Grounding social foundations for Integrated Assessment Models of climate change

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Key Points:

- Policy-makers need models with social assessment for developing effective climate policies.
- Structures of currently existing IAMs are mostly oriented at understanding interactions between economics and biophysical systems.
- Integrating social processes in IAMs may be done through the social branches of economics.

Abstract

Integrated Assessment Models (IAMs) are commonly used by decision-makers in order to derive climate policies. IAMs are currently based on climate-economics interactions whereas the role of social system has been highlighted to be of prime importance on the implementation of climate policies. Beyond existing IAMs, we argue that it is therefore urgent to increase efforts in the integration of social processes within IAMs. For achieving such a challenge, we present some promising avenues of research based on the social branches of economics. We finally present the potential implications yielded by such social IAMs.

1 Introduction

The progress in reaching climate policy goals so far has been much slower than needed to avoid catastrophic consequences. Achieving the goals of the Paris Agreement on climate change requires a fundamental transition of the economy and society that is comparable in scale to the industrial revolution or the Neolithic revolution. Such fundamental transitions are "*the result of a co-evolution of economic, cultural, technological, ecological and institutional developments at different scale-levels*" (Loorbach & Rotmans, 2010). To design feasible and viable transition pathways, we need decision-support tools that incorporate the complexity and interdisciplinarity associated with such a multi-dimensional transition. Integrated Assessment Models (IAMs) are famous for being decision-making support tools for designing climate policy solutions and have been used for informing climate policy for several decades. However, the structures of currently existing IAMs are mostly oriented at understanding interactions between economics and biophysical systems, while the principles of the social system functioning and the behavior of actors involved are addressed in the models only to a limited extent. Being convinced that IAMs will and should remain key tools for informing decision-making in the climate policy domain, we argue that IAMs need to be transformed on the level of the models' structure in order to help reaching the Paris Agreement goals as soon as possible.

IAM development has generally moved from a narrow, disciplinary orientation to more complex and integrated structures. While the earlier generation of IAMs aimed at answering quite specific research questions (e.g. DICE (Nordhaus, 1993)), the new generation of IAMs (see e.g. latest versions of IMAGE (Alcamo, 1994)) focuses on a much wider range of research questions and on multidisciplinary and integrated approaches. However, despite a higher level of integration of different domains in the IAMs' structures, social complexity is rarely portrayed there beyond purely economic behavior. Indeed, in terms of social dynamics, existing IAMs typically consider the whole world (or a small number of world regions for the RICE model) as just one or a small number of rational and farsighted agents with "rational expectations" (i.e. correct beliefs about the future) who make decisions that optimize social welfare (measured in economic terms) over the analysed time period. The goal of this approach is the identification of cost optimal pathways for climate change mitigation from a technological and economic point of view. Questions of implementation of the identified pathways in a complex social world and mitigation of social impacts are left to subsequent considerations. We argue that the identification of optimal pathways has some merit by providing a benchmark for action, but that those IAMs provide limited guidance for the design of effective climate mitigation policies. Indeed, existing IAMs are mainly used for optimizing climate policy by maximizing the discounted sum of utilities over decades despite of all parameter uncertainties (Ackerman *et al.*, 2009). Non-optimal approaches have counterbalanced these optimization-based drawbacks, based on sustainability boundaries (Heitzig *et al.*, 2016) or based on the concept of "safe operating space" applied on climate change (Mathias *et al.*, 2017). But existing IAMs are still designed to be blind to social drivers, impacts and complexity that makes existing IAMs inadequate for designing climate policies for coping with global change as highlighted by Morgan et al. (1999).). Besides, the earth system has closely tracked the baseline scenario for the past 20 years (Alcamo *et al.*, 1996) suggesting that policy-makers needs integrated tools that encompass all the socio-political complexity. But the next generation of integrated models of World-Earth dynamics that we are calling for should be able to produce trajectories that can in principle be helpful for policy-makers. This requires integrating the social system in IAMs' structures.

When it comes to better understanding what the role of the "social" is in this context, we argue that it is important to distinguish between social dynamics that *drive* climate change from those that are *impacted* by climate change. Finally, it is essential to understand whether and how actions of different parties are mutually dependent, and how they unfold synergies or counteract each other because of social complexity. On the impact side of social dynamics, the concept of social cost of carbon (Pindyck, 2019) currently dominates climate policy discourse, addressing such issues as climate change effect on agricultural productivity, human health, or property damages for instance (Mearns & Norton, 2010). Therefore, for better accounting of social cost, it has become increasingly important to address in IAMs such social system aspects as equality, welfare distribution, ethical or justice issues (Ackerman *et al.*, 2009). Increased accuracy of climate damages accounting will be beneficial for understanding both the underestimated and the overestimated share of social costs (Ackerman *et al.*, 2009).

