

Externality and Corrective Measures

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Microeconomic Theory

Lecture 20

Questions

Question

- *What is an externality?*
- *What corrective measures are available to control externality?*
- *Are these measures equivalent in terms of efficiency implications?*
- *Are these measures equivalent in terms of the information needed to determine their optimal levels?*
- *Are these measures equivalent in terms of the cost of their implementation?*
- *Do different measures have different distributional consequences for the parties involved?*
- *Can market solve the problem of externality under some circumstances?*

WE and Externality

Recall:

- The Competitive equilibrium (WE) is Pareto optimum.
- The equilibrium factor allocation, $(\mathbf{z}^{*1}, \dots, \mathbf{z}^{*J})$, is Pareto optimum.
- The equilibrium factor demand, $(\mathbf{z}^{*1}, \dots, \mathbf{z}^{*J})$, maximizes the aggregate/total profit for the economy.
- The production plan $(\mathbf{y}^1, \dots, \mathbf{y}^J)$ can be aggregate/total profit maximizing for the economy if and only if it is a Pareto optimal.

However, in presence of externality,

- all these results breakdown
- in fact, the existence of WE cannot be guaranteed any more
- Government intervention is needed - generally but not always

A simple illustration I

Assume

- There are two 'competitive' firms
- Firm 1 uses one FOP, l_1 , to produce a marketable output, y_1 . But it also uses another 'non-marketable' output/input e for its production process
- Firm 2 also uses only one FOP, say l_2 , to produce one marketable output y_2 . However, 'non-marketable' factor e also affects its payoff
- There is no market in e
- Firm 1 decides on the level of e ; firm 2 has no direct control over choice of e
- The profit functions are $\pi_1(y_1, l_1, e, \mathbf{p}, \mathbf{w})$ and $\pi_2(y_2, l_2, e, \mathbf{p}, \mathbf{w})$, respectively

A simple illustration II

Note for given \mathbf{p} and \mathbf{w} , we have

$$\begin{aligned}\phi_i(\mathbf{e}, \mathbf{p}, \mathbf{w}) &= \max \pi_i(y_i, l_i, \mathbf{e}, \mathbf{p}, \mathbf{w}) \\ &\equiv \phi_i(\mathbf{e})\end{aligned}$$

Note: You can think of

- $\phi_1(\mathbf{e})$ as the maximum profit for 1 given the level of e opted by firm 1.
- $\phi_2(\mathbf{e})$ as the maximum profit for 2 given the level of e opted by firm 1.

Assume

$$\phi_1'(\mathbf{e}) > 0, \phi_1''(\mathbf{e}) < 0, \phi_2'(\mathbf{e}) < 0, \phi_2''(\mathbf{e}) \leq 0, \text{ i.e.,}$$

- e is good for firm 1 but bad for firm 2.

A simple illustration III

- Moreover, there exists \bar{e} , such that $\phi_1'(\bar{e}) < 0$; and e^p such that $\phi_1'(e^p) = 0$

Question

Which firm is the cause behind the externality?

Firm 1 will solve $\max_e \{\phi_1(e)\}$. It will choose e^p that solves the following FOCs:

$$\phi_1'(e) = 0 \quad (1)$$

That is, $\phi_1'(e^p) = 0$. However, the total profit maximization problem is

$$\max_e \{\phi_1(e) + \phi_2(e)\} \quad (2)$$

For this OP, the FOCs is:

$$\phi_1'(e) + \phi_2'(e) = 0 \quad (3)$$

Let e^* solve (3).

A simple illustration IV

That is, $\phi'_1(e^*) + \phi'_2(e^*) = 0$. Clearly,

$$e^D > e^*.$$

Question

- *What is a Pareto optimal level of externality - e^D or e^* ?*
- *What is wealth maximizing level of externality - e^D or e^* ?*
- *What is Kaldor efficient level of externality - e^D or e^* ?*

Corrective Measure: Quantity Regulation I

Let us go back to the simple case.

- There are two firms
- Firm 1 causes negative externality for Firm 2

Suppose,

- There is a regulator appointed by government
- The regulator sets standards for the externality generators
- The regulatory standard $e^R = e^*$. That is,
- Firm is allowed to produce up to e^* and not beyond
- Sever penalty for production beyond e^*

Corrective Measure: Quantity Regulation II

The Outcome ?

- In equi, Firm 1 will choose $e = e^*$
- The outcome is Pareto efficient.
- The outcome is Wealth Maximizing.

