

Coupling regional modules within CIAMⁿ

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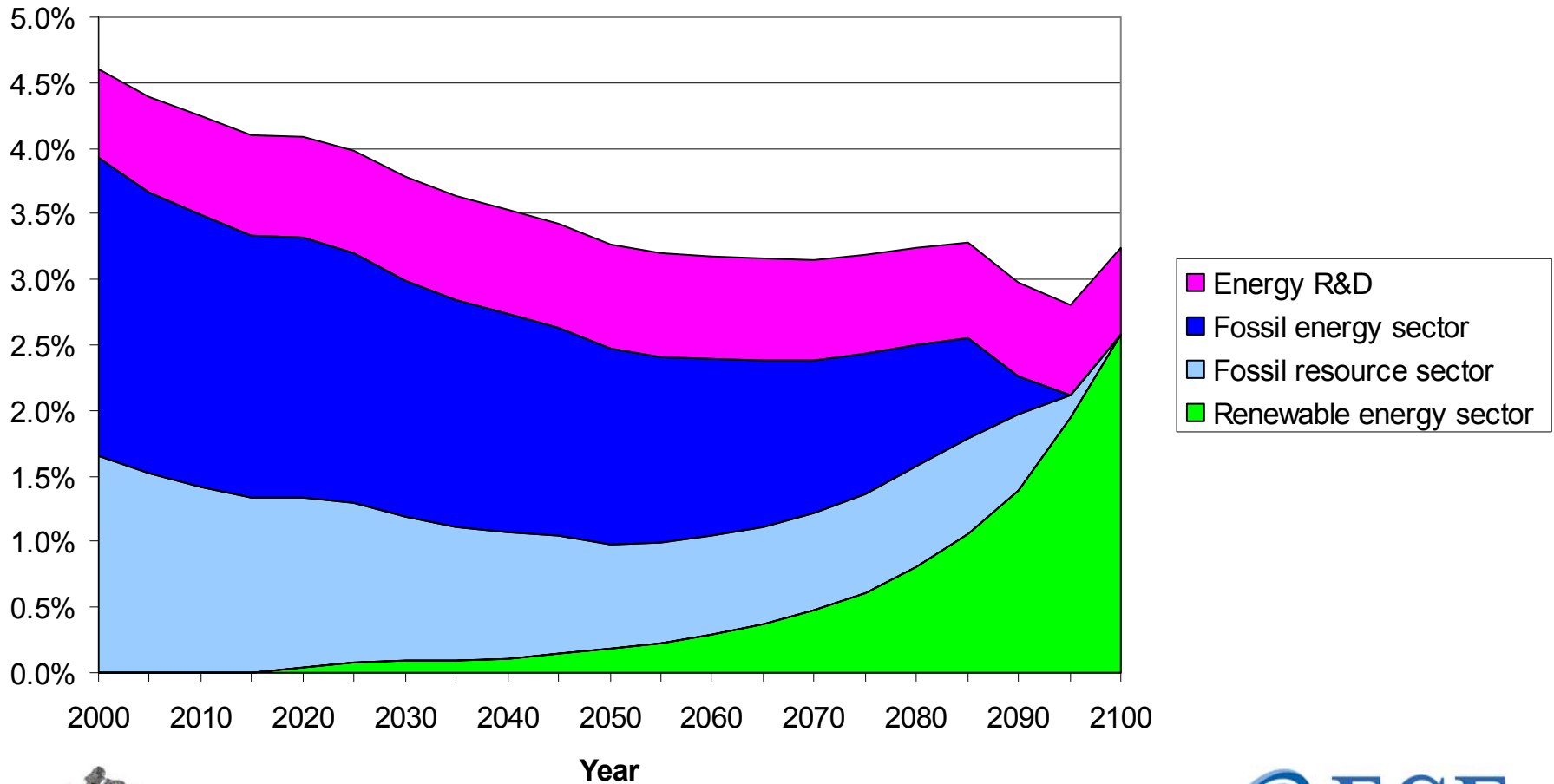
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Deficits in current state-of-the-art IA models

- Concerns of South (e.g., intra- and intergenerational equity and responsibility) are neglected
- Policy instruments are treated exogenously
- Biomass energy and carbon capturing and sequestration gain importance – respective modules needed
- Dynamic foreign investments (e.g. into the energy sector) neglected in IA models
- Spillovers beyond substitution and leakage effects are missed



