M2R APE
Environmental Economics
Chapter 2: Environmental regulation in an uncertain world

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Chapter Outline

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1. Precautionary principle
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2. Choice between price/quantity instruments under uncertainty
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Chapter 2: Environmental regulation in an uncertain world

1. Precautionary principle
2. Choice between price/quantity instruments under uncertainty

Characteristics of environmental risk

- Uncertain results
  - Ex : oil spills (Exxon Valdez, Erika, etc.)
  - Accidents caused or not by negligence
  - Harmful materials in soils, etc.
- Complexity
  - Difficulties in the analysis of consequences (pesticides residuals, ozone accumulation, GHG : impacts on ozone layer and climate change)
  - Difficulties in establishing the links between behaviors and environmental impacts
  - Length of the causal chain between the shock and the measurable effects: (bio-geo-chemical cycles, balances matter-énergy)

Characteristics of environmental risk

Environmental risk and uncertainty / information asymmetry

- Objective / subjective risks
    - Ex : nuclear sector about which the public perceive a much higher risk than experts
    - Pb : how to distinguish between subjective risk and objective risk ?
- Controversial risks
    - Ex : risk of climate change caused by GHG perceived as lower by some countries / people
- Voluntary / Involuntary risks
    - Volontary : e.g. as a country (nuclear risk)
    - Involuntary : all victims of pollution

Characteristics of environmental risk

Environmental risk and uncertainty / information asymmetry

- Exogenous
  - probabilistic = risk
  - otherwise = uncertainty
- Behavioral = Information asymmetry
  - Ex ante
    ≡ Adverse selection (antisélection)
    ≡ Issue of hidden characteristics
  - Ex post
    ≡ Moral hazard (alea moral)
    ≡ Issue of hidden behavior

1. Precautionary principle

Precaution $\neq$ Caution $\neq$ Prevention

- Caution (prudence)
  - = proved risks with assessable frequency
  - probabilistic $\equiv$ insurable (ex: oil spill)
- Prevention
  - = known risks with non assessable frequency
  - uncertain $\equiv$ non insurable (ex: nuclear risk)
- Precaution
  - = risks with non assessable frequency and gravity, given the current knowledge
  - ex: GMO, mobile phone waves, hydraulic fracturing

1. Precautionary principle

Precautionary principle in the law

"where there are threats of serious and irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."
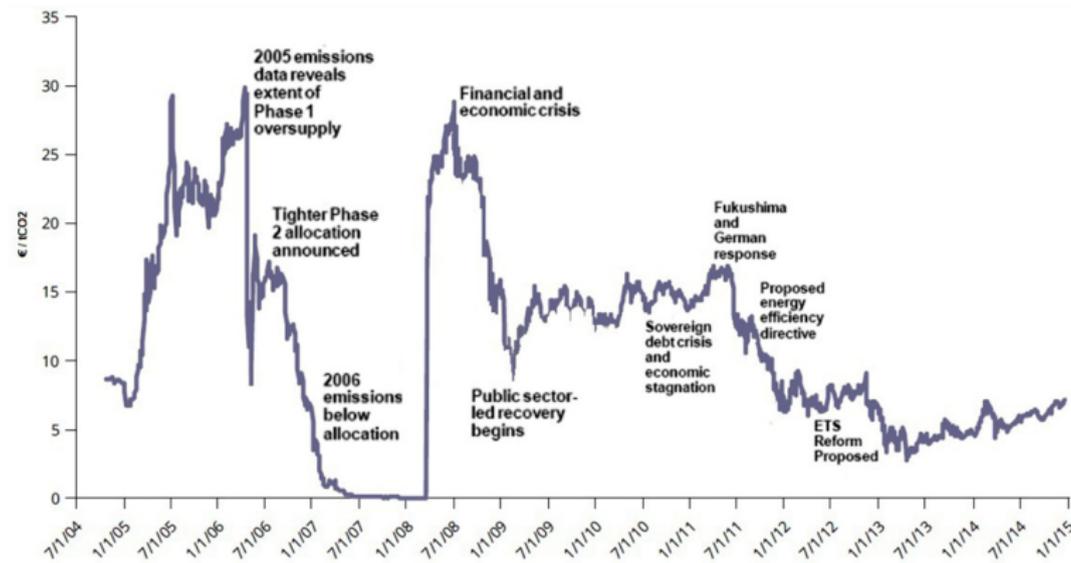
Article 15 of the Rio Declaration (1992)
↪ French Constitution (2005)

1. Precautionary principle

Precautionary principle (Lees, 2012)