2 Building climate transition pathways on social foundations

IPCC – as well as a large part of the scientific community – favors transition pathways that include social aspects such as motivational factors, institutional feasibility or behavioral changes. However, we have to move forward from these intentions to operational tools for policy-makers. For developing such operational tools, we suggest a "paradigm shift" in IAM development. In particular, the above outlined social drivers are neglected in IAMs and their use, so far. However, they are crucial for understanding actual dynamics of climate change mitigation action. Moreover, including them in models becomes all the more important as soon as social impacts of climate change begin to affect social drivers – leading to a feedback loop that may drive non-linear dynamics which traditional IAMs are not able to capture. As a starting point, we argue that IAMs should progressively include the results that connect economics with social sciences as IAMs currently connect economics with climate. More specifically, IAMs are mainly founded in neoclassical economics while several other branches of economics consider social aspects. Among them, we point out three branches of economics from which social processes may be considered and formalized for tackling climate issues: behavioral economics, welfare economics and political economics.

First, behavioral economics may overcome the limitation of rational choice theory by formalizing psychological processes involved in climate-economics interactions. Indeed, while most IAMs focus on economic decisions by a hypothetical rational social planner, actual technological and behavioral change comes from many boundedly rational players at different societal levels, interacting not only via price signals but also through non-economic processes such as social norms, spreading information or preferences with non-monetary components. For instance, a recent study in North Carolina (USA) shows the impact of intergenerational learning on the perception of climate change (Lawson *et al.*, 2019). This study shows how education of children may affect the behavior of parents without any economic incentives. This intergenerational learning also highlights the unexpected effects of population inversion - the global population will become older in following decades. Therefore, beyond the quantitative effect of population inversion on the economy, it is also important to study the qualitative effect of a change in the population structure through the lens of behavioral economics. The emerging fields of social simulation and complexity economics suggest that such behavioral effects can cause much more nonlinear trajectories than represented in close-to-equilibrium economic models, containing tipping behavior highly relevant for the transitions that IAMs are meant to study (Farmer *et al.*, 2019).

Second, formalizing components of welfare economics in IAMs may evaluate inequity and distributional impacts that affect the feasibility of climate policies (Hirth & Ueckerdt, 2013) as shown, for instance, by the "yellow jacket" crisis in France. The fuel tax implemented by the French government created distributional effects (especially between rural and urban populations) yielding weekly protestations whereas the same people support actions against climate change. Existing IAMs analyze measures based on their consequences on the whole economy (GDP) and on CO_2 emissions. However, such measures also have distributional effects within the economy (i.e. *who "wins" and who "loses"*) that may affect population's welfare. A truly "integrated assessment" of climate protection measures should include an assessment of such distributional side-effects, because those side-effects are the most important in the feasibility of measures. The current approach of IAMs to inequality is to disregard it or at best include it in some inequality-averse welfare measure that is then used as the optimization target. This ignores however the feedback effects of inequality on economic pathways and on the feasibility of policy measures. Welfare economics can therefore provide operational tools (Fankhauser *et al.*, 1997) in order not to reinforce potential inequalities that may emerge from climate policies. Since agents' perceptions of what a just climate policy regime is not only depend on issues such as inequality but also strongly on various notions of historical responsibility, the design of welfare measures for use in IAMs should also make use of tools from the emerging field of formal ethics (Chockler & Halpern, 2004).

Third, political economics would highlight resistance or support dynamics on climate policies emerging from the effects of political power and lobbying. These political processes are neglected in IAMs whereas measures have to be decided within a socio-political context that renders some measures unfeasible while others may receive more support from influential actor groups. Political leaders typically seek compromise with important stakeholder groups beforehand. For instance, in the case of the Waxman-Markey bill in USA which would have set a limit on the emission of greenhouse gases, the role of political lobbying over climate policy has been estimated to US$60 billion in terms of social costs (Meng & Rode, 2019). In this latter case, the effect of lobbying has been neglected whereas it significantly downsizes the expected results. Such socio-political factors contributing to the lack of climate ambition are not taken into account in IAMs so far despite of their well-established impacts (Meng & Rode, 2019). Even if it doesn't encompass all the complexity of power and politics, integrating politico-economic processes (e.g. lobbying) in IAMs may give new insights in terms of climate trajectories in order to take into account, for instance, the strong resistance to a sustainable future (« negative resilience ») from those benefiting from the current situation (for instance oil companies) and how they may influence the policy-making process.