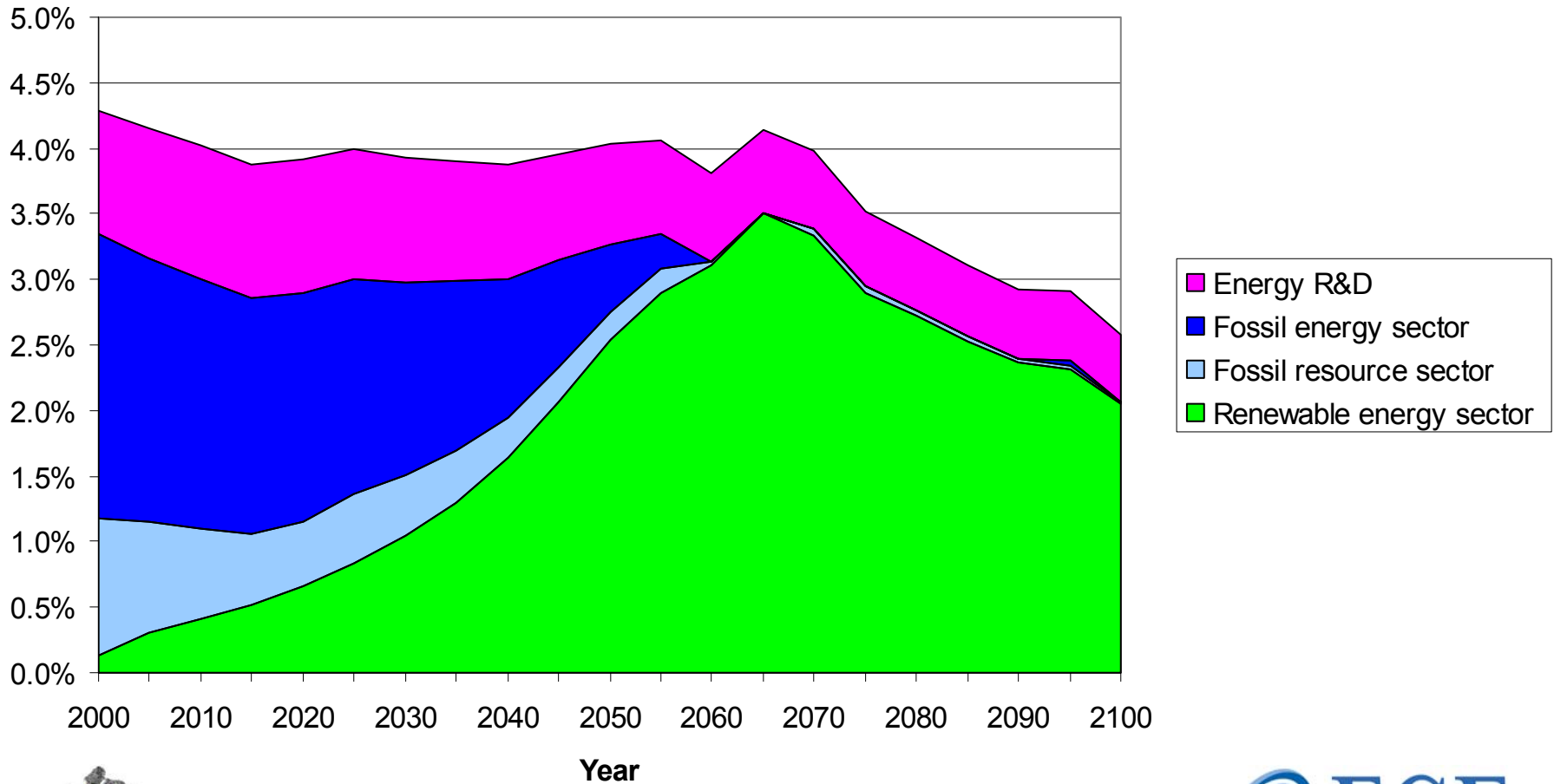
Energy Related Investment Shares in the BAU-Scenario



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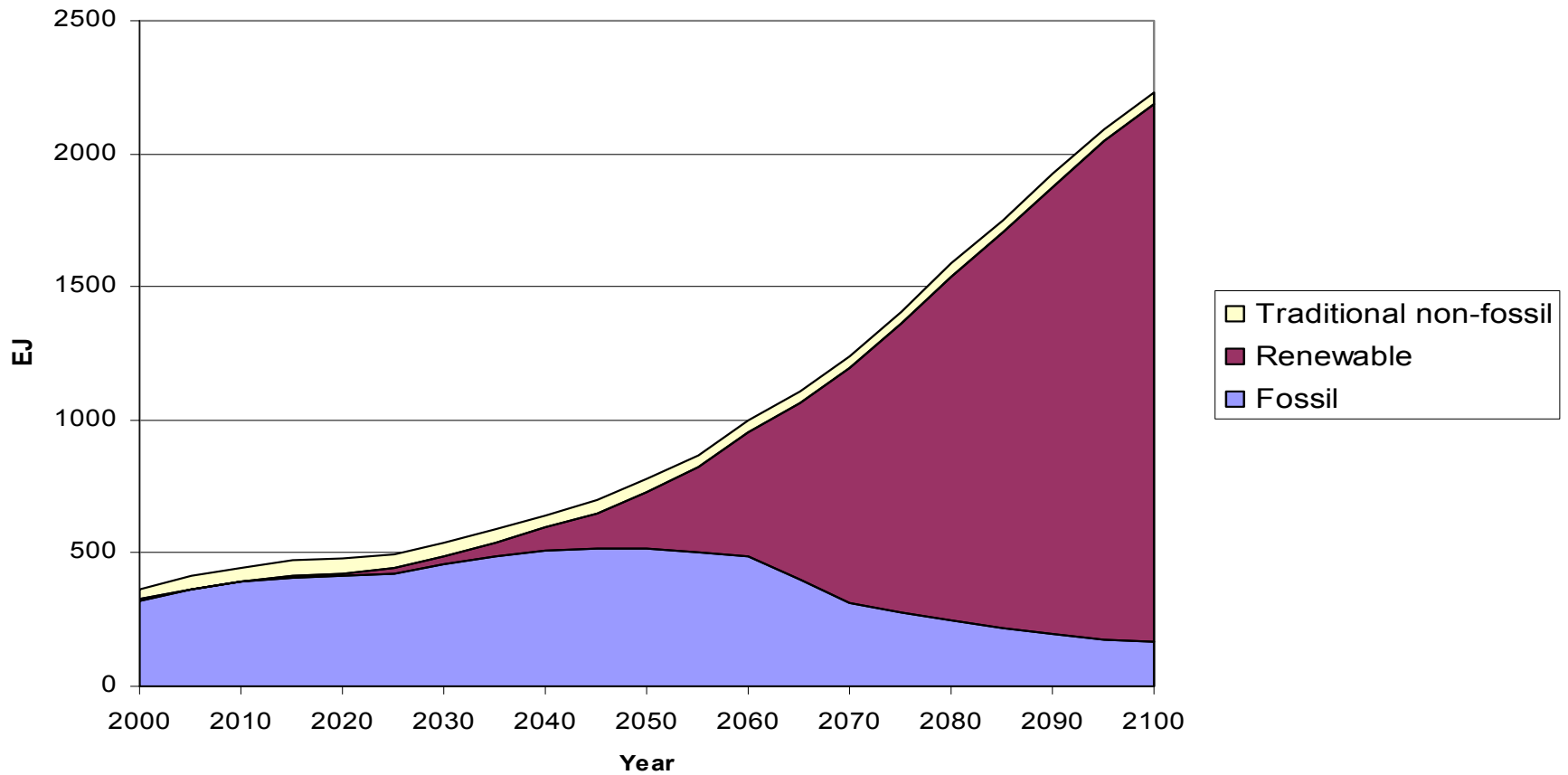
Energy Related Investment Shares in the UmBAU-Scenario