- " better safe than sorry "
- justifies regulation **before full scientific certainty can be established** (and **before permanent environmental damage occurs**)
- enables legislators to shift the burden of the proof from the tradition that requires regulators prove that regulation is necessary to **requiring that the industry proves that regulation is unnecessary**

2. Choice between price/quantity instruments under uncertainty

When the marginal cost of abatement or the marginal damage are not known with certainty by the policy-maker, **what is the best instrument?**

Efficiency criterion: minimizing the welfare loss compared to first-best (with certainty)

The EU-ETS: Price volatility as a main characteristic

Intertemporal evolution of EUA prices and major events in the period 2005–2015.
*Source: Borghesi and Montini (2016)*

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The EU-ETS: Now improved

Intertemporal evolution of EUA prices in the period 2014–2023.

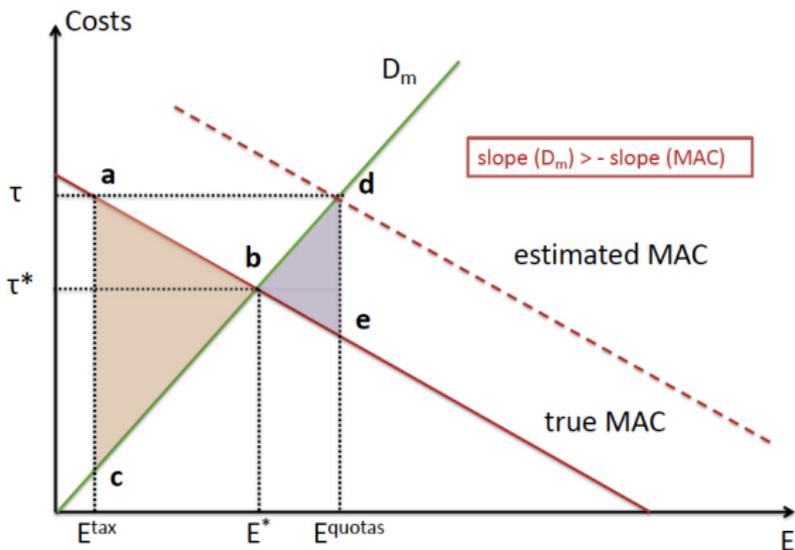# 2. Choice between price/quantity instruments under uncertainty

Instrument choice with unknown marginal damage (Weitzman [1974])
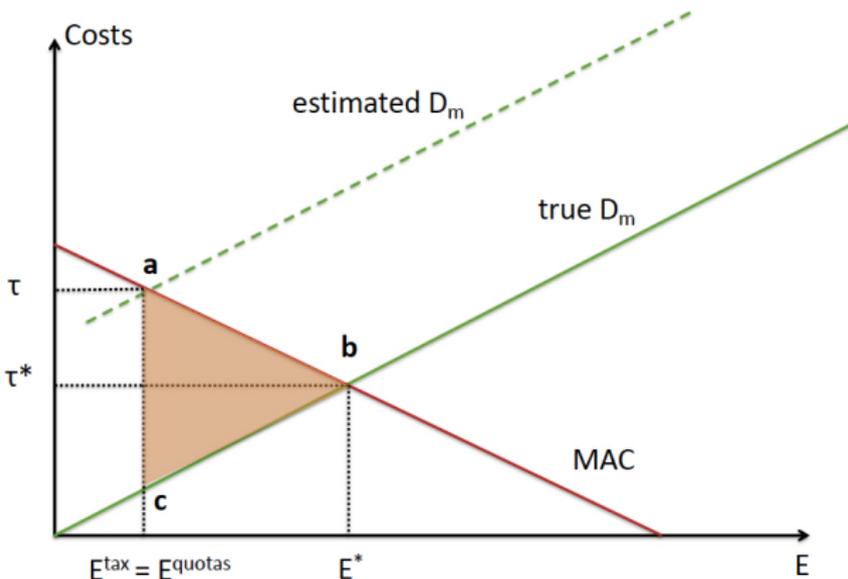
Welfare loss in both cases: **abc**

