Externalities

Microeconomics 2

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I. What are externalities – I.1. Classics !

Meade's example of a positive external effect

- Honey producer H raises bees so as to produce honey
- Next to H, P has an orchard and produces fruits
- The more bees, the better the pollination of fruit trees; the larger the orchard, the larger the production of honey
- Production functions depend on input / output decisions of another agent.

Examples of negative externalities also often mentioned

- Smoking: My utility depends on your consumption of cigarettes
- Noise: My listening to loud heavy metal impacts your enjoying a quite night
- GHG emissions: environmental externalities and corresponding climate policies (Kyoto protocol, Emission Trading Systems, Carbon taxes,...)

I.2. Definitions of externalities

Pigou (1932): "*...one person A, in the course of rendering some service, for which payment is made, to a second person B, incidentally also renders services or dis-serves to other persons, of such a sort that payment cannot be extracted from the benefited parties or compensation enforced on behalf of the injured parties.*"

Standard definition: "*...whenever a decision variable of one economic agent enters into the utility function or production function of another*"

Note: "directly enters", i.e. not indirectly through how the price may be modified when decisions change. This last case corresponds to a *pecuniary externality*

Externalities and markets

- A and B pump water from a well for their own consumption
- Given the finite amount of available water, the more A pumps, the more difficult for B to pump: externality
- If the well were owned by a firm C, that pays A and B a fixed hourly wage to pump water which then C sells, on the water market, to A and B: no externality ...!
- So the definition at best incomplete

Hence later definitions by Meade, Arrow, Heller-Starett: "externalities as nearly synonymous with nonexistence of markets."

I.2. Definitions of externalities

Externalities and merger

- Two firms exert negative pollution externalities on each other
- If they merge, the cross effect becomes a technical relationship within the merged entity; no externality anymore
- If the economy consisted of one unique economic agent, there would be no externalities

Externalities (standard definition) disappear when they are mediated by an appropriate market or in specific institutional setting!

But micro-economic framework does not endogenize the set of economic agents nor the creation of markets. Take these as given!

I.3. Road map for today

Objectives:

- Impact of externalities in the standard microeconomic framework
- Foundations for public / market intervention
- Introduction to public economics and environmental economics

Precise roadmap:

- Definition of externalities
- Basic market failure in a simple example: Pareto optimum, competitive equilibria, intuition
- Restoring efficiency: quotas, taxes, mergers, creating new markets (competitive or not)
- What about remedies under informational problems ?

II. The basic market failure – II.1. A simple economy with externality

A simple distribution economy:

- Two-good economy (1 and 2), two firms (a and b), and one consumer
- Production of good 2 by firm a affects the production function of firm b
- (Differentiable and concave) production functions: $y_2^a = f^a(y_1^a)$ and $y_2^b = f^b(y_1^b; y_2^a)$
- (Differentiable, increasing and strictly quasi-concave) utility function for the consumer: $U(x_1, x_2)$
- Consumer's initial endowment: (ω_1, ω_2)

II.2. Pareto optimal allocation

$$\max_{x_h \geq 0, y_h^j \geq 0} U(x_1, x_2)$$
$$\omega_1 - y_1^a - y_1^b - x_1 \geq 0 \quad [\lambda_1]$$
$$\omega_2 + y_2^a + y_2^b - x_2 \geq 0 \quad [\lambda_2]$$
$$f^a(y_1^a) \geq y_2^a \quad [\mu_a]$$
$$f^b(y_1^b; y_2^a) \geq y_2^b \quad [\mu_b]$$

Optimality condition at the optimum $X^0 = (x^0, y^{a0}, y^{b0})$:

$$\frac{\lambda_1}{\lambda_2} = \frac{\frac{\partial U}{\partial x_1}}{\frac{\partial U}{\partial x_2}} = \frac{\partial f^b}{\partial y_1^b} = \frac{\partial f^a}{\partial y_1^a} + \frac{\partial f^b}{\partial y_2^a} \cdot \frac{\partial f^a}{\partial y_1^a}$$

Equalization of MRS to **social** MRT, where "social" means taking into account all effects, direct and indirect (external)