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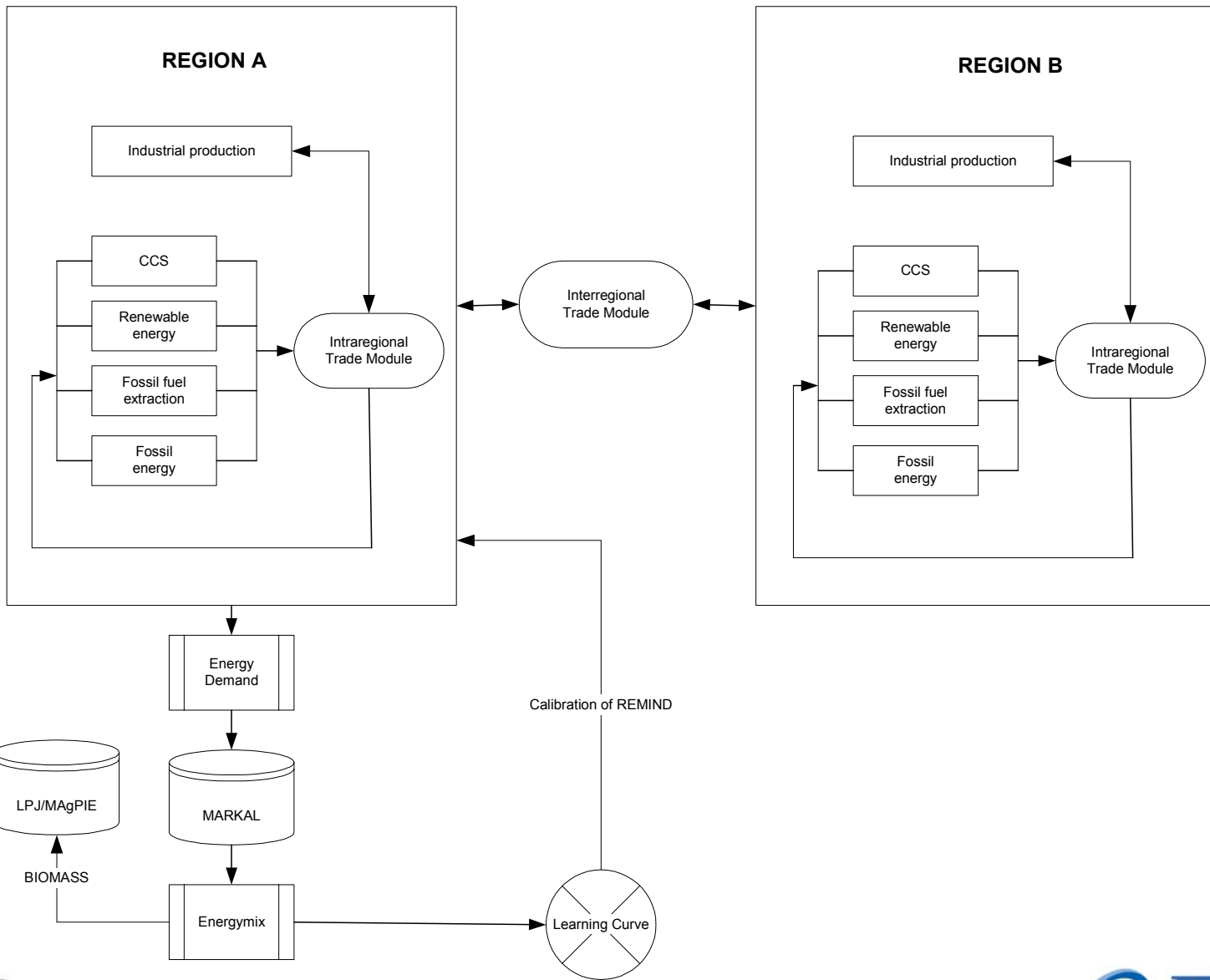


