INTEGRATED SINK ENHANCEMENT ASSESSMENT

INSEA PARTNERS

Mitigation in EU agriculture

GHG abatement and carbon sequestration costs

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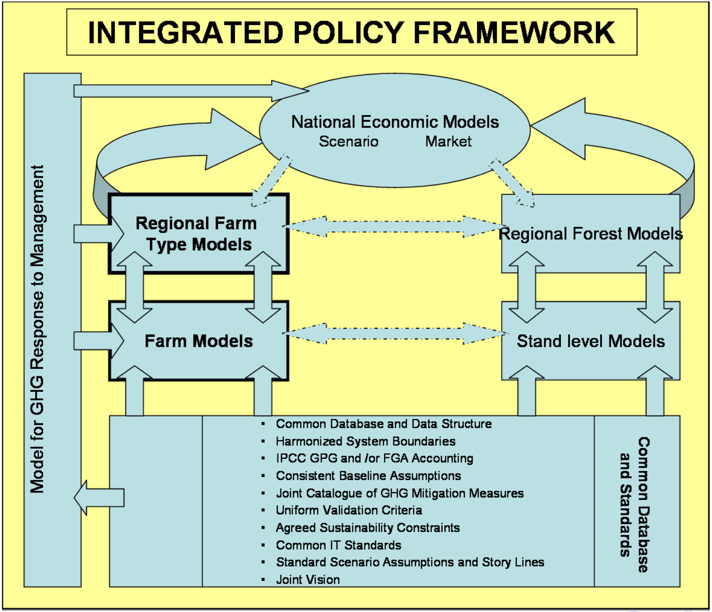
INRA's participation to INSEA

- Development of a farm-type model of the European agricultural supply
- Assessment of GHG marginal abatement cost curves
- Disaggregated approach: focus on results at the farm-type level
- Analysis of the role of farm-type heterogeneity in the design of economic instruments
- Economic evaluation of incentives to adopt carbon-friendly agricultural practices
- Analysis of interactions between GHG abatements and carbon sequestration

INRA' participation to INSEA



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- Overview
- Farm typology
- Key modelling features

GHG emissions from agriculture
- Agricultural GHG emission accounting
- EU-wide marginal abatement cost curves
- Regional and individual distribution of marginal abatement costs

Carbon sequestration through alternative tillage practices
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- Results

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Objectives

- How much does it cost to farmers to meet a given abatement target?
- For a given CO_2eq price, by how much farmers are willing to reduce their emissions?

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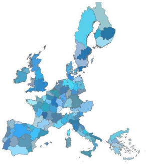
- For a given CO_2eq price, by how much farmers are willing to reduce their emissions?
- How do marginal abatement costs vary across regions and types of farming?
- How does farm-type heterogeneity affect the design of economic instruments?
- How does the contribution of adoption of carbon-friendly practices compare with reductions of non-CO_2 emissions?
- How do carbon sequestration and emission reductions interact at the farm-type level?

A farm-type based modelling approach

- Micro-economic approach (farm-level)
- Farmers are assumed to behave as gross-margin maximisers
- Price-taker assumption (constant input and output prices)
- Detailed representation of agronomic and CAP-related constraints faced by EU-15 farmers
- The modelling approach is described in De Cara *et al.* (2005). Revised and updated version based on FADN 2002.

Overview of the model



- **Input data:** 2002 FADN (EU-15), IPCC Guidelines, National Inventory Reports and CRF, FAO.
- **Typology:** 1074 farm-types, covering annual crop and livestock farmers, as well as mixed crop/livestock systems.
- **Exogenous variables:** Total area, baseline livestock numbers, yields, prices, variable costs, CAP-related parameters, technical coefficients (agronomic, livestock feeding, emission coefficients, etc.).
- **1074 independent models:** MILP, maximization of total gross margin subject to crop area, CAP, livestock feeding constraints
- **Calibration:** Based on FADN 2002 data
- **Output:** Crop area mix, livestock numbers, animal feeding, emissions

Farm typology

Surveyed farms in the FADN sample are grouped into farm-types

- Typology is based on automatic classification techniques
- Variables used for the classification: FADN region (101 regions in EU-15), type of farming, elevation class (3 classes: <300m, 300-600m, >600m), economic size.
- *e.g. Large dairy farms in Baden-Württemberg located below 300m*
- Distinction between crop- and animal-oriented activities
- Representation of mixed farming systems (both crop and livestock)

