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Next generation of advanced integrated assessment modelling to support climate policy making

Critical reflection of Integrated Assessment Models (IAMs) scenarios

based on Keppo et al., Environ. Res. Lett 16 (2021) 053006

Isabela Butnar (UCL)

with contribution from **Oreane Edelenbosch** (PBL), **Panagiotis Fragkos** (E3-Modelling),

Julien Lefèvre (CIRED), **Roberto Schaeffer** (COPPE), and **Will McDowall**, UCL

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Context

- IAMs – key tools for building and assessing long term climate mitigation scenarios
  - Capture several interacting systems, e.g. energy, economy, land use
  - Build and assess decarbonisation scenarios, offering insights on the available options, and consequences of different strategies of GHG emission reduction
- Central role in IPCC assessments and climate policy analyses/ influence beyond academia
- Concerns over
  - Capabilities of IAMs to capture key elements of the real world
  - How IAM results and recommendations translate into real mitigation activities

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Aims

- Review of
  - The main critiques of Integrated Assessment Modelling in the literature
  - The research efforts undertaken by IAMC to respond to these critiques, including learning from other research fields
- Identify key research gaps & suggest next steps for improving performance and communication of IAMs to the broader climate change community

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Approach

- Focused literature review of critiques to IAMs
  - multiple teams in parallel + input from the wider Navigate consortium
- Identify recurring topics across the review teams
  - all + discussion with the consortium => 6 broad areas of critique:
    - Representation of actor heterogeneity
    - Technology diffusion and dynamics
    - Representation of capital markets and finance
    - Energy-economy feedbacks
    - Policy instruments and policy making
    - Use and interpretation of model results
- Discussion of critiques within the context of IAMC ongoing research
  - One topic per team

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Unpacking the IAM "umbrella"

IAM similarities	IAM differences
Integrate several disciplines	Range of models which work differently
Usually global in scope	Different system boundaries; Different socio-economic and political representation
Cover sufficient GHG sources to be able to project anthropogenic emissions to 2050/2100	Models designed to answer different questions & different evolution, e.g. economic models vs energy system
Describe pathways that achieve long term policy goals, e.g. climate objectives, while highlighting trade-offs between choices	Level of detail: Detailed process based, activity focused models vs *cost-benefit models (not in scope)*
	Solution method over the time horizon: optimisation vs simulation models, perfect foresight vs myopic
	Heterogeneity: single representative agent, vs heterogenous agents with heterogenous preferences

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C1: Representation of actor heterogeneity

- Important role in societal transitions
- Key critiques
  - Limited actor diversity,
  - Single representative agent with economically rational, optimising decision-making, usually based on perfect foresight,
  - Limited representation of inequality, social and distributional impacts.

- Modelling heterogeneity = more detail
  - Trade-offs between capturing the overall behaviour and increased uncertainty and constraints
  - 2 situations when degree and type of heterogeneity is important:
    - Behaviour is uncoordinated and differs between actors
      - Key gap identified: modelling heterogeneity of businesses, governance and institutions
    - Behaviour is coordinated, and actors follow each other's behaviour
- Documentation of embedded assumptions to represent heterogeneity can be improved

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C2: Technology diffusion and dynamics

- Partial representation of technological change in IAMs
  - E.g. improved efficiency over time, endogenous or exogenous technological learning, are present in all IAMs. Not covered: e.g. changes in the product or service itself, spillovers from sectors not covered in detail in the model
- Speed of technological diffusion
  - Model specific
    - Technology substitutability options and systemic integration requirements
    - Expansion/decline technology constraints, or multinomial logit functions to determine market shares, capital motion equations
  - Active IAMC research to cover wider drivers behind diffusion speed

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C3: Representation of capital markets and finance

- Key critiques
  - Representation of the financial system: overestimation of vs no crowding out,
  - Perfect capital markets.
- Modelling the financial system
  - Allocation of finance between borrowers/ banks as creators of finance vs channels for limited savings
- Improvements in the representation of capital markets
  - CGE type IAMs could include financing schemes for the repayment of loans, detailed budgeting of debt across time and agents disposable income, debt accumulation and debt stability
  - Demand driven IAMs consider finance created by demand, include worthiness of borrowers
- Key gaps: allocation of finance between borrowers & creation of financial capital

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C4: Energy - economy feedbacks

Critiques	IAMs in practice
Conventional economics assuming perfect functioning markets	Some IAMs have long explored the implications of second-best formulations, other operate out of equilibrium – not mainstreamed
Missing economy-energy feedbacks	Most IAMs are now hybrids/ either ES linked to macroeconomic growth models or CGE/other economy wide models with explicit technologies in key sectors.
Limited representation of life-cycle impacts of technologies	Active research area to expand IAMs with other features or linking them to other models, e.g. LCA, IE
Unrealistic decoupling between economic growth and energy/emissions, particularly in developing countries	Research gap, also including effects of climate change on growth

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C5: Policy representation in IAMs

- Two ways of representing mitigation policies:
  - Policies target emissions/environmental outcomes, e.g. C price or emission standards
  - Energy and/or sectorial policies targeting specific technologies, e.g. feed-in tariffs, subsidies, technology mandates
- Key critiques:
  - Effectiveness of carbon pricing ⟷ benefit from collaboration with STET+
  - Policy mixes and innovation
    - Technology availability vs broader socio-politic context
    - Technology landscape vs technology maturity & scale of deployment
  - Political processes
    - No policy feedback mechanisms
    - Favouring mitigation for long term objectives vs immediate action
    - Trade-offs and synergies with other societal goals, e.g. SDGs

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C6: Use and interpretation of model results

- Transparency and explicit documentation of modeller choices
- Provision of salient, credible and legitimate analysis
- “Possibility space” - Relevance to diverse voices and perspectives
- Focus on technologies and costs shifting towards wider impacts on the society
- Model interpretation/ mapping “model land” to the real world
  - Recognition of model limits
  - Interpretation phase as discrete phase of work

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Concluding remarks

- IAMs: internally consistent, virtual laboratories of the complex, interacting social, economic, technical and physical systems.
- Our review identified six areas of critiques & critical items for future IAM development and use:
  - Heterogeneity: trade-offs between added complexity and better behaviour representation
  - Technology diffusion: use of empirically derived “stylised facts” to better reflect differences between technology options
  - Capital markets and crowding out: new research & improved modelling of finance in IAMs
  - Energy-economy feedback would benefit from broader range of visions for the economy
  - Policy instruments: trade-offs from modelling policies radically differently
  - Interpretation and use of model results: open sourcing, reflecting more diverse interests and perspectives in the formulation of scenarios

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Thank you!

Developing the next generation of integrated assessment models (09/2019-08/2023)

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