II.2. Pareto optimal allocation

In the productive sector, $dy_1 = dy_1^b$ induces an increase in output $dy_2 = \frac{\partial f^b}{\partial y_1^b} dy_1^b$; no external effect:

$$SMRT_{1,2} = -\frac{dy_2}{dy_1^b} \mid_{Prog} = \frac{\partial f^b}{\partial y_1^b} = MRT_{1,2}^b$$

In the productive sector, $dy_1 = dy_1^a$ induces an direct increase in output via $dy_2^a = \frac{\partial f^a}{\partial y_1^a} dy_1^a$ and an indirect increase in output via $dy_2^b = \frac{\partial f^b}{\partial y_2^a} dy_2^a$:

$$SMRT_{1,2} = -\frac{dy_2}{dy_1^a} \mid_{Prog} = \frac{\partial f^a}{\partial y_1^a} + \frac{\partial f^b}{\partial y_2^a} \cdot \frac{\partial f^a}{\partial y_1^a} = MRT_{1,2}^a + \frac{\partial f^b}{\partial y_2^a} \cdot \frac{\partial f^a}{\partial y_1^a}$$

Another example: externality in consumption

- Two-good economy, one firm and one consumer
- Consumption of good 1 by the consumer affects the production function of the firm : $y_2 = f(y_1; , x_1)$
- Optimality condition: equalization of social MRS and MRT

$$\frac{\lambda_1}{\lambda_2} = \frac{\frac{\partial U}{\partial x_1} + \frac{\partial U}{\partial x_2} \cdot \frac{\partial f}{\partial x_1}}{\frac{\partial U}{\partial x_2}} = \frac{\partial f}{\partial y_1}$$

- dx_1 yields direct increase $\frac{\partial U}{\partial x_1} dx_1$ and an increase in output $dy_2 = \frac{\partial f}{\partial x_1} dx_1$, used to increase utility further by $\frac{\partial U}{\partial x_2} \frac{\partial f}{\partial x_1} dx_1$; to compensate, dx_2 yields $\frac{\partial U}{\partial x_2} dx_2$
- $SMRS_{1,2} = -\frac{dx_2}{dx_1} = \frac{\frac{\partial U}{\partial x_1} + \frac{\partial U}{\partial x_2} \cdot \frac{\partial f}{\partial x_1}}{\frac{\partial U}{\partial x_2}} = MRS^U_{1,2} + \frac{\partial f}{\partial x_1}$

II.3. Competitive equilibrium

Competitive equilibrium with externalities

Same as without externalities, except that agents take prices AND others' decisions as given: $(p^*, x^*, y^{a*}, y^{b*})$ with:

- y^{a*} maximizes $p_1^*(-y_1^a) + p_2^* y_2^a$ s.t. $y_2^a \leq f^a(y_1^a)$
- y^{b*} maximizes $p_1^*(-y_1^b) + p_2^* y_2^b$ s.t. $y_2^b \leq f^b(y_1^b; y_2^{a*})$
- x^* maximizes $U(x)$ s.t. $p^* \cdot x \leq p^* \cdot \omega + \Pi(p^*)$
- Markets clear: $x_1^* = \omega_1 - y_1^{a*} - y_1^{b*}, x_2^* = \omega_2 + y_2^{a*} + y_2^{b*}$

Equilibrium: equalization of private MRS and private MRT to ratio of prices:

$$\frac{\frac{\partial U}{\partial x_1}}{\frac{\partial U}{\partial x_2}} = \frac{\partial f^b}{\partial y_1^b} = \frac{\partial f^a}{\partial y_1^a} = \frac{p_1^*}{p_2^*}$$

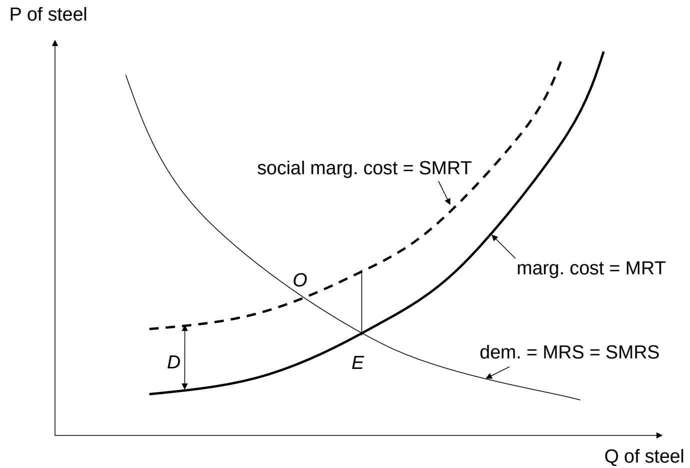
Inefficiency of competitive equilibrium under externalities

