

Flip the classroom

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Introduction

It sometimes make sense not to lecture, instead have students read the book and watch lectures of previous years, and use the time of the lecture to quiz the students about the material. Flipping the classroom breaks the routine and creates ample time for discussion. It works better with small groups of confident students. You can cover less material, as students need more time than an experienced lecturer to formulate key insights and you need to spend time confirming, completing and sometimes correcting what they say. The questions below follow the chapters of the second edition of *Climate Economics*.

1 The science of climate change

- What is a greenhouse gas?
- If a greenhouse gas is transparent to visible light, how come the media often post photos of carbon dioxide?
- What are the most important anthropogenic greenhouse gases?
- What is the most important natural greenhouse gas?
- What happened to the atmospheric concentrations of carbon dioxide, methane, and nitrous oxide since the start of the agricultural revolution?
- And since the start of the industrial revolution?
- How important are human emissions in the gross emissions of carbon dioxide?
- And in the net emissions?
- What happens when there are greenhouse gases in the atmosphere?
- The first-order climate impact of an enhanced greenhouse effect is simple: Warming. Name three feedbacks that complicate the projection of future climate change.
- The climate system is very complex. How good are climate models at reproducing the observations of the recent past?
- Does that give you confidence in these models?
- What is the range of global warming that we can reasonably expect by 2100?
- How can a small change in the atmospheric concentration of carbon dioxide, measured in parts per million, cause substantial warming?
- Is warming uniform?
- What will happen to rainfall as the Earth warms?
- What will happen to storms?
- How much will sea level rise?
- How can a small change in temperature cause substantial sea level rise?
- What is ocean acidification?
- Why is ocean acidification a problem?
- Why do some people doubt that climate change is real and human-made?

2 Emission scenarios and options for emission reduction

- What are the main sources of the emissions of
 - Carbon dioxide
 - Methane
 - Nitrous oxide
- What is the Kaya Identity?
- Can you give me a rough idea of the order of magnitude of the four components of the Kaya Identity over the last 50 years?
- What is the difference between a forecast and a scenario?
- How would you judge the credibility of a scenario?
- What do estimates of fossil fuel reserves and resources tell us about future carbon dioxide emissions?
- What are the four basic options for emissions reduction according to the Kaya Identity?
- Is population shrink effective? Is it an option?
- Is economic shrink effective? Is it an option?
- How fast should energy efficiency improve to keep emissions constant?
- How can that be achieved?
- Does energy efficiency improvement always lead to reduced energy use?
- What is a principal-agent problem?
- Why is it relevant for energy efficiency?
- What's good and bad about
 - hydropower?
 - nuclear power?
 - wind power?
 - solar power?
 - bioenergy?
- What's carbon capture and storage?
- What are the problems with CCS?
- What is geoengineering?
- What are the problems with geoengineering?

3 Abatement costs

- Why does emission reduction cost money?
- What is a first-best policy?
- How much would it cost, approximately, to fully decarbonize the economy, if policy is first-best?
- Models disagree, by up to an order of magnitude, on the costs of climate policy. What role do price and substitution elasticities play in this disagreement?
- Why do people disagree about elasticities? Can't we just estimate these?
- What role does the availability of technological options play in the disagreement on the costs?
- What role do relative prices, now and in the future, play in the disagreement on the costs?
- How does R&D respond to climate policy? Can this explain why models disagree on the costs of emission reduction?
- Should near-term emission targets be ambitious or lenient? Why?
- Should emissions be reduced in all countries or just a few? Why?
- Fiscal reform for climate policy has three effects, an emission reduction effect, a revenue recycling effect, and a tax-interaction effect. What is the emission reduction effect?
- What is the revenue recycling effect? Is it bigger or smaller than the first effect?
- What is the tax interaction effect?
- Is it possible to have a double dividend? Is it likely?
- It is often said that greenhouse gas emission reduction is regressive. Why?
- Is there a way to compensate regressivity?
- Can you think of a reason why climate policy would be progressive?