Primary Energy Use in the UmBAU-Scenario



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Challenge

- CIAMⁿ supports a modularization of economic models
- Within a multiregional model each region may be represented by a single module
→ decentralized agents
- How to link decentralized agents within the CIAMⁿ framework?
- Can a social optimum be achieved?
- Compare social optima with the outcome of decentralized markets



CIAMⁿ Integrated Assessment Model

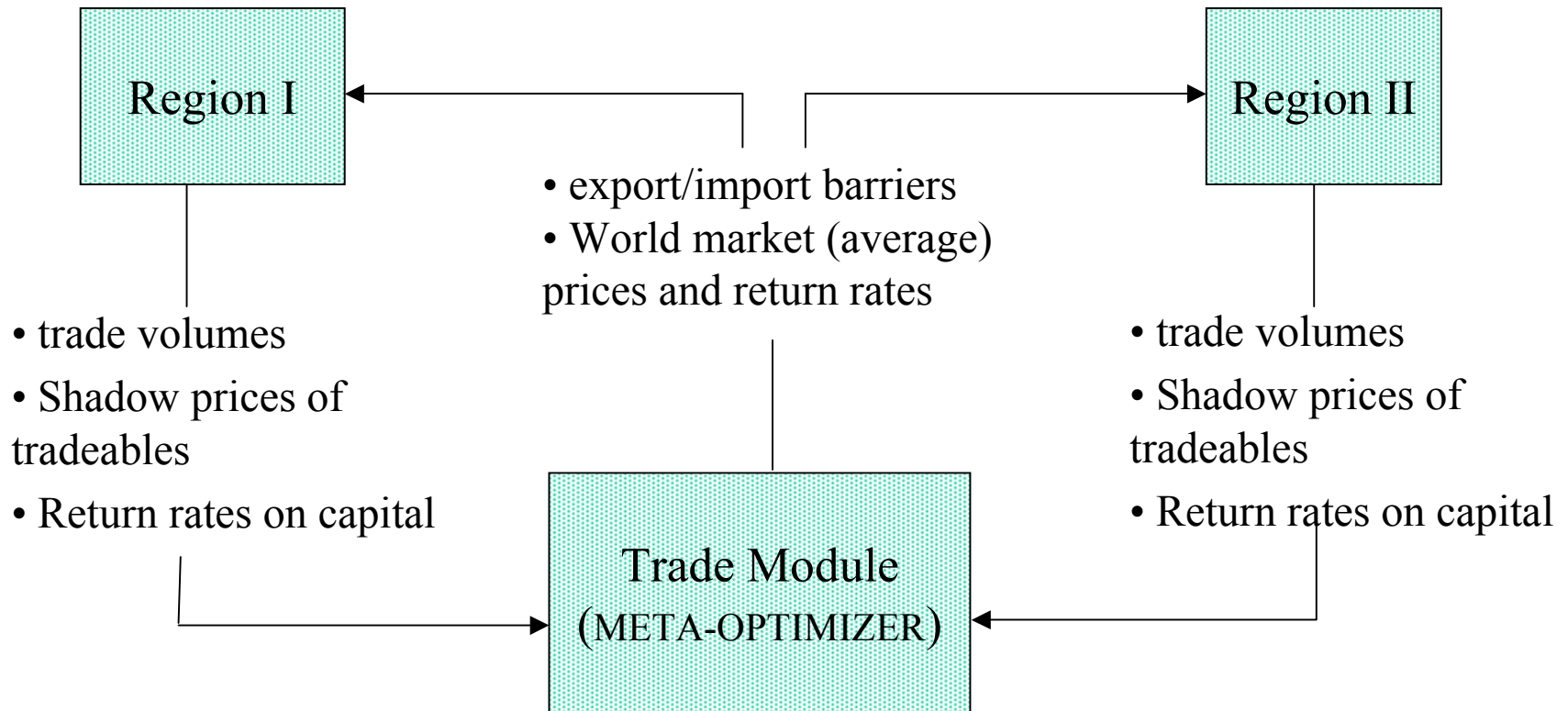
CIAM integrated assessment model (IAM) consist of a number of independently running modules.

Three basic module types:

1. Knowledge domain modules
 - Functional modules (Optimisation or Simulation models)
 - Data modules
2. Numerical coupling modules
3. Job control module (CIAMⁿ Controller)



Modular structure of experiments (barrier approach)



Region modules

- Ramsey type economic growth model (maximizes intertemporal welfare of a representative household)
- Control variables: investments, trade flows
- Foreign trade (consumption good, investment good, energy resources)
- Capital mobility (foreign direct investments, other investments)
- Balance of payment constraint (links foreign trade and foreign investments)
- Net export is restricted by a barrier (the net export barrier represents a lower boundary - maximum amount of tradeables that can be imported).



Trade module

- Intertemporal budget constraint
- Temporal trade balance (clearing of export and import markets)
- Objective function: $\text{Max } \sum_t \sum_i (\hat{p} - p_i) x_i$ (maximizes exports into regions with higher profits/return rates)
- Bounds on the export barrier (actual control variable of this module)

The purpose of the trade module is to adjust the export barriers while clearing the markets and ensuring intertemporal balancing.