Examples,

- Noise Control - say, no loud music after 10pm
- Exploitation of natural resources - green belt, no-go zones
- Zonal regulations - Master plans, residential zones, no-smoking zones, etc
- Traffic speed limits - different for different areas/zones or times

Corrective Measure: Pigouvian Tax (Price Regulation)

Suppose,

- Govt imposes tax on the externality 'creator'
- Firm 1 pays a 'per unit' tax $\bar{t} = -\phi'_2(e^*)$.

Now, 1 will choose e that solves:

$$\max_e \{\phi_1(e) - \bar{t}e\}, \text{ i.e., } \max_e \{\phi_1(e) + \phi'_2(e^*) \cdot e\}$$

$$\begin{aligned}\phi'_1(e) - \bar{t} &= 0, \text{ i.e.,} \\ \phi'_1(e) + \phi'_2(e^*) &= 0, \text{ i.e.,}\end{aligned}$$

the firm 1 will choose $e = e^*$.

Corrective Measures: Subsidy

Suppose,

- Govt offers subsidy to the externality creator for a reduction in externality level below e^p
- Subsidy rate is: $-\phi'_2(e^*)$ for each unit of reduction in pollution.
- Gross subsidy is: $s(e) = -(e^p - e)\phi'_2(e^*)$.

Now, 1 will choose e that solves:

$$\max_e \{\phi_1(e) + s(e)\}, \text{ i.e., } \max_e \{\phi_1(e) - (e^p - e)\phi'_2(e^*)\}$$

$$\begin{aligned}\phi'_1(e) + s'(e) &= 0, \text{ i.e.,} \\ \phi'_1(e) + \phi'_2(e^*) &= 0, \text{ i.e.,}\end{aligned}$$

Again, equilibrium choice is $e = e^*$.

Corrective Measures: Liability

Let

- $\bar{\phi}_2$ be the profit of Firm 2 in the absence of externality, i.e.,
 $\bar{\phi}_2 = \phi_2(e = 0)$

Suppose,

- The externality creator is required to compensate the 'victim' of externality
- Firm 1 pays a compensation equal to loss; i.e., $l(e) = \bar{\phi}_2 - \phi_2(e)$.

Now, in equilibrium, 1 will choose e that solves:

$$\max_e \{\phi_1(e) - l(e)\}, \text{ i.e., } \max_e \{\phi_1(e) - [\bar{\phi}_2 - \phi_2(e)]\}$$

$$\begin{aligned}\phi_1'(e) - l'(e) &= 0, \text{ i.e.,} \\ \phi_1'(e) + \phi_2'(e) &= 0, \text{ i.e.,}\end{aligned}$$

equilibrium choice is $e = e^*$.

Regulation Vs Tax/Subsidy

- Tax/Subsidy is a 'Price-Regulation' - externality is controlled by increasing or decreasing the costs of the externality
- 'Quantity-Regulation' - here, externality is controlled directly - externality costs nothing up to permissible limits.

Implementation:

- Detecting violation of 'Quantity-Regulation' is easier than 'Price-Regulation'
- Therefore, in several situations, enforcement of 'Quantity-Regulation' is easier than that of 'Price-Regulation'
- Private parties can also help in enforcement of regulation

However, Regulator may choose inefficient rules/standards because

- Regulator does not enough information; Or
- Regulators could be corrupt; Or
- There could be regulatory capture

Regulation Vs Liability

- Regulation is ex-ante
- Liability is ex-post

Question

- *What is the information needed to achieve efficiency under regulation?*
- *What is the information needed to achieve efficiency under liability?*

Depending of situation

- Regulation can be better than liability - prevents serious losses, there could be judicial delays
- Liability can be better - less vulnerable to corruption and capture

In real world,

- Regulation and Liability are used simultaneously
- Examples: Road accidents, product liability, environmental damages, etc

Externalities: Does Law Matter? I

An (hypothetical) Example:

- There is town with 50 residents. A factory has come up nearby.
- Factory generates net profit of 600
- Smoke from the factory is injurious to the health of the residents.
- In the absence of any corrective measure, each resident will suffer a harm of 10 each, that is, a total harm of 500.
- However, the following corrective measures are available:
 - A smokescreen can be installed at the factory at a cost of 150; or
 - Residents can buy masks at a cost of 5 each, that is, at a total cost of 250.

Which option is the efficient choice?

