Foreseeability of economic damages related to inadequate climate mitigation and adaptation

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Abstract

This article examines the economic relevance of insufficient climate change mitigation and adaptation and emphasises the contribution of economics in quantity estimates when attributing responsibility and liability: Based on attribution sciences, economics uses models to quantify gross climate damages (with or without effective mitigation and adaptation measures). The calculation of social benefits of effective mitigation and adaptation allows to weigh them against the costs of mitigation and adaption, so that economically sound policies can be adopted in terms of climate protection. Thereby, the Paris Agreement, according to which the international community committed itself to limit the global temperature increase to well below 2 degrees, with efforts to limit it to below 1.5 degrees, constitutes an essential point of reference. The remaining global carbon budget derived from the temperature target allows for the calculation of national, regional and sectoral carbon budgets, which in turn determine whether mitigation measures are perceived as 'sufficient'. It becomes clear that the economic damage of unmitigated climate change exceeds the costs of adaptation and mitigation, inaction is thus economically unjustifiable.

1 Introduction

Climate change is real, both observed as materialising and known to be growing in its implications. This is not only clearly visible in scientific results, such as condensed in the IPCC Assessment Reports,[1] but also in the enhanced awareness of the public in societies worldwide. While climate change damages had earlier mainly hit the global South at significant scales, the industrialised world is increasingly affected, raising popular awareness even further in these countries. For example, in the summer of 2021, floods hit many European countries, most severely in eastern Belgium and in Germany (North Rhine-Westphalia and Rhineland-Palatinate); in Germany, this was the deadliest flood since the North Sea Flood of 1962, and months

1 IPCC, *Climate change 2021: The physical science basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge University Press 2021); available at <https://www.ipcc.ch/report/ar6/wg1/#FullReport> accessed 13 October 2021.

later, the affected cities are still without any local shop infrastructure, have housing stock with wet walls and in some cases lack a supply of fresh water.

How should climate-change-related responsibility and liability be addressed? Complementing the natural science attribution (addressed in the first chapter of this publication), we here focus on the state-of-art in determining the economic relevance, both current and foreseen. Two dimensions can be distinguished. First, economic evaluation of (future) climate damages (i.e., increasing weather- and climate-related impacts due to climate change) can serve as a basis to identify which of these can be reduced and mitigated by adaptation and the net benefits materialising as a consequence. The second dimension concerns greenhouse gas emission mitigation. Aware of the fundamental impacts that unrestrained climate change would imply, the global community in the Paris Agreement,[2] bound itself to limit global warming to well below 2 degrees (above pre-industrial), with efforts to limit it to below 1.5 degrees. This target can be translated to a global carbon budget,[3] and in turn, broken down to countries, regions, or sectors.[4] If legislators do not ensure sufficient action to reduce greenhouse gas mitigation immediately, future generations will be hit harder by stronger emission reduction requirements, more significant climate damages, or both. In April 2021, the German constitutional court ruled that parts of the 2019 German climate law are unconstitutional, as the law was not stringent enough on greenhouse gas mitigation, thus burdening future generations over-proportionally. In this respect, economics can inform about the availability of instruments to ensure compliance with the remaining carbon budget and the order of magnitude of economic impacts shifted across generations connected with non-compliance with such a budget.

This contribution addresses the economic evaluation of climate impacts and their possible mitigation (and adequacy thereof) in section 2 and of greenhouse gas emission mitigation (again including adequacy) in section 3, concluding with remarks on the economics of climate change responsibility and liability with respect to both lines of analysis.

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2 Paris Agreement (adopted 12 December 2015, entered into force 4 November 2016) UNTC No 54113; the full text is available at <https://bit.ly/3IJkyGw> accessed 28 March 2022.

3 IPCC, *Global warming of 1.5°C. An IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* (2018); available at <https://bit.ly/3qGE1l1> accessed 28 March 2021.

4 Karl W Steininger et al., ‘Sectoral carbon budgets as an evaluation framework for the built environment’ (2020) 1 (1) Buildings and Cities <https://doi.org/10.5334/bc.32> accessed 13 October 2021; Keith Williges et al., ‘Fairness critically conditions the carbon budget allocation across countries’ (2022) 74 Global Environmental Change 102481 <https://bit.ly/3ILwibi> accessed 31 March 2022.

