Modeling and analysis of external effects

Prof. Andriy Stavytskyy

Outline

1. External effects
2. Ways to correct market failures
3. Private and public goods

External effects

The essence of external effects

- The market price should reflect all the costs that arise in the economy in the process of production of a particular good, and characterize all the benefits received by consumers of this good.
- In fact, the production and consumption of goods often have "external effects", which are not reflected in prices.

External effects

- **External effects** – these are costs (benefits) from market operations, not reflected in the prices of goods.

- The effects are called "external" because they affect not only the economic agents involved in the operation, but also third parties.

Consequences of external effects

- In the presence of externalities, the price of a commodity does not necessarily reflect its social value, so firms may produce either too many or too few products, making their activities in the market inefficient.
- It is not provided in the market mechanism Pareto-effective distribution.

Classification of effects – 1

- External effect by consumption occurs if one consumer is directly interested in the production or consumption of another.
- External effect by production occurs when the production capacity of one firm is influenced by the choice of another firm or consumer

Classification of effects – 2

- A negative external effect occurs when the activities of one economic agent cause costs to others.
- A positive external effect occurs when the activities of one economic agent benefit another.

Examples of external effects

	From consumption	From production
Positive	Flowers in a neighbor's garden	Bee pollination of a nearby orchard; development of education
Negative	Smoking in institutions; a neighbor who loves rock music; smog from cars in cities	Industrial pollution

Economic result of economic activity

Private income – private expenditure = private income

\+ + +

External benefits – external costs = external profit

= = =

Society revenues – Society expenses = Society benifits

Calculation of external effect

$$MSC = MPC + MEC$$

where

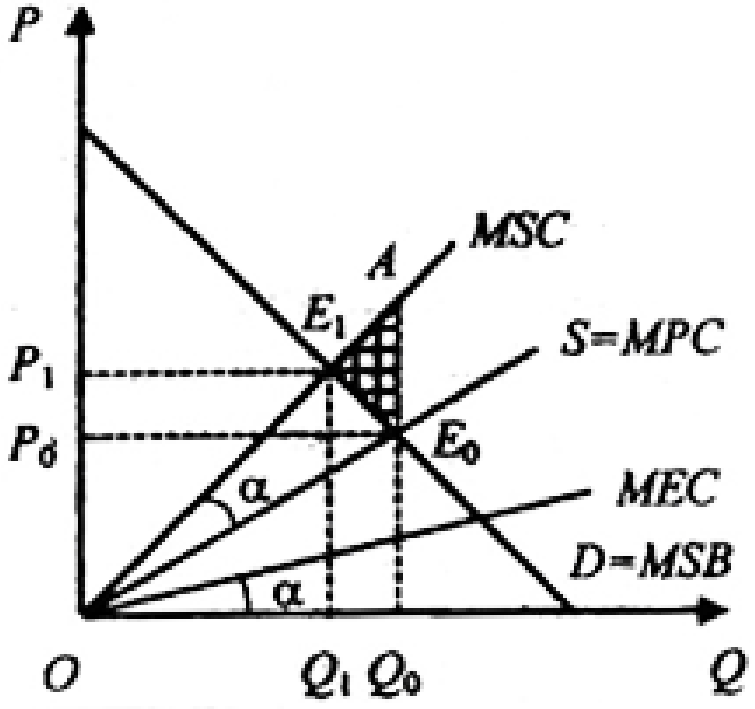
- MSC (marginal social cost/benefit) – marginal social costs/benefits;
- MPC (marginal private cost /benefit) – marginal private costs/benefits;
- MEC (marginal external cost/benefit) – marginal external costs/benefits

An example of a negative external effect – 1

- The pulp and paper plant releases insufficiently purified water into the river. Sewage emissions are proportional to the volume of production, i.e. with the growth of production the volume of environmental pollution increases.

