Evolution of the economics of climate change

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Surely there can be hardly anyone left who truly doubts that climate change is real and that it is here. The recent experiences of severe weather events – floods, fires, droughts, and storms – visibly drive home what scientists have been saying for years: global warming threatens life on a planetary scale; it is man-made, predictable and, although not reversible, its further escalation is mitigable.

Today, it is rare to have conversations of the 'but there was always climate change, and who says that this time is different' type. Instead, both public and private actors seem to be aggressively embracing the fight against climate change. Rare indeed, these days, is the financial institution that does not promote its environmental, social, and governance (ESG) credentials. At the time of writing, world leaders are meeting for the COP26 conference in Glasgow and expectations are simultaneously high and low. There are high expectations for some further progress but low expectations of sufficient progress towards the goal of limiting global warming to 1.5 degrees.

Submerged beneath the flood of information, initiatives, ideas, and pronouncements, it is hard to keep sight of what is needed for this goal. It is easy to get lost, primarily because the science of climate change is complicated, requires very long-run forecasts and involves large confidence intervals. The same is true of the *economics of climate change*: separating the signal from the noise, filtering out the quality research is hard.

Research published by CEPR and our policy platform VoxEU has served this purpose for years: it filters and disseminates the economic research you ought to read.

This eBook is a collection of 45 VoxEU columns on the economics of climate change, mostly published over the past 2-3 years. The sheer quantity is testimony to the acceleration of research, knowledge, and interest in the economics profession. I had to limit the number of columns chosen and to exclude many interesting pieces from this collection. My selection bias was for recent and solution-oriented contributions. However, in a few cases I have included older pieces, those that trace some of the 'history of thought'. Below, I highlight a few selected insights on the economics of climate change as illustrated in this collection, but first I want to focus on the science of climate change.

SCIENCE FIRST: SOME NUMBERS WORTH REMEMBERING

To keep eyes on the goal, a few numbers from the latest report of the IPCC are extremely helpful.[1] **The numbers are: 40, 300 and 2,390**. Forty gigatonnes represents the current yearly emissions of CO2 at the global level, 300 gigatonnes is the remaining carbon budget of global emissions, if the 1.5 degree goal is to be reached with high (more than 80 percent) likelihood, and 2,390 gigatonnes of CO2 is the estimate of cumulative historical emissions since 1850, already in the atmosphere.[2] These numbers make an impression for several reasons.

First, the 2,390 gigatonnes show the size of the historical burden: past emissions mean that the world has already almost exhausted the total carbon budget if we are to limit global warming to 1.5 degrees. These emissions will remain in the atmosphere for hundreds of years to come and have already warmed the earth by about 1 degree (over preindustrial levels). It is noteworthy that this historical burden was accumulated almost exclusively by high-income countries.

Second, the 300 gigatonne remaining budget matters because it is absolute. This is all that remains, full stop. This is how much this and any future generations have left if warming is to be limited to no more than 1.5 degrees. At the current rate of 40 gigatonnes per year, the world has about eight years left. To my mind, this simple fact is such a powerful illustration of the challenge: the famous race to net zero needs a fast start if we are to limit global warming to 1.5 degrees. Were the world to give up on the 1.5 degrees target and set the limit to 1.7 or 2 degrees, the remaining carbon budgets would amount to 550 and 900 gigatonnes, respectively. This would allow a bit more time to get to net zero, as illustrated in Figure 1, but it does little to reduce the urgency to act and the environmental costs of any further delays.

If we were to translate the remaining budgets into minutes until midnight, the clock would say that it is 7 minutes to midnight for 1.5 degrees, 11 minutes to midnight for 1.7 degrees and 16 minutes to a midnight of 2 degrees warming. It is worth noting that although the relationship between emissions and warming seems to be near linear, the consequences of higher temperatures are not. Another way of looking at these numbers is to conclude that we need to develop carbon extraction technologies very fast and at scale. Unfortunately, this technology does not seem to be 'just around the corner'.

