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**EAERE**

European Association  
of Environmental and  
Resource Economists

# EAERE Magazine

Climate Impacts  
and Adaption

*Module 1:  
Europe Union*

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2022



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European Association  
of Environmental and  
Resource Economists

EAERE Magazine serves as an outlet for new research, projects, and other professional news, featuring articles that can contribute to recent policy discussions and developments in the field of environmental and natural resource economics. It is published quarterly in the Winter, Spring, Summer, and Fall. Contributions from the wider EAERE community, especially senior level researchers and practitioners, and EAERE Country Representatives, are included in the magazine.

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Regular readers will be aware that, in issues 11, 12, 13 and 14 we published modules (4 papers in each) on climate policy (mitigation) respectively in the U.S., China, the EU and India. These were compiled and, together with two framing papers, were published as a volume – Convery, F.J., & Johnson, K. (Eds.). (2021). EAERE Magazine: The Climate Policy Baseline of the Big Four (China, European Union, India, U.S.). Venice, Italy: European Association of Environmental and Resource Economists – which was made available for COP 26, Glasgow. In this issue, we begin to address the corollary of mitigation, namely, climate impacts and adaptation.

### **Climate Impacts and Adaptation**

I am recently back in Dublin after a visit with family and friends in northern California and Denver Colorado. It was striking how much discussion in person and in the media was around drought, forest and brush fires, the fact that insurance is being withdrawn from properties judged to be at fire risk, and how widely climate change is seen as the underlying cause of this chain of events. This perception that climate change is happening in real time is relevant to this issue of our magazine, in which we publish our first module on the impacts of climate change and adaptation, addressed specifically to these two issues in the European Union. This is the first of a series of modules on climate impacts and adaptation; it will be followed in our next issue by the India climate impacts and adaptation module, which will be coordinated by Shreekant Gupta, Professor, Department of Economics, Delhi School of Economics, University of Delhi. I expect these to be followed in turn by modules for the U.S. and China, and perhaps also one focussed on Africa.

As you will see, the EU module comprises two papers, the first on impacts [Francesco Bosello, Department of Environmental Sciences, Informatics and Statistics, Ca' Foscari University of

Venice and Euro-Mediterranean Centre on Climate Change (CMCC) and Carmelo J. Leon, Universidad de Las Palmas de Gran Canaria, TiDES Institute] and the second on adaptation [Paul Watkiss, Paul Watkiss Associates, Ltd. and Eva Preinfalk, Wegener Center for Climate and Global Change, University of Graz]. Bosello and Leon provide a very up to date assessment of the literature in this space, including the methodological and empirical challenges posed for estimating future macroeconomic (GDP changes from baseline) and sectoral impacts over time – 2030, 2050 and 2070 – using alternative temperature scenarios and show (Figure 1) the macroeconomic geographic distribution of these across the EU. As regards the latter, the much higher costs that are likely to be borne by the Mediterranean member states are notable, as is the role of Estonia as an outlier in this regard in the North. In their adaptation paper, Watkiss and Preinfalk highlight the interface between climate adaptation and the public finances, the huge benefits of early action; in Figure 1 he shows benefit to cost ratio estimates for the UK to 12 different adaption interventions. In both papers, the authors identify the gaps in knowledge that need addressing, and this will be of great value to others who want to prioritize the focus of their future research.

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## Why do citizens and economists disagree on carbon taxation?

For most environmental economists, the logic of applying a tax on greenhouse gas emissions as the core climate policy instrument is compelling<sup>1</sup> to the point where we struggle to understand why the rest of the world demurs. But they do.

“To tax and to please, no more than to love and be wise, is not given to men”. Thus wrote the Irish statesman and writer Edmund Burke in 1774. What was true 248 years ago is still true today - logic runs up against the Burkean reality – it is hellishly difficult in practise to implement a carbon tax of substance, meaning a tax that is sufficiently high and inclusive to make a difference at scale in terms of emissions reduction. In: “Why do citizens and economists disagree on carbon taxation?” Tomas Douenne (University of Amsterdam) draws on his PhD research to deepen our understanding anchoring his assessment on the ‘Yellow Vests’ rebellion in 2018 against an increase in the carbon tax in France. It is an important paper because it interrogates the granularity of the oft proposed solution – use some of the revenues accruing to compensate the poorer ‘losers’- and concludes that implementing the practice in ways that does indeed compensate the losers is very challenging to achieve.

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<sup>1</sup> It immediately sends a signal to emitters that: the capacity of the atmosphere to absorb more emissions is very scarce and getting scarcer; every ton of emissions will cost, thereby incentivising emissions reduction, and this incentive operates 24 hours a day, 365 days a year; the polluter pays; revenues are generated that can be used to reduce other taxes, or be spent for other purposes, including supporting investment in emissions abatement and compensating losers. It is cost-effective - it incentivises discovery of abatement choices by polluters, and allows emitters to decide how much to adjust, so that the effort will be undertaken where the costs of doing so are lower. And it has the huge analytical advantage of expressing policy effort in one variable, which makes modelling choices dramatically easier. Finally, it has the advantage of integrating climate policy into economic policy which means that, rather than being institutionally isolated in an often relatively powerless Ministry for Environment, it is embedded in the Ministry of Finance, which in every government is at the heart of decision-making and resource allocation. And the same applies to companies – a carbon tax moves corporate climate policy from the boiler room to the board room.



# Section I

## The EU Module

# Climate change impacts in the EU: new evidence from recent research

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## Abstract

*This short article offers a condensed view of the recent research on the economic costs of climate change for the EU, its countries, regions, and sectors. It emphasizes ranges of economic damages, the relative importance of the different climate impact categories, the differences across direct and indirect costs estimates and finally presents the economic role in damage determination of some non-immediately evident transmission mechanisms that are receiving increasing attention by research. It shows that macroeconomic losses in the EU can be larger than previously estimated. Extreme events, and climate change stress on EU infrastructural endowment, are among the most prominent drivers of GDP and direct economic losses. Health impacts on mortality and morbidity or on labour productivity associated to extreme events are another concerning source of economic costs. Research also emphasizes the possible occurrence of socio-economic tipping points that can be widespread and may have disruptive social and economic effects although at the more local level. All this calls for an aggressive mitigation action supported by a widespread agreement in the literature that both average and spikes in local economic losses are greatly reduced in low emissions scenarios. The analyses also emphasize that the trends in economic losses magnify the dichotomy across northern and southern and across high and low-income EU regions with a particular vulnerability of EU island communities confirming, also in a rich area like the EU, the adverse distributional effects of climate change. Against this background, adaptation is a fundamental complement of mitigation. It demonstrates a high benefit to cost ratio and most importantly, due to climatic inertias, confirms the key role of climate impact contrast strategy in the first half of the century. Impacts on ecosystem and biodiversity, the distributional consequences of climate change, the connection between fiscal-financial stability and climatic impacts and the emergence of social economic tipping points deserve further investigation.*

## Introduction

The economic assessment of climate change impacts is surely one research field where the economic discipline faces large theoretical and methodological challenges, confronts with

complex and often heated debates, constantly develops new or advances existing assessment methodologies. As is well known since the first evaluation efforts, peculiar challenges are posed by the long-term nature of climate change, its global dimension, and the fact that non-market



values are also involved. All is further complicated by the fact that the phenomena under study are nonlinear, characterized by irreversibility, subjected to epistemic and aleatory uncertainty. Assessments are therefore debatable and have been indeed debated as this is what occurs in a lively scientific community. Just two topical examples of this are the “follow up” to the Stern Review (see e.g., Stern et al., 2006; Nordhaus, 2007; Tol & Yohe, 2006; Weitzmann, 2007) or more recently, the neat criticisms expressed by some scholars against some of the evaluation methodologies used (Stern, 2013; Pindyck, 2017). In fact, methodologies are the most diverse. Integrated assessment models, econometrics, semi qualitative methods based on expert elicitation, all have been used and integrated in multi and trans disciplinary research efforts to shed more light on the cost issue. All have strengths and weaknesses.

We are aware of all that, and we address the readers interested in deepening their knowledge on challenges, methodologies and findings to the many surveys that also recently have been produced to organically and critically present this rapidly evolving literature (e.g., van den Bergh & Botzen, 2015; Carleton & Hsiang, 2016; Howard & Sterner, 2017; Aufhammer, 2018; Tol, 2018; Bosello & Parrado, 2020; the contributions of Working Group II to the IPCC Assessment Reports).