An example of a negative external effect – 2

- The plant's marginal private costs are lower than the public marginal costs, as they do not include the cost of creating an additional treatment plant system.
- The amount of output exceeds the effective output



Analytical interpretation – 1

- Suppose that the pulp and paper mill for each unit of product pours into the river *h* from toxic substances. The less the plant pollutes the river, the higher its production costs due to the cost of treatment facilities, i.e. its function of production costs is:

$$C_k = C_k(Q_k, h)$$

$$\frac{\partial C_k}{\partial Q_k} > 0; \ \frac{\partial C_k}{\partial h} < 0$$

Analytical interpretation – 2

- Due to the production activities of the plant, the cost of water purification in the water supply station is increasing, its cost function is as follows:

$$C_B = C_B(Q_B, h)$$

$$\frac{\partial C_B}{\partial Q_B} > 0; \ \frac{\partial C_B}{\partial h} > 0$$

- Although the cost of production of the water supply station depends on the amount of pollution *h*, however, it cannot affect this value.

Analytical interpretation – 3

- Since the plant produces two types of products – paper and pollution, the profit of the plant can be expressed by the formula:

$$\pi_k = P_k Q_k + P_h h - C_k(Q_k, h),$$
$$P_h = 0$$

- Profit water supply station is determined by the formula:

$$\pi_B = P_B Q_B - C_B(Q_B, h).$$

Analytical interpretation – 4

- The conditions for maximizing the profits of the pulp and paper mill will be the equations:

$$\frac{\partial C_k}{\partial Q_k} = P_k$$

$$\frac{\partial C_k}{\partial h} = 0$$

- The profit of the water supply station reaches a maximum at:

$$\frac{\partial C_B}{\partial Q_B} = P_B$$

Union of firms – 1

- Suppose that the pulp and paper mill merge with the water supply station into one firm, whose activities will be aimed at maximizing the total profit from the sale of paper and water:

$$\pi(Q_k, Q_B, h) = P_k Q_k + P_B Q_B - C_k(Q_k, h) - C_B(Q_B, h) \to \max$$

Union of firms – 2

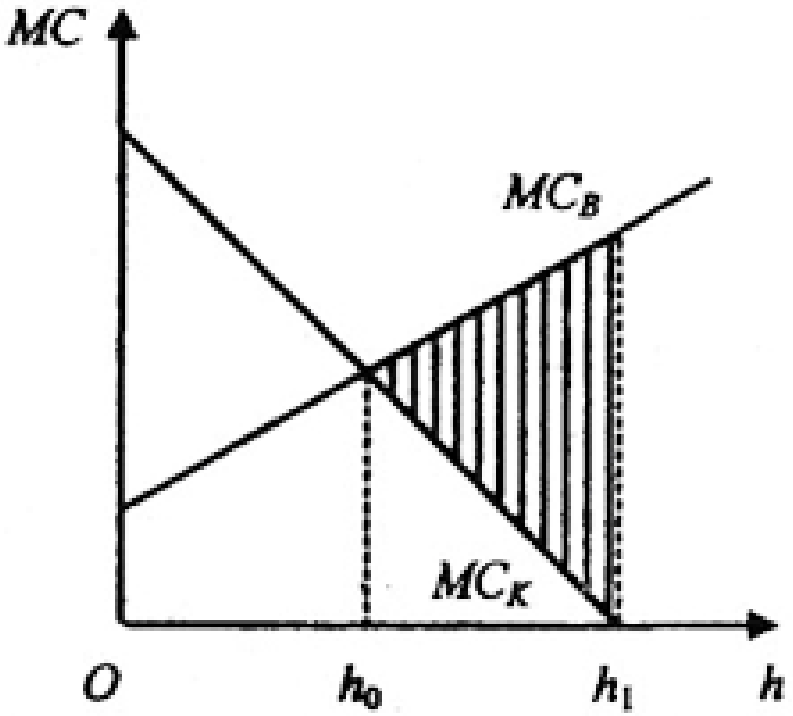
- Profit maximization condition:

$$\begin{cases} \dfrac{\partial C_k}{\partial Q_k} = P_k; \\ \dfrac{\partial C_B}{\partial Q_B} = P_B; \\ \dfrac{\partial C_k}{\partial h} + \dfrac{\partial C_B}{\partial h} = 0 \Rightarrow \dfrac{\partial C_k}{\partial h} = -\dfrac{\partial C_B}{\partial h} \end{cases}$$

- the profit of the merged firm reaches a maximum when the maximum savings of the plant from water pollution is equal to the marginal increase in costs of the water supply station from this pollution.