2. Choice between price/quantity instruments under uncertainty

Instrument choice with unknown abatement cost (Weitzman [1974]) Case 1
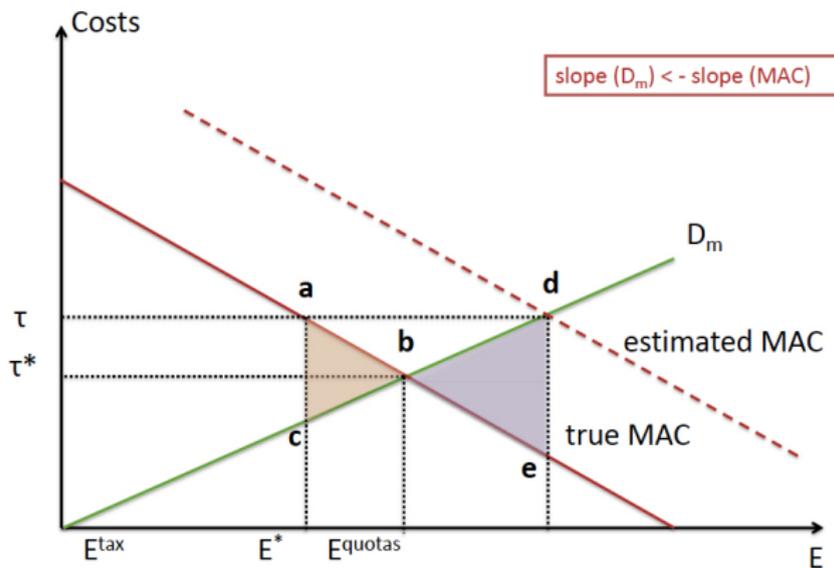

Welfare loss:
Tax : abc
Cap-and-trade: bde

abc > bde

2. Choice between price/quantity instruments under uncertainty

Instrument choice with unknown abatement cost (Weitzman [1974]) Case 2

slope (D_m) < - slope (MAC)

Welfare loss:
Tax : abc
Cap-and-trade: bde

abc < bde

2. Choice between price/quantity instruments under uncertainty

Instrument choice with unknown abatement cost (Weitzman [1974])

Let $R = \dfrac{\left|\dfrac{\partial D_m}{\partial E}\right|}{\left|\dfrac{\partial MAC}{\partial E}\right|}$

- If $R < 1$ and as $R \longrightarrow 0$, tax is better
- If $R > 1$ and as $R \longrightarrow \infty$, cap-and-trade is preferable

2. Choice between price/quantity instruments under uncertainty

Instrument choice with unknown abatement cost (Weitzman [1974])

- For a given curve of marginal abatement cost, the higher the slope of the marginal damage, the more cap-and-trade is preferred to the tax.
- For a given curve of marginal damage, the higher the slope of the marginal abatement cost, and the more the tax is preferred to cap-and-trade.

2. Choice between price/quantity instruments under uncertainty

Hybrid system between taxes and cap-and-trade (Roberts and Spence [1976])

- *Pollution cap:* Permits (called license in Roberts-Spence 1976) in quantity l.
  Each firm i holds l_i permits. Market price of permits q.
- *Residual incentive to abate if abatement costs have been overestimated:* Unit subsidy s paid to any firm whose permits holding l_i exceeds its emissions x_i
- *Escape valve if abatement costs have been underestimated:* Penalty (or tax) p paid by any firm for its emissions x_i exceeding its permits holding l_i.

2. Choice between price/quantity instruments under uncertainty

Hybrid system between taxes and cap-and-trade (Roberts and Spence [1976])

Abatement costs $C^i(x_i, \varphi)$ with φ a random variable. Expected damage $D(x)$.

The firm i minimizes its total costs by choosing x_i and l_i.

$$\begin{cases} C^i(x_i, \varphi) + q l_i - s(l_i - x_i) & \text{if } x_i \leq l_i \\ C^i(x_i, \varphi) + q l_i + p(x_i - l_i) & \text{if } x_i \geq l_i \end{cases} \quad \text{and } l = \sum_{i=1}^{I} l_i$$

At the equilibrium:

- if $q < s$, it would be optimal for each firm to reduce costs indefinitely by buying permits $\implies$ impossible
- if $q > p$, it would be optimal for each firm not to buy any permit $\implies$ inconsistent with the equilibrium in licence market

$$\implies s \leq q \leq p$$

2. Choice between price/quantity instruments under uncertainty

Hybrid system between taxes and cap-and-trade (Roberts and Spence [1976])

$$C_x^i(x_i, \varphi) = -q \quad \forall i$$

because

- if $q = s$, the firm will choose $l_i \geq x_i$ and minimize $C^i(x_i, \varphi) + sx_i$ by setting $C_x^i(x_i, \varphi) = -s = -q$
- if $s < q < p$, the firm will set $l_i = x_i$ and minimize $C^i(x_i, \varphi) + qx_i$
- if $q = p$, the firm will choose $l_i \leq x_i$ and minimize $C^i(x_i, \varphi) + px_i$ by setting $C_x^i(x_i, \varphi) = -p = -q$

$\implies$ *Abatement is efficiently distributed among polluters*
and $C_x(x, \varphi) = -q$ for $x = \sum\limits_{i=1}^{I} x_i$.

