Using medium-term models to analyze GHG emission mitigation policies in agriculture

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Outline

- Motivation: the role of medium-term models in analyzing emissions
- The example of the CAPRI model – some results:
  - Disaggregation of GHG emission inventories per EU Member State
  - Estimation of "emission leakage" caused by unilateral EU climate policies
  - Calculation of sectoral marginal abatement costs
  - Efficiency gains of cap & trade policies
- The road ahead – trying to answer the proposed questions:
  - Agriculture in an *"inter-sectoral climate policy"?*
  - Agriculture and "*competing land uses*" (AFOLU)?
  - GHG mitigation options from an "*intra-sectoral perspective*"?
  - Mitigation potential of agriculture from an "*inter-temporal perspective*"?
- Summary and discussion

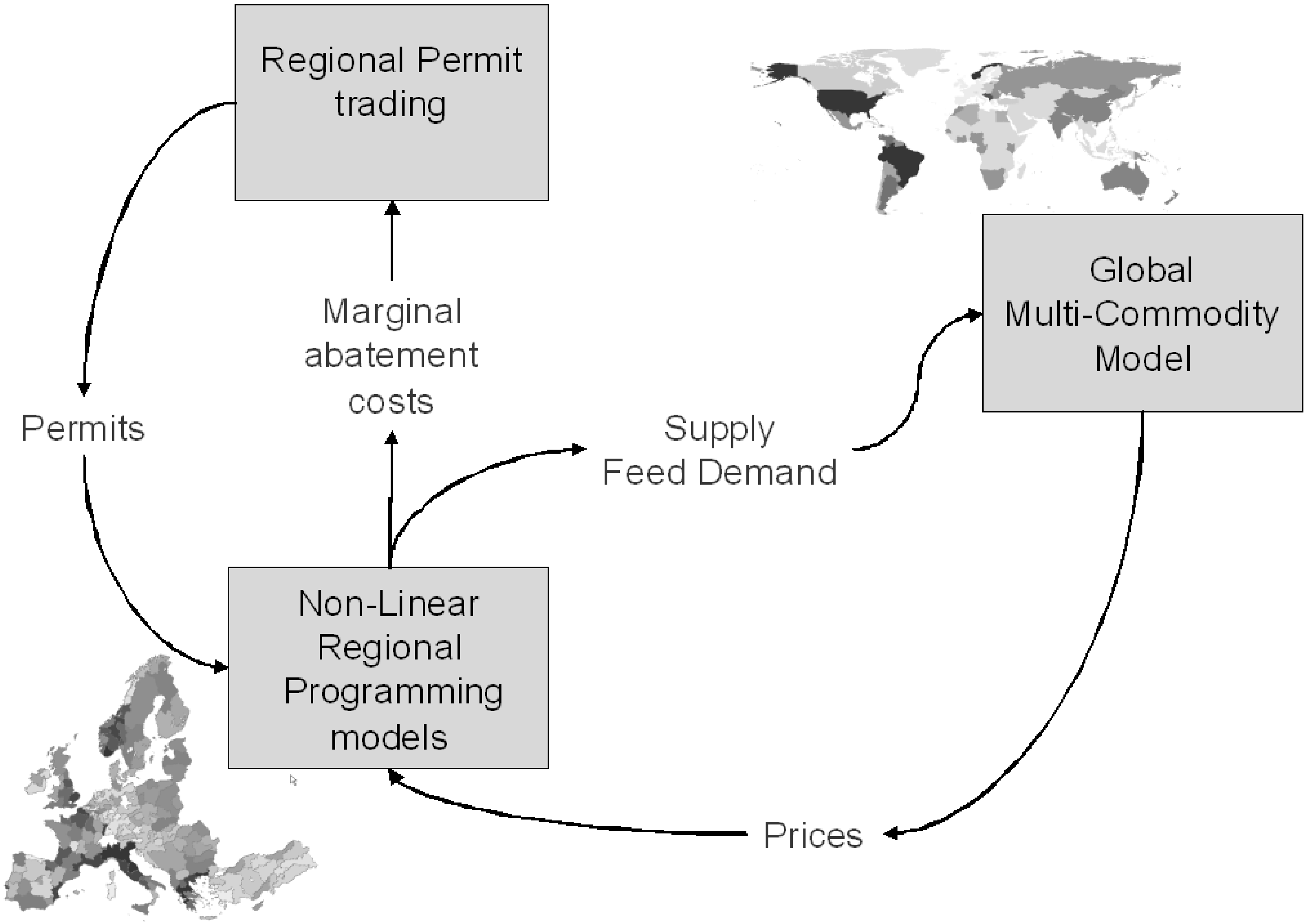
Motivation: the role of medium-term economic models

