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What *Should* We Be Teaching Students about the Economics of Climate Change: Is There a Consensus?

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ABSTRACT

Research on the economics of climate change has advanced drastically in the last 20 years, but how has treatment of climate change evolved in the classroom? Many economics, environmental studies, and public policy departments now offer climate economics and climate policy courses, but it is unclear what topics are covered, what resources are used, and with what knowledge students are expected to walk away. In this paper, we assess what topics are (or should be) taught in climate economics courses, how those topics have shifted over time, and what learning goals are articulated for students. Our assessment is based on a review of common teaching materials, an informal collection of syllabi, and the results from a survey of environmental and resource economists.

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Overall, there is a reasonable degree of consensus on the key topics for inclusion across survey respondents, although some topics may complement or crowd out those in standard courses in environmental and resource economics. Despite relatively broad consensus on topics, we find that climate economics courses can diverge greatly in practice, perhaps because there is no central teaching resource used across courses. We conclude constructively by proposing a set of learning goals that instructors can draw from and build upon, which we hope will aid in developing shared expectations for what students will learn in a climate economics course.

Keywords: Climate change; economic education; climate economics; environmental economics; learning goals

JEL Codes: A2, Q5, Q54

1 Introduction

On January 20, 2021, the United States announced its intention to rejoin the Paris Agreement, re-affirming a commitment to working toward mitigating global CO_2 emissions. On January 25, the Federal Reserve created a Supervision Climate Committee. The mission of this committee is "to assess the implications of climate change for the financial system—including firms, infrastructure and markets in general."[1] Much of this work will involve a risk assessment. This came after the Federal Reserve Board, for the first time, acknowledged climate-related risk in its semi-annual *Financial Stability Report.* (Board of Governors of the Federal Reserve, 2020). And on January 27, President Biden signed an executive order creating the White House Office of Domestic Climate Policy with a goal of creating a carbon-free power sector by 2035 and a path to a net-zero economy by 2050 all while

[1] Climate Wire. https://www.eenews.net/climatewire/2021/01/26/stories/1063723523?utm_campaign=edition&utm_medium=email&utm_source=eenews%3Aclimatewire 1/26/2021.

creating new well-paying jobs.[2] All of these steps suggest that the United States may be moving toward implement climate policy that has until now been elusive.

Economics, and environmental and climate economics in particular, has a large role to play in the evaluation of policy. The measurement of benefits and distributional impacts of policies focused on mitigation of and/or adaptation to climate change requires careful economic analysis. Courses that focus on teaching undergraduate students might best serve those students by teaching them decision-making tools from our discipline and the underpinnings of those tools. The incorporation of uncertainty and the large trade-offs we face as well as the massively unequal distribution of costs and benefits are additional skills that will help create future decision-makers that understand the complex analysis and the importance of using science to inform policy. Are we doing that? What are we teaching our students, what should we be teaching our students, and how has that changed over time?

In this paper, we present the synopsis of an informal review of syllabi on climate economics and policy courses, and we assess common material and resources covered in those courses. We then present the results of a survey of environmental and resource economists on teaching with a focus on topics relevant to climate change economics and policy. Overall, there is a reasonable degree of consensus on the key topics for inclusion across survey respondents, although some topics may complement or crowd out those in standard courses in environmental and resource economics. Despite relatively broad consensus on topics, we find that climate economics courses can diverge greatly in practice, perhaps because there is no central teaching resource used across courses. We conclude constructively by proposing a set of learning goals that instructors can draw from and build upon, which we hope will aid in developing shared expectations for what students will learn in a climate economics course.