The purpose of this short article is much narrower. We would like to report on some very recent research quantifying the economic costs of climate change for the EU, its countries, regions, and sectors. We think that it can be useful and interesting to get a picture of ranges of economic damages, of the relative importance of the different impact categories, of the differences across direct and indirect costs estimates and finally of the economic role in damage determination of some non-immediately evident transmission mechanisms that are receiving increasing attention by research.

Accordingly, in this survey we are only marginally mentioning physical consequences of climate impacts in the EU, we are not addressing at all climatic trends, and we derive only very general implications for climate change policies. Also, discussion on methodologies is kept to a

minimum and developed just to enable an easier interpretation of differences across studies. Finally, to be up to date, we are reporting much information from the grey literature. We scrutinized reports and the results of EU research projects that albeit publicly available and published, only partially appear in peer review journals.

In what follows: section 2 surveys recent contributions reporting the aggregate or “systemic” cost of climate change in the EU, section 3 reports estimates referred to the direct costs of climate change, section 4 discusses the relevance of some transmission channels for and mechanisms at play in the determination of economic consequences of climate change impacts, section 5 offers a peculiar geographical focus on EU islands presenting the result of the recently concluded H2020 SOCLIMPACT project, section 6, finally, concludes.

### **Macroeconomic impact of climate change in the EU**

Dellink et al. (2019), Kahn et al. (2019), Szweczyk et al. (2020), the Horizon 2020 COACCH project<sup>1</sup> (COACCH 2021a,b,c), and Guo et al. (2021) offer some recent estimates of aggregated GDP losses from climate change for the EU. Studies are not easily comparable, as they are conducted with different approaches, under different counterfactual scenarios and include different climate change impact categories. Nonetheless, they offer insights that, being common to such different methodologies, are particularly robust.

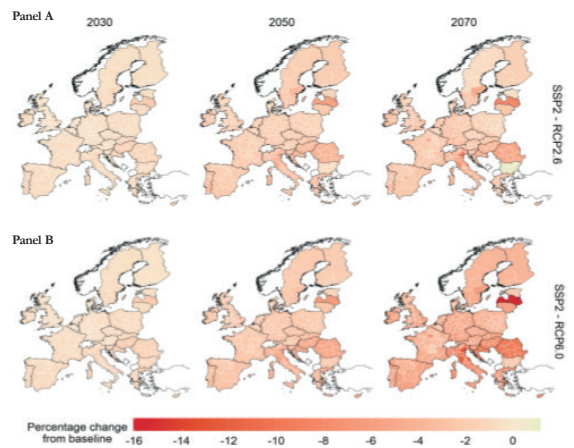
Firstly, it is confirmed that a climate mitigation scenario consistent with the Paris goal can greatly reduce EU macroeconomic or welfare losses: In the low concentration Representative Concentration Pathway 2.6 (RCP2.6) scenario, small per capita GDP gains by mid-century and only negligible losses in 2100 are highlighted by Kahn et al. (2019). GDP contractions do not exceed the 0.3% in a 1.5°C scenario according to Szweczyk et al. (2020), and 0.2% in Guo et al. (2021). The COACCH exercise (COACCH 2021b) reports larger losses in RCP2.6. These however remain relatively limited amounting, averaging across the exercise sensitivity runs, to 1.9% of EU GDP in 2070. The study also

shows that up to 2050, macroeconomic losses do not differ substantively across RCPs. This suggests that climate change impacts in the next three decades can only be reduced with adaptation thus confirming the strategic complementarity across mitigation and adaptation. All the studies highlight the uncertainty around the estimates admitting the possibility to experience high economic losses, peaking to 2.8% of GDP according to Guo et al. (2021), also in low emission scenarios. This should support a precautionary approach to mitigation policy providing justification to a “well below 2°C” temperature target.

“Unmitigated” or “moderately mitigated” scenarios, entail higher losses. Here quantitative findings, although pointing in the same direction, diverge more. It is therefore worth to briefly commenting on study differences. Kahn et al. (2019) develop an econometric assessment, COACCH (2021b), Dellink et al (2019), Szweczyk et al. (2020) conduct a “soft-link” integrated assessment exercise where Computable General Equilibrium (CGE) models are used to translate in economic terms impacts from process-based impact models. Guo et al. (2021) extrapolate losses from reduced-form climate change damage functions. As suggested by Howard & Sterner (2017) and O’Neill et al. (2022) econometric estimates tend to produce higher damage estimates than models. This is due to the different capacity of the observed data, at the basis of macro-econometric estimates, and of structural relations, at the basis of models, to capture frictions and adjustment costs. Further differences derive from the evaluation methods applied to assess climate impacts. For instance, the study by Dellink et al. (2019) monetizes health mortality/morbidity impacts through the macroeconomic effects of loss of labour productivity, while Szweczyk et al. (2020) monetise changes in mortality through the value of statistical life. The latter gives a much higher damage estimate: a loss equalling roughly 1% of EU GDP vs a loss of roughly 0.2% in the former. Impact categories included in the studies are also different. For instance, health impacts are not part of COACCH macroeconomic estimates. Finally, the spatial detail of the assessment seems to matter. In COACCH (2021b) the analysis is conducted with the granularity of 138

EU administrative units (Fig. 1). This allows better identification of “hot spots” for economic damages highlighting, for instance, that by 2070 in RCP 8.5 one fourth of these sub national regions can lose more than 5% of regional products. This is then reflected also into higher damages when the “mean” values are computed.

This said, Dellink et al. (2019) project in 2060 for a 2.5°C temperature increase a macroeco-



**Figure 1.** Climate change impacts on the EU gross regional product (medium impact case and high investment mobility) in 2030, 2050 and 2070. Panel (A): SSP2 RCP2.6. Panel (B): SSP2-RCP6.0. Values in percentage change from the baseline. Source: COACCH (2021b)

nomical loss of roughly the 0.4% of GDP in the OECD EU (0.2% in the 4 larger EU economies); Guo et al. (2021) of 1% (but recognizing the possibility of losses 10-time higher) in response to a global warming of 3.2°C, Szweczyk et al. (2020) an annual welfare loss of 1.38% of GDP (or € 175 billion) in response to a global warming of 3°C. COACCH (2021b) projects higher losses equalling an average 2.4% GDP decline (within a range of 0.7-4.8%) in the EU in RCP8.5 in 2070, while Kahn et al. (2019) project GDP per capita losses in the range of 2.7-6.7% in 2100.

None of these results account for the probability of catastrophic events, climate irreversibilities or losses from ecosystem degradation. Authors thus warn to consider these estimates as possible underestimations of the full costs.

There is a good agreement across studies on the geographical distribution of these losses. A

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North-South divide is particularly evident in Sczewzyck et al. (2020) where southern EU is projected to experience losses roughly 5 times larger than central and northern areas. The trend is confirmed by both Kahn et al (2019) and COACCH (2021b) where southern EU countries (Spain, Italy, Greece, France, Cyprus) or regions in these countries (like for instance Veneto, Emilia Romagna in Italy, Attika in Greece, Alentejo, Algarve in Spain) show higher losses. The latter two studies, also emphasize a particular vulnerability of Eastern EU areas like Bulgaria, Check Republic, Slovenia, or Hungary.

#### **What impact categories originate these losses?**

Again, studies offer a good degree of agreement. The first and second most significant sources of GDP contractions are coastal damages from sea-level rise and riverine floods. Together, they account for more than 70% of GDP “market” losses in all studies. According to Sczewzyck et al. (2020) flooding impacts constitute an annual € 8.5 billion of welfare loss with 1.5°C, which increases to € 40 billion with 3°C global warming. COACCH (2021b) reports a 6-time higher yearly end-of-century GDP loss under the RCP8.5 from sea-level rise alone mostly related to different assumptions on sea-level rise exposure and coastal protection patterns. These findings stress the important infrastructural dimension of climate change for the EU. They also suggest that climate proofing infrastructure should be a high priority. In addition to the reduction of direct damages, infrastructural (but also other form of) adaptation can indeed lead to further secondary benefits which are typically associated to lower macroeconomic losses such as, for instance, higher tax revenues, that may allow higher levels of government consumption and public transfers or lower debt and debt servicing in a scenario with than without adaptation (COACCH, 2021b; Parrado et al., 2020).