In general, the competitive equilibrium is not a Pareto optimum

- Competitive equilibrium equalizes private MRS and MRT; Pareto optimality requires to equalize social MRS and MRT
- Hence they are not consistent (except in degenerate cases, e.g. here if for the equilibrium allocation, $\frac{\partial f^b}{\partial y_2^a} = 0$)
- Too much *decentralization* of economic decisions
- **Partial equilibrium argument**: an agent whose consumption / production creates positive (negative) external effects decides typically to consume / produce too little (too much) compared to the Pareto optimum
- **In general equilibrium**, though, i.e. through price and revenue effects, this intuitive prediction can be reversed.

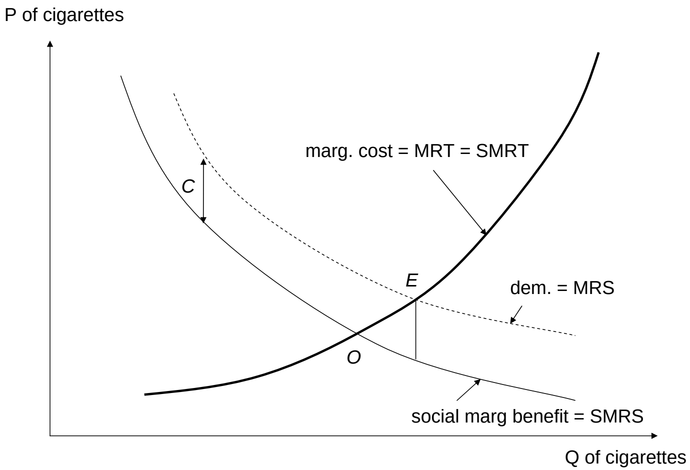
II.4. Partial equilibrium reasoning

Producing steel imposes additional cost D to society (USD 100 / ton): Equilibrium yields too high production of steel



II.4. Partial equilibrium reasoning

Smoking causes disutility C to society (USD 40c / pack): Equilibrium yields too much smoking



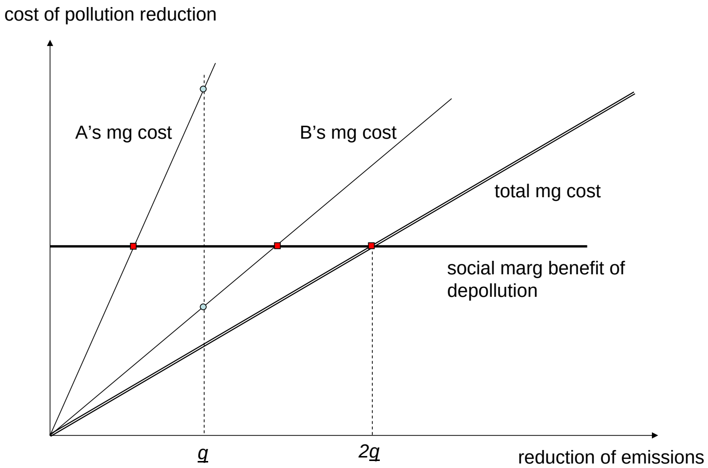
III. Restoring efficiency – III.1. Quotas and taxes

Since the competitive market does not lead to an efficient allocation, there is scope for government intervention besides pure redistributive purposes

First solution: central planner imposes the level of externality-generating activities

- Impose all externality-generating decisions at their optimal levels
- Or, depending whether the equilibrium leads to an excessive or an insufficient decision from the agent, impose a maximum quota (ceiling) or a minimum quota (floor) at the optimum level of this activity
- Not realistic if multiple local decentralized externalities
- Even if one large externality by multiple heterogeneous actors: information necessary and monitoring of each actor