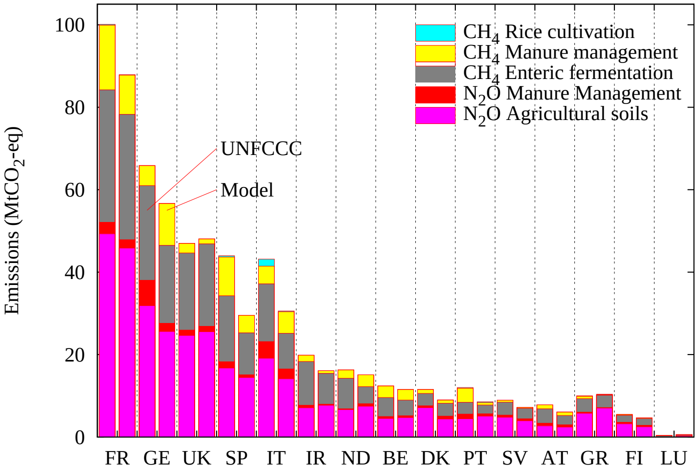
Key modelling features

- **CAP measures:** mandatory set aside, milk quotas, compensatory payments, intervention prices, etc.
- **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.
- **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.

Emission accounting

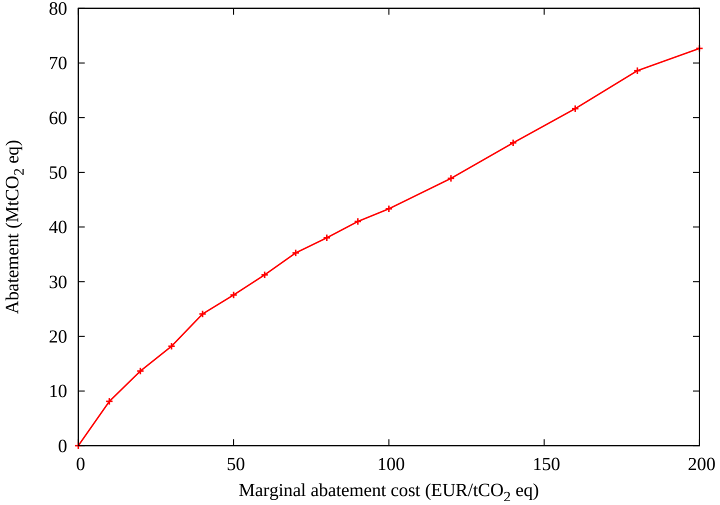
- Emission accounting methodology
  - Based on the IPCC *Good Practice Guidelines* emission factors linked to the relevant optimal levels of producing activities at the farm-type level
  - Emission coverage consistent with the 2003 NC to the UNFCCC
  - Country-differentiated emission factors if available in the 2003 NC to the UNFCCC; default IPCC emission factors otherwise
- Baseline run:
  - Calibration year: 2002
  - Includes Agenda 2000 provisions of the CAP
- An emission tax is added to the objective function: from 0 to 200 €/tCO_2

Emission coverage (cont'd)



(Based on 2003 EU National Communication to the UNFCCC)

Abatement supply (EU-15)



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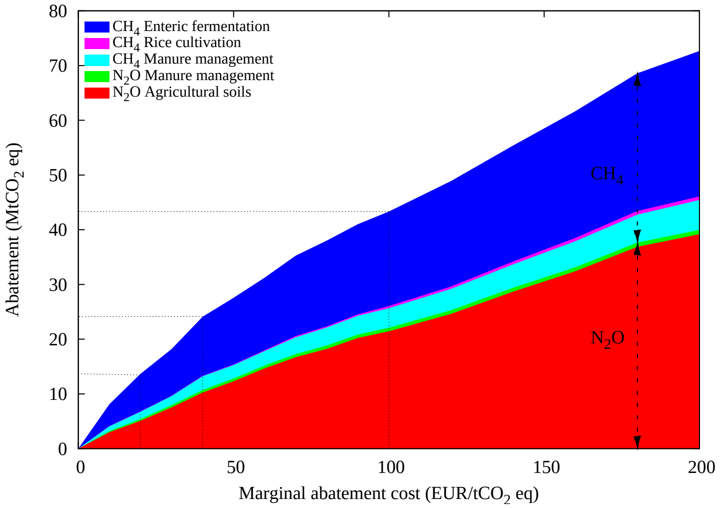
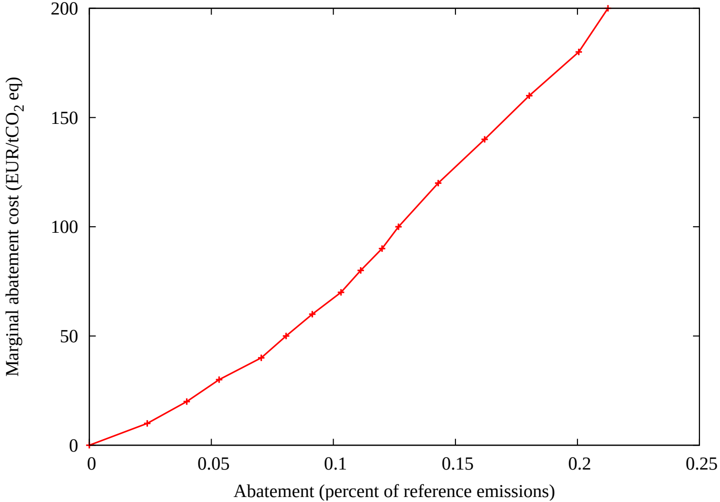