Tâtonnement process

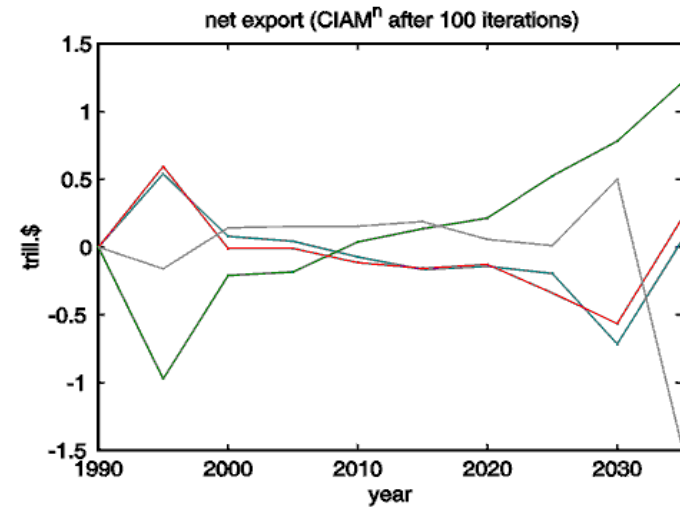
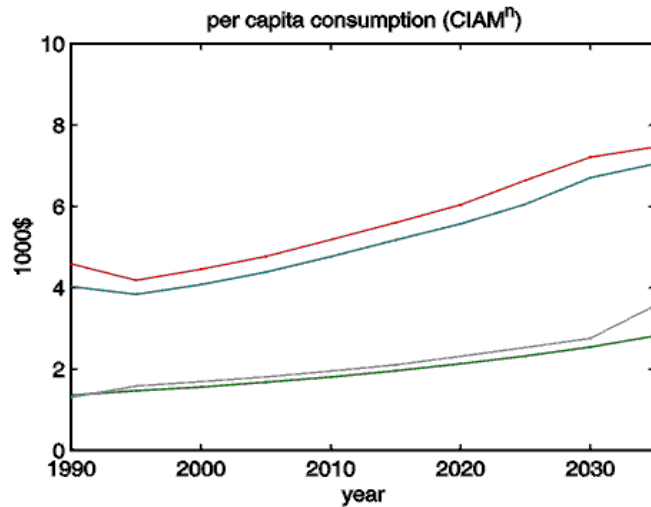
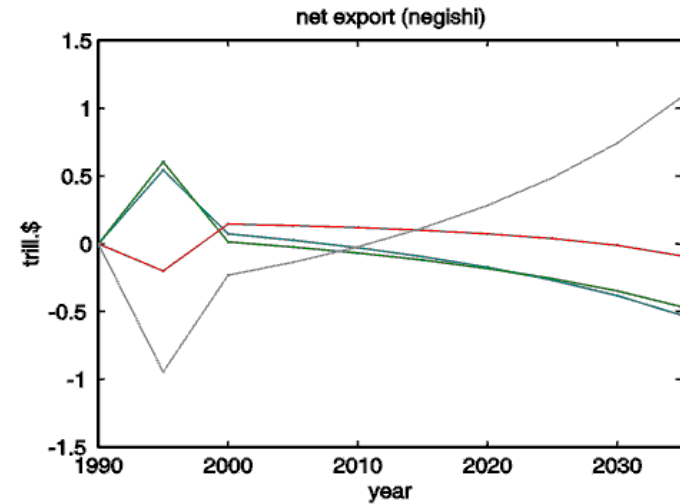
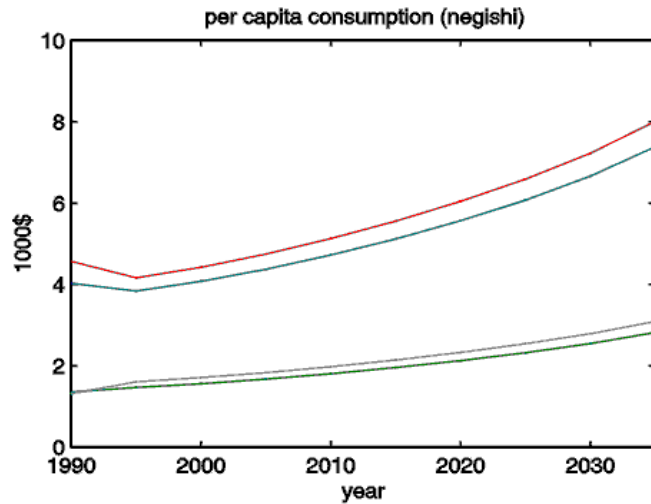
Equilibrium conditions:

- equalized rates of returns on capital
- balanced intertemporal budget constraint
- clearance of trade markets