4 Policy instruments

- The First Welfare Theorem has that the market equilibrium is a Pareto Optimum, but not in the presence of externalities. Why?
- What is a Pigou tax?
- Do Pigou taxes interact with market power?
- Give three examples of direct regulation for greenhouse gas emission reduction.
- Is direct regulation cost-effective? Why?
- Name three forms of market-based regulation.
- Are taxes cost-effective? Subsidies? Tradable permits?
- How do taxes and subsidies compare in the short-run? And in the long-run?
- How do taxes and tradable permits compare on costs? And on emissions?
- What is the Weitzman Theorem?
- Are taxes or tradable permits better for a problem like climate change? Why?
- Give four ways to initially allocate permits and discuss their pros and cons.
- Does the initial allocation matter for the market price?
- What is upstream, midstream, downstream trade in emission permits? What are its advantages and disadvantages?
- What is the difference between seller- and buyer-beware liability for consumer products?
- What is Benford's Law? How can it be used to detect fraud?
- Why are there so many markets for emission permits? Why do these markets not merge into a single world market?
- The UK now has its own emission trading system. What problems are there?
- Why did British Steel go bankrupt?
- What is the difference between emission permits and emission credits?
- What problems are there in defining emission credits?

- Why is technological change so important for climate policy?
- Is knowledge a private or a public good? Does the market properly incentivize research and development?
- What is a patent?
- Name other ways in which the government can stimulate R&D?
- How does emission reduction policy interact with R&D for emission reduction?

5 Impacts and adaptation; valuation

- What does climate change imply for natural vegetation?
- What does climate change imply for crop yields?
- What is adaptation? Is it important?
- What does climate change imply for energy use?
- What are the impacts of sea level rise?
- Is adaptation important?
- What does climate change imply for labour productivity?
- What does climate change imply for human health?
- Are adaptation and mitigation substitutes or complements?
- Mitigation is a global public good. What's that?
- Is adaptation a global public good too?
- The future is uncertain. When does this pose a problem for adaptation?
- How would you adapt in the face of an uncertain future?
- Why are national governments formulating adaptation plans?
- How are multilateral adaptation monies spent?
- What justifies public intervention on adaptation?
- What aspects of dealing with heatwaves are private, and what public?
- Is flood protection public or private?
- Do agricultural subsidies help or harm adaptation?
- Why would you want to put a monetary value on the impacts of climate change on nature and health?
- How does the travel cost method work?
- How does hedonic pricing work?
- What are the advantages of revealed preference methods? And its disadvantages?
- How does contingent valuation work?
- How does contingent choice work?
- Name three biases in stated preference methods.

- What is the difference between willingness to pay and willingness to accept compensation?
- How big is this difference? How come?
- Why is this important for climate change?
- What is benefit transfer?
- How easy is benefit transfer?
- Why is this important for climate change?

6 Impacts of climate change

- How does the enumerative method to estimate the impacts of climate change work? What are its pros and cons?
- At present, the Thames Barrier protects against the 1000-year flood. That is, every year, there is a chance of 0.1% that the barrier will be overtopped and London will flood. That would cost some £1 billion in damages. If sea level would rise by 20 cm, the chance would increase from 1 in 1000 to 1 in 500. How much would the annual damage be?
- What can be done against this?
- How would you use a computable general equilibrium model to estimate the impacts of climate change? What are its pros and cons?
- How does the Ricardian method to estimate the impacts of climate change work? What are its pros and cons?
- How large, roughly, are the economic impacts of a 2.5°C warming?
- Are these estimates complete? How large do you think the missing bits are?
- Some estimates have that the initial impacts of climate change are positive. Why?
- How large is the uncertainty about the impacts of climate change? Why?
- Is the uncertainty symmetric? Why?
- Extinction Rebellion is so called because it rebels against the possible extinction of the human species because of climate change. Why does their estimate of the impact of climate change differ so much from the estimates published in the economics literature?
- What is the social cost of carbon?
- Why are there so many more estimates of the social cost of carbon than of the total impact of climate change?
- What does the discount rate do to the social cost of carbon? And to the uncertainty about the social cost of carbon?