1 IPCC Climate Change 21, The Physical Science Base
2 See Table SPM.2 . IPCC Climate Change 21, The Physical Science Base,

FIGURE 1A TOTAL CO2 BUDGET TO LIMIT WARMING TO 1.5, 1.7 OR 2 DEGREES

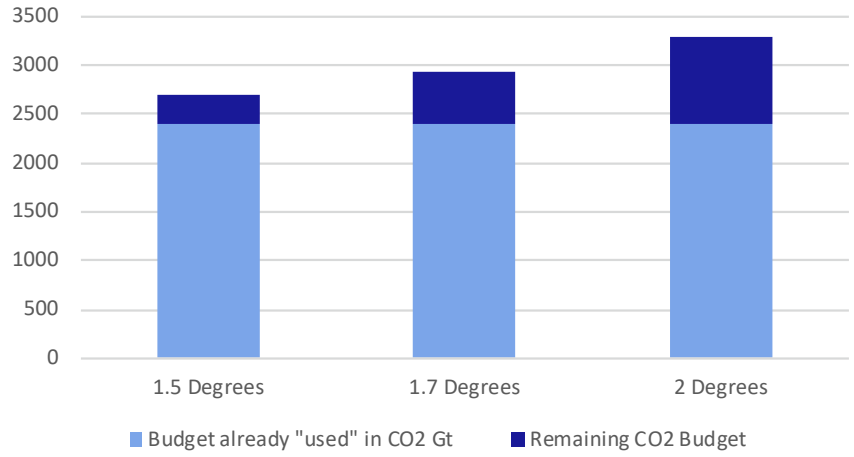
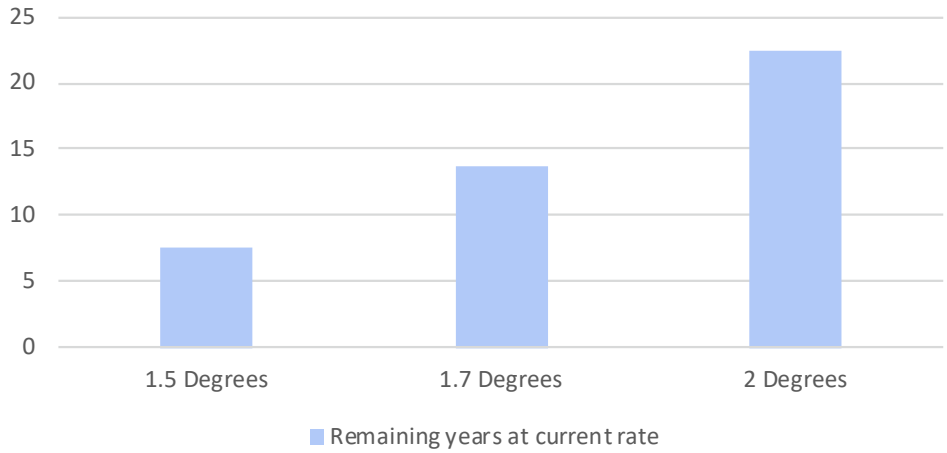


FIGURE 2B REMAINING YEARS AT CURRENT RATE OF EMISSIONS, GIVEN A LIMIT OF WARMING TO 1.5, 1.7 OR 2 DEGREES



Source: Author[s] calculations based on Table SPM.2 . IPCC Climate Change 21, The Physical Science Base,

IS THE ECONOMICS PROFESSION RISING TO THE CHALLENGE?

Given the size of the challenge, what are economists doing? Not much, according to Andrew Oswald and Nicolas Stern (Chapter 1). They look at the number of articles on climate change published in top economics journals and conclude that the economics profession has been failing the world. According to their count, the *Quarterly Journal of Economics* (QJE), for instance, had not published even one article on the economics of climate change until 2019 (a quick Google search for climate and QJE suggests that this may be unchanged, although it did reveal one QJE article published in 1917 on climate change as an element in the fall of Rome).

Not all economists can be accused of staying silent on the issue. Some of the most prominent economists were working on solutions years ago, as shown in Section I of the book. In several VoxEU columns from 2007-2009 (Chapters 2-7), Nicolas Stern, Geoffrey Heal, Jean Tirole, Michael Spence, Jeffrey Frankel and Philippe Aghion (with Reinhilde Veugelers and David Hemous) engage and put forward proposals on how to achieve a global deal. These pieces are worth re-reading for the historical record but also because some of issues they raise remain relevant today.

1. Fixing the price of carbon

Among the core issues, carbon pricing has attracted most attention from economists, and rightly so. Starting from Weitzman's 1974 "Prices versus Quantities", economists have been debating, over the last 50 years, the best way to price carbon under uncertainty. Robert Stavins' 2019 obituary for Martin Weitzman, calls him the gift that keeps on giving. The columns collected in (Chapters 8-19) are part of this literature, on cap-and-trade, carbon taxation and the social cost of carbon. Some earlier contributions showcase the debate among experts regarding the optimal discount rate, the magnitude of the social cost of carbon and the need to advocate against those who 'do not believe in climate change'. For instance, Rezai and van der Ploeg in 2015 estimated the optimal global carbon price at about 15 dollars per tonne of CO2, which from today's perspective would seem a low number. And in 2018, after the election of Donald Trump, these same authors engage 'climate change deniers' by showing that even a high probability of the views of such deniers being correct does not change the optimal policy of carbon pricing, because the risks still dominate.