2 The knowns and unknowns in future economic climate impacts

'Climate change (…) is shifting what is expected in our geological age. This affects the determination of foreseeability of climate-related risks, which may in turn translate into shifting liabilities for professionals and others in a court of law,'[5] Marjanac and Patton summarise the challenge. This present volume discusses the legal implications of a world where climate change impacts are occurring, and in particular, more frequent and severe extreme weather events are not only preventable, 'but demonstrably reasonably foreseeable.' Building upon extreme weather attribution science (see chapter 1 of this volume), economics can support the quantification – in economic terms – of the magnitude of both foreseeable climate damages and those that can be mitigated by adaptation. Given the availability of the former, legal interest could be particularly high in the latter.

Data from international reinsurance companies indicate that weather- and climate-related damage values have been on the rise for the last three decades.[6] However, the future development of damages – both unmitigated and mitigated – is subject to uncertainty due to climate and socio-economic development. To give an example for the relevance of socio-economic development: regardless of specific climate development, future heatwaves will impact populations harder, the larger the share of the elderly and the poorer they are, as poverty could result in less adaptable environments (due to e.g., less availability of air conditioning).

While more robust estimates for expected damages are available at the aggregate level, especially for multi-year averages, such estimates are much more uncertain when sought for specific, smaller regions or locations. However, physical, or hard, climate change adaptation can only take place at specific locations (e.g., the building of a dam as flood protection or growing an alpine protective forest as avalanche protection). This implies that economic instruments, such as fostering insurance protection and soft adaptation, like disaster emergency planning and organisational structures, also have significant relevance due to being effective across much greater spatial scales.

To capture the uncertainties due to socio-economic development, the IPCC Assessment framework uses scenarios of so-called Socio-economic Pathways ('SSPs') spanning a broad range from 'green and sustainable growth', over 'regional rivalry' to 'fossil-led growth'. This approach can be used in spirit to develop uncertainty

5 Sophie Marjanac and Lindene Patton, 'Extreme weather event attribution science and climate change litigation: An essential step in the causal chain?' (2018) Journal of Energy & Natural Resources Law <https://doi.org/10.1080/02646811.2018.1451020> accessed 2 November 2021.

6 Munich Re, 'NatCatSERVICE: Natural catastrophes in 2020' (2021) <https://bit.ly/3r48TMz> accessed 28 March 2022; Munich Re, 'TOPICS Geo Natural Catastrophes 2017 (2018) <https://bit.ly/3iIcT0p> accessed 28 March 2022.

scenarios at the local and regional level, where damage values prove to be subject to stronger variability (and uncertainty).

One of the most comprehensive (for its time) examples of an economic evaluation of future climate change damage at the national level was triggered by the demand of a finance ministry to cover future climate change-related expenses in its long-term public budget planning. A cross-sectoral climate impact quantification for Austria up to mid-century employing IPCC uncertainty scenarios at the national and subnational level has been made available to address this demand.[7] The method can serve as an example for other countries. For Austria, weather- and climate-related damages have been projected to rise six-fold (from an average annual level of € 1 bn. in the 2000s) by mid-century, with a potential for a twelve-fold increase. This covers just those impact chains for which robust quantification methods were available at the time (37 out of the more than 80 domestic impact chains that were identified, and including just three international ones).

This result demonstrates the foreseeability of climate change impacts, both in aggregate and split up by impact fields. But economics can be employed to further analyse and identify how adaptation can reduce or limit those damages.

Even if the globe succeeds in achieving climate neutrality, and even if already in the not-too-distant future, without adaptation, most of these impacts will be unavoidable, with many expected to further intensify. As strategies to adapt to and deal with observed and anticipated impacts are available, they can be analysed in simulations that indicate their future effectiveness. Building upon the above cross-sectoral impact assessment for Austria, Steininger et al.[8] and Bachner et al.[9] assessed the economy-wide effects of public adaptation. In three relevant adaptation fields (agriculture, forestry and catastrophe management) sufficient data was available. While bearing additional costs for implementing adaptation actions in these three fields, the welfare loss due to climate change damages was found to be cut by more than half (net impact, net welfare loss reduction by 56%, measured in terms of Hicksian equivalent variation). Beyond the main implication of lower economic damages, co-benefits of adaptation also occur, e.g., from additional employment.

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7 Karl Steininger et al., 'Consistent economic cross-sectoral climate change impact scenario analysis: Method and application to Austria' (2016) 1 Climate Services <https://doi.org/10.1016/j.cliser.2016.02.003> accessed 13 October 2021; Karl Steininger et al., *Klimapolitik in Österreich: Innovationschance Coronakrise und die Kosten des Nicht-Handelns* (Wegener Center Research Briefs 1-2020) <https://doi.org/10.25364/23.2020.1> accessed 13 October 2021.

