31E99906 Microeconomic policy

Lecture 8: Missing markets

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NOBEL PRIZE 2018: MISSING MARKETS PROBLEMS FOR THE ENVIRONMENT AND INNOVATIONS

WILLIAM D. NORDHAUS
"for integrating climate change into long-run macroeconomic analysis"
PAUL M. ROMER
"for integrating technological innovations into long-run macroeconomic analysis"

Another Nobel Prize candidate

MARTY WEITZMAN

who passed away Aug 27, 2019. Today's lecture builds on his seminal contribution

Plan for the lecture

Missing markets

1. The objective in this lecture is to focus on the instrument design
    - The externality problem is known from earlier studies
2. We start by discussing a few situations of missing markets: scarce resources, pollution
3. We continue by focusing on pollution markets
    - A key property is uncertainty
4. What instruments are efficient?
    - Prices, quantities, and hybrids of the two

Illustrations

Two very different examples of missing markets:

1. Scarce public resource to be allocated for private use
    - electromagnetic waves ("electromagnetic spectrum" or just "spectrum"), are needed for transmitting data wirelessly. The use is rival and thus must be controlled by government. Government organized a spectrum auction 2018, see *here*.
    - Allocation is a one-time event distributing the rights to use.
2. Externalities
    - pollution is the prime example
    - allocation is a day-to-day activity.

In both cases, government can be seen to own the resource (spectrum, clean environment), and can decide on how sell rights to use it to (i) achieve efficiency and (ii) raise revenue (which is important if the shadow cost of public funds is positive).

Recent spectrum auction:

The auction of 3.5 GHz spectrum arranged by the Finnish Communications Regulatory Authority was concluded on 1 st October 2018. The winning operators are Telia Finland Oyj, Elisa Oyj and DNA Oyj. The auction generated EUR 77 605 000 in revenue to the state.

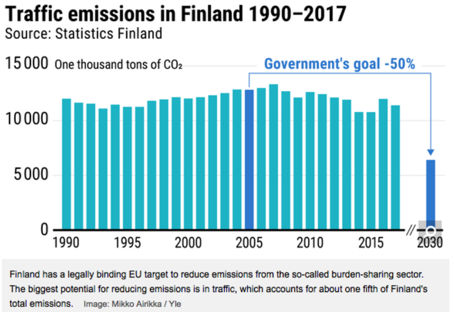
The winning bids are:

Frequency band 3410–3540 MHz (A)
Telia Finland Oyj
EUR 30 258 000

Frequency band 3540–3670 MHz (B)
Elisa Oyj
EUR 26 347 000

Frequency band 3670–3800 MHz (C)
DNA Oyj
EUR 21 000 000

YLE, Oct 22, 2019: *"A team of economists at Aalto University has recommended the introduction of an annual cap on CO2 emissions from fossil fuels if Finland wants to achieve its ambitious goal of halving traffic emissions by 2030. The quota would gradually decrease every year up to 2030, thereby reducing the emissions in line with the Finnish government's targets."*



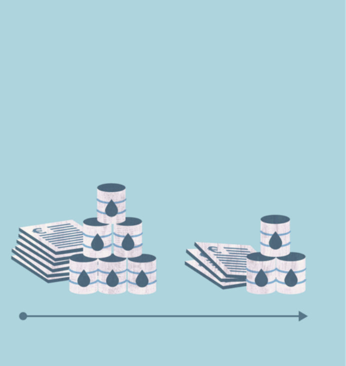
CO2 from traffic

How does it work?

Team's proposal would see the Finnish state set an annual quota for the consumption of fossil fuels.