After the Paris agreement of 2015, the expert debate on carbon pricing changed in a fundamental way. It moved from a *Pigouvian internalisation* approach to carbon pricing (i.e. estimating the present value of the flow of marginal damages of one tonne of CO2) to a *maximum quantity approach* (i.e. estimating the carbon budget which results from the optimal dynamic path for the shadow carbon price compatible with the set budget (Gollier, Chapter 15)). In determining this carbon price path, the two main variables are the initial level and its rate of increase of the price. Most integrated assessment models (IAMs) use a relatively low initial level of carbon prices and then a steep increase of 8% or more. Gollier uses an asset-pricing approach, with uncertainty about technology and economic growth, and finds a much lower growth rate for the optimal carbon price (4% plus inflation). This, in turn, implies a much higher price for carbon today to satisfy the maximum carbon budget.

The question of the optimal dynamics of carbon pricing is also important from a political economy perspective: policymakers may prefer a strategy of 'start with low carbon prices and then promise a steep increase', inviting all the usual problems of credibility and time inconsistency. It may also raise the further question of whether carbon taxes should vary over the cycle, as suggested by Benmir et al. in Chapter 16.

Carbon prices/taxes are already in place in many countries, and in some they are sizeable. In Switzerland a tonne of carbon is taxed at more than 100 Swiss francs.[3] In the largest cap-and-trade system, the European Trading System (ETS), a permit costs about 60 euros now, more than double the price in 2018-19. Carbon leakage therefore becomes a real issue, and two contributions here show that in the cases of Holland (Hoogendoorn, Chapter 17) and California (Bartram et al., Chapter 19) it can be substantial. A mechanism to deal with differences in carbon prices at the border – a Carbon Adjustment Mechanism (CBAM) – therefore becomes essential, as advocated by the French-German council of economic advisors (Chapter 13).

2. Harnessing green finance and green monetary policy

Prominent voices, from Mark Carney to Bill Gates, have calculated the necessary sum of investments needed to achieve net zero by 2050 at 3-5 trillion dollars per year. Clearly such sums will not be reached through public funding alone, private finance will need to flow into climate investment. At the same time, the financial industry seems to be embracing ESG finance whole-heartedly. Virtually all major asset managers have made commitments towards net zero and are advertising ESG-integrated products. This in turn raises a question for researchers: is it working? Is all the green finance having a positive impact on the climate?

The columns collected in Chapters 20-28 paint a mixed picture. On the positive side are Bolton et al. (Chapter 28), who find that the cost of equity for companies with higher emissions tends to increase as investors seek compensation for carbon transition risk. They conclude that stock market pricing may be acting as another form of carbon pricing. Altunbaş et al. (Chapter 23) find that European banks have shifted lending away from more polluting firms. Similarly, Delis et al. (Chapter 20) find that, after 2015, bank loans started to price climate transition risk for firms holding large fossil fuel reserves. On the sceptical side are Elmalt et al. (Chapter 22), who conclude that ESG criteria are not enough, since they do not link tightly with emissions growth for major emitters. Ehlers et al. also find no clear evidence that firms issuing green bonds reduce carbon intensities, nor that they have lower intensities than firms that did not issue green bonds.

From the financial risk perspective there is more agreement: climate change can represent severe risks for the balance sheets of financial intermediaries or, as Timo Löyttyniemi (Chapter 24) puts it, '[c]limate change is a new serious threat to financial stability'. Paul Hiebert (Chapter 25) shows how modelling climate risk for the EU financial system is progressing at the ECB, by mapping firms' climate exposures to financial exposures of banks, insurance companies, and investment funds.

3 A further increase of the tax to 200 Swiss Francs and expansion of coverage to the transport sector was voted down in a popular referendum in summer 2021

Any researcher who has ventured into the of forest of ESG finance will quickly have discovered that it is a jungle, with hundreds of standard setters, metrics, ratings, self-declarations, etc. Regulators have been trying to catch up by designing taxonomies and setting standards, which are themselves very complex. Ahead of COP26, therefore, Bolton et al. (Chapter 28) argue that a simple measure of carbon emissions for scope 1 should be made mandatory; every firm should have to publish its carbon footprint in absolute terms, in tonnes of CO_2. It is quite surprising that this simple metric is not easily available today.