2. Choice between price/quantity instruments under uncertainty

Hybrid system between taxes and cap-and-trade (Roberts and Spence [1976])

Determination of x and q

- First case: low costs of abatement $C_x(l, \varphi) + s > 0$
  then $x < l$ and $q = s$ and x is set by $C_x(x, \varphi) + s = 0$
- Second case: intermediate costs $s < -C_x(l, \varphi) < p$
  then $x = l$ and x is set by $q = -C_x(x, \varphi)$
- Third case: high costs $C_x(l, \varphi) + p < 0$
  then $x > l$ and $q = p$ and x is set by $C_x(x, \varphi) + p = 0$

2. Choice between price/quantity instruments under uncertainty

Hybrid system between taxes and cap-and-trade (Roberts and Spence [1976])

The mixed effluent-license system produces levels of emissions, conditional on costs, that reproduce exactly the emissions that would occur if

(1) the polluting firms were merged (and made cleanup decisions centrally) and

(2) they faced a piecewise linear penalty function, that approximates the expected damage function, of the form $P(x) = sx + p\max(x - I, 0)$
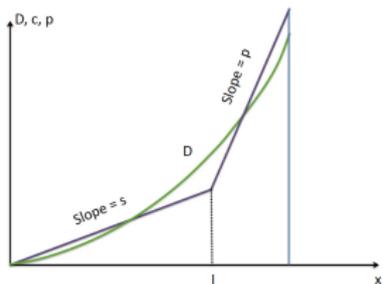
The regulator sets I, p and s by minimizing $E\left[D(x) + C(x, \varphi)\right]$

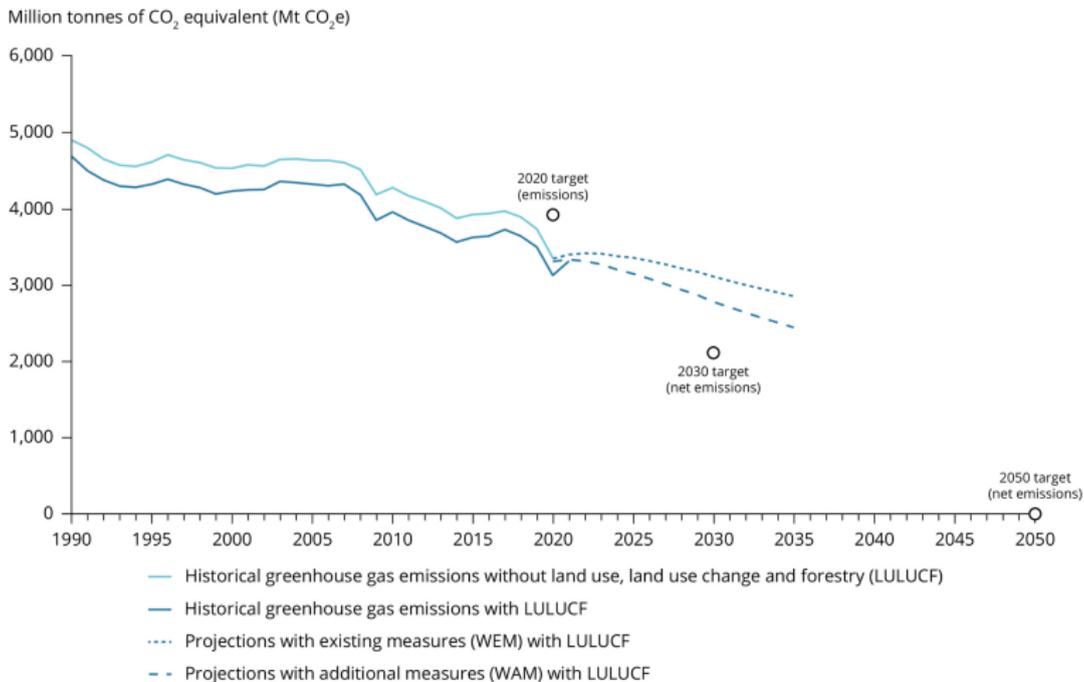# 2. Choice between price/quantity instruments under uncertainty

Hybrid system between taxes and cap-and-trade (Roberts and Spence [1976])

- The hybrid system allocates abatement among polluting firms efficiently.
- It is preferable to either a pure polluant tax or a pure license scheme.
- The system operates as if there were just one polluting firm confronted with a piecewise linear penalty function with one kink in it.
- The pure emission fee and pure license systems are special cases of the mixed system.