Decreased labour productivity due to thermal stress can be another important driver of macroeconomic losses. Most affected regions are in southern and central-eastern EU with potential losses that in some regions can reach 1.5-2% or production in the 2070s under higher warming scenarios. Cooler areas (northern-Europe)

might, on the contrary, experience a gain (COACCH, 2021b).

GDP impacts from agriculture are considerably smaller given also the relatively low share of the sector in the production of EU value added. In fact, in northern EU areas positive yield effects can lead to GDP gains while moderate losses peaking to a maximum of 0.12% of GDP are projected for the Central and Southern EU (Schewzyck et al. 2021). Moreover, in the case of internationally traded agricultural and forestry commodities, trade effects might originate moderate GDP gains in the EU notwithstanding possible negative effects on yield or timber productivity (COACCH, 2021b).

Macroeconomic impacts from the energy sector are linked to energy supply and demand dynamics. Global warming is expected to affect wind and solar production only marginally. More relevant effects are associated to changes in water availability. These suggest potential for electricity production increase in Northern and reduction in Southern EU (Després & Adamovic, 2020). This could lead to possible annual GDP gains of 0.26% in the former and losses of 0.04% in the latter according to Schewzyck et al. (2020). Changes in heating and cooling needs can lead to increases in the production costs of firms in Southern European regions, but also in Romania and Bulgaria. Household energy expenditures are also projected to increase in the Mediterranean EU. In 2070, these costs increases could be greater than 1% of regional GDP especially in small Mediterranean islands such as Cyprus and Malta (COACCH, 2021c).

Important GDP impacts finally could be triggered by changes in tourism flows in the light of the importance of the sector. These will depend however on how much climate change will impact the climatic attractiveness of EU countries (although there is agreement that it will increase the appeal of northern EU destinations and decrease that of southern EU ones), of the importance of climate in destinations’ attractiveness and on adaptive responses of the tourism sector itself. It is thus difficult to derive a net economic estimate from these trends which are also highly dependent upon non climatic variables.

## Direct cost of climate change impacts in the EU

The picture provided by the systemic GDP impact of climate change of the previous section can be complemented by direct costs estimates. This is a different evaluation method for economic losses that does not consider market adjustments. However, it does capture, differently from GDP-based measures, “stock”, or asset losses, adding useful insights.

Direct costing methodologies for instance emphasize the huge costs of mortality from extreme heat in the EU. These are projected to reach € 122 billion at 3°C global warming, or € 313 billion in RCP 8.5 by 2080 in Sczewzyck et al. (2020) and COACCH (2021c) respectively. Most of the damages are concentrated in the southern EU, that is hit more severely by human mortality from extreme heat.

Sea-level rise and river flooding are prominent also in terms of direct loss of assets. Sea-level rise for instance, would cost an annual € 234 billion up to an extreme € 2.4 trillion in a high emission scenario without upgrading of coastal protection (Vousdoukas et al., 2020; COACCH, 2021c). Studies also highlight the high benefit to cost ratio of coastal protection measures. Adaptation can reduce expected annual damages roughly by 90% at a cost that is roughly 2% of the avoided damage (COACCH, 2021c). Losses from riverine floods in moderate temperature increase scenarios can amount to roughly € 21 Billion by mid-century and € 30-40 Billion end of century in high emission scenarios (Dottori et al., 2020, COACCH, 2021c). Accounting for all the different climate change hazards and the overall (energy, transport, industry, social) infrastructural endowment of the EU, Forzieri et al. (2018) conclude that by 2080s climate stress on infrastructure can amount to an expected annual damage of € 37.6 trillion, 10 times higher than the current damage.

Direct costs for the EU agricultural sectors are non-negligible, but considerably smaller. Highest negative impacts on both crop yields and the agricultural sector in general, are found under RCP8.5 and when CO<sub>2</sub> fertilisation is not con-

sidered. Under this scenario, the production costs of climate change can be in the order of € 906 million for arable production and € 831 million for the agricultural sector in 2050 (COACCH, 2021c).

The economic consequences in shifts of energy consumption patterns are mostly distributional. At the EU level there is evidence that decrease in heating demand will be larger than the increase in cooling needs determining a net reduction in energy demand. Household energy demand is also projected to shift away from natural gas (-27.5%) and oil products (-41.5%) towards electricity (3.8%) (Spano et al. 2021). The stress on EU energy infrastructure will increase. Under a medium to high emissions scenario, expected annual damage from extreme events will be € 4.2 and € 8.2 billion in 2050 and 2080 respectively, roughly 7 and 15 times larger than today (Forzieri et al., 2018).

## Other mechanisms at play

Somehow “hidden” behind direct and indirect costs there are many transmission mechanisms at play that can convey losses while contributing to exacerbate or smooth them.

One of the most important and discussed are trade effects. International trade, in particular, can either transmit to the EU markets climate-change driven losses originated outside the EU or offer a possibility to smooth a negative effect enabling the substitution of a resource (say land, water) which is becoming scarce domestically with foreign imports of the resource itself or of the goods whose production is intensive in the scarce resource. Furthermore, in the case of internationally traded commodities, often “relative” or comparative advantages are more important than “absolute” effects. Accordingly, GDP gains might be originated in those countries experiencing direct losses than however are smaller than those affecting the direct competitors.

Hristov et al. (2020), for instance, show that the interplay between changes in agricultural production in the EU and other major cereal producing countries that could be damaged more

severely by climate change, may in fact lead to EU export increases in wheat, barley, grain maize and soybean, with the EU producer prices increasing between 1% to around 7%. This can result in increases in the EU producers' income between 25% and 50% in Northern Europe and 10% to 30% in Southern Europe. Similar conclusions are reached in COACCH, where, notwithstanding negative direct impacts on yields and net timber production, positive GDP impacts are eventually expected from the agricultural and forestry sectors in most of EU countries. Schewzicz et al. (2020) also shows that negative spill-over effects from agricultural losses outside the EU are significant in comparison to the economic losses from the internal EU climate changes. For instance, in a moderate 1.5°C warming scenario increase in yields are projected that might lead to an increase in GDP by € 3.2 billion. Nonetheless more damaging climate impacts in the rest of the world are estimated to have a negative impact on EU GDP of almost as much, netting a small positive balance. In the 3°C scenario both the EU's impact and the spillover are negative, adding up to a € 12 billion GDP loss.

Related to international trade effects are supply chain effects. Analyzing the EU input-output connectivity between sectors and countries COACCH (2021b) concludes that due to the single market and stronger export orientation the EU receives more supply chains shocks from abroad than, for instance, the U.S. especially in manufacturing and agriculture. The potential stress on the supply chain from climate change extremes is then projected to negatively affect export value in all the EU countries by up to 16% in RCP4.5 by the end of the century. This calls for a geographical diversification in global supply chain networks, intensification in the use of storage facilities or firm-level insurance against risks.

A particularly challenging issue is that of defining and assessing "tipping points". If climatic tipping points associated with catastrophic events are unlikely within this century, social economic tipping points are more probable and widespread. This is a relatively new concept (Van Ginkel et al., 2020; Otto et al., 2020) that recognizes that even gradual climate change may

abruptly and significantly alter the functioning of socioeconomic systems, and lead to major economic costs, at a more local level. Many of these "tipping points", even though more common in high climate signal scenarios, can materialize in the EU relatively early (by mid-century), and in relatively moderate emission scenarios (COACCH, 2021a). As an example, "tipping points" of rural abandonment are projected to occur in middle and southern parts of Europe, most notably in Southern Spain, Italy and Greece. Another of such tipping points is the possible collapse in local flood insurance markets (Tesselaar et al., 2020). Increasing flood risk can lead to excessive increase in premia leading to insurance unaffordability. Such unaffordability problems occur particularly in regions with below average income per capita with the largest decline in insurance penetration in Eastern European regions as well as Portugal. In some areas within these countries, insurance uptake is projected to decline almost completely by the 2080s. In the EU, socio-economic tipping points can be significant in economic terms and potentially pervasive; they are however difficult to characterize and measure, the result of complex socio-economic and climate drivers, as well as policy responses.