Externalities: Does Law Matter? II

Now consider the following alternative legal positions:

- 1 The law entitles the residents to smoke-free air -, i.e., residents have the right.
- 2 The law allows the factory to operate but requires it to compensate the residents for the harm caused - liability regime.
- 3 The law allows the factory to operate unhindered by the residents;
 - Perhaps the smoke is within the permissible limits of environmental regulations,
 - Or, there is no environmental regulation in place.
 - And, there is no liability for the factory.

Externalities: Does Law Matter? III

Question

In the above example

- *Who is the cause of externality - the factor or the residents?*
- *What would be the outcome under each of the above legal rules?*
- *Will the outcome be different under each of the above legal rules?*
- *Which rule is most efficient?*
- *Which rule is Pareto efficient?*
- *Which rule is K-H efficient?*

The Law and the Outcomes I

- Under the First legal rule, the factory can be operated only with smokescreen installed, i.e., only after incurring a cost of 150.
- Under the Second rule, the factory owner has to decide whether to
 - install smokescreen, i.e., incur a cost of 150; or
 - pay the liability cost of 500; or
 - pay 5 to each resident so that they can buy masks, i.e., incur a cost of 250.
- Under the Third legal position, the owners have to decide
 - whether to buy masks or not
 - Or?

Question

What would be the outcome under the third rule?

The Law and the Outcomes II

Now, the residents have to decide

- whether to buy masks at a cost of 5 each, i.e., incur a total cost of 250; or
- negotiate a deal at the cost of 3 each, i.e., incur a total cost of about 150
- So, they will end up negotiating with the factory to get the smoke-screen installed
- The outcome is efficient.

Coase Theorem I

When people concerned can negotiate costlessly, the outcome has the following features:

- A social cost of 150 is incurred, regardless of the legal rule in force.
- That is, the outcome is efficient regardless of the choice of the legal rule.
- However, who bears the burden of this cost depends on the legal rule in force.

Coase Theorem: When negotiations are costless, the outcome will be efficient, regardless of the choice of the legal rules.

Coase Theorem II

The outcome has the following features:

- The legal entitlements (legal rights and obligations) create a market in externality - the buyer and seller can transact in externality.
- Regardless of the legal entitlements, the outcome will be socially efficient - it will be Pareto efficient Kaldor efficient, as well wealth maximizing.
 - In the last factor-residents example, a social cost of 150 is incurred, regardless of the legal rule in force.
- However, who bears the burden of this cost depends on the legal entitlement.

Externality as Missing Market I

Suppose,

- Firm 2 has right to externality free environment
- However, there is market in the externality
- Suppose, firm 2 can sell the right to 1 to create externality
- p is the per-unit price of the externality

Now, firm 1 will demand e units of externality by solving:

$$\max_e \{\phi_1(e) - p \cdot e\}, \text{ i.e.,}$$

The profit maximizing e_1 will be such that

$$\phi_1'(e_1) - p = 0,$$

2 will offer to sell e units of externality by solving:

Externality as Missing Market II

$$\max_e \{ \phi_2(e) + p \cdot e \}, \text{ i.e.,}$$

The profit maximizing supply, e_2 , will be such that

$$\phi'_2(e_2) + p = 0,$$

In equilibrium, $e_1 = e_2 = e$, therefore,

$$\phi'_1(e) + \phi'_2(e) = 0, \text{ i.e.,}$$

$$e_1^p = e_2^p = e^*.$$

- Similar outcome will be achieved if you can give Firm 1 the right to create externality - now Firm 2 willing to pay to reduce externality
- Therefore, the **property rights** can restore Pareto efficiency of competitive equilibrium

Property Rights: Limitations

The above reasoning is not likely to work in the context of 'multi-lateral' externalities. Examples:

- Road use, road accidents
- Environmental damages
- Littering, not picking after pets, etc

In these contexts, many people are involved on both sides of the externality.

Question

How is externality controlled in such contexts?

Road use:

- Quantity regulation - tax as per vehicle size, speed limits,
- Tax - diesel and petrol tax/cess
- Liability for accident harms

Costly negotiations

Coase Theorem: When negotiations are costly, the outcome

- will depend on the legal rule, i.e., can/will vary across rules
- may or may not be efficient, depending on the rule in force.

Suppose, in the above factory-residents example, the per-person transaction cost is 4.

Question

What will be the outcome under different legal positions, if the transaction costs are high?

Question

What would be the outcome under the third rule?

Now, the residents have to decide

- whether to buy masks at a cost of 5 each, i.e., incur a total cost of 250; or
- negotiate a deal at the cost of 3+4 each, i.e., incur a total cost of at least 350