7 Climate and development

- Are poorer countries more or less vulnerable to climate change?
- Give three structural reasons why.
- Can you give an example of richer countries being more vulnerable than poorer ones?
- What is adaptive capacity? What are the components of adaptive capacity?
- What would economic growth do with these three determinants of vulnerability?
- What is Schelling Conjecture?
- Does the Schelling Conjecture always hold?
- Schelling also wrote about climate policy as international redistribution and preferences thus revealed. Can you explain this in your own words?
- How does climate change affect economic growth?
- Floods and storms damage capital goods, and lead to their early replacement. Why is this not good for economic growth?
- Suppose climate change has a negative effect on output. This would reduce investment and hence future output, unless we save more. Would we do that?
- How large are the dynamic effects of climate change relative to the static ones?
- Hot countries tend to be poor and poor countries tend to hot. What does Jared Diamond have to say about this?
- Jeffrey Sachs?
- Daron Acemoglu?
- What is a poverty trap?
- Name two possible poverty traps that would be worsened by climate change.

8 Optimal climate policy

- Article 2 of the UNFCCC calls for the stabilization of atmospheric carbon dioxide. What does that imply for emissions? Why?
- The Paris Agreement has two temperature targets, 1.5°C and 2.0°C warming relative to pre-industrial times. Where does the 2°C target come from?
- Where does the 1.5°C target come from?
- How would you characterize a social optimum in terms of the costs and benefits of solving a static problem?
- And for a dynamic problem?
- If you move from no emission reduction to complete emission reduction, what happens to the marginal abatement costs?
- And to the marginal benefits?
- What does this imply for optimal emission reduction?
- What are the three main findings of Nordhaus (1992) and later cost-benefit analyses of climate policy?
- Why does optimal climate policy start with lenient targets and moderate taxes?
- Why does climate policy accelerate?
- What are the characteristics of a backstop technology?
- What does a carbon-free backstop do to optimal climate policy?
- Are secondary benefits a reason to cut greenhouse gas emissions?
- What happens if there is a second policy that directly targets those secondary benefits?

9 Discounting

- Why is the discount rate important?
- What are the two reasons to discount the future according to the Ramsey Rule? What are the two components of the second reason?
- Why is the pure rate of time preference controversial?
- Is the second component of the Ramsey Rule, the growth rate of happiness, controversial too?
- Do you want to use the same discount rate for different public policy interventions?
- Why does an exponential discount rate measure the relative price of time in the absolute distance in the time?
- Is this a desirable property of exponential discounting?
- What is hyperbolic discounting? Does it have empirical support?
- Where did Geoff Heal start his career?
- Why is Maureen Cropper the first woman we met in this module?
- Suppose two people disagree on the discount rate. What happens if you split the difference on the discount rate? And if you split the difference on the discount factor?
- Now suppose you are uncertain about the discount rate. How does the certainty-equivalent discount factor behave?
- How does a declining discount rate compare to a constant one in the short run? And in the long run? What are the implications for the social cost of carbon?
- Tjalling Koopmans showed that, for infinite horizon problems, an intertemporal welfare function cannot satisfy both Strong Pareto and Anonymity. What's Strong Pareto? What's Anonymity? Why did Koopmans sacrifice Anonymity?
- There is an intertemporal welfare function that satisfies Strong Pareto and Non-Dictatorship of present and poorest. What does that look like? What are the implications for the social cost of carbon?
- How would you measure the rate of discount?

10 Uncertainty

- How does the expected or mean social cost of carbon relate to the best-guess or modal social cost of carbon? Is it bigger, smaller, the same? Why?
- What is the first-order condition for optimality for a static problem? How do you trade-off costs and benefits?
- What is the first-order condition for optimality for a dynamic problem? How do you trade-off costs and benefits?
- What is the first-order condition for optimality for a static problem under uncertainty? How do you trade-off costs and benefits?
- What is the first-order condition for optimality for a dynamic problem under uncertainty? How do you trade-off costs and benefits?
- When thinking about dynamic problems, what does irreversibility mean?
- When thinking about dynamic problems, what does learning mean?
- How can the *prospect* of future learning affect current decisions?
- We talked about the expectation of damages of climate change. What is the certainty equivalent?
- What is the risk premium? Is it positive or negative? Why?
- Under what conditions can the risk premium become very large? Does this apply to climate change?
- Explain Marty Weitzman's Dismal Theorem in your own words.
- If you cannot do expected cost-benefit analysis, how would you advise policy instead?
- How would you measure the rate of risk aversion?