Distribution of equal quotas to heterogeneous firms vs global quota with tradable permits among firms (perfect competition)



Second solution: tax the externality-generating activity

- Normalize $p_2 = 1$
- Let τ the *ad-valorem* personalized tax (subsidy) paid by a-firm on its production of good 2
- The total amount of taxes levied is redistributed to the consumer as a lump sum payment T (assume consumer takes this transfer as given !): adds up to the consumer's revenue
- Competitive equilibrium with taxes: choose tax at the level of its marginal externality effect evaluated at the Pareto optimum, $\overline{\tau} = -\frac{\partial f^b}{\partial y_2^a}(X^0)$ (Pigouvian taxes)

Competitive equilibrium with taxes yields:

$$\frac{\frac{\partial U}{\partial x_1}}{\frac{\partial U}{\partial x_2}} = \overline{p}_1$$

$$\frac{\partial f^a}{\partial y_1^a} = \frac{\overline{p}_1}{1-\overline{\tau}} = \frac{\overline{p}_1}{1+\frac{\partial f^b}{\partial y_2^a}(X^0)} \quad \text{and} \quad \frac{\partial f^b}{\partial y_1^b} = \overline{p}_1$$

Therefore, the Pareto optimum X^0 is an equilibrium with price:

$$\begin{aligned} \overline{p}_1 &= \frac{\frac{\partial U}{\partial x_1}(X^0)}{\frac{\partial U}{\partial x_2}(X^0)} \\ &= \frac{\partial f^b}{\partial y_1^b}(X^0) = \frac{\partial f^a}{\partial y_1^a}(X^0) + \frac{\partial f^b}{\partial y_2^a}(X^0) \cdot \frac{\partial f^a}{\partial y_1^a}(X^0) \end{aligned}$$

- **In the example**, the (unique) competitive equilibrium with these taxes is the Pareto optimum
- $\overline{\tau}$ = marginal externality at the optimum, i.e. firm b' willingness to pay to reduce firm a's production below its optimal level. When faced with $\overline{\tau}$, firm a internalizes the externality that it imposes on firm b
- Subsidizing reduction of production below some $\bar{y}_2$ at rate $\overline{\tau}$ determines firm a's profit:

$$-p_1 y_1^a + y_2^a + \overline{\tau}[\bar{y}_2 - y_2^a] = -p_1 y_1^a + (1 - \overline{\tau}) y_2^a + \overline{\tau}\bar{y}_2$$

  Equivalent profit maximization program: what matters is the marginal price signal

- **In general**, there exists a level of Pigouvian taxes such that there exists a competitive equilibrium allocation with these taxes that is a Pareto optimal allocation and the level of taxes equals the marginal value of the externality at this allocation.
- Existence: concavity of objectives / convexity of technology w.r.t own decision variables given externalities at optimum
- Victims do not necessarily receive compensation: e.g. in example firm b (depends on redistribution of taxes)
- Solution is also informationally demanding: information about preferences and technology, monitoring taxed activities
- Note: without uncertainty, all information available, equivalence between quotas or taxes

If both firms **merge**:

- In a competitive equilibrium framework, the merged entity maximizes $p_2(y_2^a + y_2^b) - p_1(y_1^a + y_1^b)$ s.t. $y_2^a = f^a(y_1^a)$ and $y_2^b = f^b(y_1^b; y_2^a)$
- FOC yield: $\frac{p_1}{p_2} = \frac{\partial f^b}{\partial y_1^b} = \frac{\partial f^a}{\partial y_1^a} + \frac{\partial f^b}{\partial y_2^a} \cdot \frac{\partial f^a}{\partial y_1^a}$
- that is, the competitive equilibrium is Pareto optimal.
- Note that for given prices p, the merger yields productive efficiency, hence larger profits: beneficial merger
- Yet, equilibrium prices may be different pre- and post-merger, and post-merger equilibrium profits may be smaller than pre-merger ones.

III.4. Creating a competitive market that was missing

Externalities related to missing markets: when externalities are translated into a market relation, the conditions for optimality should be reestablished!

In our leading example: default environment is externality-free

- Create a market for *rights to cause industrial external effects*, and firm a faces an institutional constraint: acquire rights α^a to cover the externality: $y_2^a \leq \alpha^a$
- Firm b can supply and sell rights: $\alpha^b \geq 0$.