8 Steininger et al., Consistent economic cross-sectoral climate change impact scenario analysis (n 7).

9 Gabriel Bachner et al., 'How does climate change adaptation affect public budgets? Development of an assessment framework and a demonstration for Austria' (2019) 24 Mitigation and Adaptation Strategies for Global Change <https://doi.org/10.1007/s11027-019-9842-3> accessed 13 October 2021.

Public adaptation strategies differ strongly across countries. In a comparative analysis across Spain, the Netherlands and Austria, Van der Wijst et al.[10] provide evidence that the economy-wide net benefits of adaptation also prevail in other EU member states. They find that national adaptation in Spain and the Netherlands is effective in reducing the negative sectoral and economy-wide effects of a range of climate impacts at a scale of 30% to 96% (net impact, change in loss of Hicksian equivalent variation, comparing climate impacts with and without adaptation). The high end of this range occurs for scenarios where climate impacts that would otherwise occur are counteracted by adaptation measures (such as the Delta flood protection program in the Netherlands) which are designed to prevent damages due to events up to precisely the scale simulated (e.g., the very rise in water level). Despite increased spending, this also leads to net improvements in public budgets.

For a detailed analysis of quantitative climate impacts across Europe, the Horizon2020 research project COACCH (CO-designing the Assessment of Climate Change costs) has supplied a tool to depict climate impacts across different time horizons and socioeconomic scenarios (SSPs), disaggregated at the NUTS2 regional level for all European countries.[11] Results on climate impacts are available for a variety of sectors, scenarios (combinations of one of the SSPs and one of the greenhouse gas concentration pathways (representative concentration pathways, RCPs)), impact variables (e.g., GDP) and time horizons (up to 2070). Maps and data tables are available. With such transparency and public availability at this level of detail, it is difficult to argue that climate change impacts would be too uncertain to be of any foreseeability.

3 Economic damages of inadequate greenhouse gas emission mitigation policy

Given that the absorption capacity for greenhouse gases of the atmosphere is a global common, and the effectiveness of emission mitigation depends only on aggregate emission reduction, the determination of a specific level of emission reduction considered to be the responsibility of any particular actor (nation state, region, business) – which then could serve as a reference for liability claims – at the outset appears quite complex. However, as there is a clear overall mitigation target agreed upon by the global community and settled in the Paris Agreement, this target can serve as an anchor point. Limiting global warming to well below 2 degrees, with efforts to limit it below 1.5 degrees, can be translated into a well-defined carbon budget, i.e., an

10 Kaj-Ivar van der Wist et al., *D4.3 macroeconomic assessment of policy effectiveness. Deliverable of the H2020 COACCH Project* (2021) <https://bit.ly/3wFnZeZ> accessed 28 March 2021.

11 The tool can be accessed at <www.coacch.eu/interactive-tool/> accessed 2 November 2021.

amount of CO_2 (and considering all greenhouse gases in this specification) that is still available to be emitted at the global level, but not to be exceeded. Depending on the respective actual temperature limit (2 degrees or 1.5 degrees) and the likelihood sought to remain below this temperature, a specific global carbon budget can be derived. The IPCC quantifies the remaining carbon budget from 2018 onwards for not exceeding 1.5 degrees of warming by the end of the century at 420 Gt CO_2 (if a likelihood of 66% is sought), or at 580 Gt CO_2 (for one of 50% only).[12]

These global carbon budgets can be broken down into nation-states or other geographically defined entities (municipalities, cities), economic sectors, or even firms. For geographical disaggregation, a mechanism based on equal per capita shares in the global budget is the most applied method. Enhancing justice requires introducing adjustments to account for differential capability, differential benefits still received from past emissions, and unequal historical emissions.[13] In any case, and regardless of such adjustments, a well-specified carbon budget again emerges for geographic entities, e.g., nation-states or regions within. In this way, a global responsibility can be attributed to legal entities subject to potential liability.

How large is the economic damage if these legal entities (e.g., national governments) do not act to safeguard remaining within the carbon budgets they are ´entitled´ to? Or, broken down to shorter time periods, if emissions from within their territories (or agents covered) for specific time periods exceed the respective allocated share of their budget? There are at least two answers to this type of question.