Union of firms – 3

- As $\partial C_B / \partial h > 0$ combined firm reduces the amount of pollution, although not to zero.

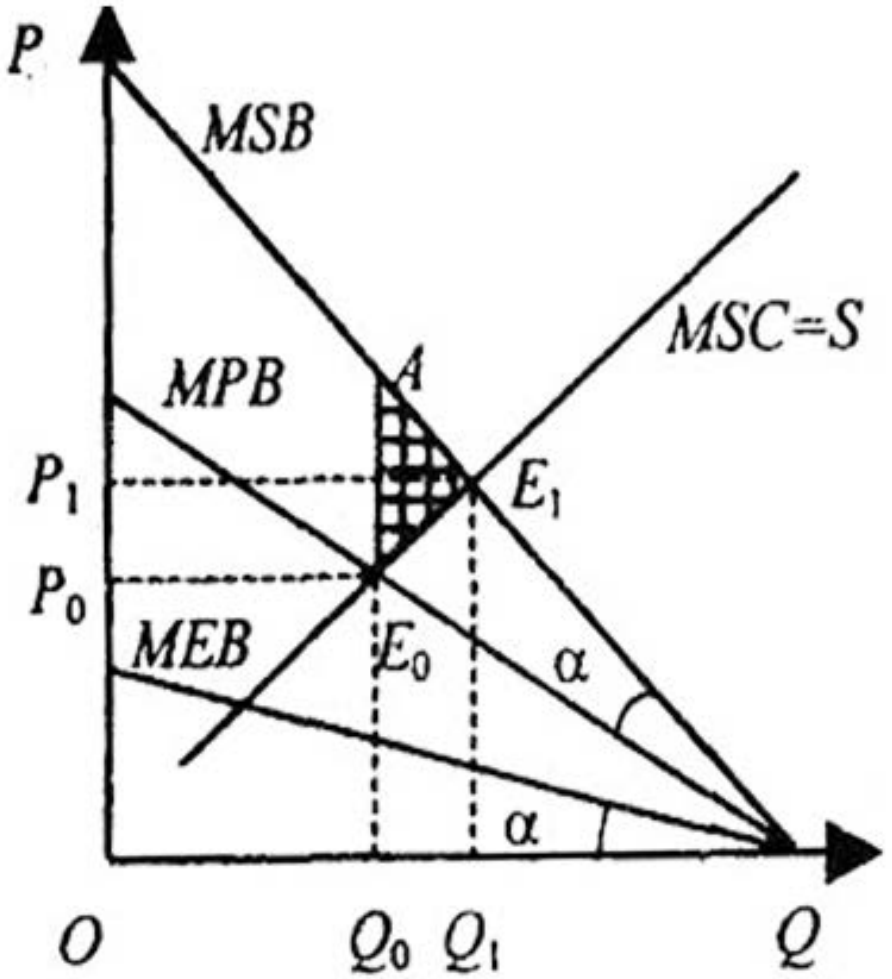


An example of a positive external effect

- One example of a positive external effect is the development of education.
- Every member of society benefits from the fact that students receive education, but no one thinks about the benefits that society receives.
- Investment in human capital may be lower than optimal for society.

Positive external effect

- MPB – readiness of entrants to pay for higher education (maximum usefulness of education for those wishing to study);
- MSB – changing of the marginal social utility of a student



An example of a positive external effect

- Let there be two service companies in the city – a sports complex and a polyclinic.
- The function of operating costs of the sports complex is:

$$C_c = 5 + 0.25Q_c^{\,2},$$

$$\mathrm{Q_c} - \text{number of services}$$

- The costs of the clinic are characterized by the function:

$$C_n = 2Q_n^{\,2} - Q_c,$$

$$Q_n - \text{number of medicine services}$$

Sport complex

- Profit of the sport complex:

$$\pi_c = P_c Q_c - 5 - 0.25 Q_c^{\,2}$$

- reaches a maximum when:

$$P_c = 0.5 Q_c$$

- Supply function of the sport complex:

$$Q_c^{\,s} = 2 P_c$$

Clinic

- Profit of the clinic:

$$\pi_n = P_n Q_n - 2Q_n + Q_c$$

- becomes the maximum when:

