Marginal abatement costs of greenhouse gas emissions from EU-24 agriculture

Greenhouse Gas Emission Abatement Workshop, Dublin

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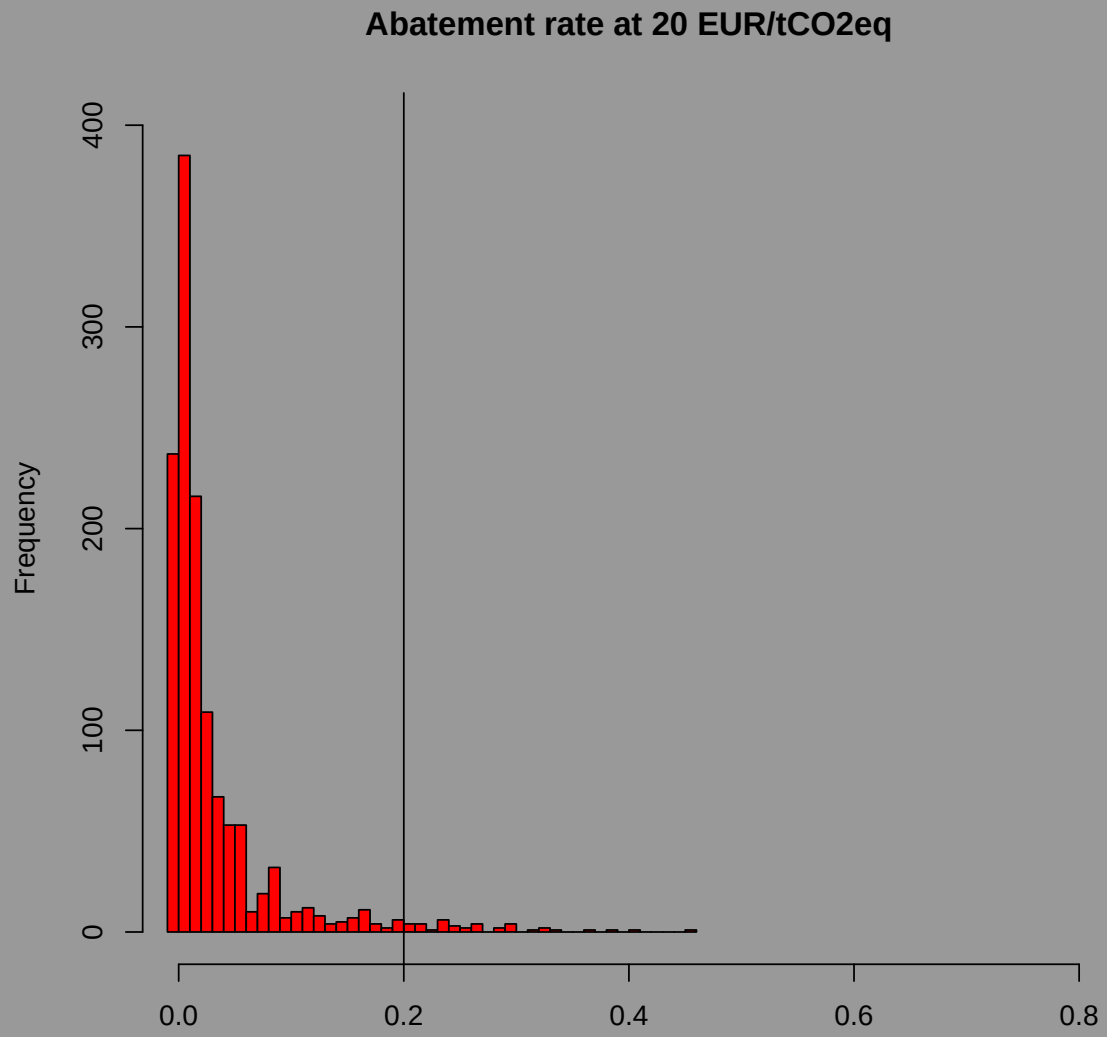
Agricultural MACs in the literature



Results from 15 studies:

- Various modelling approaches: bottom-up, supply-side LP, partial and general equilibrium
- Various resolutions, scales and coverage

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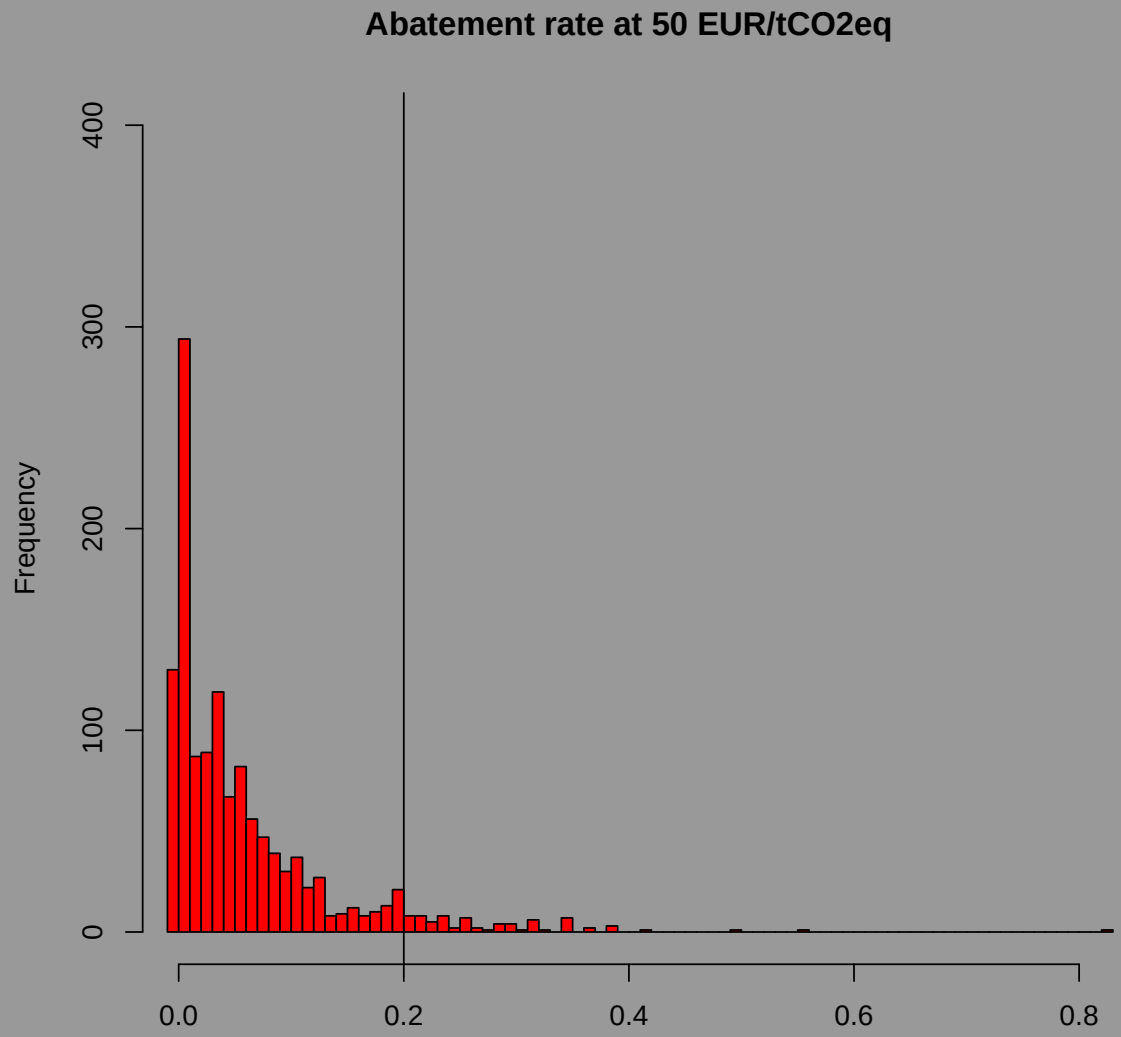