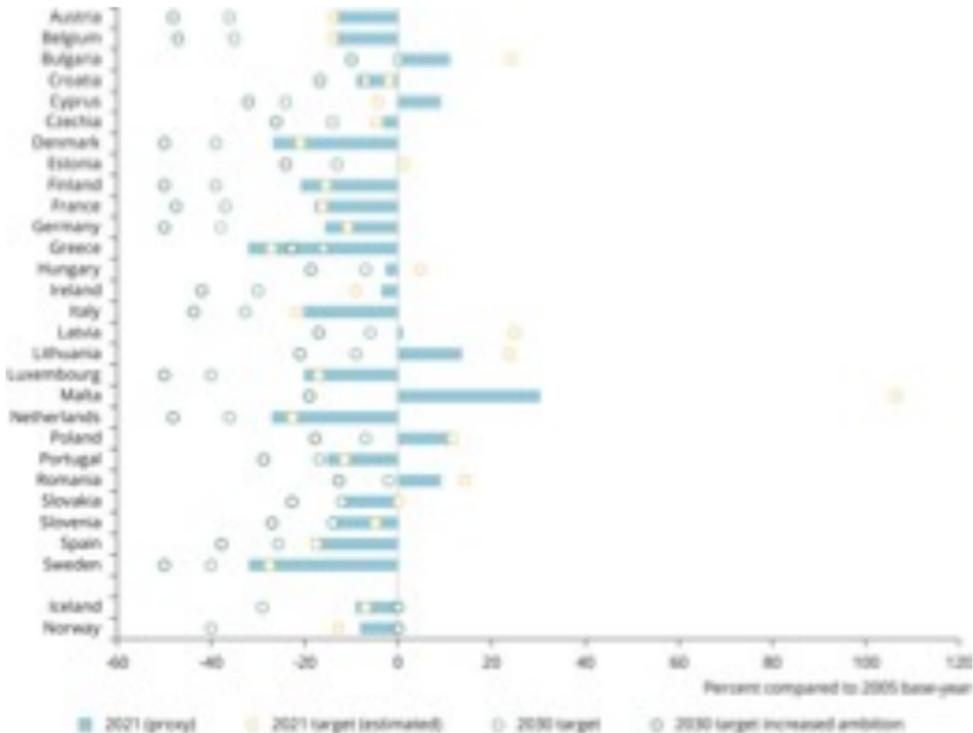# Enhancing the efficiency of the EU-ETS: reducing the price volatility

- Back-loading initiative adopted by the European Council and the Parliament in 2013: postponing auctions for 900 millions allowances planned for 2014-2016
- Establishment of a market stability reserve (MSR) in 2014, to address the historical surplus of allowances in the market
- BUT, according to I4CE and Enerdata (2018), from 2016 on, achieving the Energy Efficiency (30%) and deployment of Renewable Energy Sources (27%) targets could on their own be sufficient to respect the EU ETS's emission constraints policies, effectively 'overlapping' with the EU ETS, and ultimately *limiting its role as a driver for decarbonization*.

EU greenhouse gas emission trends and projections

Million tonnes of CO_2 equivalent (Mt CO_2e)

Legend:
— Historical greenhouse gas emissions without land use, land use change and forestry (LULUCF)
— Historical greenhouse gas emissions with LULUCF
···· Projections with existing measures (WEM) with LULUCF
- - Projections with additional measures (WAM) with LULUCF

Source: European Energy Agency (EEA) - 2022

Current progress of Member States towards their Effort Sharing Decision targets

Source: European Energy Agency (EEA) - 2022

Total CO2 emissions from fuel combustion

Kaya identity: drivers of CO₂ emissions, World

Percentage change in the four parameters of the Kaya Identity, which determine total CO₂ emissions. Emissions include fossil fuel and industry emissions. Land use change is not included.

Source: Global Carbon Budget; UN; Energy Institute; EIA; World Bank; Maddison Project Database
Note: GDP per capita is measured in 2011 international-$ (PPP). This adjusts for inflation and cross-country price differences.
OurWorldInData.org/co2-and-greenhouse-gas-emissions • CC BY

2. Choice between price/quantity instruments under uncertainty

Is it only uncertainty?

More asymmetric information than shared uncertainty :
" It is assumed that firms know or can find out their cleanup cost functions. The uncertainty therefore attaches to the regulatory authority. "

This stream of literature gives first insights about the optimal regulation under asymmetric information.

↪ Further analysis in Chapter 3.