$$P_{\mathrm{n}} = 4Q_n$$

- Polyclinic supply function:

$$Q_n^{\ s} = 0.25P_n$$

Merged firm

- Profit of the merged firm:

$$\pi = P_c Q_c + P_n Q_n - 0.25 Q_c^{\,2} - 2Q_n + Q_c - 5$$

- Maximization condition:

$$\begin{cases} P_c + 1 = 0.5 Q_c, \\ P_{\mathrm{n}} = 4 Q_n. \end{cases}$$

- The supply functions of the merged firm are:

$$\begin{cases} \mathrm{Q_c}^{s} = 2P_c + 2, \\ Q_n^{\,s} = 0.25 P_n. \end{cases}$$

The conclusion of the model

- Under the same offer of medical services, the joint venture increases the volume of sport and recreation activities

Ways to correct market failures

Non-optimality

- We can conclude that in the presence of external effects the market mechanism does not provide Pareto-optimal distribution.

Solution

- Restoration of optimality consists in internalization of external effects, i.e. in their transformation into internal.
- This means forcing the producers of negative effects to pay external costs and thus compensate third parties for the damage they receive.
- It also means paying for external benefits – paying compensation to producers of positive effects at the expense of their recipients.

Internalization of external effects

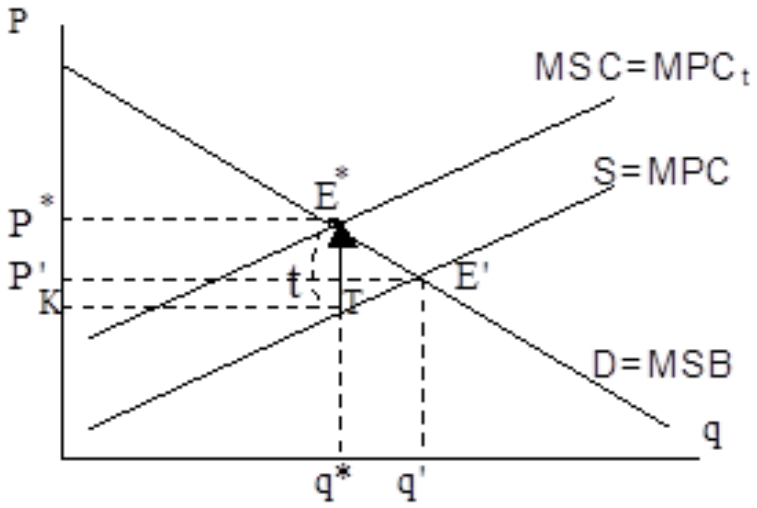
- **Internalization of external effects** – the process of transforming external effects into internal ones, which is achieved by bringing marginal private costs (and, accordingly, benefits) closer to marginal public costs (benefits).

Means of the state in the fight against external effects

- Taxation and subsidies;
- Setting standards for harmful emissions;
- Emission fines;
- Temporary emission permits (pollution markets);
- Consolidation of property rights.

Corrective tax

- Corrective tax (Pigovian tax) is a tax on the production of economic goods characterized by negative externalities.



Example – 1

- If the plant for each unit of pollution must pay a tax of tgr. units, its profit will be determined by the formula:

$$\pi_k = P_k Q_k + P_h h - C_k(Q_k, h) - th$$

- Maximization conditions:

$$\begin{cases} P_k - \dfrac{\partial C_k}{\partial Q_k} = 0; \\ \dfrac{-\partial C_k}{\partial h} - t = 0. \end{cases}$$

Example – 2

- Tax rate in this example should be equal to the marginal increase in the cost of water treatment for Pareto-effective distribution.

$$t = \partial C_B / \partial h$$

Corrective subsidy

- Adjustment subsidy is a subsidy to producers or consumers of economic goods, the activities of which have positive externalities, which allows to bring the marginal private benefits closer to the marginal public benifits.
- In the case of education, a grant (S) equal to the marginal external benefit S = MEB could be provided to students, which would increase their demand for educational services to a level at which MSB = MSC.

Problems of taxes and subsidies

- It is quite difficult to accurately account for marginal costs and benefits;
- the amount of damage is determined in the course of legal and political discussions quite approximately;
- corrective taxes paid by producers of goods with negative externalities do not always achieve the goal.