III.4. Creating a competitive market that was missing

- prices p_α for industrial rights
- Firm a : $\max[p_2 f^a(y_1^a) - p_1 y_1^a - p_\alpha \alpha^a]$ with $f^a(y_1^a) = \alpha^a$:

$$(p_2 - p_\alpha)\frac{df^a}{dy_1^a} = p_1$$

- Consumer: $\frac{\frac{\partial U}{\partial x_1}}{\frac{\partial U}{\partial x_2}} = \frac{p_1}{p_2}$
- Firm b: $\max[p_2 f^b(y_1^b, \alpha^b) - p_1 y_1^b + p_\alpha \alpha^b]$

$$p_2 \frac{\partial f^b}{\partial y_1^b} = p_1 \text{ and } p_2 \frac{\partial f^b}{\partial y_2^a} + p_\alpha = 0$$

- New market clears: $\alpha^a = \alpha^b$
- Altogether,... back to the Pareto optimality conditions !

III.4. Creating a competitive market that was missing

Efficient equilibrium with markets for externalities

The competitive equilibrium of the enlarged economy in which the commodity space is extended to include markets for rights to exert externalities is Pareto optimal.

- This market has one agent on each side: perfect competition hypothesis ?
- Often, however, externalities are generated and felt by many agents (see multilateral externalities / public good, next session)
- Monitoring to check that institutional constraints are met; but not much information needed at central level.

III.4. Creating a competitive market that was missing

Allocation of initial property rights w.r.t. externalities is neutral for efficiency; it implies some redistribution, however

- Reverse the institutional setting: the basic right is one with some externality
- Firm a is entitled to emit up to $\overline{y}$ with $\overline{y} > y_2^{a0}$ and firm b has to buy units of reduction of the externality
- Firm a's profit:

$$-p_1 y_1^a + p_2 y_2^a + p_\alpha(\overline{y} - y_2^a) = -p_1 y_1^a + (p_2 - p_\alpha) y_2^a + p_\alpha \overline{y}$$

- Same marginal effects

In a general equilibrium model, this may lead to a different competitive equilibrium (revenue effects, changes in profits)

III.4. Creating a competitive market that was missing

Existence requires convexity in the enlarged space: problems!

Positive externalities and increasing marginal returns

- Suppose that: $f^b(y_1^b, y_2^a) = (y_1^b)^\alpha (y_2^a)^\beta$, with $(\alpha, \beta) \in [0,1]^2$
- Firm b's profit function is then proportional to: $(y_2^a)^{\frac{\beta}{1-\alpha}}$, and therefore convex in y_2^a when $\beta > 1-\alpha$ (Cf knowledge externality in growth models)!

Negative externality, shutdown and non-convexity

- Suppose: negative externality: $\frac{\partial f^b}{\partial y_2^a} < 0$, and firm b can ensure zero profits choosing $y_1^b = y_2^b = 0$
- Then, f^b cannot be concave in y_2^a at given y_1^b since a decreasing concave function has to cross zero and therefore the firm would rather choose not to produce and to sell infinite amount of rights to firm a!

III.5. When missing markets are not competitive

If perfect competition is not tenable:

- Assume right to externality-free environment: a-firm cannot generate any externality without b-firm's permission
- Bargaining: firm b makes an offer to firm a, demanding payment T in return for permission to externality y
- Firm a agrees iff: $p_2 y - p_1 (f^a)^{-1}(y) - T \geq 0$
- Firm b will saturate this constraint and solve:

$$\begin{aligned} & \max_{y_1^b, y, T} [p_2 f^b(y_1^b, y) - p_1 y_1^b + T] \\ = \ & \max_{y_1^b, y} [p_2 f^b(y_1^b, y) - p_1 y_1^b + p_2 y - p_1 (f^a)^{-1}(y)] \end{aligned}$$

- Hence, efficiency even though the market for rights is not perfectly competitive.