The first answer, of relevance if the global community as a whole exceeds the global carbon budget, is that such insufficient policy implies enhanced climate change and thus rising climate change damages. Their economic quantification has been covered in the previous section 2 of this chapter; here, it is the implied increase in damages at the global level that is the relevant number. Note, that the case of the Peruvian farmer Saúl Luciano Lliuya against the German company RWE brought forward at the Upper State Court in Hamm (Germany) addresses a respective share of these damages. The subject matter of the claim was the enhanced risk of glacial lake flooding affecting the farmer´s city of Huaraz, which has been shown by Stuart-Smith et al.[14] to be almost entirely attributable to anthropogenic climate change, i.e., the share on the impact side relevant for the plaintiff and on the source/causation side of the defendant.

12 IPCC, Global warming of 1.5°C (n 3).

13 Keith Williges et al., ‘Fairness critically conditions the carbon budget allocation across countries’ (2022) 74 Global Environmental Change 102481 <https://bit.ly/3ILwibi> accessed 28 March 2022.

14 Rupert Stuart-Smith et al., ‘Increased outburst flood hazard from Lake Palcacocha due to human-induced glacier retreat’ (2021) 14 Nature Geoscience <https://doi.org/10.1038/s41561-021-00686-4> accessed 13 October 2021.

The second answer is relevant if the global community, in practical terms, enforces global compliance with the global carbon budget requiring future governments to compensate earlier inaction with additional and stricter climate mitigation policy. A stronger fossil lock-in (again due to inaction) and the resulting later (and even steeper) emission reduction needed both increase societal costs of the transition. To quantify the economic damages of a delayed and increasingly steep reduction in emissions is difficult, as climate-neutral social and technological innovation are inherently dynamic processes, where laggards are punished on multiple levels (missing out on cost advantages, losing markets, lacking relevant learning by doing, etc.). As an optimistic lower bound of damages, one might consider a compensating acquisition of emission permits at a scale to close the emission reduction gap – if the world is in a scenario in which it enforces compliance with the carbon budget at the global level and permits are thus accordingly priced.

Assuming very cautious innovation dynamics, Steininger et al.[15] quantify the advantage of an earlier greenhouse gas emission reduction for Austria, in line with the increased EU ambition of at least 55% emission reduction by 2030, relative to 1990, moving beyond the earlier effort sharing decision based on the EU 40% emission reduction by 2030. Such an advantage could amount to an average 0.2% (for the 55% ambition) to 0.5% (for the 60% ambition) of GDP per anno, when aggregated over 2020-2050. The analysis thereby also supplies a full set of instruments and respective stringency levels for all sectors. In all scenarios, climate neutrality is achieved by 2050 at the EU level and by 2040 at the Austrian level for sectors not covered by the European Emission Trading System (ETS), as introduced in 2005 and integrating air transport in 2012.

4 Concluding remarks on the economics of climate responsibility and liability

While the challenges and opportunities of attributing responsibility and liability for climate change are manifold, the concepts and methods of economics can be one cornerstone in addressing them. More specifically, building on attribution science, economics can be employed to quantify the societal relevance of inaction in adaptation to a changing climate as well as in mitigation of greenhouse gas emissions.

For insufficient adaptation, both the foreseeability of climate impacts can be demonstrated in versions of integrated assessment models (IAMs), and the quantification of the ability of adaptation to reduce impacts can be achieved by implement-

15 Karl Steininger et al., *The economic effects of achieving the 2030 EU climate targets in the context of the corona crisis – an Austrian perspective* (Wegener Center Scientific Report 91/2021, Wegener Center Verlag, University of Graz 2021); available at <https://wegccloud.uni-graz.at/s/yLBxEP9KgFe3ZwX> accessed 13 October 2021.

ing adequate measures in economic models. The former (quantification of gross climate damages) settles that agents cannot back out of responsibility via blaming general ignorance or brute uncertainty of climate change. The latter even identifies the dimension of the social benefit of adaptation (or the cost of the lack of it) to be weighed against the cost of adaptation policy to determine an adequate scale of the latter.

Economic valuation methods have repeatedly been found adequate and highly relevant in the juridical context in the past. A salient example is the use of contingent valuation – a monetary evaluation of use and non-use values by means of creating a hypothetical market – in damage evaluation after oil spills or other environmental damages. A panel established by the US National Oceanic and Atmospheric Administration concluded in 1993, that this method

> can produce estimates reliable enough to be the starting point of a judicial process of damage assessment, including lost passive-use values… [A well-constructed study] contains information that judges and juries will wish to use, in combination with other estimates, including the testimony of expert witnesses.[16]

We can expect state-of-the-art economics to serve at similar relevance and reliability in judicial processes on climate responsibility and liability.

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