Another trigger of potentially important consequences for macroeconomic and public finance stability that is receiving increasing attention relates to the link between climate change physical risk and sovereign risk (Volz et al., 2020). Combining climate projections with economic data and machine learning, Klusak et al. (2021) simulate the effect of climate change on sovereign creditworthiness. Results highlight detectable impacts of climate change as early as 2030, with significantly deeper downgrades across more sovereigns as climate warms and temperature volatility rises. In the EU, France and Germany are projected to experience an additional cost of sovereign borrowing larger than \$ 5 billion in RCP8.5 in 2100. A highly indebted country like Italy could face a \$ 810 million increase in the cost of borrowing.

#### **A focus on EU islands**

Islands are territories especially susceptible to the impacts and damages of climate change.

They are all surrounded by water and endowed with valuable environmental goods such as beaches, landscapes and ecosystems that are likely to be significantly damaged by the expected changes in climate. In addition, from an economic point of view, most islands are economies with low levels of diversification. Most islands have found specialization on tourism and blue economy sectors the key pillars for their processes of economic growth and social development.

There are more than 2000 islands in Europe with a population of more than 15 million people. The smallness and remoteness of many islands mean that they can take limited advantages of scale economies in the production processes, suffering also higher transportation costs for the exchange of tradable goods. Thus, the vulnerabilities of islands' nature and human societies to climate change are enhanced because of the challenges raised for the implementation of cost-efficient adaptation projects and the need to anticipate physical and social damages at small resolution scales.

The assessment of climate change impacts on islands requires downscaled modelling both from climatic and economic perspectives, since most available models are large scale and aggregated. The EU project SOCLIMPACT<sup>2</sup> addressed this modelling challenge for a set of EU islands - Azores, Balears, Canaries, Crete, Cyprus, Malta, Madeira, Sardinia, and Sicily - considering the impacts on the Blue Economy sectors of tourism, marine transportation, and energy (Vrontisi et al., 2020). Island-specific databases were assembled for modelling with two alternative macroeconomic models: an island-level application of the large hybrid general equilibrium model GEM-E3, GEM-E3-ISL, and an applied macro-econometric model, GINFORS. Detailed impact assessment for the Blue Economy sectors were fed into the models by modelling a set of climate change impact chains that represent the sequence of linkages between the climatic and environmental systems and the socioeconomic system (Arabadzhyan et al., 2021; Bacciu et al., 2021). The bottom-up evaluation of the climate change impact chains involved the utilization of transfer functions

from the literature, survey data, big data analysis and experts' assessment.

The models are simulated under various climatic and impact scenarios to be compared with the baseline or economic outlook scenario for each of the islands. The time frames for the simulations considered two periods: i) the near period, i.e., from 2040 to 2065 and ii) the distant period (only with GEM-E3-ISL), i.e., years from 2080 to 2100. In addition, two alternative climatic projections are considered -RCP2.6 and RCP8.5 concentrations- that refer respectively to the climate impacts under a well-below 2°C climate stabilization by the end of the century and under business as usual.

The macroeconomic impacts of the climate change on the Blue Economy sectors vary by specific islands, time horizons and climatic scenarios. The results with the GEM-E3-ISL CGE model show that GDP losses under the RCP2.6 scenario range from -0.2% to -2.6% in 2050 and -0.3% to -6.0% in 2100, while losses under the RCP8.5 scenario range from -0.6% to -5.7% in 2050 and -1.4% to -13.8% in 2100. With the macro-econometric GINFORS, GDP losses range from -0.16% in 2030 to -3.8% in 2050 under RCP2.6 scenario and from -0.3% in 2030 to -7.3% in 2050 under the RCP8.5 scenario. Thus, on average, GDP losses under the RCP8.5 scenario double the losses under the more moderate RCP2.6, and the amount of losses increases exponentially for the more distant future and for the more severe climate scenario.

In general, there is large heterogeneity in the impacts of climate change under the alternative scenarios of climatic conditions across islands, with some islands expecting to experience high levels of macroeconomic impacts while others expecting more moderate effects (Figure 2). The group of islands with higher impacts includes Sardinia, Madeira, Balearics and the Canaries. The group with moderate impacts comprises Cyprus, Azores and Malta, and there is a group with relatively lower impacts formed by Sicily and Crete.

The magnitude of the economic impacts is driven by the handicaps of remoteness and low

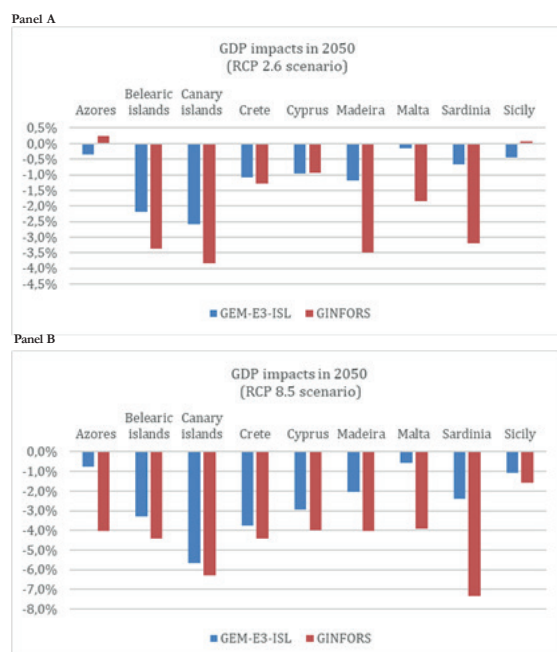


Figure 2. GDP impacts in 2050 in EU Islands with the GEM-E3 and GINFORS models. Panel (A): RCP2.6. Panel (B): RCP8.5

economic diversification, as well as by the different intensity of the expected trajectory of direct climate impacts. Those islands that are more distant to the mainland and which are specializing in tourism are more vulnerable to climate change impacts in the longer term, thereby expecting higher economic losses. For instance, the Canary Islands and Azores share high remoteness and high share of tourism in total value-added that lead in conjunction with higher expected temperatures to more acute economic losses in longer terms horizons. Remoteness also implies higher costs of investing on the infrastructures needed for attending higher energy demand provided through renewable energy systems for cooling and desalination.

Impacts on employment are expected to be also negative and with similar orders of magnitude and islands variability as those projected for GDP losses, which are due mostly to the decreased employment in the labour-intensive tourism industries and the loss of competitiveness due to higher electricity prices. Thus, both modelling approaches show similar results for islands' Blue Economy climate change impacts in terms of signs and magnitude, but with slightly higher damages expected with the macro-econometric model than with the CGE

model in the short and medium terms. Impacts on Blue Economy sectors are primarily driven by changes in demand and the loss of physical and natural capital but also the additional low-carbon investments and increasing energy and other production costs need to be considered. The assessed impacts highlight the large scope for undertaking climate change mitigation and adaptation actions that benefit islands and reduce the expected losses from climate change.

## Conclusions

The economic consequences of climate change impacts can be relevant also for a developed area like the EU. Indeed, recent research conducted with different methodologies seems to suggest that macroeconomic losses can be larger than previously estimated. Extreme events, in particular sea-level rise and riverine flooding, but more in general, climate change stress on EU infrastructural endowment, are among the most prominent drivers of GDP and direct economic losses. Health impacts on mortality and morbidity or on labour productivity associated with extreme heat are another concerning source of economic costs. Research also emphasizes the possible occurrence of socio-economic tipping points that can be widespread and may have disruptive social and economic effects although at the more local level. All this calls for an aggressive mitigation action supported by a widespread agreement in the literature that both average and spikes in local economic losses are greatly reduced in low emissions scenarios. The analyses also emphasize that the trends in economic losses magnify the dichotomy across Northern and Southern and across high and low-income EU regions confirming, also in a rich area like the EU, the adverse distributional effects of climate change. In particular, some EU islands: Sardinia, Madeira, Balearics and the Canaries, result highly vulnerable. This is driven by the handicaps of remoteness combined with a low economic diversification mostly specialized in tourism activity. Against this background, adaptation is a fundamental complement to mitigation. It demonstrates a high benefit to cost ratio and most importantly, due to climatic inertias, confirms its key role of climate impact contrast strategy in the first half of the century.