III.5. When missing markets are not competitive

- As for a competitive market, the allocation of the initial rights is irrelevant for efficiency ...
- ... although it may modify the equilibrium through revenue effects
- The result would hold if firm a made an offer to firm b, too
- In fact, it would hold provided bargaining leads to an efficient outcome

Coase Theorem

If trade of the rights to exert an externality can occur freely (well-defined rights, no distortionary tax, no transaction costs, perfect information), bargaining over the externality will restore efficiency, irrespective of the initial allocation of rights.

III.5. When missing markets are not competitive

Problems with Coasian solutions: much more convincing for small localized externality than for large and global ones:

- Difficult to allocate all rights, and lot of trade necessary
- Multi-party negotiations difficult to formalize and issue of efficiency
- With many agents, issue of redistribution become serious
- With shared rights, who sells / buys ?

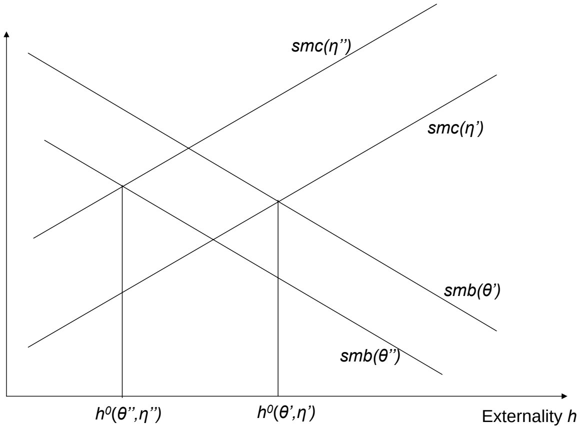
Asymmetric information in even simpler framework

Simplified example

- One firm exerts an externality $h \in \mathbb{R}_+$ on one consumer
- Let $u(h, \eta) + m$ denote the consumer's utility (concave in h for any η, linear in money) for externality h, where η is a idiosyncratic parameter
- Let $\pi(h, \theta)$ the firm's indirect profit (concave in h for any θ) for externality
  h, where θ is a specific cost parameter
- η is privately known by the consumer; θ privately known by the firm
- η and θ are independent, with commonly known distributions

IV.1. Tax or quota under asymmetric information ?

- Aggregate surplus $u(h, \eta) + \pi(h, \theta)$ maximized at $h^0(\eta, \theta)$
- smb: social marginal benefit $\partial_h \pi(h^0, \theta)$ equals smc: social marginal cost $-\partial_h u(h^0, \eta)$



IV.1. Tax or quota under asymmetric information ?

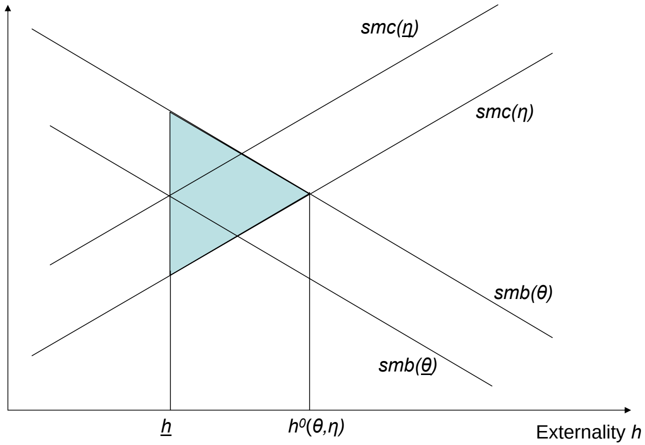
Effect of a quota at $\underline{h}$

- The firm's program: $\max_{0 \leq h \leq \underline{h}} \pi(h, \theta)$, with optimal choice: $h^Q(\underline{h}, \theta)$.
- The level of externality is less sensitive to the marginal cost for consumer: here, not sensitive at all to η
- The level of externality is also less sensitive to the marginal benefit parameter for the firm: here, if $\partial_h \pi(\underline{h}, \theta) > 0$ for all θ, then $h^Q(\underline{h}, \theta) = \underline{h}$ for all θ.
- Loss in aggregate surplus:

$$\int_{h^0(\eta,\theta)}^{h^Q(\underline{h},\theta)} [\partial_h \pi(h, \theta) + \partial_h u(h, \eta)] dh$$

- Graphical representation for $\underline{h} = h^0(\underline{\eta}, \underline{\theta}) < h^0(\eta, \theta)$ and $\underline{\eta} = \mathbb{E}[\eta]$ and $\underline{\theta} = \mathbb{E}[\theta]$

Effect of a quota at $\underline{h}$



IV.1. Tax or quota under asymmetric information ?