[2] https://www.whitehouse.gov/briefing-room/statements-releases/2021/01/27/fact-sheet-president-biden-takes-executive-actions-to-tackle-the-climate-crisis-at-home-and-abroad-create-jobs-and-restore-scientific-integrity-across-federal-government/

2 Background

2.1 Literature and Teaching Materials

A review of the literature produces numerous articles on the teaching of general methods of the economics of pollution mitigation (which can include climate change), such as on cap and trade or taxes (see, for example, Decker, 2019; Duke and Sassoon, 2017; Weber, 2002; McPherson *et al.*, 2014; Lewis, 2011; Nguyen and Woodward, 2008; Holt *et al.*, 2010; Corrigan, 2011; Foquet, 2013; Carattini *et al.*, 2020; Anderson and Stafford, 2000; Ando and Harrington, 2006); as well as some literature on the teaching of the problem of the commons (Andrews, 2002; Hazlett, 1997), and on enforcement (Murphy and Cardenas, 2004). This literature is examined in more detail in another paper in this special issue (Gonazelz, Cavilgia-Harris and Whitehead, this issue).

Only a handful, however, tackle climate change head-on. Those include Tsigaris and Wood (2016), Fortmann *et al.* (2020) and Casey (forthcoming).

With a focus on teaching undergraduate students, Tsigaris and Wood (2016) present a simple integrated assessment model, which includes a simple growth model based on the Solow model and a simple climate model. This is basically a simplified version of the DICE model, which allows students to explore a range of options based on differing damage functions, discount rates, and growth assumptions. There are also varying parameters on temperature and emissions. They then explore the use of benefit–cost analysis. Most useful for teaching, Appendix A provides details for setting up and running the model in Excel.

Fortmann *et al.* (2020) also utilize Excel modules for teaching. They present two models; one in which students estimate (and graph) marginal expected damages from sea-level rise, and the other for which they estimate (replicate) the total economic value of the arctic. For both of these modules, students use referenced literature to determine the parameters of the models. Students also have the ability to add an updated parameter if one exists. Fortmann *et al.* also provide the teaching materials for these two modules.

Both of these articles rely on computation-guided inquiry for teaching. Casey (forthcoming) provides a personal evolution in the teaching of climate change economics in his Environmental and Natural Resource

Economics course. Within this course, he teaches a module on energy, air pollution and climate change, and this paper outlines his approach to that module. He highlights some of the changes over time in coverage in some environmental economics textbooks; he also emphasizes changing perceptions (beliefs) about climate change over time. He introduces what he calls a call TADCOM model, or the Total Acquisition and Dissipation COst Model. This model is used to calculate the full cost of producing and consuming energy resources. He emphasizes the science of climate change and the uncertainty as it relates to discount rates and urgency. This article provides examples of the literature he uses in his course and the caveats he believes students need to be exposed to.

While these articles all provide useful examples, they illustrate how thin this literature is. In this paper, we attempt to fill a gap in the literature about the teaching of climate change, focusing on more fundamental and holistic questions of what topics are being taught and what knowledge students should walk away with.

2.2 How Good Is the Treatment of Climate Change in Our Textbooks?

Economics principles courses have, for the most part, increased their coverage of climate change. Economist Yoram Bauman in 2000, began an analysis of introductory textbooks when he discovered a text that described climate change as a hoax. In 2010, he produced an online "Grading Economics Textbooks on Climate Change," which was updated in 2012, 2014 and 2017 with each subsequent grading round producing somewhat better treatment of climate change. In a survey of 27 principles texts, Liu *et al.* (2019) find that

> "not all texts touch upon climate science, and a small subset deviates from the scientific consensus on the human causes of climate change. All texts conceptualize climate change as a problem of carbon emission's negative externalities and the preferred market-based solutions, such as emission trading and Pigouvian tax. Besides externalities, some authors include various useful points of engagement through GDP (Gross domestic product) accounting, economic growth, collective action problems, cost–benefit analysis, and global inequality."

In general, they find that current coverage of climate change is quite narrowly focused, appearing primarily in the theory of externalities or environmental economics section if there is one.

> "In our audit, 10 out of the 27 books clearly presented the idea of a scientific consensus about climate change; thirteen books did not discuss climate science. Somewhat alarmingly, there were four texts that focused on the idea that climate science was not settled."

While noting that in most principles textbooks, the words "climate change" do not appear until later chapters in the book, they also note that almost all texts devoted significant attention to market-based incentives such as cap and trade and Pigouvian taxes. Twenty one of the 27 books also covered the Coase Theorem. They also note that policy discussions in virtually all texts are significantly outdated. Other than the externality framework, introductory texts seem to vary widely on what, if any, additional climate-related topics are covered and how, including global inequality, adaptation, cost–benefit analysis, green GDP, for example.