Many indirect mechanisms are also at work. Among these, international trade can play an ambiguous role. There is evidence that it can transmit to EU GDP negative shocks occurring outside the EU. At the same time, it can also favour EU export gains modifying comparative advantages especially in climate sensitive sectors like agriculture and forestry. Furthermore, the EU supply chain seems particularly vulnerable to climate change extremes that can lead to non-marginal reduction in exports in many EU countries. Finally, there is also quantitative support showing that the creditworthiness of EU sovereignty can be impaired by climate change risk with increasing cost to service public debt, which is particularly concerning for highly indebted countries of the southern EU.

In the light of this, there are areas where further research is needed. The assessment of the non-market impacts of climate change, on ecosystems, biodiversity, but also on health, needs to be improved with more solid quantitative evidence. The distributional impacts of climate change, not only across regions, but also across households with different characteristics, including gender aspects, need to be better understood. The analysis and “spatial” detection of local socio-economic tipping points should be systematically expanded. The connection between the real and the financial dimension of climate change impacts needs to be further investigated.

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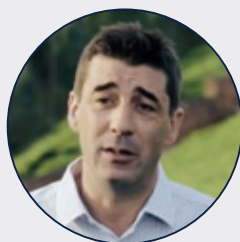


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# The economics of climate adaptation in the EU: new evidence from recent research

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## Abstract

*This article offers some new insights on adaptation economics in the EU and Member States. It moves beyond impact-adaptation-modelling to explore two key policy questions. First, should the EU and national governments be thinking about the implications of adaptation on the public finances? On this issue, our research finds that adaptation is effective in reducing the macroeconomic disruption of climate change and the resulting impact on the public finances. While adaptation requires public expenditures, it reduces impacts on revenues by alleviating the effect on the tax base. Our results show that adaptation reduces the impact on sectors that are negatively hit by climate change impacts, highlighting the role for government action. Second, how should national policymakers use economics in adaptation policy, and what are the current priorities for early action? Our research finds there is a strong case to move beyond the current focus on the economic appraisal of options, applying economics earlier in the adaptation cycle to investigate how to deliver adaptation policy effectively. A case study found that applying an economic rationale can help identify priorities for near-term adaptation, providing information that is important for national adaptation plans and budget allocations. Finally, the paper highlights a number of emerging areas where similar policy questions are emerging, and new economic research is needed, notably on adaptation financing and the economics of transformational adaptation.*

## Introduction

There is a small but established literature on the economic costs of climate change, which has primarily used global integrated assessment models (IAM) or sector damage cost models. These provide estimates of the social cost of carbon and the aggregate economic costs of impacts (reported as an equivalent % of GDP), as well as sectoral impact costs.

These studies continue to be updated with more recent studies on physical impacts, as reported in the literature (IPCC, 2022). In recent years, additional modelling approaches have also been used to estimate costs, including computable general equilibrium (CGE) models (e.g., Kompas et al., 2018) and econometric studies (e.g., Kahn et al., 2019). Many (but not all) of these new methods and studies report higher estimates than earlier assessments. Examples of recent estimates for Europe are reported by Bosello and Leon, in this issue.

Some of the modelling approaches above also extend to the economic analysis of adaptation. These typically use a common conceptual framework (UNDP, 2016). This initially estimates the economic costs of climate change, as calculated in the descriptions above. It then assesses the potential for adaptation to reduce these impacts (the benefits) and compares these to the costs of adaptation. This calculation also assesses the residual impacts after adaptation, to allow for trade-offs to be considered, because reducing impacts down to very low levels involves potentially disproportionately high adaptation costs. Such a framework can be used to assess the costs and benefits of adaptation and (theoretically) the economic optimal level of adaptation. These frameworks have been used to explore the mix of mitigation and adaptation in IAMs (e.g., Hof et al., 2014) or different objectives for adaptation in sector models (e.g., Ward et al., 2017). Such studies find that adaptation is extremely efficient in reducing the economic costs of climate change. Adaptation can reduce expected damages – often by an order of magnitude – and at reasonable cost. As an example, Bosello and Leon, this edition, report on estimates from the COACCH project which demonstrate adaptation is extremely cost-beneficial in reducing impacts in key sectors (coastal, river floods, heat-related mortality).

However, while these studies provide key headline information for policy makers on the economic benefits of adaptation, they are somewhat stylized. They often consider adaptation in a rather generic way, or else are strongly focused on technical options. They do not fully address the real-world questions that policy makers may be asking. Two such questions are the focus of this article.

The first explores a new question on the macroeconomic implications of adaptation, asking *‘what does adaptation mean for the public finances?’* This is likely to be a key question facing Ministries of Finance or Treasuries in Europe over coming years, especially as adaptation often requires considerable public investment. The second explores the use of economics in formulating national adaptation policy, which to date has been mostly limited to appraisal. An emerging question is *‘how should economics be used in*

*shaping adaptation policy?’* Related to this, while existing models tell us that adaptation is extremely effective in reducing impacts in the 2050s, they do not provide the information for Member States on *‘what to do today?’*, i.e., for their National Adaptation Plans. These questions are critical for Ministries in delivering national adaptation within the existing policy landscape.

### **Macroeconomic effects of adaptation in the EU and Member States**

The physical impacts of climate change are now recognised as a major financial and macroeconomic risk, with implications for the public finances (NGFS, 2019). Many of these risks can be reduced with adaptation but this involves additional costs which may also affect public budgets. These additional costs could be considerable. Indicative estimates of adaptation investment needs in the EU are estimated to range between EUR 35 billion and 500 billion annually, the large variation reflecting different underlying assumptions and methodological approaches (EC, 2017).

Assessing these effects involves complex pathways and transmission mechanisms, e.g., the implications of climate change on government revenues and expenditures, debt levels, etc. and feedbacks across the economy. In order to look at these effects, therefore, there is a need to use economic models which can consider the macroeconomic implications of impacts and adaptation in an integrated framework. The COACCH project has undertaken such an analysis (Botzen et al., 2021), using a multi-sectoral, multi-regional comparative static Computable General Equilibrium (CGE) model (COIN-INT). This model is described in Bachner et al. (2019) and Knittel et al. (2020).

This case study has looked at the macroeconomic effects of climate change and adaptation in three different countries in Europe: Austria, Spain, and the Netherlands, addressing climate hazards in forestry, agriculture and flood risk management respectively. To do this, the analysis considered different categories of current public adaptation expenditures in these countries (investment, maintenance and operating costs) and how these might evolve in the future through to

2050. Different types of adaptation actions (structural, ecosystem-based, informational) were considered. This analysis was based on a review of existing literature, budget and project reports and consultation with national experts and stakeholders. The economy-wide repercussions and budgetary consequences of adaptation policies were then assessed in the macroeconomic model, using two steps.

First, an *impact scenario* was developed for each country, including the relevant climate hazards (productivity losses in forestry in Austria, agricultural yield losses in Spain, floods in the Netherlands) based on results from the COACCH project. Second, the model was refined to include country-specific adaptation measures and their effectiveness in reducing climate risks (*adaptation scenario*). This allows an evaluation of the consequences of impacts and adaptation expenditure for government budgets, including both direct (expenditures) and indirect effects (e.g., changes to the tax base from changes in economic output, labour and capital income). The analysis provides key policy insights for Member States, i.e., whether adaptation is cost-effective from a macroeconomic perspective, and how public adaptation affects public budgets.

The *impact scenario* found that climate risks spread beyond directly affected sectors, reducing aggregate production levels via sectoral spill-overs. The magnitude of these economy-wide feedback effects depends on the severity of the biophysical impact considered, but also on the socio-economic circumstances and relative importance of the exposed sectors. The effect of climate impacts on the public finances is reflective of macroeconomic developments: with lower economic activity, the tax base shrinks and so do government revenues. In order to deliver a balanced budget, this leads to a reduction in government consumption and transfers to private households, given the government's role in providing public services such as education, security or healthcare and the importance of public transfers especially for low-income households.