Fuel distributors in Finland - such as ABC, Neste and Teboil - would then be required to obtain an emission permit for every litre of petrol or diesel they sell, which must be purchased from the state via an auction. Each litre fuel sold needs permits based on the CO2 content of the fuel

CO2 from traffic



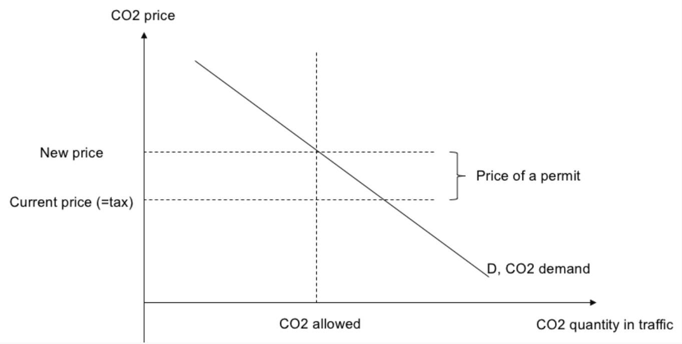
How should the auction be organized?

State sells the rights/permits to distribute fuels (or CO2) in frequently organized auctions

- Availability of permits important
- Permits expire
- Freely tradable afterwards
- Price floor and ceiling needed to limit uncertainties.

Number of rights annually auctioned decline year-to-year to reach 50% reduction by 2030

In Finland, there is a CO_2 tax already – What is the impact of the new system?



Design questions

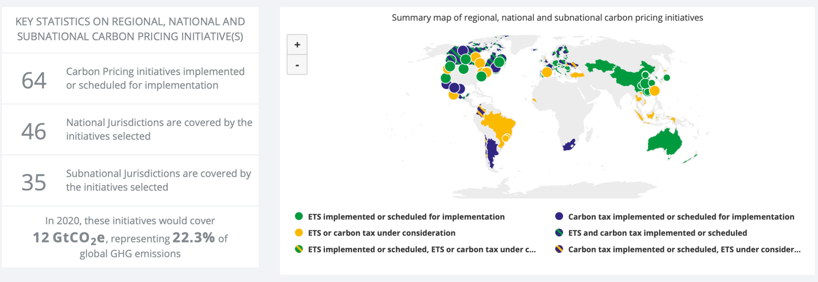
What is the optimal instrument for regulating pollution?

The proposal above suggested a system of tradable rights. But is the conceptual basis for this suggestion? A number of questions to be answered:

- Why is this system better than a tax on CO2?
  - Answer from the theory for optimal instrument design: price or quantity instrument may be chosen depending on the fundamentals of the problem
  - Uncertainty is one such fundamental
- Why is the price collar (floor, ceiling) needed in the proposal? The optimal instrument may a combination of the prices and quantities

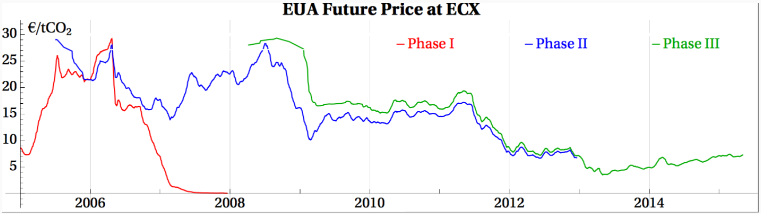
Reminder 1: there is a lot of experience from market instruments to regulate externalities

(Link to the source) More than 20% of global emissions subject to some form of carbon pricing



Reminder 2: one common lesson is that uncertainty is prevalent

European Union Emissions Trading System (EU ETS)



Credit: Bluenext

Prices vs. Quantities Analysis

A design question for regulation

A fundamental problem for market design, illustrated by the EU ETS experience:

- *Uncertainty*. The private cost of the regulation is not known at the time of instrument design. For example, setting prices on externality causing activities or quantities limiting the level of the activity are, in principle, equivalent but important differences arise when there is uncertainty.

The outcome in the EU ETS would have been very different under a tax on pollution (price instrument). How to optimally make the choice between the instruments?

- *price instrument*: Pigouvian tax on pollution
- *quantity instrument*: a system of tradable rights

Choice between prices vs. quantities

Let x now denote an uncertain factor that influences consumer (or market) valuation of pollution-generating activity. x may be "technology" or "productivity" measure that is uncertain. We denote the amount of pollution by z.
Timing:

1. Policy is chosen: price on z or, alternatively, quantity cap on the total amount of z
2. x is realized, and firms choose z.