Additionally, we conducted an informal survey of environmental economics textbooks, which suggests that the coverage of climate change has increased in recent years. Just about every topic covered in a typical environmental economics text could be applied through the lens of climate change — benefit–cost analysis, valuation, mitigation, biodiversity, etc., however, the amount of coverage in textbooks varies widely. Though the textbooks have stand-alone chapters on climate change are limited, there are some notable exceptions.

For example, early editions of Tietenberg's *Environmental and Resource Economics* textbook covered climate change as part of the global and regional pollutants chapter. That chapter first appeared in the second edition (1988), and it contained a section discussing climate change, greenhouse effect, and greenhouse gases. That section had six pages. Climate change first had its own chapter in the 9th edition (Tietenberg and Lewis, 2012). This edition also included a separate chapter on energy which was not new to the book, but its location in the text was about ten chapters away from climate change.

By 2020, however, with the publication of the 7th edition of *Environmental Economics and Policy* (Lewis and Tietenberg, 2020), there were four chapters devoted exclusively to climate change, including the following chapter titles: "The Nature of the Problem," "The Role of Energy Policy," "Carbon Pricing," and "Adaptation."

Additionally, Harris and Roach (2018) have two stand-alone chapters on climate science and climate policy, respectively. Perhaps most progressive on climate change, Goodstein and Polasky (2020) infuse climate change examples throughout their book. Several other textbooks do not mention climate change in the table of contents (e.g., Field and Field, 2017; Kolstad, 2010; Perman *et al.*, 2011).

2.3 Alternatives to Textbooks: Nordhaus vs. Weitzman and Wagner

Textbooks focused exclusively on the economics of climate change are few. As a result, two widely used resources include *Climate Casino* by William Nordhaus and *Climate Shock* by Martin Weitzman and Gernot Wagner. Neither of these books is a traditional "textbook" as they are written for a more general audience for the most part, but they do show up frequently as required readings in undergraduate courses. Typically, these are paired with a more traditional environmental economics textbook (Keohane and Olmstead (2016) is a common choice here) and/or with articles from both the literature, popular press, and governmental agencies. Tol's *Climate Economics* (2014) is another possibility though the coverage is much more advanced and likely most widely used with graduate students, though it is also appropriate for advanced undergraduates.

Based on a sample of 30 syllabi that we collected informally from colleagues, the Nordhaus book shows up quite frequently as required or optional reading on syllabi for courses that focus on the economics of climate change. Usually, that reading requirement is partnered with an environmental economics textbook.

Unfortunately, the Nordhaus book is now quite dated and relies on climate model findings and impacts that are now woefully behind the reality and pace of climate change. The book also leans hard on the growth/environment tradeoff and frequently comes down on the side of not being willing to sacrifice much growth in order to prevent damages that are "far into the future."

The book favors strict benefit–cost analysis and there is an emphasis on traditional integrated assessment models. It is also mostly silent on the major distributional impacts of climate change impacts and policies and sometimes ignores the complexity and barriers to adaptation strategies such as migration.

Weitzman and Wagner's *Climate Shock* is in some ways a much lighter read, but the thorough endnotes provide enough citations and explanations to create an extensive course reading list. This book focuses more on fat tails, uncertainty, and climate catastrophe than *Climate Casino*. As such, it paints an entirely different picture about the limitations of benefit–cost analysis and of integrated assessment models. Weitzman and Wagner also spend time discussing the potential for geoengineering and the potential for unintended consequences and negative side effects.

While both books discuss the DICE model and its important contributions to the economics of climate change, Weitzman and Wagner spend more time discussing its limitations and the grossly simplifying assumptions of many integrated assessment models. They also spend time pointing out that growth and environment are not necessarily tradeoffs. Nordhaus suggests that if damages from climate change are a small percentage of GDP, and those damages are far into the future, the global economy will have grown so much by then, it will offset those impacts. Weitzman and Wagner emphasize that simply changing the functional form of the damage function (or assumptions about growth rates) can result in very different policy recommendations. They also emphasize that there is great uncertainty about what the distribution of damages looks like at high temperatures so we should consider the entire distribution rather than relying on expected values.