MACs: Comparison with previous estimates



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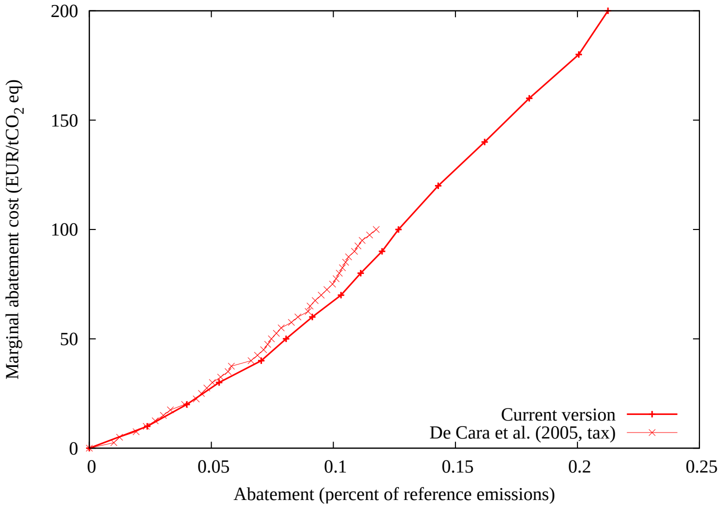

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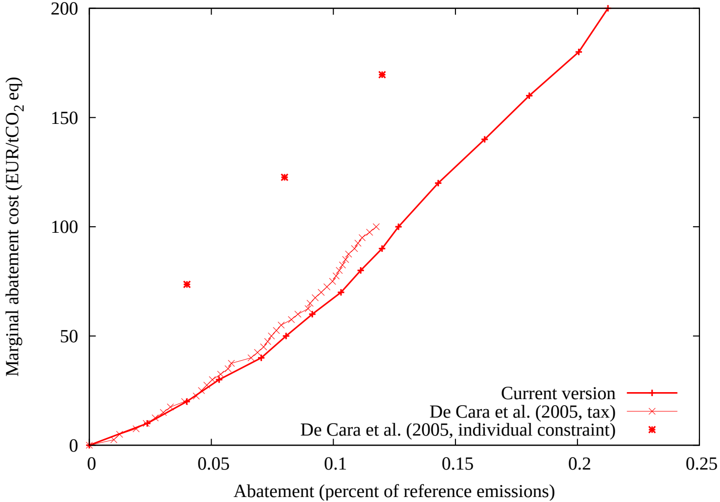

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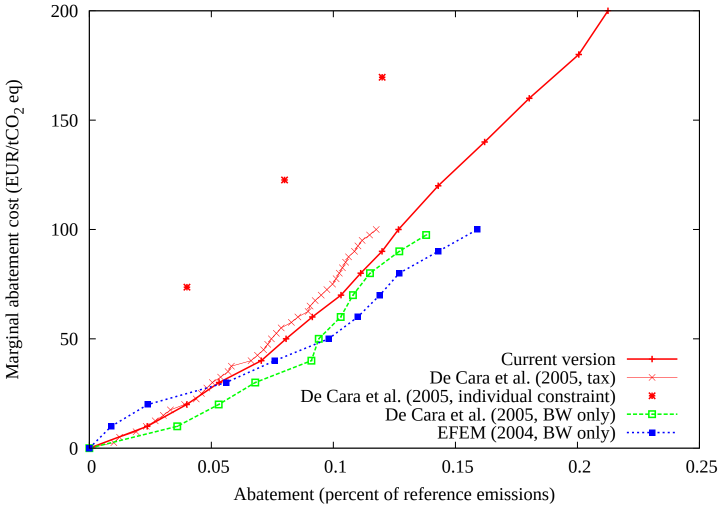