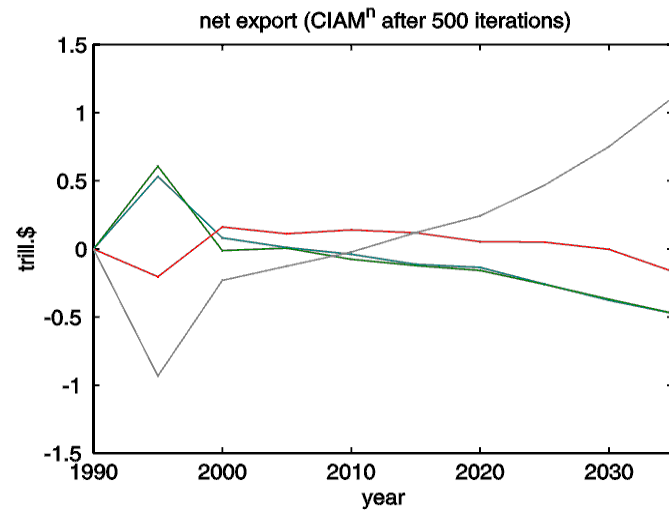
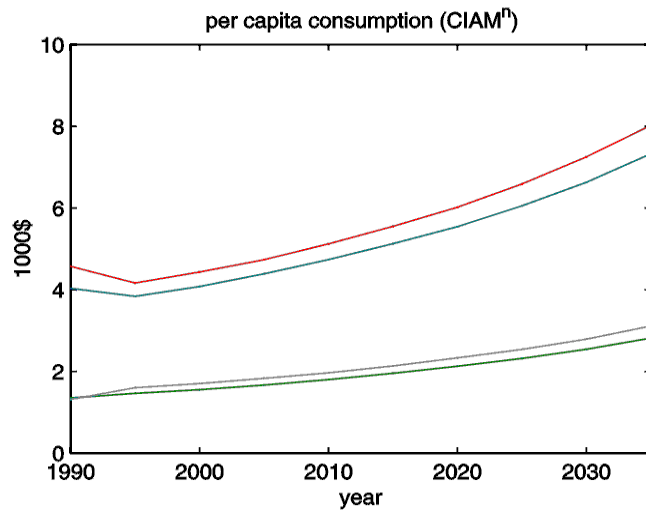
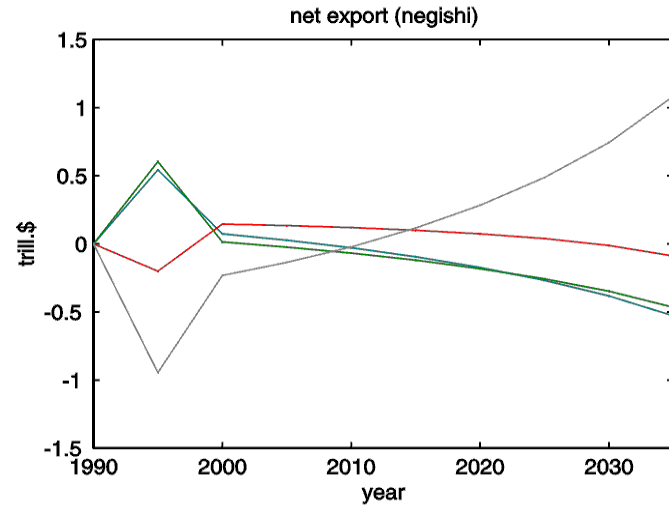
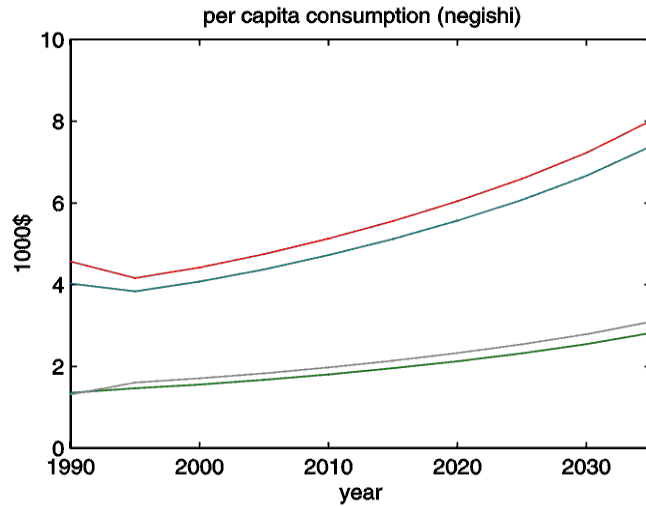
Negishi approach	CIAM ⁿ approach
Iterative adjustment of welfare weights	Iterative adjustment of export barriers
Equal rates of return on capital in each iteration	Intertemporal budget constraint is balanced in each iteration
Achieve balanced intertemporal budget constraint	Achieve equalized rates of returns on capital