The *adaptation scenario* found that for the strategies considered, national adaptation is effective in reducing the negative sectoral and econo-

my-wide effects of climate impacts and leads to positive outcomes for public budgets. This holds true for moderate (e.g., RCP4.5 –SSP2) and high (e.g., RCP8.5 –SSP5) warming scenarios and across a range of assumptions on the effectiveness of adaptation. For example, we found that adaptation reduces the negative welfare effects of climate change by at least 30% for impacts on forestry in Austria. In Spain, adaptation was estimated to mitigate 73% and 100% of Spanish GDP losses related to the reduction of agricultural productivity levels for high and medium warming scenarios, respectively. The net-benefits of adaptation arise also on public balance sheets, where government revenues increase because of higher tax bases compared to an impact scenario without additional adaptation action. Thus, while adaptation constitutes an additional government liability and a budgetary burden, effective adaptation creates distinct fiscal space.

The adaptation actions considered are effective in avoiding direct capital damages from river flooding, and they reduce climate change induced losses in sectoral productivity levels in agriculture and forestry sector. Adaptation thus generates a higher level of economic activity despite the macroeconomic costs of implementation. It reduces climate-change induced disruptions to the tax base, alleviating the negative effects of climate impacts on the revenue side of public budgets, as compared to a scenario without adaptation. This finding occurs even though the adaptation actions considered are financed out of the public budget, and so divert financial resources away from other government expenditures. The benefits of adaptation on government revenues, generated through taxes on consumption, factor income, output and trade, more than offset the direct costs of adaptation on the expenditure side. In turn, this allows higher levels of government consumption and public transfers to private households in a scenario with adaptation. In summary, additional public expenditure targeted towards effective adaptation actions leads to overall economy-wide benefits including the effects on the public budget.

The deep-dive into national adaptation actions, however, revealed important differences between countries and sectors. National adaptation across Europe does not follow a one-size-fits-all ap-

proach. In particular, there were different findings from the deep dive on the Dutch Delta programme, as compared to the Austrian and Spanish cases. While the aggregate economy-wide effects on GDP and welfare were found to be positive in Austria and Spain, this was not the case for expected annual average flood damages in the Netherlands, due to the high protection standards. Such high levels of adaptation can crowd out government expenditure elsewhere and require substantial levels of public spending. The benefits of avoided flood damages generally do not compensate for the direct and indirect costs of implementation. However, when the occurrence of a more extreme flood event (a 1000-year flood event) was considered, this finding changed. Such low-probability, high-impact events would cause severe macroeconomic and budgetary disruptions, with a significant share of private and public capital destroyed. High protection levels largely avoid these losses, preventing economy-wide disruptions and a reduction of the tax base. The higher government revenues in the adaptation scenario offset government expenditures on flood risk management many times over, leading to positive economy-wide and budgetary net-benefits. However, the uncertainty concerning the occurrence and magnitude of such events and the considerable costs of implementing such measures may prevent governments from implementing such actions, especially when there are scarce public resources.

### **Economics in adaptation policy for the EU and Member States**

Most adaptation in Europe and Member States is implemented through a mainstreaming approach. This reflects the fact that there is no single pan-European or national goal for adaptation, as is the case for mitigation, and so adaptation is integrated (mainstreamed) into existing policies, plans and programmes, rather than as a stand-alone objective. This means that adaptation policy follows existing norms, with European policy on adaptation being stronger in areas where there is an existing European mandate, and less where there is greater subsidiarity. Similarly, adaptation policy in Member States follows the existing policy landscape, differing between countries and sectors. Mainstreaming has im-

portant advantages as it embeds adaptation in core policy and can leverage sector budgets, but it also involves many challenges. It also implies a need to think about adaptation in a different way to current adaptation economic modelling.

This move to real-world adaptation is emerging quickly, as adaptation scales up. Nearly all EU countries have an adaptation strategy (see EEA, 2022) and the European Commission has published several adaptation policies, most notably the recent Adaptation Strategy (EC, 2021). However, the role of economics has been limited in this policy development to date. Indeed, most national adaptation plans to date have not included economics at all (Mullan et al., 2015).

A standardized adaptation policy cycle has been developed in Europe and promoted through the European Environment Agency's adaptation support tool (EEA, 2022). In this cycle, the role of economics comes late (in the fourth step of six) and is confined to the economic appraisal of options (i.e., costs, benefits, and net present values). It is therefore applied towards the end of a science-led process. The first issue to raise, therefore, is whether there should be a greater use of economics in shaping adaptation policy.

Many countries use economic principles for guiding public policy. This involves the use of economics at the start of the policy cycle to address a number of key questions. As an example, the UK Green Book (HMT, 2022) sets out guidance on appraisal and the delivery of public value, based on the principles of welfare economics, considering all costs and benefits that affect the welfare and wellbeing of the population. The first step in this appraisal guidance is to provide the economic rationale for intervention. This includes the consideration of market failures, and thus why it is appropriate for government to intervene, as well as how it might best intervene, i.e., to address these failures. To date, there has been insufficient use of these standard economic perspectives in setting upstream adaptation policy by Member States. Further, government appraisal generally uses economics earlier in the policy cycle to help shape the type of interventions, and has a broader list of type of interventions than just

technical options. These broader considerations are missing in the current economic models. A key recommendation is that the introduction of economics earlier in the adaptation policy cycle is essential.

This leads to a related second policy question. While existing adaptation economic studies tell us that adaptation is extremely effective in reducing climate impacts in the 2050s, they do not tell a policy maker *'what to do today?'* They do not provide the information for National Adaptation Plans, which are focused on the next five years or so. Providing this short-term advice is challenging, because of time preferences and uncertainties. There is now a growing use of methods that can provide such information, especially for economic appraisal, with the greater use of decision making under uncertainty (DMUU) (e.g., Dittrich et al., 2016). However, such approaches tend to focus on defined projects or investments. These methods are useful for a detailed project appraisal, but there is a greater potential to use economics earlier in the policy cycle and to guide adaptation policy in national plans.

The COACCH project undertook analysis on these broader policy issues, with case study work in the UK. This supported the UK's 3rd UK Climate Change Risk Assessment (CCRA3). The UK has developed methods (Watkiss & Betts, 2021) for national risk and adaptation analysis, which identify early adaptation action that can be justified from an economic perspective in the next five years. This focuses on three areas:

- To address the current adaptation gap with 'no-regret' or 'low-regret' actions that reduce risks associated with current climate extremes and variability, as well as building future climate resilience.
- To intervene early to ensure that adaptation is considered in near-term decisions that have long lifetimes and therefore reduce the risk of 'lock-in', such as for major infrastructure. This can include the use of decision making under uncertainty

(DMUU) concepts (i.e., flexibility, robustness).

- To fast-track early adaptive management activities, especially for decisions that have long lead times or involve major future change. This can enhance learning and allows the use of evidence in forthcoming future decisions (option value).

At the national level, for most risks, a combination of all three of these is needed (a portfolio<sup>1</sup>).

The case study work in the COACCH project considered the economic costs of all the climate change risks and opportunities considered in the CCRA3: some 60 risks in total. A number of insights emerged. First, the number of risks in the UK national assessment was much larger than covered by most climate impact studies, and also included many opportunities. This highlights that the economic costs (and occasionally benefits) of climate change are much wider than reported in most of the literature, and that coverage of climate change risks is partial. There is a need to expand model coverage.

Second, in many areas, the review was able to identify a strong case for early adaptation. Whilst there is a temptation to think about adaptation as tomorrow's problem, and thus to allocate available resources to other, more pressing issue, the COACCH review found evidence to counter this argument. It undertook a review of the potential economic case for early adaptation, compiling evidence on no- and low-regret adaptation for all 60 risks, based on a detailed review of the literature (academic and grey). To illustrate the findings, a figure of benefit to cost ratios was developed, shown below. While such figures should only be considered indicative, the review found a large body of evidence that early adaptation can deliver high economic benefits. Many early adaptation investments were found to deliver high value for money, with benefit-cost ratios typically in the range of 2:1 to 10:1. This helped support the case for government policy action and potential budget discussions.

<sup>1</sup> The three 'building blocks' each involve a different timescale of risk and investment. No- and low-regret options are implemented now and deliver benefits now. Addressing lock-in involves immediate decisions now, but targets risks that will arise in the future. Early adaptive management seeks to inform future investment for future risks. While all involve some action in the next five years, the nature of investment is very different.