Reflects reality: policy such as the EU emissions trading scheme must be chosen first, and then firms learn the private value of the pollution activity.

Consumers' utility from services that generate pollution z

$$u(z) = u_0 + (u_1 + x)(z - z^*) - \frac{u_2}{2}(z - z^*)^2$$

where coefficients u_0, u_1, u_2 are given. We can think of this expression as being a quadratic approximation of some general utility function at $z = z^*$. So z^* is a given constant as well. Marginal utility is then linear:

$$u'(z) = u_1 + x - u_2(z - z^*)$$

To make the analysis really simple we reduce the number of parameters by setting $u_1 = z^*$, renaming $u_2 = a$, and also by multiplying x by a so that

$$u'(z) = z^* - a(z - z^* - x).$$

This is then the linear demand curve pollution.

The total social cost curve for producing services that generate pollution z is

$$c(z) = c_0 + c_1(z - z^*) + \frac{c_2}{2}(z - z^*)^2$$

where coefficients c_0, c_1, c_2 are given. Again, we can think of this expression is a quadratic approximation of some general cost function at $z = z^*$. So z^* is a given constant as well. Marginal cost is then linear:

$$c'(z) = c_1 + c_2(z - z^*)$$

To make the analysis REALLY simple we set $c_1 = z^*$, and rename $c_2 = b$ so that

$$c'(z) = z^* + b(z - z^*).$$

This is then the linear social supply curve of z.

The social optimum: ex ante

Assume that $E\{x\} = 0$: the technology or demand is not expected to change in a systematic way. How should we choose pollution z if we could do that after observing x? Just equate the private demand price and the social cost, that is, $u'(z) = c'(z)$:

- The socially optimal pollution (FB=first best) is

$$z^{FB} = z^* + \frac{a}{a+b}x$$

You see that when $x = 0$ (no uncertainty), then $z^{FB} = z^*$. BUT: we cannot observe x at the time of policy making. We are restricted to second-best policy.

Second-best: quantity policy

- What is the optimal z, to be chosen before observing x? The optimal choice is

$$z^Q = z^*$$

where "Q" refers to quantity policy, that is, quantity set before the realization of uncertainty.

Proof: The expected loss from setting z is:

$$E\{\int_{z^*}^{z}(p^d(k) - p^s(k))dk\} = -\frac{a+b}{2}(z - z^*)^2$$

which is minimized by setting $z^Q = z^*$.

Second best: price policy

When facing tax τ per unit of pollution, private agents respond by choosing z such that

$$\max_z \Big(u(z) - \tau z \Big)$$

$$\Rightarrow$$

$$z^* - a(z - z^* - x) = \tau$$

This allows us choose τ so that the expected pollution is at the desired level, that is, $E\{z(\tau)\} = z^*$.

- Optimal tax τ per unit of z is

$$\tau^* = z^*$$

$$\Leftrightarrow$$

$$E\{z(\tau)\} = z^*$$

Choosing between quantities and prices

Recall that once the uncertainty is realized $x \neq 0$, the policy will lead to an outcome that deviates from the first best. The quantity policy z^Q will be off by this much

$$z^{FBE} - z^Q = \frac{a}{a+b}x$$

while the price policy z^τ leads to a deviation in the other direction

$$z^{FBE} - z^\tau = -\frac{b}{a+b}x.$$

To make the choice between the instruments, we need to compare the resulting losses from these deviations.

Choosing between quantities and prices

Let Δ^Q and Δ^τ denote the expected loss from deviations $z^{FBE} - z^Q$ and $z^{FBE} - z^\tau$, respectively

- The optimal policy depends only on the slopes of the marginal private valuation and the marginal social costs:

$$\Delta^Q < \Delta^\tau \Leftrightarrow b > a$$

- to be explained in the class

prices vs. quantities: lessons

- price instrument makes sense in climate change: the social cost arises from changes in stocks $\Rightarrow b$ is low. See References I
- Suppose uncertainty can take two values, $x \in [x^L, x^H]$. The quantity instrument can be supplemented with prices to achieve first best! Regulator can sell more rights in state $x = x^H$, and buy back permits in the low state $x = x^L$. Difficult to implement if uncertainty has a richer structure but gains in general to be achieved through this "hybrid" price-quantity scheme. See References II