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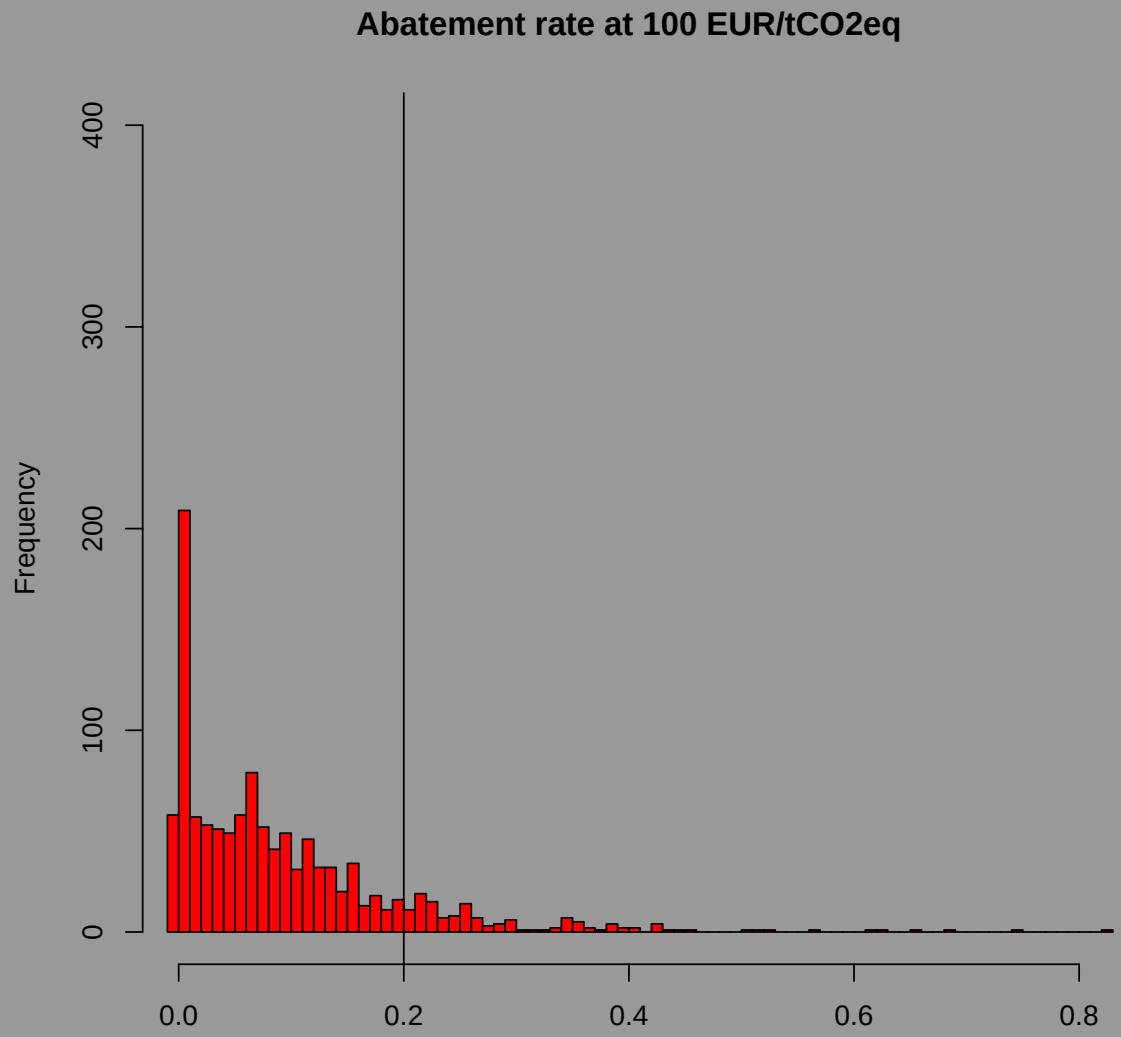

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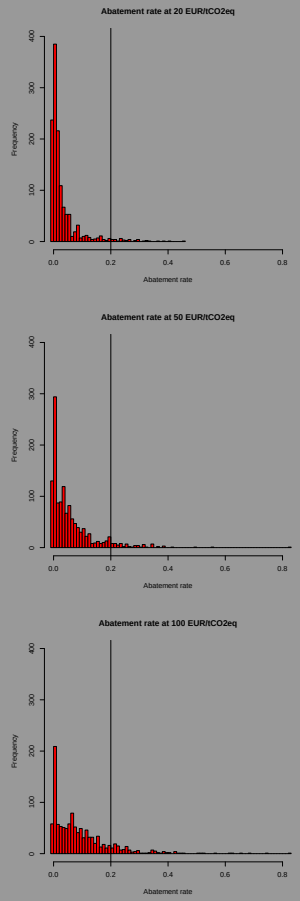

- Variability is a key feature, both between studies and across space
- Modelling assumptions matter (equilibrium vs supply side models, mitigation options, negative-cost abatements,..)