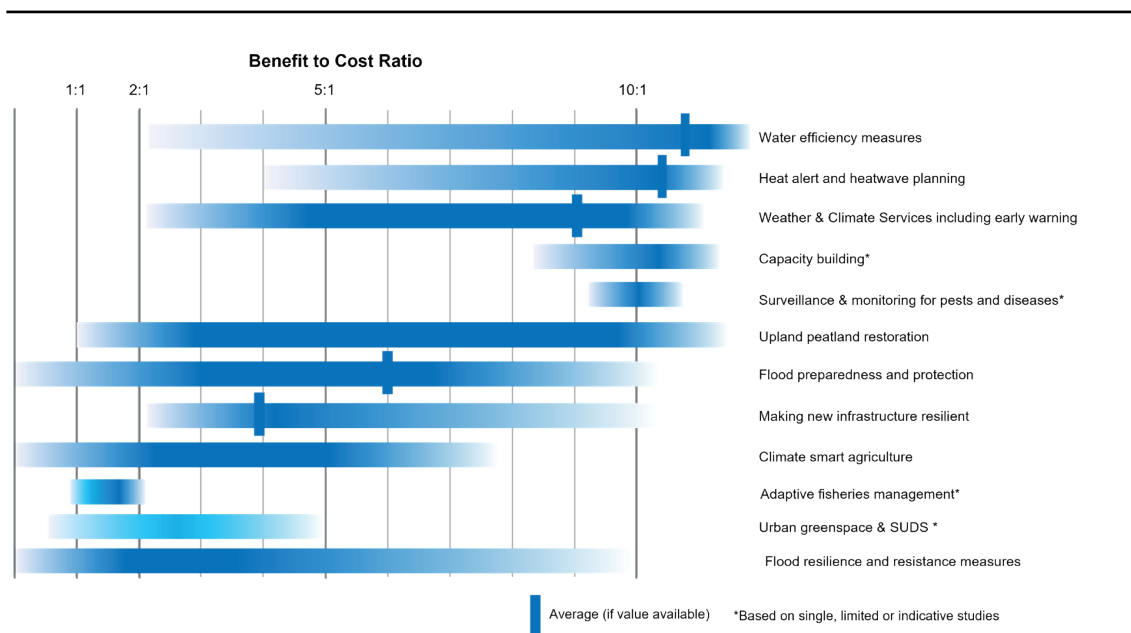


Figure 1. Illustration of low regret options for the UK (CCC, 2021).

Vertical bars show where an average BCR is available, either from multiple studies or reviews. It is stressed that BCRs of adaptation measures are highly site- and context-specific and there is future uncertainty about the scale of climate change: actual BCRs will depend on these factors.

Complementing these early actions, the research gathered evidence on where early prioritisation by government might be needed to address lock-in risk (defined in CCRA3 as immediate actions or decisions that involve long lifetimes or path dependency, which will potentially increase future risk or vulnerability and that are difficult or costly to reverse later (quasi-irreversibility), as well as the need to invest in adaptive management to inform future major adaptation decisions (option values).

### Emerging questions

The sections above identify real-world questions that policy makers in Europe are starting to ask. There will be other similar questions emerging, and we identify two key areas where economic research needs to gear up now to be ready to provide insights for decision makers in the near future.

The first relates to the financing of adaptation. Global financial flows of adaptation are currently dominated by the public sector (CPI, 2021). There is clearly a need to scale up private flows, but this is challenging given the nature of adaptation (timing of benefits, time preference, public good characteristics, leading to low private returns). There are a range of emerging financial instruments that could use public finance to de-risk private investment, or address positive externalities, notably with blended finance (UNEP, 2021) and a greater need to develop markets for adaptation. These are a key priority for economic and financial research.

The second relates the type of adaptation. To date, most adaptation in Europe has been incremental, aiming to maintain the essence of the system or process. However, the new EU Adaptation Mission on Climate Adaptation (EC, 2021b) sets out the need to move to transformational adaptation, which involves a shift or transition to a new system or state, i.e., doing different things. There is an emerging question of what transformational adaptation looks like (Watkiss & Cimato, 2020), though the broad consensus is it should involve systems-level thinking and governance change. However, beyond long-term sea level rise, there is little economic evidence on transformational adaptation, at either the micro- or macro-level. Long-

term, systemic change will pose major challenges for policy, and there is an urgent need to start scaling up research to provide economic insights for this shift.

### **Conclusions**

The examples above identify a set of new policy issues related to the economics of adaptation.

On the first area, on the macroeconomic effects of adaptation, the conclusion is that adaptation is very effective in reducing the macroeconomic disruptions of climate impacts and the resulting pressure on public finances. While the implementation of adaptation requires public resources, which at least partly divert expenditure away from other public policy priorities, it reduces climate change impacts on revenues by alleviating the effect on the tax base. The public adaptation actions considered in this study reduce the direct impacts on sectors that are negatively hit by climate change and thereby reduce sectoral spill-over effects. This highlights the important role for government action on adaptation.

On the second area, on the role of economics in European and national adaptation policy, the recommendation is that there is a strong case to move beyond the use of economics only in the appraisal of adaptation options, towards a more direct role in determining how to set adaptation policy. There is a need to introduce economics earlier in the adaptation policy cycle, especially in the context of national policies and plans. Following from this, our research indicates that early adaptation might pass a cost-benefit test and the greater role for economic analysis in national adaptation plans.

Finally, the paper highlights a number of new policy questions that are likely to emerge soon, where new economic research would be welcome. These include the financing of adaptation and the economics of transformational adaptation. Prioritizing economic research in these areas will be critical for both these transitions.



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# Section II

**Celebrating EAERE  
Doctoral Awardee**

# Why do citizens and economists disagree on carbon taxation?

**Thomas Douenne**  
University of Amsterdam



**Thomas Douenne** (t.r.g.r.douenne@uva.nl) completed his Ph.D. at the Paris School of Economics, before becoming an Assistant Professor in Economics at the University of Amsterdam in 2020. His main research field is Environmental Economics, with a focus on the link between environmental policies and inequalities.

Economists like the carbon tax. Citizens, not so much. Sapienza and Zingales (2013) compared the opinion of economic experts and average Americans on several policy issues. Of all the policies considered, the degree of disagreement was highest on carbon taxation: while 92.5 % of economic experts agreed with the statement that carbon taxation is more cost-effective than pollution standards, only 22.5 % of Americans did. Recent examples also illustrate this sharp contrast. In 2019, over 5,000 economists called for the rapid development of carbon taxation in the U.S. and in Europe.<sup>1</sup> At the same time, the French government, which had recently committed to an ambitious carbon tax trajectory, had to abandon its plans because of the public opposition known as the Yellow Vests movement.<sup>2</sup> Public resistance to carbon pricing is not specific to France, and other countries have also experienced significant opposition to such policies (see Carattini et al., 2018).

Why do citizens and economists disagree on carbon taxation? In my Ph.D. dissertation, I suggest two partial explanations. First, I show that by focusing on distributional effects *between* income groups—as opposed to *within* income groups—economists and policymakers may well have underestimated the importance of the equity concerns raised by carbon taxation, and the consequences for its design. Second, in a joint work with Adrien Fabre we show that citizens tend to be overly pessimistic about the economic impacts of carbon taxation, leading them to oppose policies even when they are expected

to financially benefit from them. Our work also suggests that these two explanations may be related, as past experiences with regressive carbon tax reforms may have affected the general perception of this policy independently of its design.

## Distributional effects of carbon taxation: early concerns and solutions

The distributional effects of environmental taxes are not a new concern. Many studies have assessed the heterogeneous impacts of energy taxes on households' purchasing power (for a recent review, see Pizer & Sexton, 2019). The main takeaway from this literature is that, in developed economies, a tax on pollution is generally regressive because poorer households spend on average a larger share of their income on polluting goods. However, since they spend less on these goods in absolute terms, it is sufficient to transfer the proceeds of the tax as a uniform transfer (a policy known as a carbon tax and dividend) to design a progressive policy. The desirability of such transfer can be debated as it involves an opportunity cost since the revenue of the tax could alternatively be used to reduce distortionary taxes, with potentially higher efficiency gains (an idea known as the weak double dividend). Still, it suggests that if society places enough weight on equity, it is feasible to design a progressive carbon tax policy. This conclusion leads to a rather optimistic view about the equity implications of carbon taxation, and it has also led to the idea that with appropriate transfers,

<sup>1</sup> In January 2019, 3,354 American economists signed a column in the Wall Street Journal in support of carbon pricing with lump-sum rebates (Climate Leadership Council, 2019). The same year, the EAERE statement on carbon pricing received 1,772 signatures.