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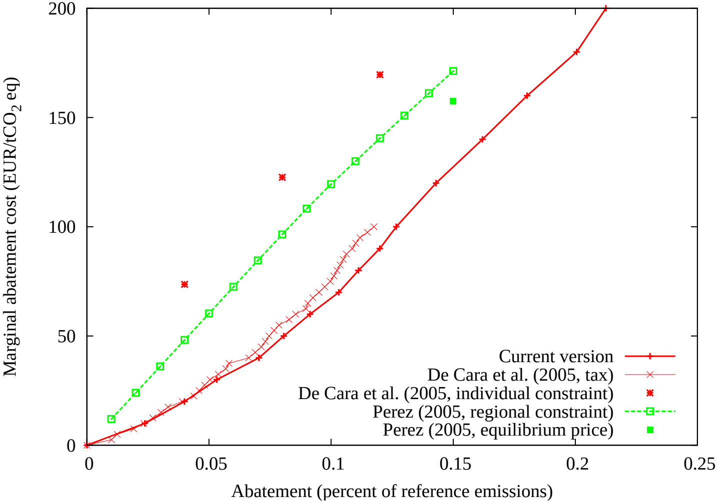
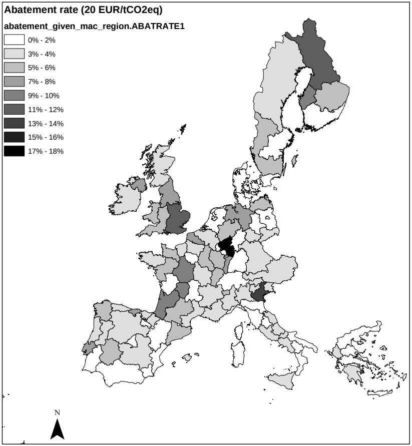


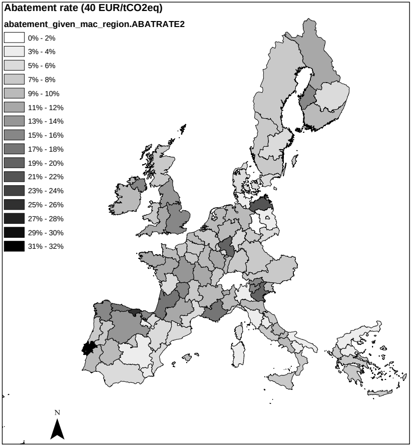
Regional abatement rates (20 €/tCO_2)



Source of the FADN region map: DG AGRI

CO_2 price: 20 €/tCO_2eq
EU abatement: 13.7 MtCO_2eq
EU abatement rate: 4.0%

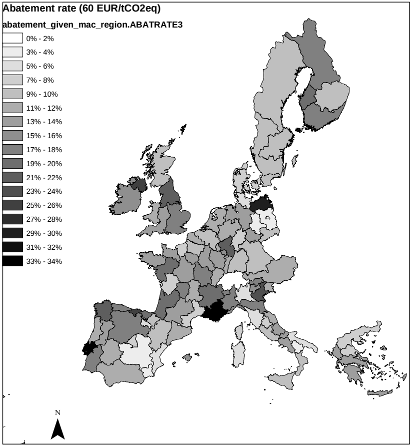
Regional abatement rates (40 €/tCO_2)



Source of the FADN region map: DG AGRI

CO_2 price: 40 €/tCO_2eq
EU abatement: 24.1 MtCO_2eq
EU abatement rate: 7.0%

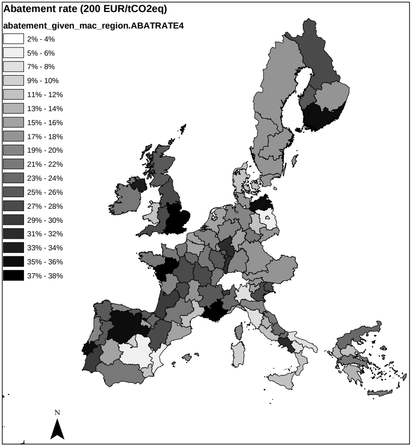
Regional abatement rates (60 €/tCO_2)