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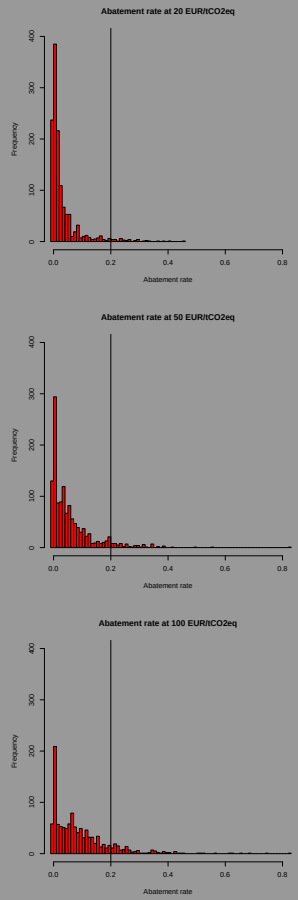

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  $\Rightarrow$ Focus on the variability of MACs across countries, regions, and (typical) farms.
  $\Rightarrow$ Explore the implications for the effort sharing among Member States
  $\Rightarrow$ Summarize the variability of MACs through response functions fitted on simulation results

Modelling framework

- Updated and expanded version of the model described in De Cara et al. (2005)
- **Input data:** FADN (119 regions in the EU-24): accountancy data, yields, area, type of farming, altitude zone
- **Typology:** 1,307 typical farms, representative at the FADN region level (119), covering annual crop and livestock farmers
- **Exogenous variables:** Total area, prices, yields, baseline livestock numbers, variable costs, CAP-related parameters, technical coefficients (agronomic, livestock feeding, emission coefficients, etc.)
- **1,307 independent models:** MILP, maximization of total gross margin subject to crop area, CAP, livestock feeding, etc. constraints
- **Calibration:** Based on EU-FADN 2004 data
- **Output:** Crop area mix, livestock numbers, animal feeding
- **Emissions:** IPCC-based relationships

Emission coverage

- **Enteric fermentation** (CH_4): linked to animal feeding (for cattle) and animal numbers
- **Manure management** (CH_4 and N_2O): linked to animal numbers
- **Agricultural soil** (N_2O): linked to fertilizer use, animal numbers (N from manure inputs), crop area (residues and N-fixing crops)
- **Rice cultivation** (CH_4): rice area

Key assumptions

- **Area constraints:** total area constraint, maximal area shares, balance between crops, between cereals and oilseeds, etc.
- **Livestock demography (cattle):** Demographic equilibrium between age classes, stable places constraints ($\pm 15\%$ of initial livestock numbers).
- **Livestock feeding:** Protein and energy requirements by animal categories, maximum ingested matter
- **Manure management:** Constant nitrogen excretion rates by animal categories, fixed shares of each management system as in the NCs to the UNFCCC
- **Fertilizer use:** Total fertilizer expenditures from FADN, split by crop for each farm type, assumption on a composite fertilizer price by crop and by country. Fixed per-hectare N input by crop and by farm-type.

Marginal abatement costs

- Base run: 2004 FADN data and corresponding CAP measures
- Introduction of a tax on (CO_2eq) emissions
- Abatement results solely from changes in crop area allocation, animal feeding, and animal numbers:
  - No adoption of alternative management practices.
  - No "cleaning" technology.
  - Constant nitrogen application by crop and farm-type.
- No price impact, no leakage (price-taker assumption).
- No structural changes (constant population of farmers).
- No change in the macroeconomic and policy environment.
- No monitoring/control costs

Variability of marginal abatement costs

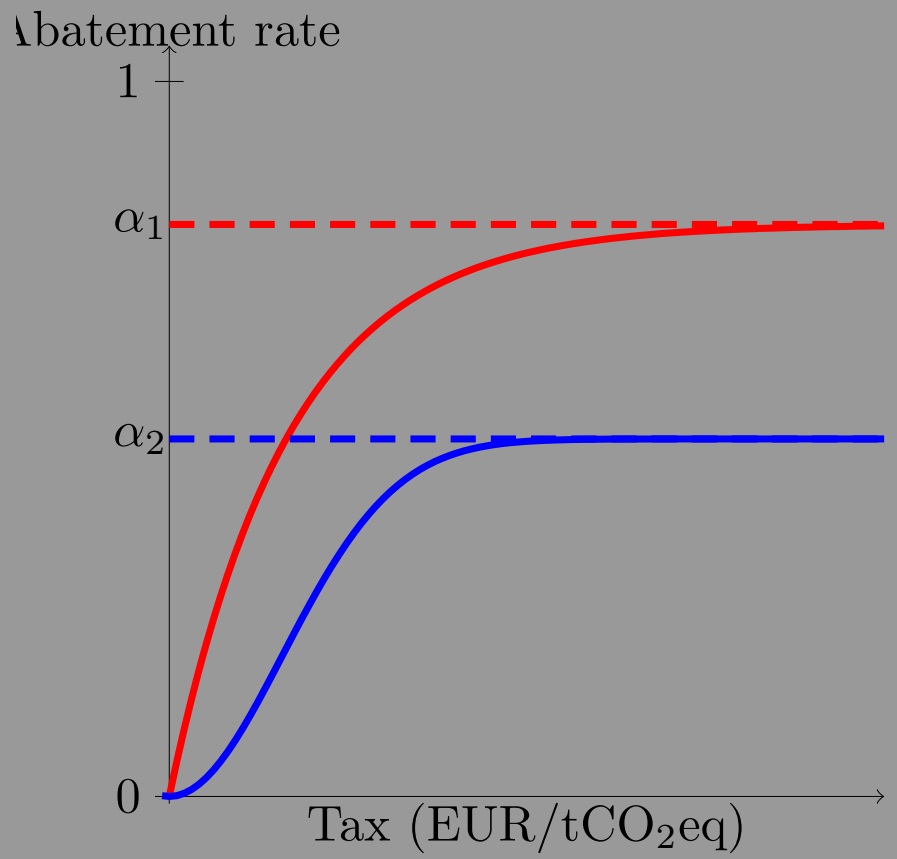
Variability in abatement costs comes from differences in :

- Factors' productivity
- Importance/type of livestock activities
- Degree of specialization, possibilities of substitutions
- Set of binding technical constraints (in particular animal feeding)
- Specific CAP provisions