11 Equity

- Suppose that you have the impacts of climate change estimated, in dollar terms, for every country. Should you add up these dollar numbers to the global total? Why?
- Describe equity weights in your own words.
- What happens to the social cost of carbon if you apply equity weights?
- Are there positive effect of carbon dioxide emissions on poor countries?
- Equity weights tend to increase the social cost of carbon. If you live in a rich country, would it not be cheaper to compensate poor people for the impact of climate change rather than pay a higher carbon tax?
- How would you measure the rate of inequity aversion?
- Is there a difference between inequity aversion and fairness?
- How would you measure preferences for fairness?
- Is there a difference between aversion to inequity between and within societies?
- According to the Ramsey rule, we discount the future for two reasons: We expect to grow richer and happier, and we are impatient. What happens to the social cost of carbon if we become more impatient?
- What happens to the social cost of carbon if the utility function is more curved?
- What happens if we introduce uncertainty?
- What happens if we introduce equity?
- What happens if we introduce both uncertainty and equity?

12 International environmental agreements

- What is a public good?
- Why is greenhouse gas emission reduction a public good?
- What does an unregulated market do to public goods? Is cooperative emission control stricter or more lenient than non-cooperative emission control?
- Describe free-riding in your own words. Who would free-ride first? What are the implications for a global agreement on greenhouse gas emission reduction?
- Cartel or coalition stability meets three conditions. What are these?
- Scott Barrett found that the stable coalition is either small and deep or large and shallow. What does he mean by that? How did he reach this conclusion?
- d'Aspremont and Barrett assume that there is one coalition only. What happens if there are multiple coalitions?
- Are multiple coalitions more or less helpful with global or continental problems?
- The international negotiations on climate policy aimed to establish legally binding emission reduction obligations. How successful was that?
- Since Lima 2014, the international negotiations are about intended, nationally determined contributions. What are those?
- Why is this a more realistic prospect?
- But what about the Paris Agreement of 2015? Did that not create binding targets?
- Game theory predicts that it is difficult if not impossible to provide a global public good such as greenhouse gas emission reduction. The experience of the international climate negotiations confirm this. Yet, there are two successful international environmental agreements, one for reducing acidifying gases and one for the protection of the ozone layer.
- What is acid rain?
- Why is acid rain a problem?
- What are the main sources of sulphur emissions?
- How long does sulphur dioxide stay in the atmosphere and how far does it travel?

- Which countries signed up to the initial agreement to reduce acidifying emissions? Did other countries join later? How is this different from the climate negotiations?
- Sulphur emissions are falling in Europe. Is this due to acid rain policy or are there other factors at play too? What role did Margaret Thatcher, famed champion of the free market, play in reducing sulphur emissions?
- Can you think of parallels to the climate problem?
- Why did coal-fired power plants in the UK close?
- Meat is an important source of methane and carbon dioxide. What is happening with novel protein foods, such as Quorn, Beyond Meat, and Impossible Burgers? How are these advertised?
- What is the ozone layer? What does it do?
- How come there is a hole in the ozone layer?
- Why is it bad that there is a hole in the ozone layer?
- What can be done to fix the hole in the ozone layer?
- How many countries signed up to the initial agreement to reduce ozone-depleting substances? How does this compare to the climate negotiations?
- Why did Ronald Reagan, famed champion of the free market, suddenly change course on environmental regulation?
- Why did India sign up to the Montreal Protocol?
- Why did China?
- How did trade sanctions incentivize small countries to sign up to the Montreal Protocol?
- What would be the parallel to climate policy?
- Can other parts of international ozone law be used to reduce climate change?