- For GHG emission accounting:
  - Detailed representation of production technologies: inter-sectoral in the case of CGEs and intra-sectoral in the case of PEs
  - Underlying harmonized and consistent data base plus a harmonized accounting methodology allow for a better comparison
  - Reported inventories can be used to “validate” calculations
  - Calculated inventories can replace ‘costly’ data gathering (e.g. request by Luxemburg for a “model-based” inventory)
- For GHG mitigation policies:
  - Contain the necessary economic mechanisms for including carbon pricing (e.g. carbon taxes), upper-bounds on emissions (e.g. ‘cap’ policies) and special market clearing conditions for carbon markets (e.g. emission trading)
  - Allows to also quantify the effects of existing policy reforms in terms of GHG emissions (i.e. cross-effects with existing ag. policies)

The example of CAPRI: introduction

- Partial equilibrium model (www.capri-model.org):
  - Economic, spatial & global (Britz 2007)
  - Coordinated by UBONN & co-developed by VTI (Braunschweig), SLU (Uppsala), IPTS (Seville) and LEI (The Hague)
- Used since the mid-90s for analyzing different CAP reform scenarios (i.e. from “McSharry” to the “Health Check”)
- Demand from large scale research consortia (e.g. SEAMLES, SENSOR) and international institutions (e.g. FAO, EEA, IIASA, OECD) for different CAPRI modules has considerably increased
- Network-based, “club good”: open access to model code, limited access to raw data (only compiled), high barriers to entry (going down...)
- Technical details:
  - GAMS software for modelling
  - Own developed JAVA interface for use

CAPRI: model flow



CAPRI Results: EU27 emission inventories

	Base Year 2004 [t]	Baseline 2020 [% to BAS]
Methane emissions from enteric fermentation (IPCC)	8278	-17
Methane emissions from manure management (IPCC)	1688	-6
Methane emissions	**9966**	**-15**
Indirect nitrous oxide emissions from ammonia volatilisation (IPCC)	52	-1
Direct nitrous oxide emissions stemming from manure application on soils except grazings (IPCC)	86	-3
Direct nitrous oxide emissions from crop residues (IPCC)	83	12
Direct nitrous oxide emissions from atmosferic deposition (IPCC)	20	-2
Direct nitrous oxide emissions from nitrogen fixing crops (IPCC)	15	-5
Direct nitrous oxide emissions stemming from manure managment on grazings (IPCC)	88	-5
Direct nitrous oxide emissions from cultivation of histosols (IPCC via Miterra)	134	-3
Indirect nitrous oxide emissions from leaching (IPCC via Miterra)	21	-7
Direct nitrous oxide emissions stemming from manure management (only housing and storage) (IPCC)	136	-5
Direct nitrous oxide emissions stemming from manure managment and application except grazings (IPCC)	222	-4
Direct nitrous oxide emissions from anorganic fertilizer application (IPCC)	226	3
Nitrous oxide emissions	**861**	**0**
Carbon dioxide equivalent emissions (global warming potential)	**476090**	**-7**
Ammonia emissions	**3036**	**-2**