We summarize variability into

- Maximum feasible abatement rate
- Price-response of abatements

Variability of marginal abatement costs

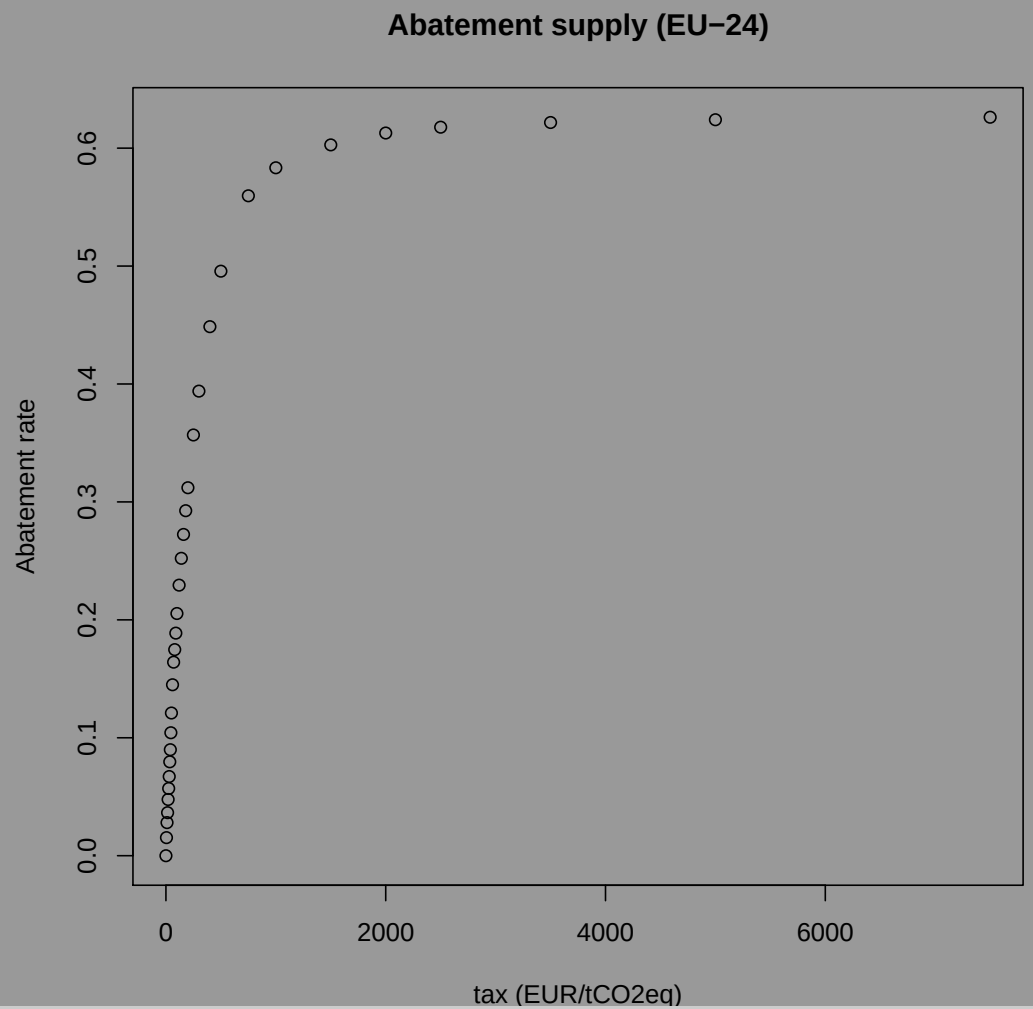


$$E(t) = E(0)(1 - r(t))$$

$$r(t) = \begin{cases} \alpha_1 \left(1 - e^{-\tau_1 t}\right) \\ \alpha_2 \left(1 - e^{-\tau_2 t^{(1+\gamma)}}\right) \end{cases}$$

$\Rightarrow$ These two models are estimated for each country, region, and typical farms

EU-24 abatement supply



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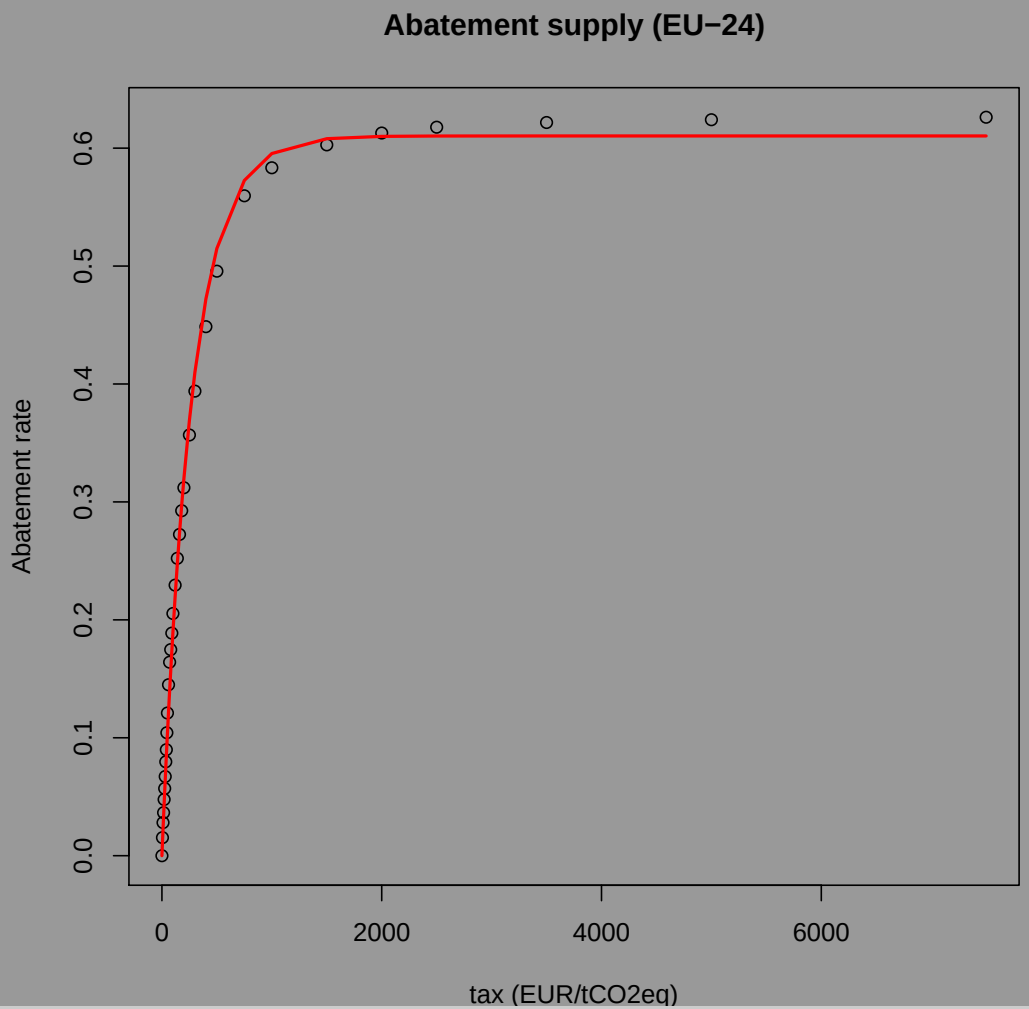