Source of the FADN region map: DG AGRI

CO_2 price: 60 €/tCO_2eq
EU abatement: 31.2 MtCO_2eq
EU abatement rate: 9.1%

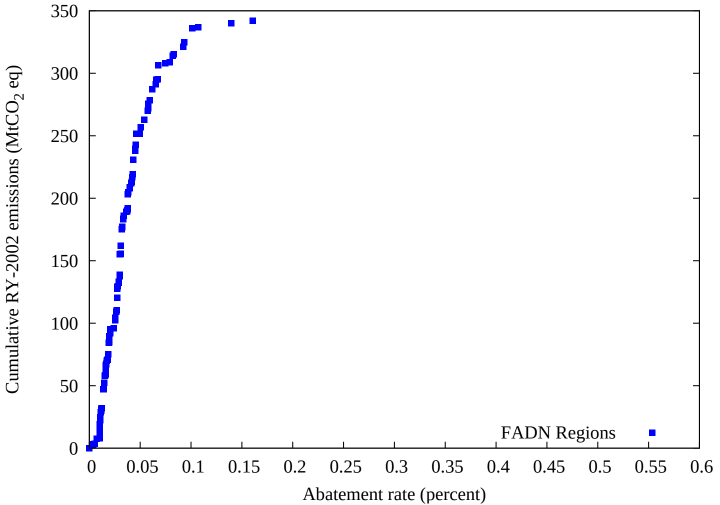
Regional abatement rates (200 €/tCO_2)



Source of the FADN region map: DG AGRI

CO_2 price: 200 €/tCO_2eq
EU abatement: 72.7 MtCO_2eq
EU abatement rate: 21.2%

Distribution of abatement rates (20 €/tCO_2eq)



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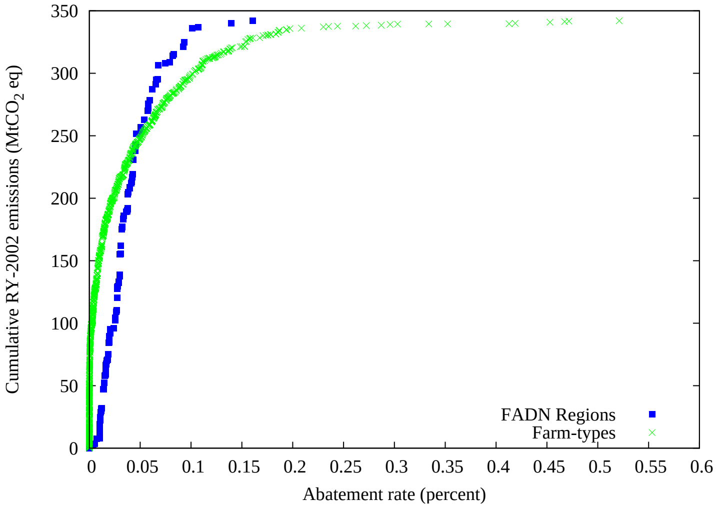