CAPRI Results: emission leakage of unilateral emission mitigation policies

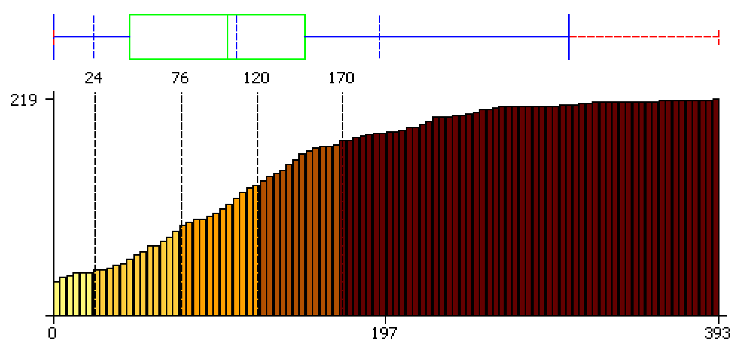
- **Policy shock**: 20% reduction in GHG emissions in the EU (year 2020 versus year 2005), unit: kg of emissions per tonne of product

GHG_ECC_STD		Wheat	Grain maize	Beef	Fresh milk products
European Union 27	Total global warming potential in CO2 equivalents	0.14 -0.19%	0.14 -0.22%	14.68 0.32%	0.52 -0.06%
	Total emissions of N2O	0.00 -0.19%	0.00 -0.22%	0.01 -0.00%	0.00 -0.06%
	Emissions of N2OAMM	0.00 -0.03%	0.00 -0.02%	0.00 0.01%	0.00 -0.07%
	Total emissions of CH4	0.00 inf.	0.00 inf.	0.50 0.44%	0.02 -0.06%

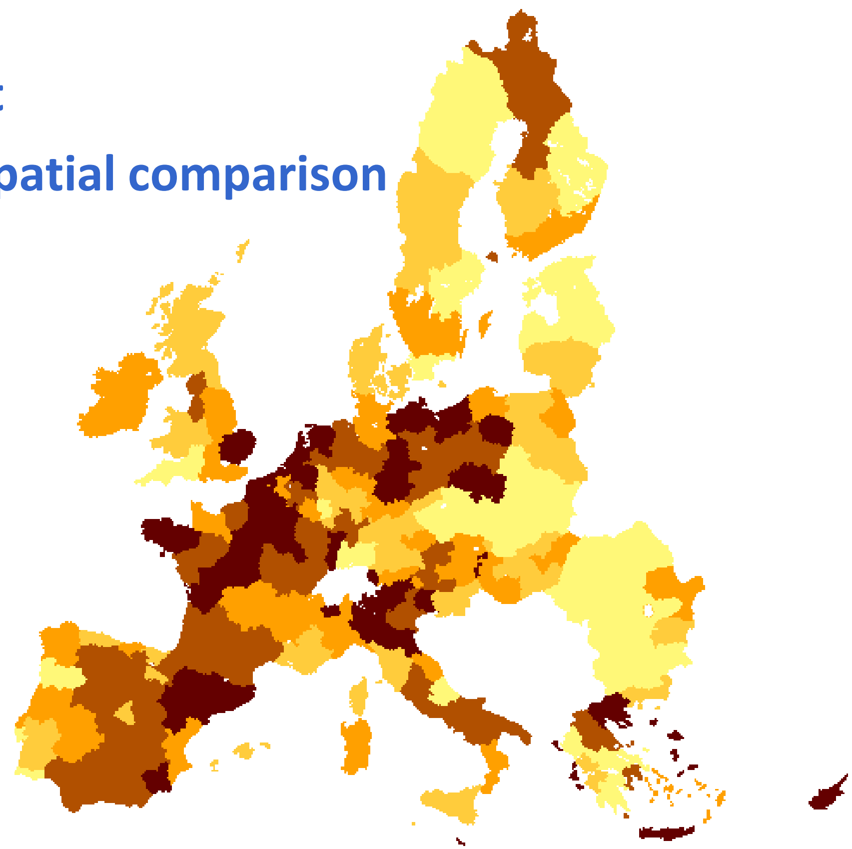
GHG_ECC_STD		Wheat	Grain maize	Beef	Fresh milk products
European Union 27	Net production [1000 t]	17861.30 -10.12%	9102.71 -14.73%	93124.59 -19.19%	26060.39 -1.33%
	Imports [1000 t]	426.58 4.91%	1.89 82.23%	43253.79 76.90%	19.43 7.82%
	Exports [1000 t]	2222.19 -23.10%	840.72 -23.25%	634.15 -87.99%	88.57 -1.56%