Model 1:	
α_2	0.6103***
τ_2	0.0037***
RSE	0.0127

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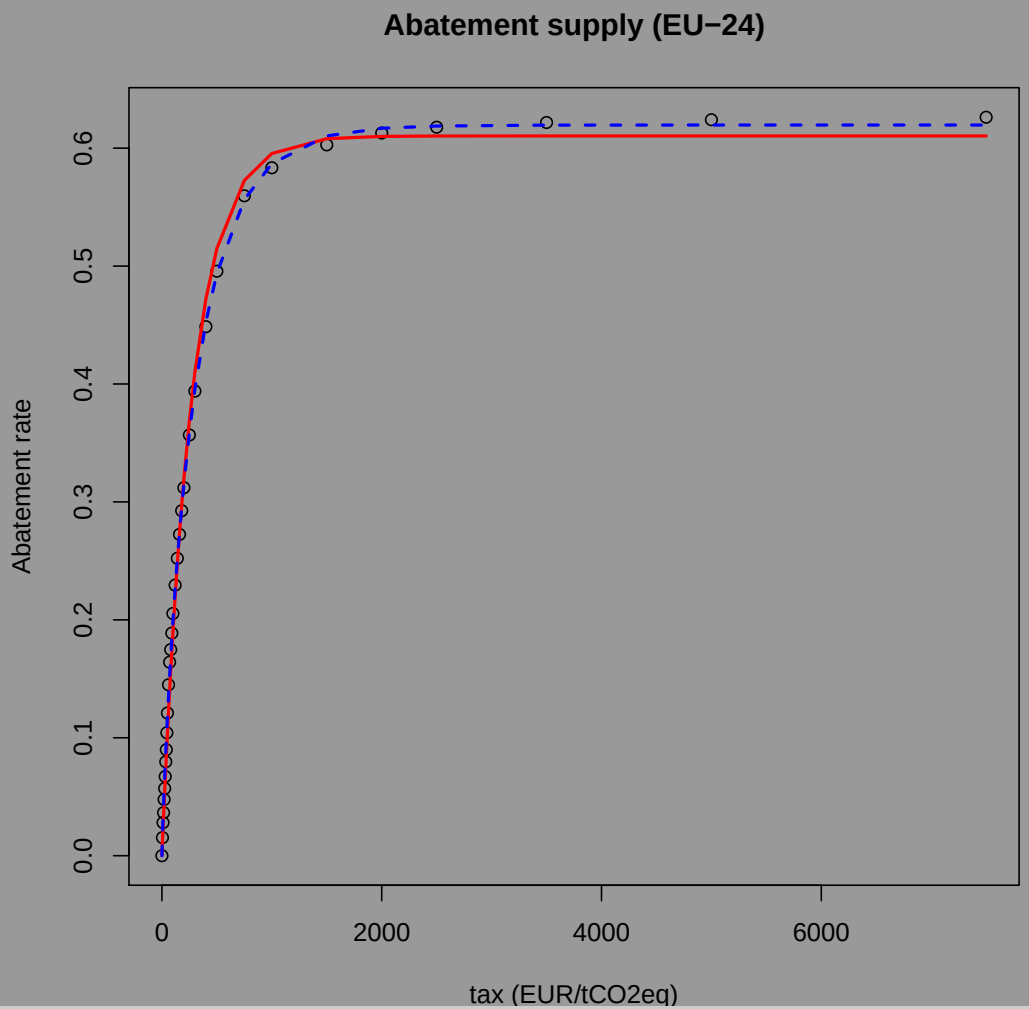
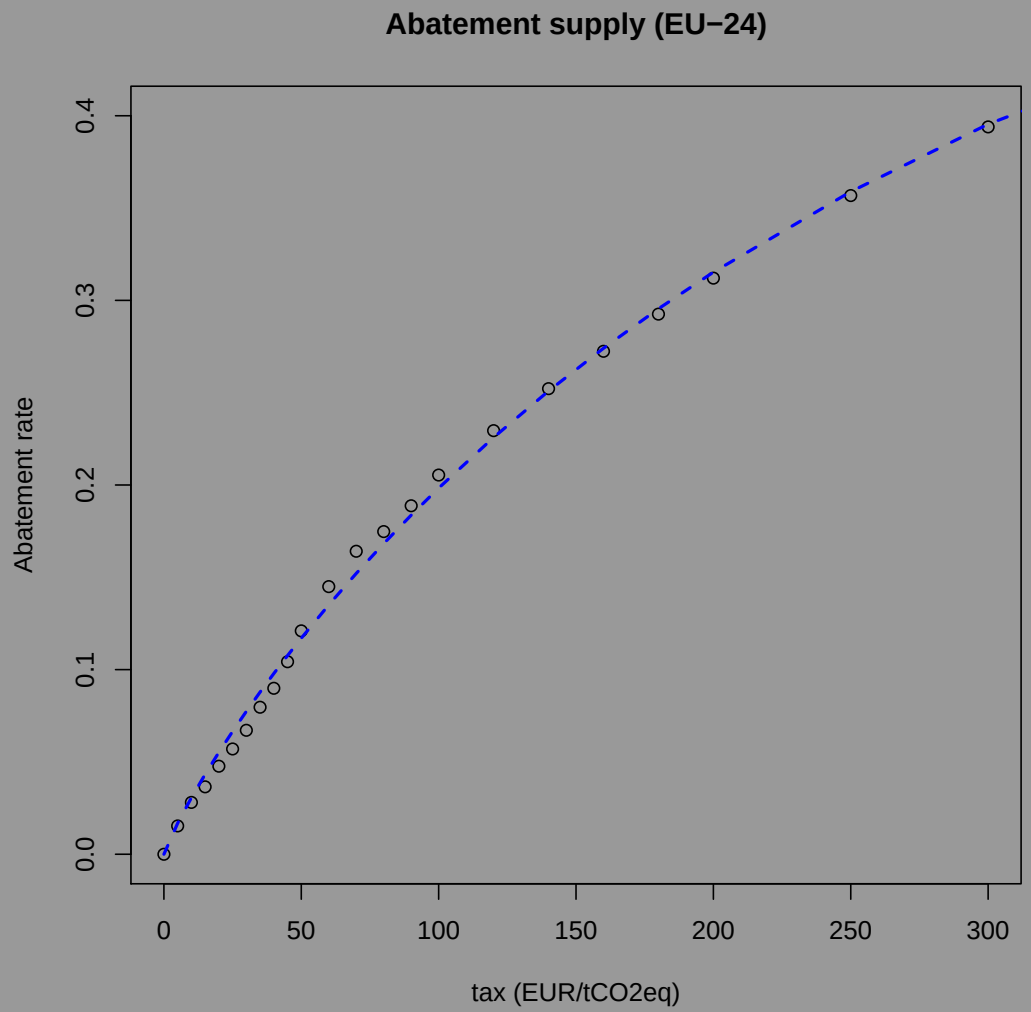