Trade in pollution rights

- This approach to internalization external effects contains elements of Coase's theorem and an approach based on the application of penalties.
- The state determines the allowable amount of emissions for a given region and, based on this, distributes (sells) among the enterprises of the region the rights (licenses) for pollution (for a certain period).
- Businesses also receive the right to sell these licenses.
- The role of the state in this case is limited to the definition of property rights and the formation of the market for the sale of licenses.

Property rights

- **Property rights** Is a system of legislative rules that describe the possible actions of individuals or firms in relation to the property they own.
- **Transaction or operating costs** – these are costs in the field of exchange associated with the transfer of property rights (information retrieval, negotiation and contracting, measurement, specification and protection of property rights, opportunistic behavior).

R. Coase's theorem

- When the property rights of all parties are carefully defined and the transaction costs are zero, the final result (which maximizes the value of production) does not depend on changes in the distribution of property rights (if we ignore the income effect).

Ownership of the station – 1

- If the ownership of clean water is assigned to one of its users, the problem of externalities will be solved as a result of bidding between water consumers.

- If the water is owned by a water supply station, the station may allow the pulp and paper mill to pollute the water for a fee.

$$P_h > 0$$

Station ownership rights – 2

- The profit of the plant will be determined by the formula:

$$\pi_k = P_k Q_k + P_h h - C_k(Q_k, h)$$

- Profit of the water supply station – according to the formula:

$$\pi_B = P_B Q_B + P_h h - C_B(Q_B, h)$$

- Profit of each firm will be the maximum when

$$\begin{cases} P_k = \dfrac{\partial C_k}{\partial Q_k}, \; P_h = \dfrac{\partial C_k}{\partial h}, \\ P_B = \dfrac{\partial C_B}{\partial Q_B}, \; P_h = \dfrac{\partial C_B}{\partial h}. \end{cases}$$

Station ownership rights – 3

- The consolidation of property rights for the water supply station allowed the market to establish a Pareto-optimal distribution.

Ownership rights of the plant – 1

- Let the pulp and paper mill have the right to discharge the pollution $\hat{h}$, and let the water supply station be ready to pay the plant $P_h > 0$ for each unit of pollution reduction.

Ownership rights at the plant – 2

- The profit of the plant will be determined by the formula:

$$\pi_k = P_k Q_k + P_h(\hat{h} - h) - C_k(Q_k, h)$$

- Profit of the water supply station – according to the formula:

$$\pi_B = P_B Q_B + P_h(\hat{h} - h) - C_B(Q_B, h)$$

- The profit of each of the firms will be the maximum when

$$\begin{cases} P_k = \dfrac{\partial C_k}{\partial Q_k}, \; P_h = \dfrac{\partial C_k}{\partial h}, \\ P_B = \dfrac{\partial C_B}{\partial Q_B}, \; P_h = \dfrac{\partial C_B}{\partial h}. \end{cases}$$

Ownership rights at the plant – 3

- The consolidation of property rights for the water supply station allowed the market to establish a Pareto-optimal distribution.
- The condition of maximizing the profits of both producers in this case is expressed by the same system of equations.

Disadvantages and advantages of Coase's theorem

- correct for a limited number of participants in the agreement (two or three), because with the increase in their number, transaction costs increase sharply, and the premise of their zero value is no longer correct.

- helps to develop the right strategy in the fight against environmental pollution.

Disadvantages of Coase's theorem

Advantages of Coase's theorem

Other ways

- Association of producers and recipients of external effects – external costs (benefits) automatically become internal.

- Social customs, moral norms, traditions, etc.