<sup>2</sup> The French carbon tax was introduced in 2014 at an initial level of 7€/tCO<sub>2</sub>. This level was rapidly rising: it was 44.6€/tCO<sub>2</sub> in 2018 and it was planned to reach 86.2€/tCO<sub>2</sub> by 2022. In November 2018, in a context of high fuel prices, protests started. The massive scale of these events and the general public opinion rapidly forced the French government to suspend the increases initially scheduled. As of today, the tax remains at its 2018 level.

carbon taxation would meet greater public support (see Climate Leadership Council, 2019).<sup>3</sup>

### Horizontal distributional effects matter

In Douenne (2020), I study the case of France and show that, although a progressive carbon tax policy could be designed using uniform lump-sum transfers, a significant share of poor households would still lose from this policy. Using the French consumer expenditure survey, I estimate the behavioral responses to energy prices and simulate at the household level the fiscal incidence of an increase in energy taxes rebated using a lump-sum transfer.<sup>4</sup> The results (see Figure 1) show that the tax incidence is very heterogeneous, with a greater heterogeneity within income groups (horizontal distributional effects) than between income groups (vertical distributional effects). These horizontal distributional effects pose a great challenge to policymakers, as no redistributive instrument can accurately and efficiently target the losers if the tax incidence depends on imperfectly observable or highly manipulable characteristics (e.g., vehicle fuel-efficiency, housing choices, preferences for energy consumption, etc.). While we can easily design progressive carbon tax policies, it is important to acknowledge that such policies can still have adverse distributional effects and raise concerns among citizens about equity and the impact on their own purchasing power.

### Pessimistic beliefs and public support for carbon taxation

Despite this important caveat, the carbon tax and dividend policy has still several attractive properties: in addition to protecting the environment, it would still financially benefit a majority of poor households, and if the distribution of energy consumption is sufficiently skewed, it could even financially benefit a majority of citizens. Thus, as the Climate Leadership Council (2019) statement suggests, a carbon tax and dividend would arguably be an effective way to reconcile citizens with carbon taxation.

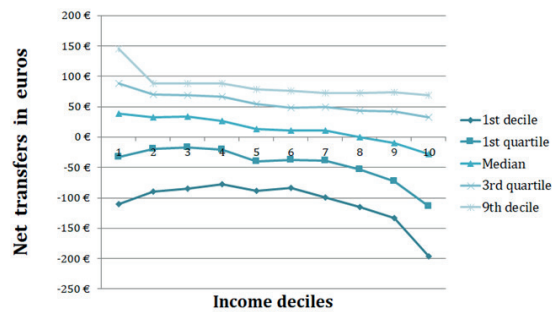


Figure 1. Vertical and horizontal distributional effects from energy taxes with lump-sum transfers (Douenne, 2020).

Note: Net (yearly) transfers are expressed per consumption unit to adjust for household size. The figure reads as follows: if the increase in tax revenue was redistributed via a uniform lump-sum transfer, 25% of households belonging to the bottom income decile (the poorest 10%) would be expected to lose more than 32€ annually, while 50% of households belonging to the top income decile (the richest 10%) would be expected to lose less than 28€ annually.

In Douenne and Fabre (2022), we assess the political prospects of a carbon tax and dividend in France after the Yellow Vests movement. We created a survey administered to over 3,000 respondents representative of the French population. We presented to respondents a budget-neutral 50€/tCO<sub>2</sub> carbon tax and dividend policy, with information on the effect on energy prices and the transfer that each household would receive. We find that people largely reject this proposal: only 10% of our survey respondents approve, while 70% strictly disapprove. However, we also show that people hold pessimistic beliefs about this policy: while we estimate that 70% of households are expected to financially win from the policy, only 14% think that this would be the case. Similarly, respondents are pessimistic about the distributional and environmental effects of the policy. We also find that the more people are opposed to the policy, the more (pessimistically) biased they are, and that the causality between beliefs and opposition runs both ways. On the one hand, when provided with new information about the policy, people discard positive news but correctly process negative ones. This phenomenon is stronger for more opposed people, which we show is consistent with the endogenous formation of beliefs through motivated

<sup>3</sup> The Climate Leadership Council (2019) statement argues that “To maximize the fairness and political viability of a rising carbon tax, all the revenue should be returned directly to U.S. citizens through equal lump-sum rebates”.

<sup>4</sup> The policy simulated corresponds to the changes in energy taxes that occurred between 2016 and 2018, i.e., the last changes before the Yellow Vests movement. The policy includes an increase in the carbon price on energies from 22 to 44.6€/tCO<sub>2</sub>, and an additional increase for diesel (0.026€ per liter) with the aim of progressively catching up with the higher rate imposed on gasoline. Note that electricity is exempted from the tax as it is already taxed on the EU-ETS market.

reasoning. In other words, the less people like the policy, the less likely they are to acknowledge positive information about it. On the other hand, our survey design enables us to show that beliefs also causally determine support for the policy: when convinced that they would financially gain, people's likelihood to accept the policy increases by 50 p.p. Similarly, the likelihood to support it is 40 p.p. higher when people are convinced that the policy would benefit the environment.<sup>5</sup> This result confirms that policy rejection is not driven by people's intrinsic preferences, but rather by endogenous pessimistic beliefs, leading to a vicious circle where opposition leads to more pessimistic beliefs that further strengthen opposition.

### **An agenda for ambitious climate policies**

Beyond the French case, I believe these results provide general insights relevant to other countries and political contexts. In particular, the self-reinforcement of pessimistic beliefs suggests that it is important to ensure sufficient political support in the early stages of policy implementation. There are at least two levers that policymakers can act upon.

The first is addressing distributional effects. The French example is a case in point: following a double dividend strategy, the increases in carbon taxation were concomitant with reductions in capital and labor taxes that favored households at the very top of the income distribution (see Ben Jelloul et al., 2019). This strategy also created ambiguity about the actual purpose of the policy, which was largely seen as a means to raise public revenues. Going forward, a better balance must be found between efficiency and equity objectives. In an ongoing project with Albert Jan Hummel and Marcelo Pedroni, we re-assess the results from the double dividend literature in a general equilibrium climate economy model based on Barrage (2019) in which we introduce heterogeneous agents. Our model allows for heterogeneity in productivity, assets, as well as preferences for energy consumption to capture both vertical and horizontal distributional effects. We consider a second-best fiscal environment in which the government can tax capital, labor, pol-

lution, and use a uniform lump-sum transfer to address three distinct tasks: raising public revenue, protecting the environment, and addressing inequalities. Our quantitative analysis will highlight the trade-off between reducing distortionary taxes and providing redistribution, and how it is affected by the decision to tax carbon.

The second lever is the use of additional environmental policy instruments. Although carbon taxation is generally considered by economists to be the most cost-effective solution to address climate change, the multiplicity of market failures (e.g., existence of public goods, information asymmetries, non-optimizing behaviors, etc.) calls for the use of multiple instruments. While governments should refrain from relying exclusively on a collection of small sectoral policies, in some cases targeted policies such as public investments, subsidies, or pollution standards can be effective complements to carbon pricing (Stern & Stiglitz, 2017). In Douenne and Fabre (2020), we show that many of such policies are widely supported by the public—arguably because the costs are less salient relative to the benefits—who would also be supportive of carbon taxation if its revenues were used to finance environmental investments. Thus, these alternative policies also offer a way for policymakers to show a clear commitment to environmental protection, which could then increase public support for an ambitious carbon tax policy.

### **Conclusion**

Economists have yet to convince citizens of the need to tax carbon. While we can easily blame citizens' free riding or the difficulty of communicating effectively about climate change, our best chance for progress is to remain critical of what we know and to learn from our experience to rethink climate policy design.

<sup>5</sup> To obtain causal effects, beliefs about environmental effectiveness are instrumented by information provision. Beliefs about one's own gains are instrumented with two independent designs that both lead to a fuzzy regression discontinuity design with very similar outcomes.

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\* As of May 2022



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