Model 1:	
α_2	0.6103***
τ_2	0.0037***
RSE	0.0127

Model 2:	
α_2	0.6196***
τ_2	0.0066***
γ	-0.1180***
RSE	0.0059

$\Rightarrow$ Price elasticity of emissions: -0.088 (40 EUR/tCO_2eq)

EU-24 abatement supply



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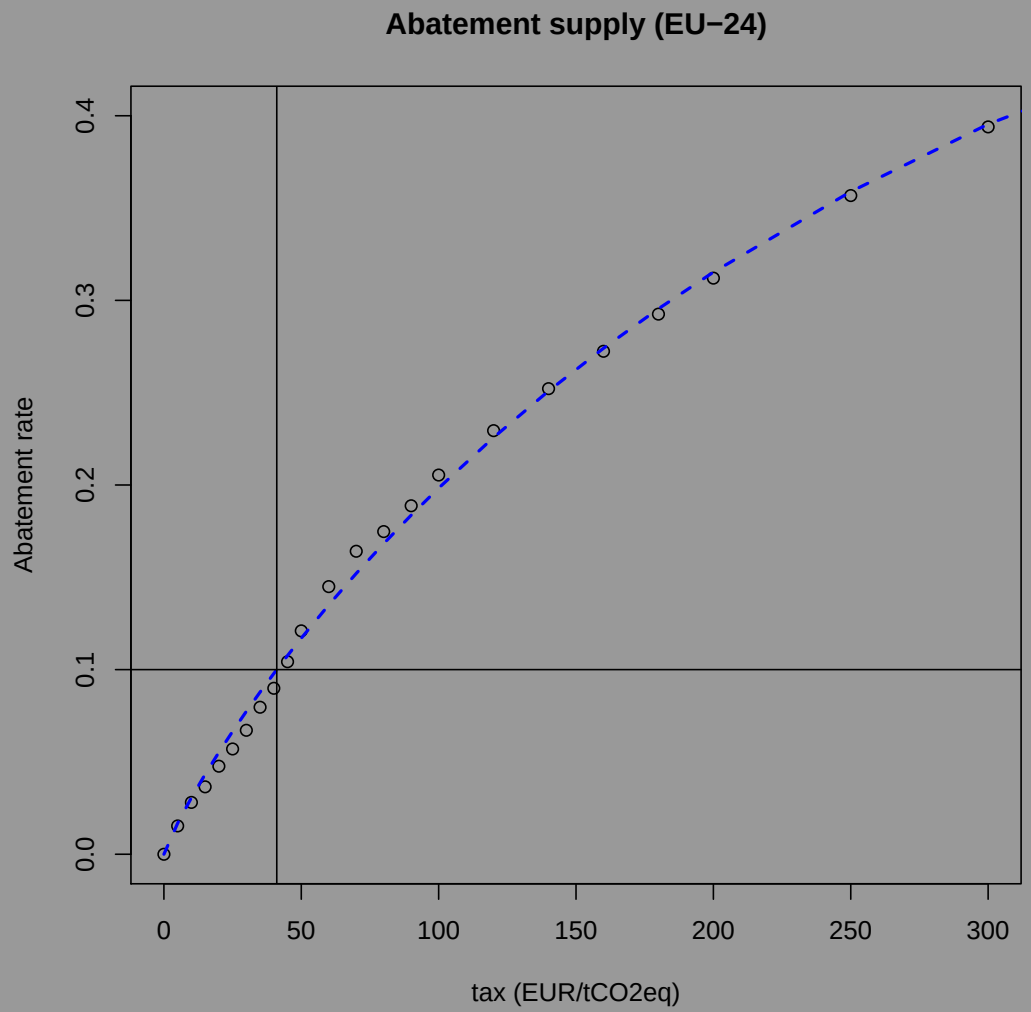
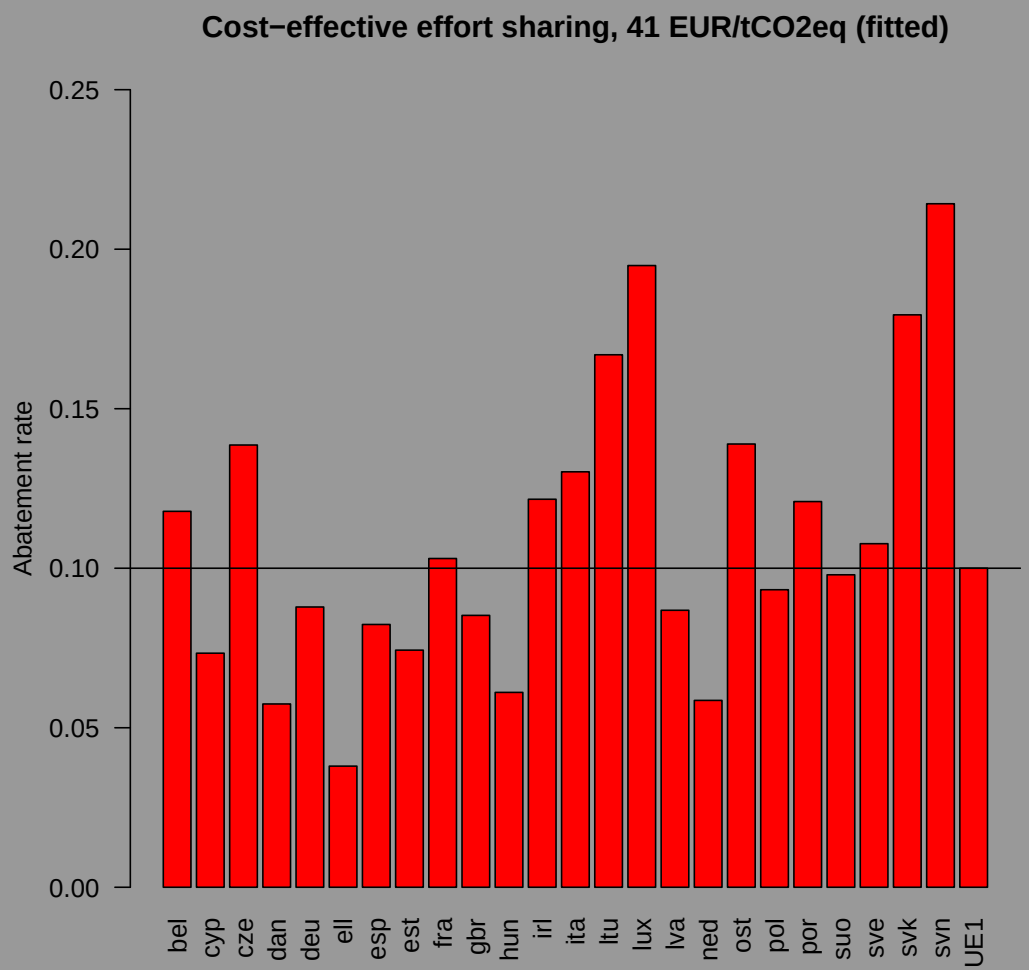
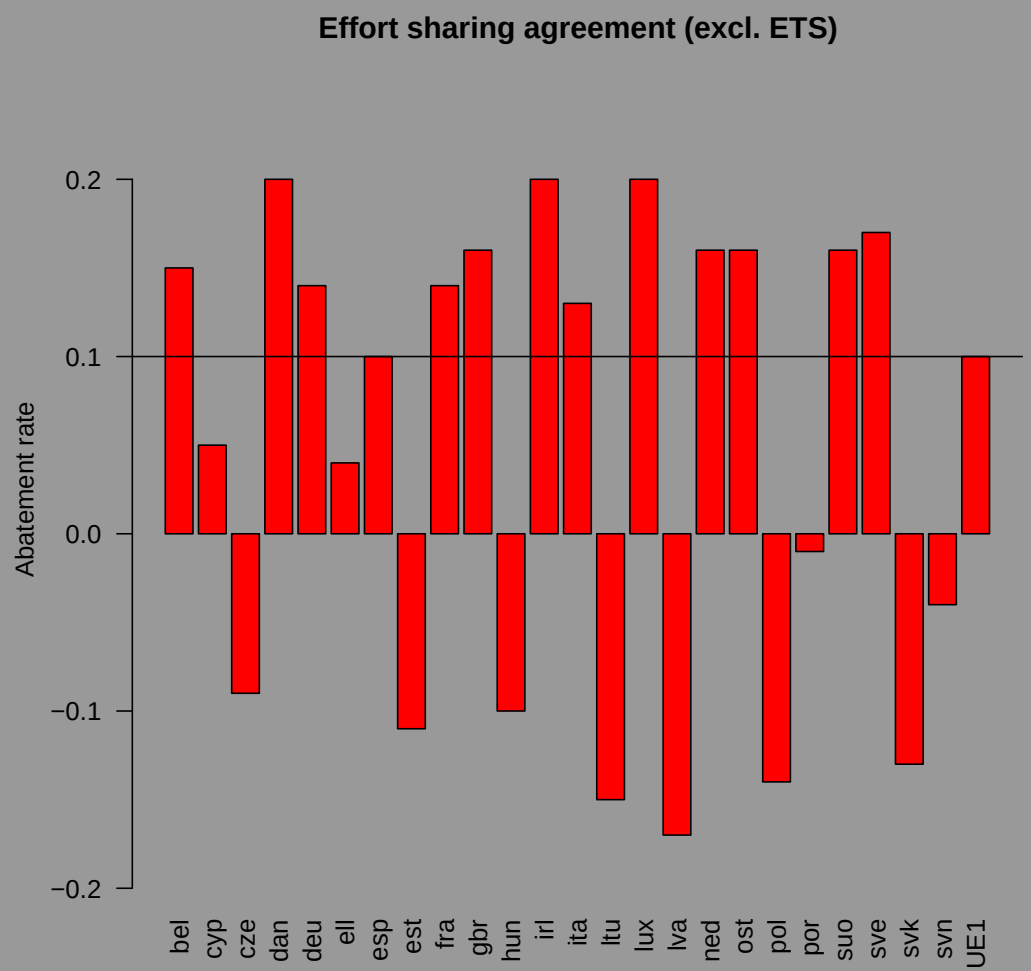