CAPRI Results: regional marginal abatement costs in the EU

- **Policy shock: 20% reduction in agricultural GHG emissions in the EU27 (year 2020 vs. year 2005)**
- **In €/tonne CO2-equivalent**
- **Scale not as important as spatial comparison**

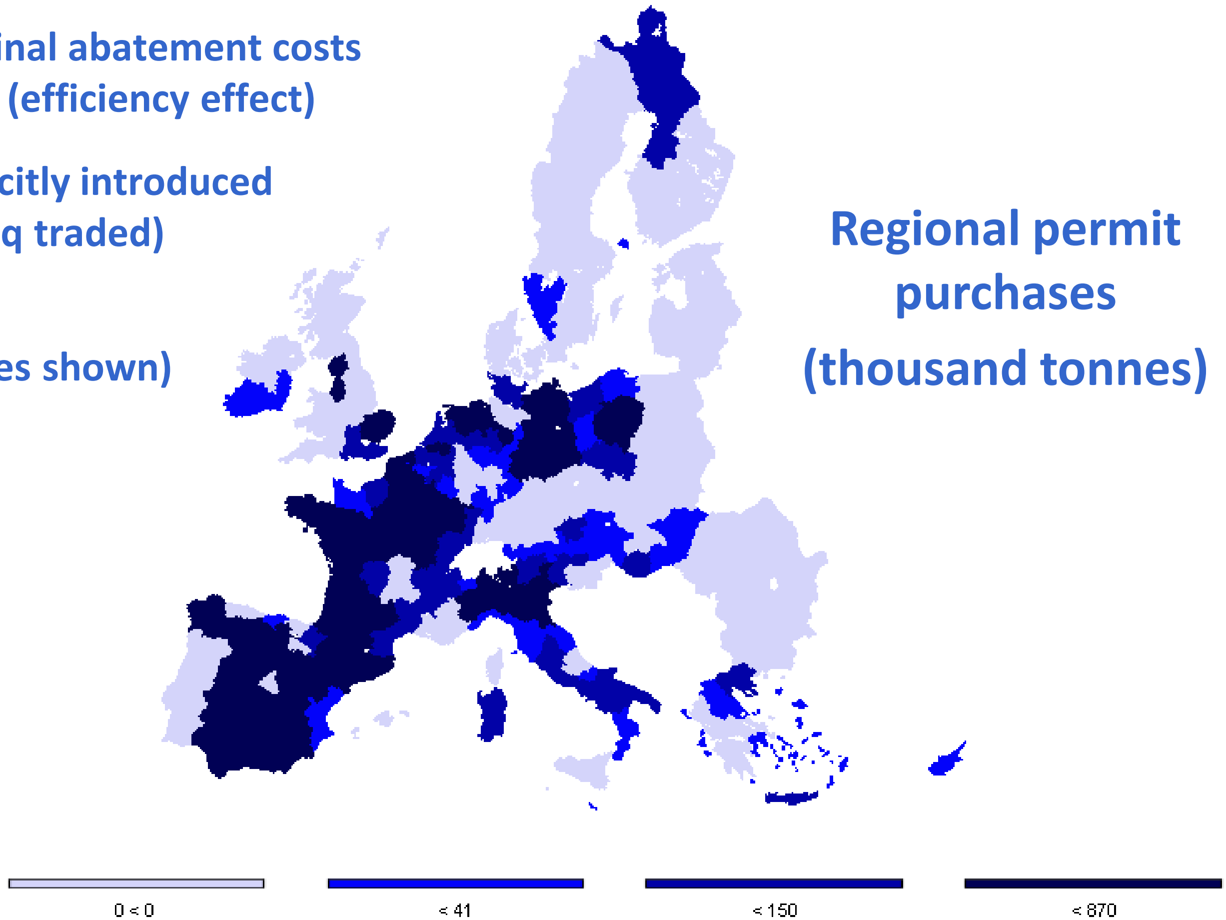


n	219		
Min	0		
Q1	45		
Median	103	Mean	108
Q3	148		
Max	393		
IQR	104	Std.Dev	84