Integrating these three main social strands in IAMs requires not only the inclusion of state-of-the-art and cutting-edge model components but also the acquisition of social data for driving and validating the models. Either such data are readily available (e.g. input-output tables, data from social networks) or data have to be elicited and assessed. Eliciting and assessing new social data may be done through a variety of participatory modelling approaches to collect perceptions of large participant groups, focusing on social climate change issues connecting to geographical locations. Such massive data may be collected through qualitative surveys and expertise using participatory face-to-face or online approaches. Once data are collected, analysis becomes challenging due to its volume and heterogeneity. Artificial intelligence – based on data mining – is a natural way for addressing the issue of quantity and heterogeneity of data for extracting social patterns. Methods for social media mining (Zafarani *et al.*, 2014) such as sentiment analysis, relational data mining and predictive modeling can represent powerful tools for discovering social patterns in data, which enriches the existing process- or cost-based IAMs with an additional social component (Figure 1).

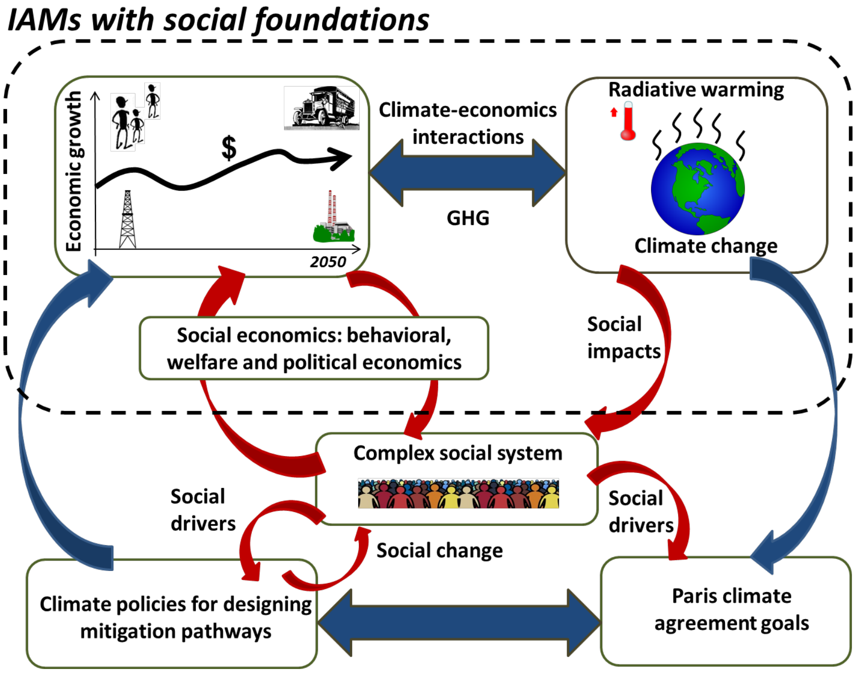

Figure 1. The role of complex social system on climate dynamics. IAMs should progressively include complex social dynamics through social branches of economics (e.g. behavioral, welfare or political economics) that are natural connections between social and economics processes already used in IAMs.

3 Implementing the global response through the lens of social change

At a glance, developing effective climate policy means to introduce a coherent methodological perspective by extending IAMs' structure towards economics that takes into account social aspects, such as behavioral, welfare or political economics. These branches of economics will foster the integration of social processes in the existing modeling of economics-climate interactions. Besides, the social branches of economics also require fundamental efforts in the different fields of social sciences as sociology, psychology, political sciences, cultural multi-scalar structure and so on. However, we argue that considering these domains as a bridge between social foundations and IAMs is required for moving from intentions to actions in order to trigger public support for stringent mitigation and what would lead to a profound transformation in climate policies (Dowlatabadi, 2000). Once these social foundations are built up in IAMs, they will open up new perspectives for climate actors in terms of mitigation pathways. More specifically, one key-outcome of considering social aspects in IAMs – and therefore in climate policies – may be a greater attention to social dynamics for coping with climate change. This transformation may be driven by different social approaches based on social norms (Nyborg *et al.*, 2016), nudge theory or social innovations (Moulaert *et al.*, 2013). For instance, social innovations refer to new ways of meeting social needs or delivering social benefits to communities. Their implementation is sought to improve human rights, tackle poverty and social exclusion (Moulaert *et al.*, 2013). The integration of social processes in IAMs can lead to complementary bottom-up approaches, where the impact of households on climate through, for example, mobility and consumption choices, can be understood and acted upon via social change interventions. This fills the gap between how household perceive their role in climate change mitigation and the input received from climate policies. IAMs with embedded social processes may provide crucial information to address this mismatch. Such approaches may build environmental-friendly solutions based on a better understanding of interactions between social, economic and climate dynamics. Ultimately, this may lead to better consumption attitudes such as extensive consumption, less waste, and more cooperation through exchange of goods for reuse or services. In the long-term, integrating social foundations in IAMs will foster such social change towards a low carbon and just society.

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