Private and public goods

Classification of benefits

Private good:

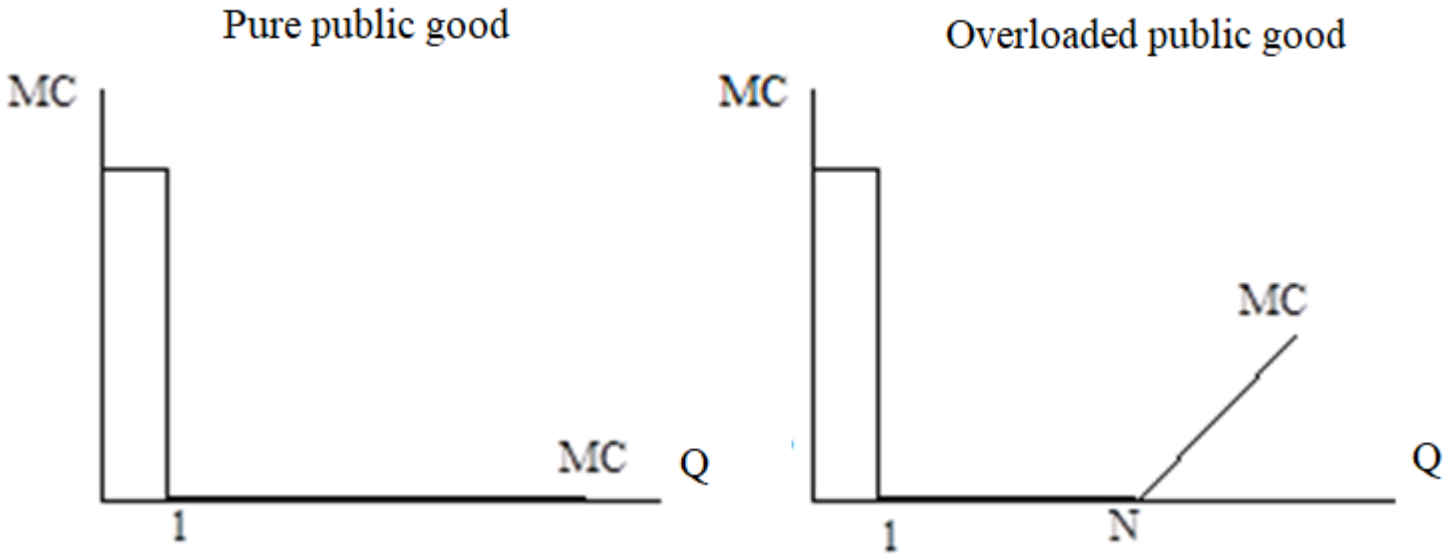
- Consumption one person makes it impossible for others to consume, not paying for it.

Pure public good:

- Consumption such a good by one person does not diminish its usefulness to another persons, i.e. borderline the cost of obtaining this benefit by another person is equal zero;
- Impossible to interfere consumption benefits to a person who has not paid for him.

Overloaded public good

- **Overloaded public good** – it is a good, the marginal cost of providing which to another consumer, starting with a number of consumers, not are equal to zero.



Freerider problem

- **“Freerider problem"** – the tendency of consumers to avoid participating in the financing of public goods production or to minimize the associated costs in the expectation that others will do so.
- "Freerider" underestimate the value of the public good, and this leads to a lower volume of its production compared to the effective volume.
- The solution to the freerider problem by using market mechanism is impossible.

Distribution of public goods

- The state takes over the customer and distributor of many public goods on behalf of the whole society.
- The supply of public goods is carried out through political institutions.