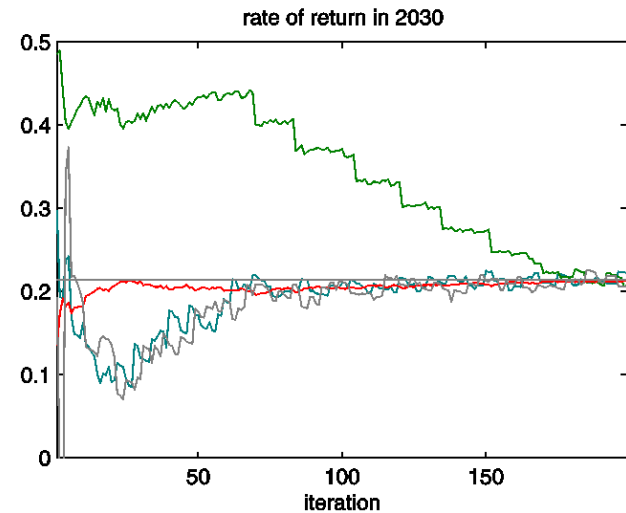
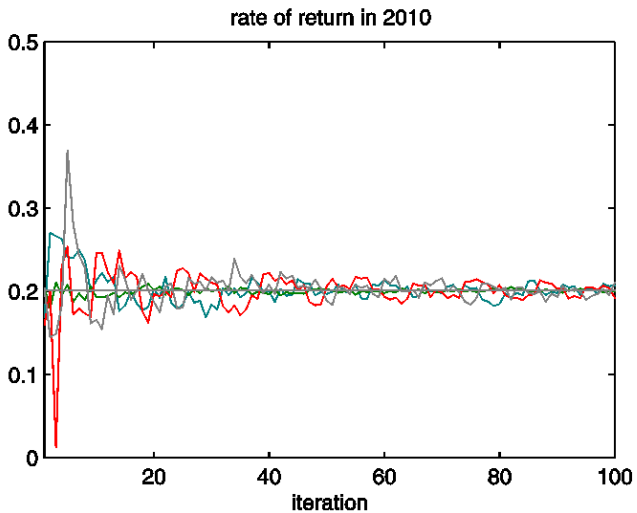
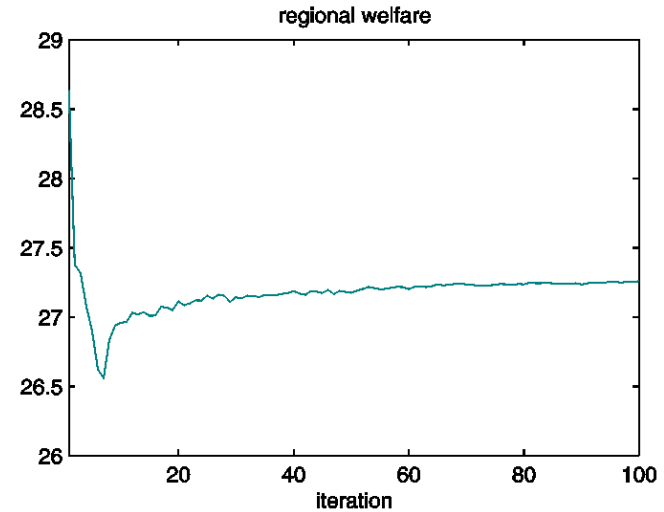
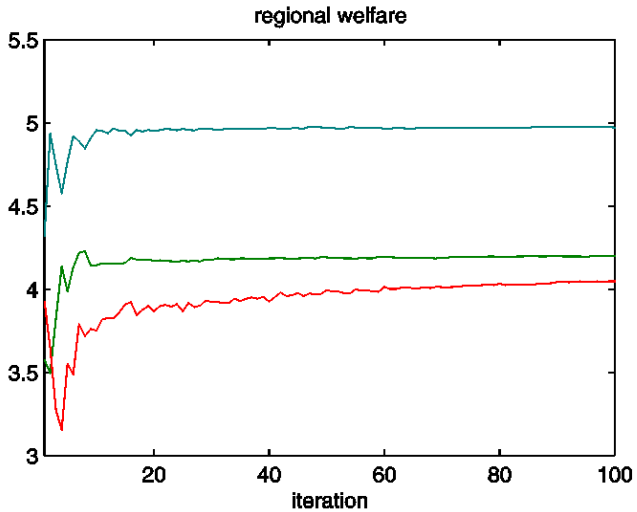
Negishi vs. CIAMⁿ



Negishi vs. CIAMⁿ



Convergence of the barrier approach



Conclusions from first experiments

- It turns out that the regional rates of returns on capital equalize
- The CIAMⁿ barrier solution reproduces the Negishi solution, hence demonstrates equivalence of social planner and decentralized market solutions
- Regional shadow prices of tradeables don't level off



Spillovers between regions

Spillovers are an essential element of modelling endogenous technological change.

Spillover categories:

- Technology diffusion (via R&D and FDI)
- Knowledge diffusion
- Policy diffusion
- substitution/leakage effects