Illustration: a hybrid instrument

Each unit of output produces one unit of pollution, denoted by z. Private demand for pollution is $z = 10 + x - p$ where p is output price and x is uncertain demand shifter that takes random values from between $[-5, 5]$. That is, when demand is highest, then $z = 15 - p$; the lowest demand is given by $z = 5 - p$. The expected value of x is zero. There is no private cost of production but the social marginal cost of pollution is 2 for $z \leqslant 5$, and 7 for $z > 5$.

1. Government wants to regulate pollution but must choose the instrument for regulation before the demand becomes known. If the government uses a tax on pollution, what is the optimal level of the tax?
2. If the government uses tradable permits, what is the optimal quantity of permits released?
3. Describe the optimal policy instrument that uses a combinations of options 1-2

Asymmetric information

- So far we have assumed that the regulation is designed before agents know their x. This describes well situations where the actions to be taken are new to all parties; not even firms have a good idea how costly, for example, emissions reductions will be.
- However, it is often the case that firms have much better information even if it is not full information. Thus, there is private or asymmetric information. This changes the nature of the policy design issue quite a bit.
- Next we illustrate how in principle one can design an auction mechanism that makes the firms to reveal their private information (see Montero, 2008)

Asymmetric information: pollution illustration

Regulator would like to choose

$$\min_z [C(z) + D(z)]$$

where $C(z)$ is the cost of abatement and $D(z)$ is the cost of emissions. Note that $C'(z) < 0$ in this formulation. The optimum is assumed to be interior and given by

$$-C'(z) = D'(z)$$

Asymmetric information: pollution illustration

For illustration, consider first only one firm. The mechanism is the following.

The firm is asked to report its marginal valuation for z at each level of z. Thus, the firm reports a curve, denoted by $\hat{P}(z)$. If $\hat{P}(z) = -C'(z)$, then the firm is reporting truthfully. The reported $\hat{P}(z)$ defines the reported cost curve $\hat{C}(z)$.

1. The regulator decides how many licenses to pollute, denoted by l, to give by solving

$$\min_{l}[\hat{C}(l) + D(l)] \Rightarrow p = -\hat{C}'(l) = D'(l)$$

2. The regulator takes p as the price of emissions and rebates money back to the firm: $\alpha p l$ where $\alpha \in (0, 1)$

Asymmetric information: pollution illustration

Firms payoff

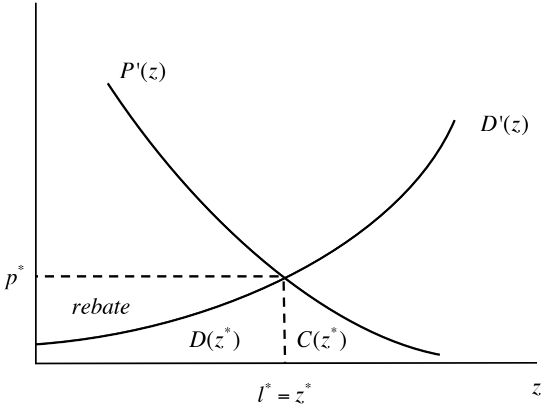
$$\min_{l}[\hat{C}(l) + pl(1 - \alpha(l))]$$

The same as the regulator's objective if

$$pl(1 - \alpha(l)) = D(l)$$
$$\Rightarrow D'(l)l(1 - \alpha(l)) = D(l)$$
$$\Rightarrow \alpha(l) = 1 - \frac{D(l)}{D'(l)l}$$

When facing the rebate rule $\alpha(l) = 1 - \frac{D(l)}{D'(l)l}$, the firm reports truthfully $\hat{P}(z) = -C'(z)$, and the resulting allocation of licenses is socially optimal, $l^* = z^*$

Figure illustrating the auction mechanism



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