Harnessing green monetary policy has been more controversial. However, some of the same arguments made for pricing climate risk in financial intermediaries also apply for the portfolios of central banks. The main debate has been whether green monetary policy should tilt asset purchases towards green assets, moving away from a 'market neutral' allocation. Dirk Schoenmaker (Chapter 29) points out that the market-neutral approach does not really avoid market distortions, since buying corporate bonds in proportion to today's market share means that the ECB's asset and collateral base will have a carbon-intensive bias. Similarly, Bartholomew and Diggle (Chapter 34) advocate abandoning the benchmark of neutrality, given the high stakes.

Less controversial is the fact that central banks will need to augment macro-modelling in order to be able to forecast and respond to physical and transition climate risks. For instance, they need to know in detail how carbon pricing will impact inflation. My study with Maximilian Konradt (Chapter 31) suggests that the answer is not obvious, at least not when looking at past CO_2 taxes, which have sometimes even been slightly deflationary. The response made by monetary policy will matter. Dietrich et al. (Chapter 32) point out that climate risks may present a very immediate challenge for monetary policy, if the expectation of climate-induced disasters affects people's behaviour today.

3. Dealing with global distributional issues

The chapters in the final section deal with some of the most difficult issues, those to do with distribution. What are the differential effects of climate change across the globe? Who will be on the winning and who on the losing side? How can we overcome the political economy obstacles? Will there be a huge international climate refugee flows? How should some of the low-income countries, already struggling with unsustainable debt burdens and high exposure to climate change, cope? This raises deep questions of fairness and inequality across the world and across generations, for which we do not have good answers.

I will not summarise all articles in this part, but there are some results that bear highlighting:

- Chancel and Piketty (Chapter 37) calculate global personal carbon inequality. They find that, "*the top 1% richest Americans, Luxemburgers, Singaporeans, and Saudi Arabians are the highest individual emitters in the world, with annual per*

capita emissions above 200tCO2e. At the other end of the pyramid of emitters lie the lowest income groups of Honduras, Mozambique, Rwanda and Malawi, with emissions 2,000 times lower, at around 0.1tCO2e per person per year", and suggest that progressive levies be targeted at the individual top emitters to fund climate adaptation.

- Cruz and Rossi-Hansberg (Chapter 40) show that the effects of climate change differ widely across regions. *"While some regions will be significantly negatively impacted, others may benefit from warmer temperatures. (..) The losers are today's poorest locations."* In their baseline scenario, welfare can increase by as much as 15% in regions of Canada and Siberia, but areas in Central and South America, Central Africa, India, and Southeast Asia can suffer welfare losses of between 10% and 15%.

- A somewhat surprising result is found by Cattaneo and Peri (Chapter 36): international climate migration flows are contained in their model, and mostly internal rather than international. The reason is depressing: *"A decline in agricultural productivity, causing a decline in rural income, seems to have a depressing effect on the possibility of emigration in extremely poor countries where individuals live on subsistence income"*. Burzyński et al. (Chapter 39) concur that massive international flows of climate refugees are unlikely, but climate change might displace between 210 and 320 million people, mostly within their own countries.

- Avinash Persaud (Chapter 45) points out that *"in countries on the frontline in the war against climate change, there is a nasty nexus between climate change and debt."* He suggests breaking this climate–debt nexus by redistributing special drawing rights (SDRs) towards the most vulnerable, recapitalising regional development banks with unused SDRs, and incorporating lending clauses in official lending, which would automatically suspend debt service following a natural disaster.

- Klenert and Hepburn (Chapter 38) start from the observation that the preferred instrument of economists, namely carbon pricing, is politically unpopular. They suggest that lump-sum dividends to citizens may make it more palatable. Furceri et al. (Chapter 44) also focus on the political economy of implementing policies to fight climate change when it is politically costly. To increase popular support, they suggest adopting stricter environmental policies in times of low oil prices, providing social insurance for those adversely affected by climate mitigation, and emission limits or 'feebates', rather than market-based emissions pricing. This last conclusion seems, much to the chagrin of economists, to be widely shared among policymakers and non-economists.

CONCLUSION

The purpose of this collection of articles on climate change, plucked from the recent crop of CEPR/VoxEU material, is threefold. First, it is intended to provide an overview of some of the key issues in climate change from the economist's perspective. Second, it aims to stimulate further research, since the answers to many key questions on global distributional issues are still wide open. Finally, it serves to demonstrate that CEPR is fully engaged with this central debate of our times, and that we will use the power of this network to promote excellent research and relevant policy. We take very seriously the warning from Andrew Oswald and Nicholas Stern (Chapter 1) that opened this collection: "*If we do not move quickly, we think the discipline will be judged harshly by the humans of the future – including by our own offspring.*"

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