responses are still uncertain and/or not well captured by IAMs. For instance, relatively small changes in climate sensitivity can greatly change the cost estimates from these models (Ackermann and Stanton, 2012; Anthoff and Tol, 2013). Quantitative modelling frameworks are also ill suited to measure important social phenomena like conflicts, mass migrations, disruption of knowledge, learning and social capital potentially triggered by climate change (Anthoff and Tol, 2013; Stern, 2013). IAMs emphasize impacts on GDP, which even disregarding its deficiency as a welfare measure, captures flow and tend to overlook stock losses (Stern 2013). Risk and irreversibility associated to high damage low probability events is usually left out of the analysis which can seriously bias downward damage estimates (Weitzman, 2007, 2008, 2009, 2010; Ackerman and Stanton 2012). IAMs tend to be overly optimistic in describing timing and scale of adaptation processes, disregarding the fact that, agents may not use perfect information and for technological, economic, psychological and cultural characteristics may resist to some changes (Patt et al., 2010). All these critiques are particularly relevant when climate change impact assessments are conducted with CGE models. They provide a peculiar richness in the analysis of climate change costs, highlighting sectoral effects and, above all, tracking endogenous market adjustments and rebounds triggered by climate change shocks. But, at the same time, they are grounded on GDP, account just for marketable relations, typically model instantaneous and frictionless adjustments. Against this background, the assessments performed with CGE models tend to fall somewhat in the lower end of cost estimates.

This paper presents a simple exercise to address the following questions. Do climate change impact assessments performed with CGE models estimate lower GDP losses than reduced-form climate change damage based assessments? What is the role of market driven adaptation in determining these estimates?

We run a standard climate change impact assessment exercise with a recursive-dynamic CGE model using updated estimates of an extended set of impacts for different temperature increase scenarios. Then we extrapolate a reduced-form climate change damage function. We show that, at the global level, this is not significantly different from that produced by some established hard-linked integrated assessment models when the same impact categories are included. Furthermore, we perform the same exercise reducing what can be defined "market driven adaptation". In practice, we restrict the elasticity of input substitution in the production function, the substitutability of domestic and imported inputs, and finally sectoral workforce mobility. We demonstrate that, notwithstanding these frictions increase the cost of climate change impacts, they do not change substantively neither the qualitative nor the quantitative picture.

K-2237a-03

Accounting for Climate Impact and Cost Uncertainty in Integrated Assessment Models

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We develop a methodology that uses the concept of a risk premium to account for risk aversion to climate change damages in the affected population. The premium is derived from the notion of risk aversion in the framework of expected utility theory, namely the amount that society would be willing to pay in order to reduce the riskiness of future damages. We estimate the risk premium for plausible average damage functions that are currently being used in Integrated Assessment Models to calculate the optimal levels of mitigation and adaptation. The new functions are referred to as risk-adjusted damage functions and they have higher damages than the expected values used previously. We have calibrated three sets of risk-adjusted regional damage functions for three different level of risk aversion, low, medium and high. With low and medium coefficients of relative risk aversion equal to 1 and 1.5 the additional damage component is quite small. The damage addition due to risk aversion is highly nonlinear and it increases significantly when the coefficient rises to 2. It is also interesting to note that the risk premium varies from region to region, implying that the degree of the adaptation response will be region-specific.

The new functions are used to estimate what they imply for optimal adaptation and mitigation with different versions of the AD-Witch model. The results show that the percentage increase in allocation to adaptation is around 10-20 percent for values of the coefficient of risk aversion of 1 and 1.5, but rises to as much as 80-200 percent for a value of the coefficient of 2. The impacts of including risk in damage estimation on mitigation are interesting and somewhat different. In the cooperative solution mitigation is increased 5-10 percent with the higher damages for low values of risk aversion and by 10-20 percent for higher values. Finally as far as the growth scenarios are concerned there appears to be little difference in terms of the impact that taking account of risk has on the calculations.

Further work is continuing to see the effects of the new damage functions at the regional level.

O-2237a-01

Global climate impacts: a preliminary economic analysis

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Understanding the global implications of climate change at the appropriate country resolution is important for the policy process. The purpose of this presentation is to gain some first insights on the sectoral and regional pattern of the biophysical and economic consequences of climate change at the global scale, benefiting from the current bottom-up sectoral impact evidence. The study will consider a set of climate model runs and a limited set of impact categories within an integrated climate-biophysical-economic framework.

The main questions to be addressed are the following. Firstly, how important are the impacts of climate change for the big players in the international climate negotiations? Secondly, what are the distributional implications of climate impacts vis-à-vis Europe? Thirdly, what are the main uncertainties in the modelling and how they influence the results?

The project scope has several dimensions. Regarding the time horizon, it covers the climate impacts over the 2071-2100, compared to 1961-1990. The study considers few impact areas, for which there exist empirical bottom-up evidence: agriculture, coastal areas, and if possible, energy.

The study methodology is based on results from process or bottom-up biophysical impact models (from the ClimateCost EU project and, possibly, the ISI-MIP project). The economic valuation of climate impact categories will be carried out in a coherent and harmonized way with an economic multi-country, multi-sector computable general equilibrium (CGE) model in order to enhance the comparability of the different damaging patterns.

The authors have already conducted preliminary analysis of impacts in agriculture and coastal areas. The results indicate that there is a wide dispersion of impacts across the world, with strong geographical asymmetries.