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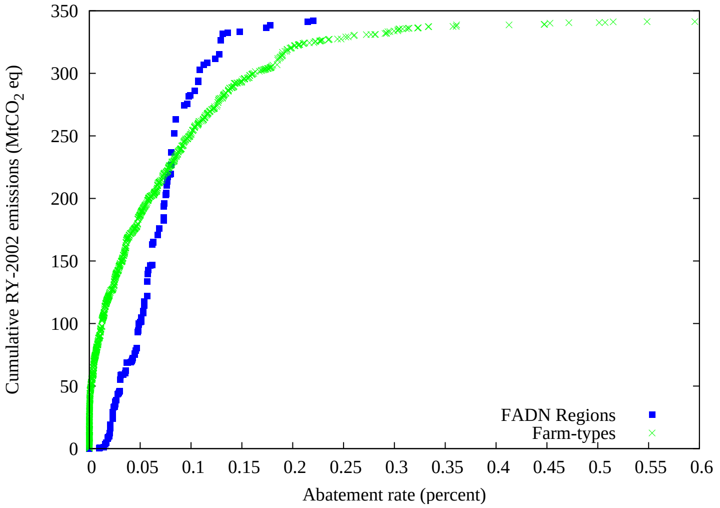
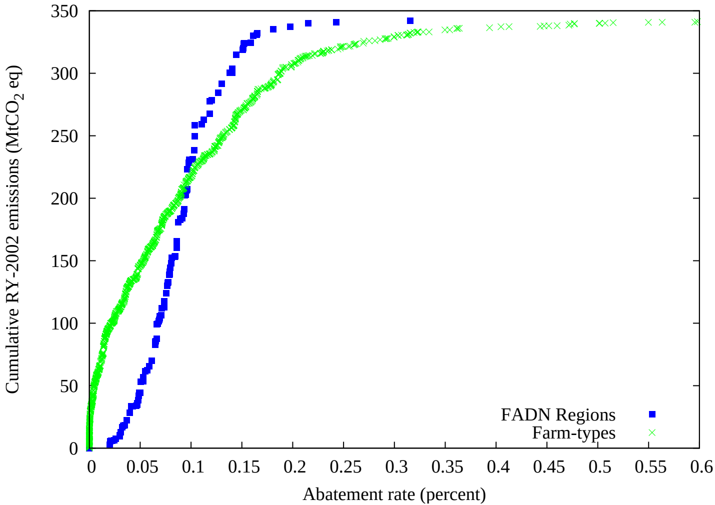
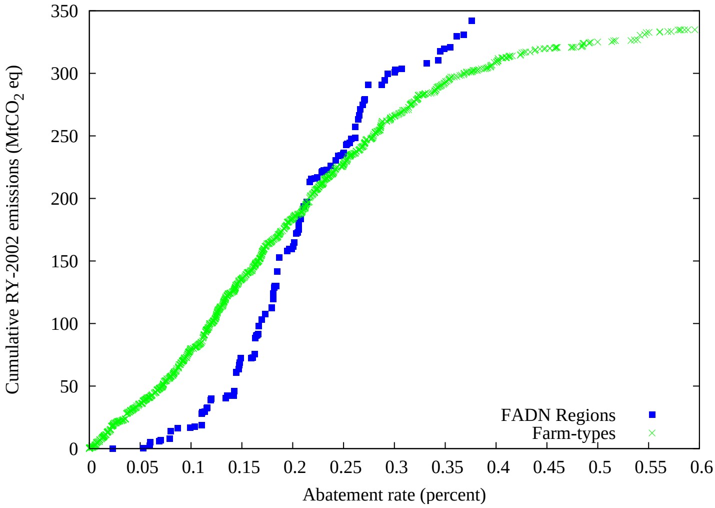


Distribution of abatement rates (60 €/tCO_2eq)



Distribution of abatement rates (200 €/tCO_2eq)



Alternative tillage practices

- Three tillage systems analyzed: Conventional, reduced, and minimum tillage
- Upon adoption of alternative tillage practices (conventional $\longrightarrow$ reduced or minimum tillage)
  - Change in soil organic carbon (SOC) over time (usually $\Delta SOC > 0$)
  - Change in variable costs ($\Delta C \gtrless 0$)
  - Change in yields (usually $\Delta Y < 0$, usually increases over time)
- Net impact on gross margin?
- Optimal adoption by farmers as a function of carbon payments

Changes in SOC and yields

- Definition of Homogeneous Response Units (HRU) for the EU-25
- EPIC simulations: endogenous rotations and uniform management, 10-year simulations, restricted to arable land (Corine Land Cover definition, cf Juraj Balkovic's and Erwin Schmid's presentation)
- Conversion of EPIC results to input data for the economic model (farm-type resolution)
  - Conventional tillage assumed to be the base management practice
  - Overlay of the FADN region map from DG-AGRI
  - Distinction between elevation classes
  - 10-year average absolute change in SOC: tC/ha/yr by crop×farm-type
  - Average relative changes in yield: % change of base yield by crop×farm-type. Applied to FADN crop yields

Changes in costs

- Based on Baden-Württemberg case study conducted within INSEA (Schmid et al., 2005)
- Cost calculation is derived from KTBL (2004) and Blank (2005), and accounts for
  - Changes in number of field trips
  - Machinery variable costs (maintenance, fuel, insurance, etc.)
  - Additional use of pesticides upon adoption of less intensive tillage practices

Changes in costs (cont'd)

	Reduced tillage		Minimum tillage	
	Cereals and oilseeds	Root crops and maize	Cereals and oilseeds	Root crops and maize
	Operation (nb of trips)			
Ploughing	-1	-1	-1	-1
Sowing	-1		-1	-1
Field tiller			-2	-1
Chisel plough	1	1		
Rotary harrow		1		
Combined rotary harrow	-2	-2	-2	-2
Herbicide spraying			2	2
Direct sowing			1	1
Harvest chopper			1	1
Combined driller	1			
	Others			
Herbicide (%)	10%	15%	30%	30%
Seeds (€/ha)				
Labour (h/ha)	-1,3	-1,8	-1,8	-2,0
Cost savings (€/ha)	*14,0*	*6,1*	*32,6*	*11,3*