Effect of a tax at t

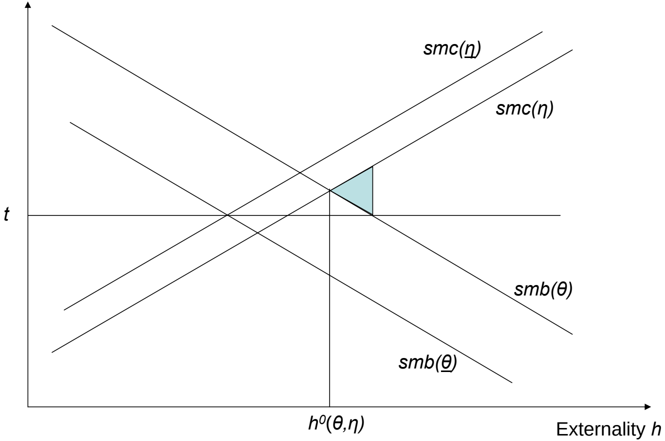
- The firm's program: $\max_{0\leq h}[\pi(h,\theta)-th]$, with optimal choice: $h^T(t,\theta)$.
- Again, the level of externality is less sensitive to η
- Loss in aggregate surplus:

$$\int_{h^0(\eta,\theta)}^{h^T(t,\theta)} [\partial_h \pi(h,\theta) + \partial_h u(h,\eta)]dh$$

- Graphical representation for $t = -\partial_h u(h^0(\overline{\eta},\overline{\theta}))$

IV.1. Tax or quota under asymmetric information ?

Effect of a tax at t

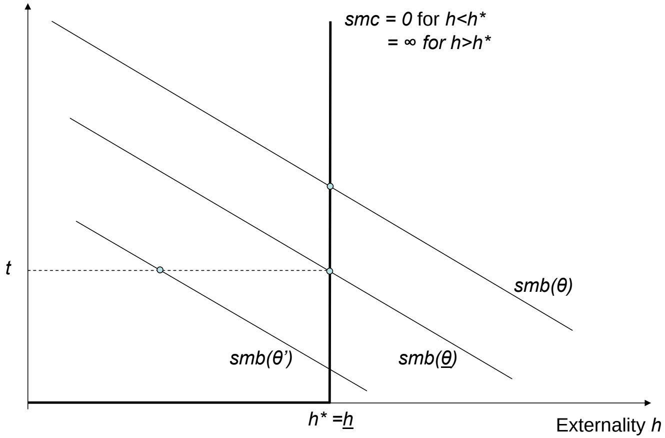


IV.1. Tax or quota under asymmetric information ?

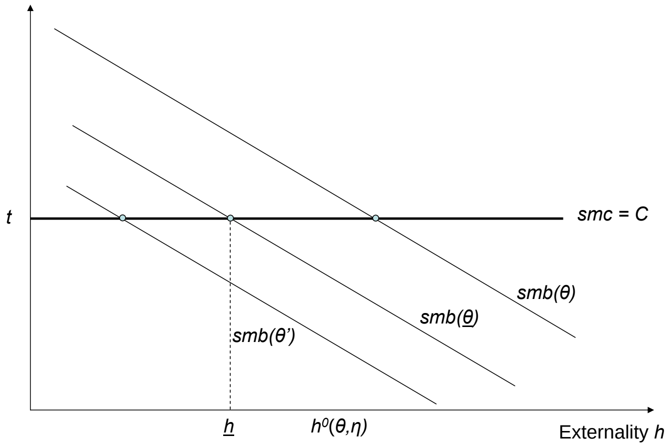
Which one is better ex ante, i.e. taking expectations wrt η and θ? Suppose η is constant, at level $\overline{\eta}$

- The quota limits the level of the externality for values of θ that induce a high marginal benefit for the firm, as it will be binding
- The tax does not take into account an increasing marginal cost for the consumer for high levels of the externality, hence is permissive to excess externality for such values of θ
- If e.g. $-\partial_h u = 0$ for $h \leq h^*$ and $-\partial_h u = \infty$ for $h > h^*$, then quota at h^* achieves full efficiency $\forall(\eta, \theta)$; no tax can
- If e.g. $-\partial_h u = C$ for all h and η, then a tax $t = C$ achieves efficiency for any (η, θ); no quota does
- Tax and quota not equivalent anymore under asymmetric information

Comparison with quantitative threshold in social marginal cost



Comparison fixed social marginal cost



IV.1. Tax or quota under asymmetric information ?

