \stackrel{!}{=} 0$$

- or equivalently:

$$p(y) \stackrel{!}{=} \frac{dC}{dy}$$

Application: Cournot duopoly

- Profit $\Pi_1(x_1)$ of firm 1:

$$\Pi_1(x_1) = p(x_1 + x_2)\, x_1 - C_1(x_1)$$

- marginal profit:

$$\frac{d\Pi_1}{dx_1} = p + \frac{dp}{dx_1} x_1 - \frac{dC_1}{dx_1}$$

Problem

Why is there an external effect of a quantity extension by firm 1? Explain verbally and analytically!

Application: Cournot duopoly

- If firm 1 takes into account the negative external effect she exerts on 2, she behaves according to

$$p + \frac{dp}{dx_1} x_1 - \frac{dC_1}{dx_1} + \frac{dp}{dx_1} x_2 \stackrel{!}{=} 0.$$

- This is the condition for optimal production in a quantity cartel:

Reminder: cartel agreement between duopolists

Cartel profit

$$\begin{aligned}\Pi_{1,2}(x_1, x_2): &= \Pi_1(x_1, x_2) + \Pi_2(x_1, x_2) \\ &= p(x_1 + x_2) \cdot (x_1 + x_2) - C_1(x_1) - C_2(x_2).\end{aligned}$$

with maximization conditions

$$\begin{aligned}\frac{\partial \Pi_{1,2}}{\partial x_1} &= p + \frac{dp}{dX}(x_1 + x_2) - \frac{dC_1}{dx_1} \stackrel{!}{=} 0 \text{ and} \\ \frac{\partial \Pi_{1,2}}{\partial x_2} &= p + \frac{dp}{dX}(x_1 + x_2) - \frac{dC_2}{dx_2} \stackrel{!}{=} 0\end{aligned}$$

- Equal marginal cost (as in "one market, two production sites")
- Negative externality $\frac{\partial \Pi_2}{\partial x_1} < 0$ in the Cournot model is accounted for in the cartel agreement $\rightarrow \frac{dp}{dX}\frac{dX}{dx_1}x_2 < 0$

Application: pharmaceutical company versus fisherman

Initial situation

- Two agents
  - A **pharmaceutical company** disposes waste water into a lake.
  - A **fisherman** plies a carp culture in this lake.
- With growing pollution, the number of fish decreases and so does the fisherman's profit.

Application: pharmaceutical company versus fisherman

Initial situation

$x =$ extent of pharma production, $y =$ intensity of fish culture
$S =$ damage function with $\frac{\partial S(x,y)}{\partial x} > 0$.
Profit function of the pharmaceutical company

$$\Pi_P(x) = P(x)$$

Profit function of the fisherman

$$\Pi_F(y,x) = \underbrace{F(y)}_{\substack{\text{profit from} \\ \text{fishing} \\ \text{without pollution}}} - \underbrace{S(x,y)}_{\substack{\text{profit reduction} \\ \text{with pollution}}}.$$

Application: pharmaceutical company versus fisherman

The social optimum

- The approach to determine the social optimum is a (theoretical) merger of both companies
- Social optimum $\left(x^0, y^0\right)$ maximizes the sum of profits

$$\Pi\left(x, y\right) = \Pi_P\left(x\right) + \Pi_F\left(y, x\right) = P\left(x\right) + F\left(y\right) - S\left(x, y\right).$$

- Maximization conditions:

$$\begin{aligned} \frac{\partial \Pi}{\partial x} &= \frac{dP\left(x^0\right)}{dx} - \frac{\partial S\left(x^0, y^0\right)}{\partial x} \stackrel{!}{=} 0 \\ \frac{\partial \Pi}{\partial y} &= \frac{dF\left(y^0\right)}{dy} - \frac{\partial S\left(x^0, y^0\right)}{\partial y} \stackrel{!}{=} 0 \end{aligned}$$

Application: pharmaceutical company versus fisherman

Damage allowed (without negotiations)

- The private profit maximum of the pharmaceutical company can be obtained by solving

$$\frac{d\Pi_P}{dx} = \frac{dP\left(x^*\right)}{dx} \stackrel{!}{=} 0,$$

- The private profit maximum of the fisherman can be obtained by solving

$$\frac{\partial \Pi_F}{\partial y} = \frac{dF\left(y^*\right)}{dy} - \frac{\partial S\left(x^*, y^*\right)}{\partial y} \stackrel{!}{=} 0.$$

$\Longrightarrow$ In case of maximization of private profits damages are not taken into account by the pharmaceutical company. Therefore, the social optimum is not reached

Application: pharmaceutical company versus fisherman

Damage disallowed (without negotiations)

- Profit functions with compensation:

$$\begin{aligned} \Pi_F(y) &= F(y), \\ \Pi_P(x) &= P(x) - S(x,y) \end{aligned}$$

- The maximization condition for the fisherman is given by

$$\frac{d\Pi_F}{dy} = \frac{dF(y^{**})}{dy} \stackrel{!}{=} 0.$$

- The maximization condition for the pharmaceutical company is given by

$$\frac{\partial \Pi_P}{\partial x} = \frac{dP(x^{**})}{dx} - \frac{\partial S(x^{**}, y^{**})}{\partial x} = 0.$$

$\Longrightarrow$ "Damages disallowed" does not yield the social optimum.

Application: pharmaceutical company versus fisherman

Pigou tax

- Profit function of the pharmaceutical company for a tax t

$$\Pi_P(x) = P(x) - tx$$

- Maximization condition

$$\frac{d\Pi_P}{dx} = \frac{dP(x^{t*})}{dx} - t \stackrel{!}{=} 0.$$

- Maximization conditions correspond to those in social optimum if the following condition holds:

$$t^0 \stackrel{!}{=} \left.\frac{\partial S(x,y)}{\partial x}\right|_{(x^0,y^0)}.$$

$\Longrightarrow$ Pigou tax equals marginal damage in optimum.

Central tutorial I

Problem R.7.1.

- Airport with $x =$ number of departures and arrivals per day
- Housing area with $y =$ number of flats

- Profit airport $= 24x - x^2$
- Profit housing area $= 18y - y^2 - xy$

a) Activity levels and profits in social optimum?
b) Activity levels and profits for "damages allowed"?
c) Activity levels and profits for "damages disallowed"?
d) "Damages diallowed" better than "damages allowed"?
e) Pigou tax for "damages allowed"?

Central tutorial II

Problem R.7.2.

- H honey
- A apples

- Cost of beekeeping $C_H(H, A) = \frac{H^2}{2} - A$
- Cost of apple plantation $C_A(H, A) = \frac{A^2}{2} - H$

- $p_H = 4$
- $p_A = 7$

a) Kind of externality?

b) Nash equilibrium?

c) Merger?