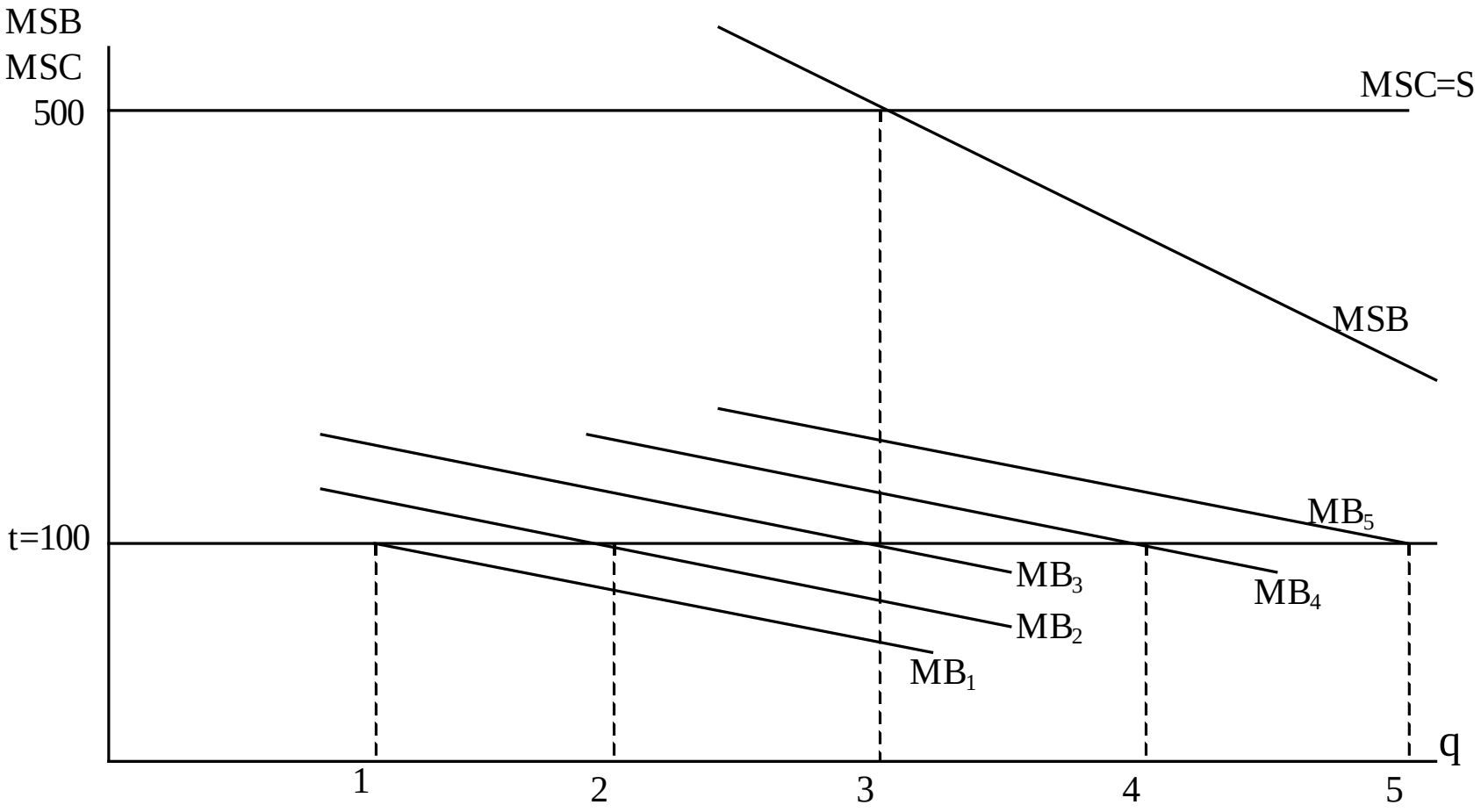
Example – 1

- Let's solve the question of the number of urban police staff, which is financed by taxes.
- Five voters are voting.
- Each voter gives 100 USD tax for each police officer.
- Marginal costs per police officer are constant and are amount to 500 USD.
- There are data on the marginal benefit of police officers for each voter:

Example – 2

Voter	Number of officers	1	2	3	4	5
A	MV_1	100	80	60	40	20
B	MV_2	120	100	80	60	40
C	MV_3	140	120	100	80	60
D	MV_4	160	140	120	100	80
E	MV_5	180	160	140	120	100
	MSB (ΣMB_i)	**700**	**600**	**500**	**400**	**300**

Graphic interpretation



Voting paradox – 1

Public goods	Voter preferences		
	A	B	C
School	1	3	2
Park	2	1	3
Cafe	3	2	1

Voting paradox – 2

And the district	II district	III district
AND	IN	IN
AND	IN	IN
AND	AND	AND

At voting of deputies by a majority of votes (2>1) will be option B selected, although it reflects the sympathies of the minority (4<5)

Lobbying and logroling

- Activities aimed at ensuring public decision-making in the interests of the group is called lobbying.
- A group of lobbyists, acting together, can achieve minority-friendly solutions if their opponents are divided and each benefits less than the cost of defending their positions.
- The likelihood of minority decisions increases when different special interest groups come together on the basis of mutual support (logroll): one group votes for a decision that benefits another group, which in turn supports another decision in favor of the first group.

Thank you!