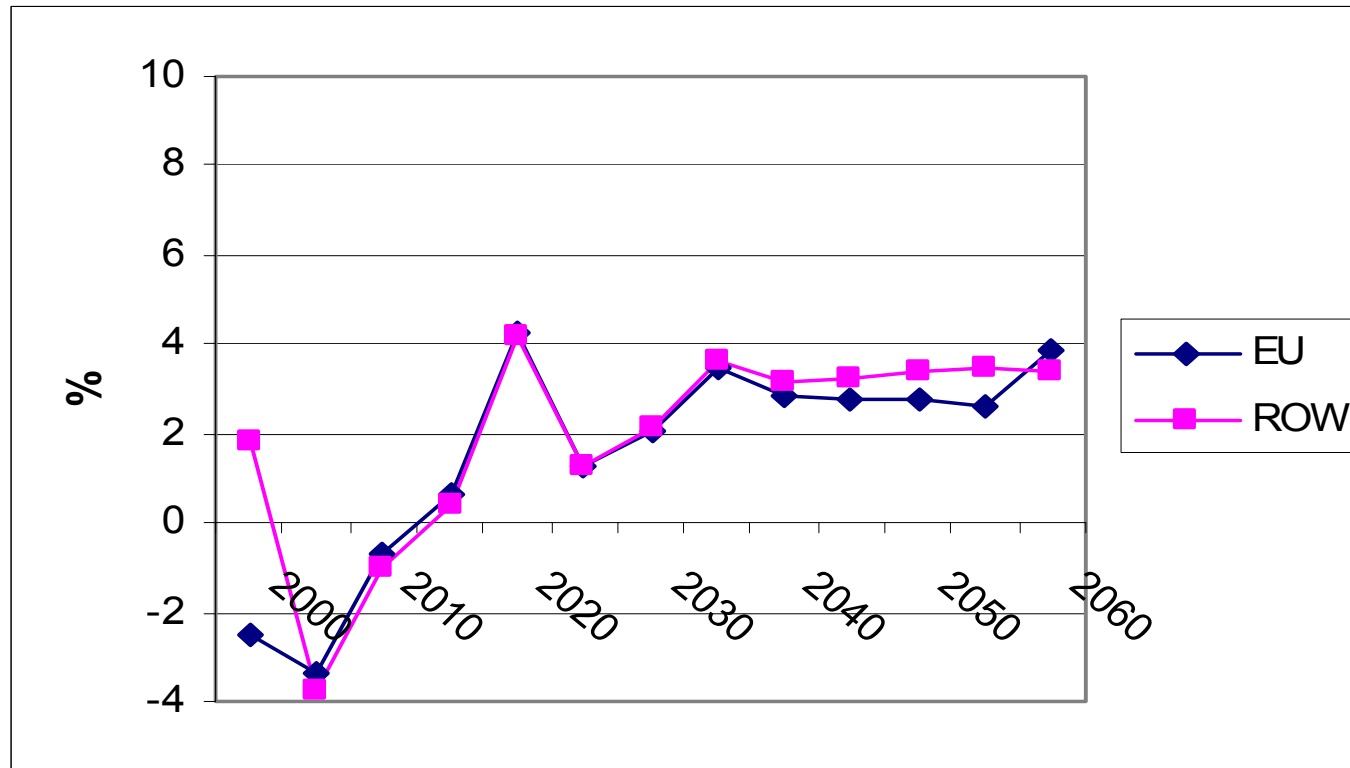


Spillovers via foreign direct investments

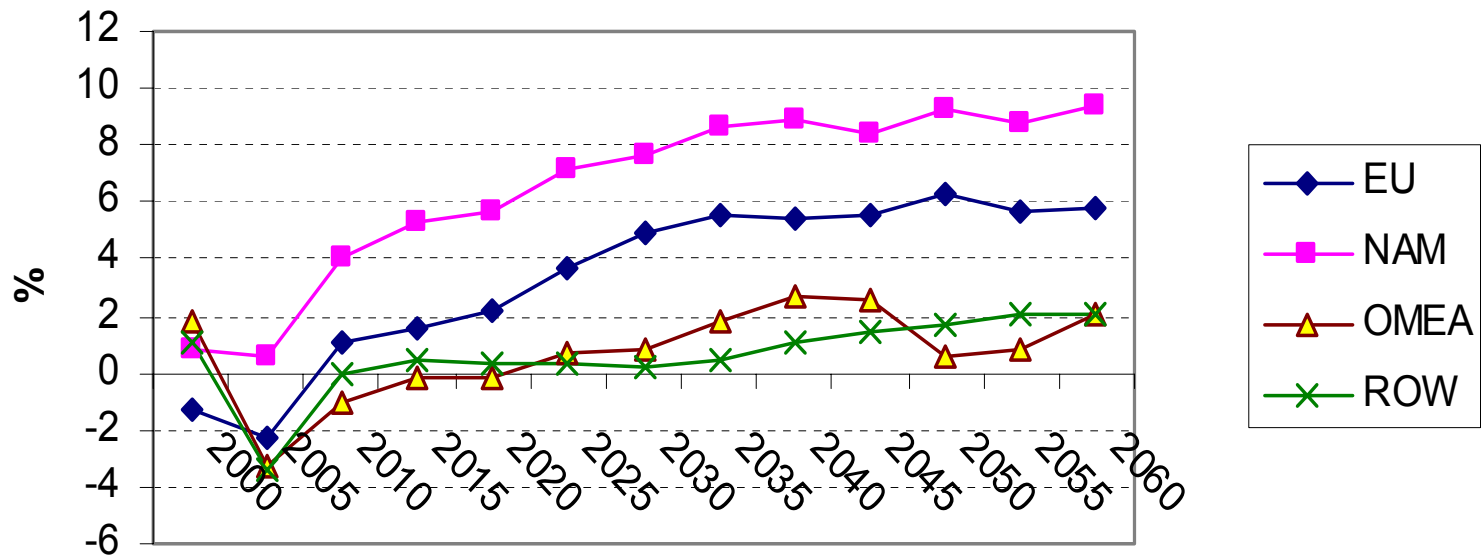
- Potentially induce non-convexities
- Require to model bilateral trading flows
- Negishi approach not applicable anymore (trade balance equation is met by definition and gives no reasonable shadow price information)
- First step within the CIAMⁿ approach: $\Delta TFP_r = f(\text{FDI}_{ir}, TFP_i - TFP_r)$
- Pareto-optimal improvements wrt the non-spillover case, however, adjustment/convergence process quite demanding



Consumption gains from spillover effect (Negishi solution)



Consumption gains from spillover effect (CIAM^n solution)



Open research questions

- What are alternative algorithms for the tâtonnement process within the trade module?
- Capital mobility (energy sector, industrial sector), unwarrantably neglected in IA models, needs further research.
- Exist a social optimum in models with IRTS effects (spillovers, learning by doing)?
- Which policy instruments help to bring about decentralized market solutions close to this optimum?