Source: Schmid et al., 2005

Modelling approach and assumptions

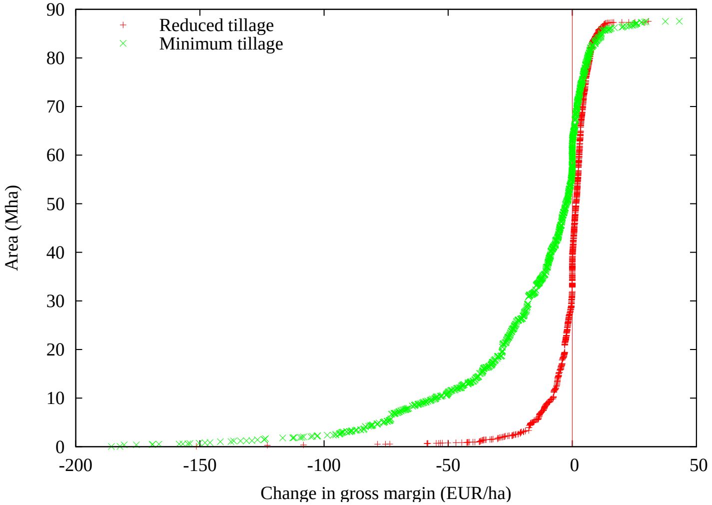
- Three sets of simulations (3×1074), one for each tillage system
- A constraint is added to prevent grassland from being converted into cropland (only additional carbon sequestration from alternative tillage is accounted for)
- Optimal choice of a tillage system depends on the ranking of optimal gross margins under the three systems (π_k^{conv}, π_k^{redu}, π_k^{mini}). At the farm-type level, only one system can be chosen
- Costs are calibrated to ensure consistency with the assumption that conventional tillage is the baseline management.
- Adjustment costs are treated as fixed costs:
  - Does not impact the optimal solution at the farm-type level for one tillage system
  - ... But does affect the ranking between different tillage systems

Conventional vs reduced vs minimum tillage

Comparison of aggregate results under each tillage system (100% adoption rates, CO_2 value is zero)

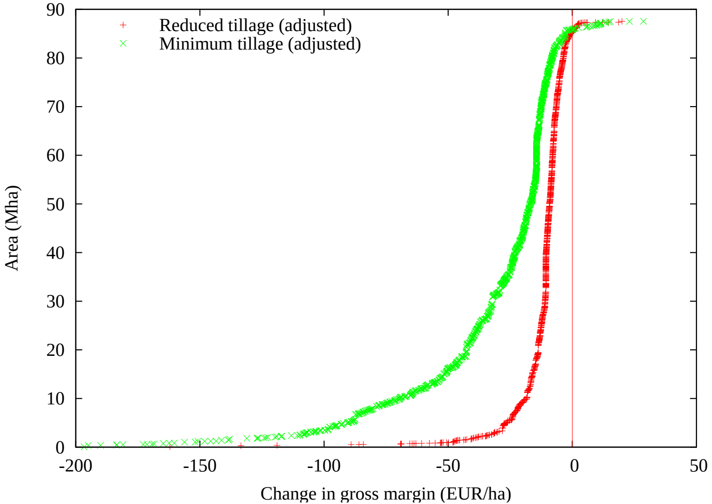
	Conv.	Reduced		Minimum	
		Δ	%	Δ	%
		(10^9 €)			
Total gross margin	89.8	-0.11	-0.1%	-1.54	-1.7%
		(10^6 tCO_2eq)			
N_2O agricultural soils	171.0	-0.55	-0.3%	-2.34	-1.4%
N_2O manure management	12.4	0.01	0.1%	0.01	0.1%
CH_4 manure management	39.3	0.01	0.0%	0.07	0.2%
CH_4 rice cultivation	0.7	0.00	-0.2%	-0.03	-4.5%
CH_4 enteric fermentation	118.5	-0.05	-0.0%	0.17	0.1%
Total emissions	341.9	-0.57	-0.2%	-2.12	-0.6%
Carbon sequestration	-	-20.88	-	-34.56	-
Total net emissions	341.9	-21.46	-6.3%	-36.68	-10.7%