CAPRI Results: emission trading

- <u>Policy shock</u>: 20% reduction in GHG emissions in the EU (year 2020 versus year 2005)
  - Heterogeneity in marginal abatement costs reduced through trade (efficiency effect)
  - Transaction costs explicitly introduced (10 Euro per t of CO_2-eq traded)
  - 26 MM t traded (here regional purchases shown)
  - EU15 as main buyer



Regional permit purchases (thousand tonnes)

THE ROAD AHEAD: SOME PROPOSALS FOR FURTHER ANALYTICAL WORK AT THE OECD

Q1: Agriculture in an "inter-sectoral climate policy"?

- Issues:
  - How to measure non-point emissions?
  - How to link mitigation efforts to emission reductions?
- Analytical options:
  - Use of detailed emission inventory calculation mechanisms (agronomics as very important) → example of IIASA family of models (i.e. technology-rich)
  - Apply land use models for a coherent estimation of LULUCF emissions → example of the CLUEs and IMAGE models
  - "Don't loose" the link to micro-/macro-economic mechanisms → examples of CAPRI and GTAP-E
  - Include "autonomous" and "expert-driven" medium-term baseline projections → examples of FAPRI and AGLINK

Q2: Agriculture and competing land uses?

- Issue:
  - Pressure on land due to increasing demand for food, fibre, timber and biofuels (AFOLU policies)
- Analytical options:
  - Need to improve the link between sectoral approaches (energy, forestry and agriculture) and inter-sectoral tools (CGEs) → example of the CAPRI-PRIMES or the LEITAP-IMAGE links
  - Expansion of existing PE models focusing one region (e.g. EU with CAPRI or US with FAPRI) to cover land use in the rest of the world
  - Important to cover "land leakage" intra-sectoral (e.g. not the whole UAAR modelled with AGLINK) and inter-sectoral → land supply functions (LEITAP, CAPRI)

Q3: GHG mitigation options from an "intra-sectoral perspective"?

- Issues:
  - Which agricultural GHG mitigation options?
- Analytical options:
  - Explicit modelling of GHG emission abatement techniques in agriculture (IIASA models → technology-driven abatement cost functions)
  - Explicit modelling of GHG emission abatement policies (CAPRI → mixed approach, endogenous response of the model to "disincentives" to emit)
  - Need to compare the economic outcome of different policy alternatives: emission taxes, emission standards, emission permits, ...
  - Need to break down emissions by activity, gas and source (AGLINK as promising test suite)

Q4: GHG mitigation options from an "inter-temporal perspective"?

- Issue:
  - What is thepotential role of agriculture in limiting climate change to 2050?
- Analytical options:
  - Difficult field for medium-term models: do not include "forecasting" methods and do not go beyond a 10-15 years horizon
  - Possibility to simulate outcomes of other kind of models (IPCC climatic models), but what about the effects of climate change on agriculture ... → moving from "mitigation" to "adaptation"
  - Potential for comparative-static stochastics: yields (changes do to weather changes), abatement cost parameters (cheaper abatement techniques), ...

Discussion

- CAPRI has revealed as:
  - a tool flexible enough to calculate GHG emissions and to be linked to other models (different methodologies: non-calibrated, one-way, sequential)
  - can be used "for free" by the OECD
  - EU database on emission coefficients directly available
- AGLINK could profit from this work and be enhanced:
  - environmental restrictions not yet modelled → still to see how Troll handles that (equation system, not optimisation)
- GTAP already working since a while in this direction:
  - could further profit from the estimated non-CO2 agricultural commodity emission coefficients of CAPRI
  - ongoing work between Purdue and Bonn exchanging factor market information (land vs. labour/capital)

www.oecd.org/agriculture

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