Take the following functional forms:

$$
\begin{aligned}
u(h,\eta) &= U - (m+\eta)(h-h^*) - \frac{A}{2}(h-h^*)^2 \\
\pi(h,\theta) &= \Pi + (m+\theta)(h-h^*) - \frac{B}{2}(h-h^*)^2
\end{aligned}
$$

- For a full quota h (floor and ceiling),

$$\mathbb{E}[u(h,\eta)+\pi(h,\theta)] = U + \Pi - \frac{A+B}{2}(h-h^*)^2$$

  maximized for $h = h^*$ for a value $U + \Pi$.
- For a tax t, the firm fixes $\partial_h \pi = t$, i.e. $h^T = h^* + \frac{m-t+\theta}{B}$. This yields surplus:

$$\mathbb{E}[u(h^T,\eta)+\pi(h^T,\theta)] = U + \Pi + \sigma_\theta^2 \frac{(B-A)}{2B^2}$$

IV.1. Tax or quota under asymmetric information ?

Quota better (worse) than tax $\Leftrightarrow A > B$ ($A < B$)

- Relative sensitivity of marginal benefit and marginal cost matters
- If there is a critical level of externality beyond which social marginal cost explodes, it means that "locally" A is very large, hence quota is better
- Debate about CO_2 taxation versus emission quotas
- If, on the other hand, the technology is highly sensitive to externality, then locally B is large and tax should be preferred.

Tax and quota under asymmetric information

Taxes and quotas cease to be equivalent in a world with asymmetric information, the relative merits depending on the sensitivity of marginal social benefit and marginal social cost to the externality.

Further simplified example

- One firm exerts an externality $h \in \{0, 1\}$ on one consumer
- Let the consumer's utility be: $-\eta h + m$ for externality h, where η is a idiosyncratic parameter
- Let the firm's indirect profit be: θh, where θ is a specific cost parameter
- η is privately known by the consumer; θ privately known by the firm
- η and θ are independent, with commonly known distributions $F(.)$ and $G(.)$ on $\mathbb{R}$

IV.2. Bargaining under asymmetric information

- Efficiency requires that $h = 0$ whenever $\eta > \theta$ and $h = 1$ whenever $\eta < \theta$.
- Suppose the consumer has the right to an externality-free environment, but that he can bargain off this right
- Suppose moreover that the consumer can make a take-it-or-leave-it negotiation offer to the firm so as to grant it the permission to emit externality
- The consumer will ask for an amount M so that:

$$\max_M [\text{Prob}(\theta > M)][M - \eta] = \max_M [1 - G(M)][M - \eta]$$

- Ex post, externality $h = 1$ is agreed upon whenever: $\theta > M^*(\eta) > \eta$
- Inefficiently low externality if $M^*(\eta) > \theta > \eta$!

- Under asymmetric information, bargaining may result in ex post inefficient resolution of conflict on the externality level
- In fact, this is a much more general result, independent of the form taken by the bargaining procedure !
- Seen later in the course

Decentralized bargaining under asymmetric information

The definition of property rights and the design of decentralized bargaining procedures do not restore in general efficiency in the determination of the externality.

IV.3. Conclusions under asymmetric information

Restoring efficiency in the presence of externalities is a simple matter under perfect information: quotas, taxes, decentralized bargaining

Under asymmetric information:

- Nothing is simple anymore !
- Taxes and quotas are not equivalent
- The Coase theorem does not hold
- Therefore, there is in general no obvious way to restore efficiency
- And no simple ranking among the possible instruments

Required Reading

- Arrow, K. (1969), in *Collected papers of K.J. Arrow*, Vol 2, Harvard Univ. Press, 1983.
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