Distribution of gross margin impacts of alternative tillage systems

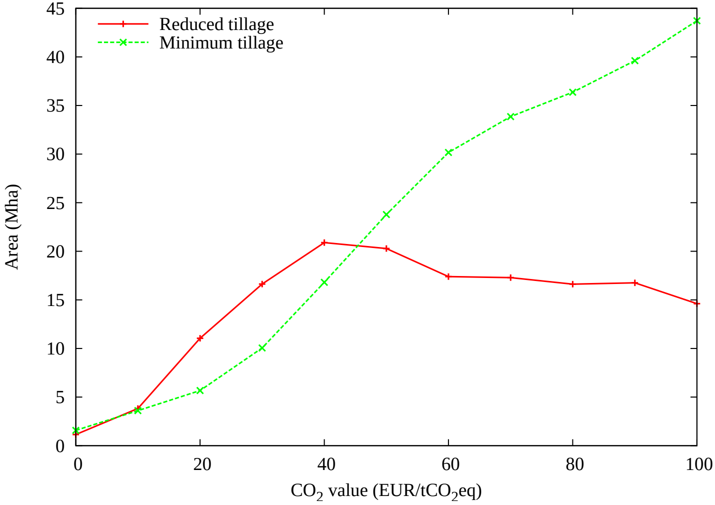


Distribution of gross margin impacts of alternative tillage systems (adjusted)

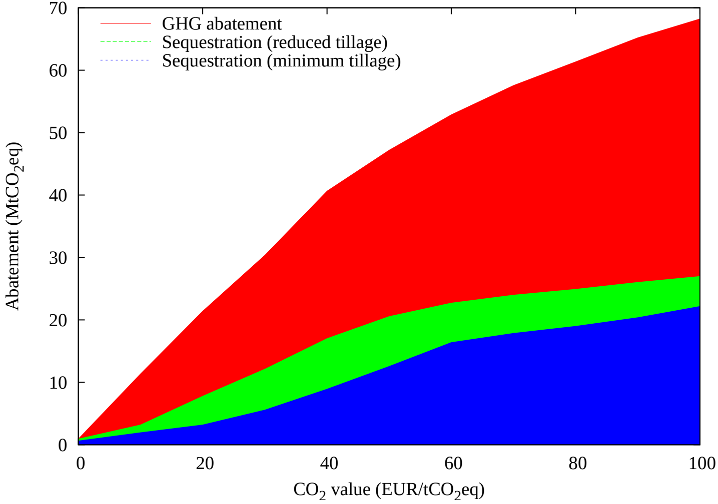
Adjustment costs: Reduced=10.64 €/ha, minimum=14.43 €/ha



Area under alternative tillage management



Abatement and carbon sequestration



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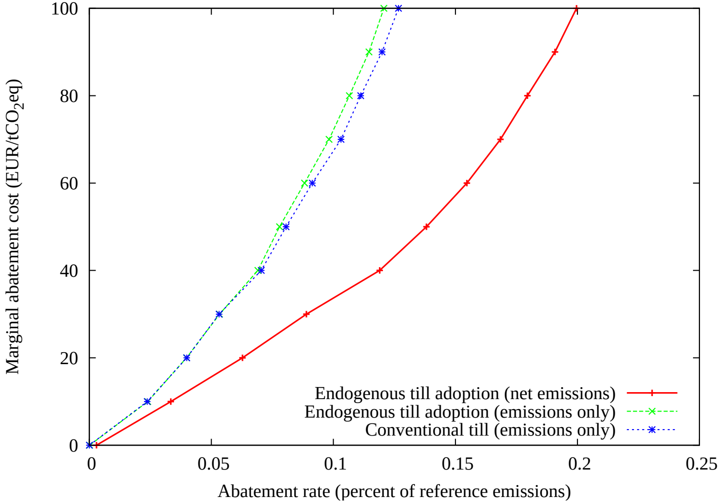

Conclusions

- Abatements from agriculture can contribute to emission reductions at current CO_2 prices
- Disaggregated approach, which highlights the importance of marginal abatement cost heterogeneity for the design of economic instruments (cost-effectiveness)
- Importance of the use of CO_2 tax revenue and/or initial allocation of emission allowances
- Disaggregated and static modelling approach: complement, rather than substitute, to partial equilibrium and dynamic approaches (cf EU-FASOM)
- Control cost issues and monitoring (carbon sequestration)