For a 10% reduction target, the corresponding price is about
41 EUR/tCO_2eq

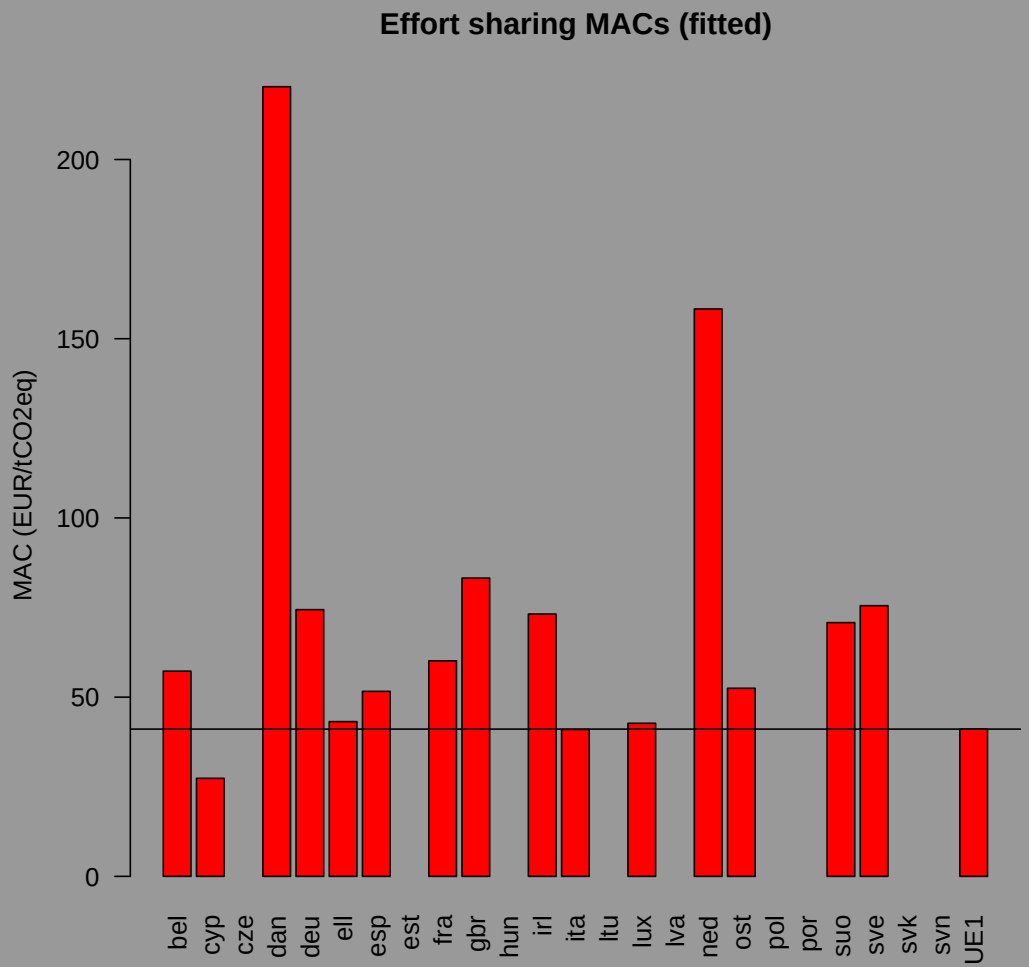
Cost-effective effort sharing for a 10% target



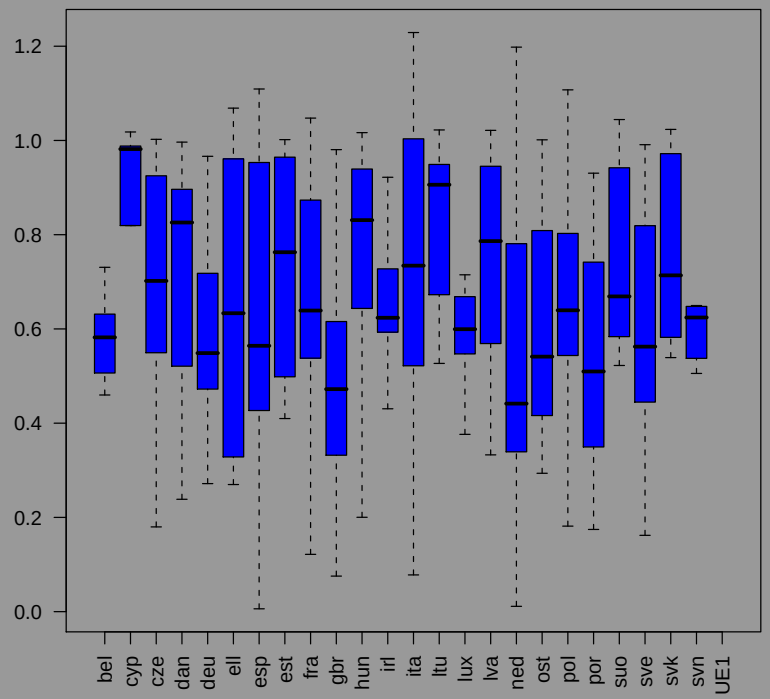
Burden sharing agreement (2008)



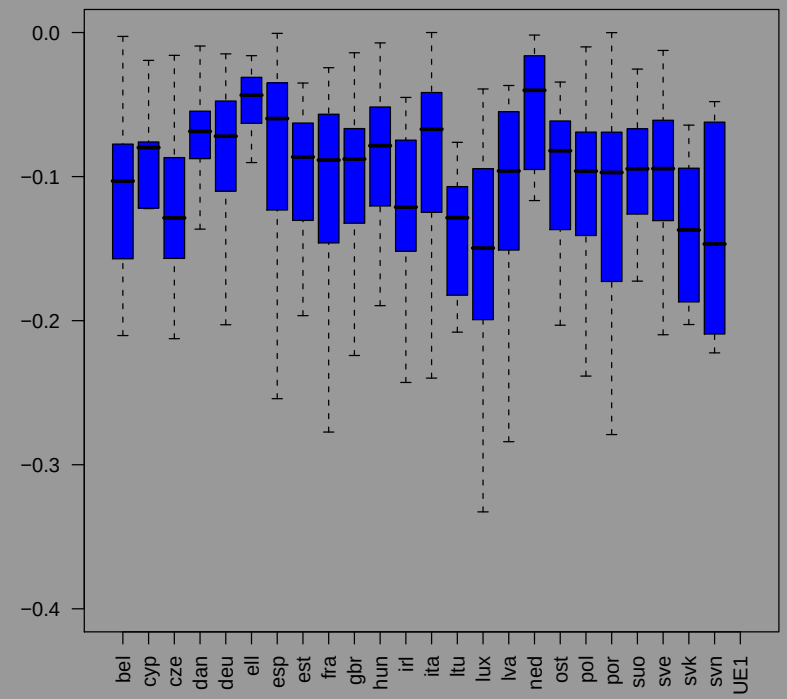
MACs corresponding to national targets



Variability of MACs at the typical farm level



Max. abatement rate



Price elasticity of emissions

Conclusions and perspectives

- Lower marginal abatement costs than in previous similar studies
- A collection of response-functions that can be helpful in other analyses
- Variability of MACS

- Econometric relationships between the parameters of MAC curves and typical farms' characteristics
- Uncertainty analysis
- MACs are not the end of the story: we need implementable economic intruments
- Linkage between GHG abatements and LULUCF-related emissions/sinks

References

De Cara, S., Houzé, M., and Jayet, P.-A. (2005). Methane and nitrous oxide emissions from agriculture in the EU: A spatial assessment of sources and abatement costs. *Environmental and Resource Economics*, 32(4):551–583.

De Cara, S. and Thomas, A., editors (2008). *Projections d'émissions/absorptions de gaz à effet de serre dans les secteurs forêt et agriculture aux horizons 2010 et 2020*. Rapport final pour le Ministère de l'Agriculture et de la Pêche. INRA.