O-2237a-02

Effort sharing taking into account adaptation costs and climate change damage

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The ongoing discussion about the feasibility of maintaining global temperatures below 2 °C encompasses not only the costs and benefits of achieving the target, but also the difficulty of reconciling regional efforts with the inequity of climate change impacts. If mitigation and adaptation actions, as well as residual damage from climate change, will be distributed diversely across the world, can we devise a policy which aligns different country and regional views and incentives? In most of the scientific literature, equity issues related to mitigation, adaptation, and impacts have been disconnected. Most studies on effort sharing have focused on fair distributions of mitigation costs without considering adaptation costs and residual damage. Our study aims to fill this gap by investigating which mitigation targets in 2030 and 2050 lead to equalizing the sum of mitigation costs, adaptation costs, and residual damage as share of GDP across regions.

We employ two alternative modelling frameworks combined with two sets of regional climate change impact functions. These models provide a mapping of the residual climate change damages of 2 °C and of the resulting adaptation costs, and allow exploring how emission rights should be allocated to equalize the sum of mitigation costs, residual damage, and adaptation costs as share of GDP across regions. We show that a 2 °C world leaves considerable residual impacts and adaptation costs. Sharing the burden of the total costs of climate change, including residual damage and adaptation costs, reshuffles the emission allocation compared to an effort-sharing regime based on mitigation costs only. The financial implications can be significant, with a total of additional resources in the order of 100-200 USD billions in 2030 would need to flow to the high impact countries in India, Africa, and Rest of Asia, by means of trading emission rights. Countries with lower-than-average impacts, such as OECD countries and China, would buy such rights thereby financing those transfers.

The above numbers assume a global carbon market being in place from 2020 onwards. Even though such a global carbon market with the implied sharing rules is not easy to implement, our paper suggests that accounting for the total costs of climate change and including adaptation and damage considerations could achieve an effort distribution being perceived fair by a wider group of countries.

O-2237a-03

A predictive model of production loss under unanticipated shocks by extreme weather events

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Risks of extreme weather events like floods, heat-waves and storms are likely to increase due to global warming. Since world markets are highly interlinked and local economies extensively rely on global supply and value added chains, extreme weather in one place may have repercussions elsewhere. Accordingly, a comprehensive climate risk management and cost estimation should take these interactions and dynamics into account.

Here, we present the dynamic damage propagation model called «acclimate». On the same time scale as the local events the model explores immediate response dynamics as well as the subsequent recovery phase of the supply network. While the pure damage propagation dynamics [1] as well as possibilities for demand changes and extension of production [2] have already been described, we concentrate here on a major extension that includes price dynamics and local economic optimization.

The model focuses on analyzing the indirect effects of local perturbations without taking into account economic growth. Its agents, i.e. production or consumption sites, are organized in a production network based on multi-regional input-output data (Eora MRIO database). This constitutes the baseline and is assumed to be an optimal state with respect to the economic rational of the model. Direct damage as perturbation due to climatic extreme events causes cascading deviations from the baseline along the network and thus leads to indirect production and consumption losses.

Each producing agent optimizes its purchase, demand distribution, as well as production and supply distribution to maximize their revenue. Due to the unanticipated nature of the events we assume limited foresight for the agents, who perform their optimization locally in a spatial as well as temporal sense. Since the time scale is too short to allow for immediate market clearance local price deviations are hereby taken into account. The agents for final consumption optimize analogously with respect to their consumption. This short-term behavior is complemented by middle-term adaptation in the form of rewiring within the production network. We furthermore allow for dissipation effects using storage capacities and temporary production extension.

With this model we estimate the economic costs of climate change induced production failures, including indirect costs with potential low-probability but high-damage events. We furthermore aim to systemically assess the limits of adaptation of the supply network. Concerning risk management, we stress the importance of global structural adaptation measures in addition to local adaptation.

[1]: Bierkandt, R., Wenz, L., Willner, S.N., Levermann, A. (2014). Acclimate - a model for economic damage propagation. Part I: basic formulation of damage transfer within a global supply network and damage conserving dynamics. Environment Systems and Decisions, 34, 507-524.

[2]: Wenz, L., Willner, S.N., Bierkandt, R., Levermann, A. (2014). Acclimate - a model for economic damage propagation. Part II: a dynamic formulation of the backward effects of disaster-induced production failures in the global supply network. Environment Systems and Decisions, 34, 525-539.

2237b - Planetary Economics (2): expanding the horizons of economic sciences and the policy implications

ORAL PRESENTATIONS

K-2237b-01

'Planetary Economics': The Three Domains and their implications

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This paper summarises and outlined evidence for the economic framework developed in the book Planetary Economics. It maps out three domains of decision-making, each of which involves different actors, processes and for which our understanding rests on different theoretical foundations. Each operates at different scales of time and social entities: they are complementary, not competing, explanations of diverse economic phenomena. For this session, the paper will also tentatively map different economic theories on to this framework.

The paper will then explain the unique characteristics of energy and climate change issues which make all three domains simultaneously important, and indeed argue that the issues raised span all three domains in approximately equal measure. The paper will also suggest that understanding the different domains help to explain the extremes of cycles in international energy markets and the poor history of energy forecasting.

The paper will then outline lessons on the three corresponding pillars of policy and why any individual policy pillar has been in practice prone to failure. It will outline correspondingly the need for policy packages spanning all three are credible, economically efficient and environmentally effective - and hence, politically stable. The concluding part of this overview talk will touch on the international dimensions, in which each pillar would raise different aspects of international cooperation.