These two books, while covering similar topics, diverge wildly on urgency and the measurement of risk. The Nordhaus book emphasizes growth that will outweigh damages, expected values, a 4% discount rate, and a $20–25 price on carbon while the Weitzman and Wagner book emphasize the catastrophic risk of climate and economic collapse, fat tails, a 2% discount rate or less and declining over time, and a price on carbon of at least $40. Both books offer little in the way of discussion of adaptation (though Weitzman and Wagner have a chapter on the promise and risk of geoengineering), but both acknowledge that both adaptation and mitigation will be necessary.

This stark contrast and wildly different tones should not be surprising to those familiar with the longstanding debate in the economics literature about discounting and the social cost of carbon (e.g., Nordhaus, 2007; Weitzman, 1998, 2007, 2011, although there are numerous others). Uncertainty suggests low or declining discount rates; for Nordhaus, 4%, Stern, 1.4%, and the US government 3% (Weitzman and Wagner, 2015). Nordhaus's *Climate Casino* leans toward a wait-and-see approach, growth will likely outweigh damages while Weitzman and Wagner express much more urgency in the need for climate policy aimed at avoiding the (too high) risk of fat tail events and climate catastrophe. Weitzman and Wagner offer two clear messages: insuring against risk is important; and pricing of externalities that reflects the true costs of our actions is needed.

Do these normative takes on what should be done about climate change help us think about appropriate pedagogies for undergraduate students? Normative debates, while extremely important, many times confuse students. Is there a convergence of opinion on what students should know?

3 What Do Environmental and Resource Economists Think We Should Be Teaching Students of Climate Economics?

These debates do offer some important insights and questions about the teaching of the economics of climate change. What should we be teaching our students? What are the topics that we should emphasize and what are the appropriate learning goals? How have these courses evolved over time as the science has evolved and as public perceptions have ranged so wildly and recently politics has distorted, sometimes grossly, the facts?

To answer some of these questions, we first collected an informal sample of syllabi from a query on both the RESECON listserv and on Twitter by the authors of this paper. The 30 syllabi we collected illustrated a strong consensus that starting a course with some examination of the natural science behind climate change is appropriate. From there, the courses diverge wildly on topics (both in breadth and depth) and on learning goals. In fact, it is possible to take two different courses on climate economics and not have any overlap in coverage of topics!

Given the wide-ranging coverage, we chose to conduct a more far-reaching survey on the teaching of climate economics and policy. Using the syllabi and various textbooks as a guide, we created a list of possible topics that a course might include.

3.1 Survey Design and Implementation

We asked several experts/experienced academics who teach environmental economics and the economics of climate change to pre-test our survey key topics to help us determine if our questions were appropriate and clear and to get input on any topics we might have overlooked. We then implemented the survey by posting it on the RESECON listserv on December 21, 2020, with a follow-up email on December 30, 2020. We also received permission from the Association of Environmental and Resource Economists (AERE) to use their membership list to send an email. This email was sent out from the AERE email on January 6, 2021.[3]

We received 256 surveys over the course of December 2020 and early January 2021. Of the 256 respondents, 196 completed the survey in its entirety. We focus on the 196 complete responses.[4] Our survey sample comprises environmental and resource economists across a range of ranks, positions, ages, and geographies. Twenty-four percent of respondents are Assistant Professors, 19% are Associate Professors, and 30% are Professors. Additionally, about 10% are post-docs or graduate students, and the remaining respondents are in government, the private sector, or at a research institute. Of the academic respondents, 76% are from research universities, 12% are from liberal arts colleges, and 12% are from primarily undergraduate universities. 81% of our respondents live and work in North America, although we have at least one respondent each from Europe, Asia, South America, and Australia.

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[3] We include the entire survey instrument in the online Appendix A.

[4] Both "completers" and "noncompleters" earned Ph.Ds, on average, in the mid 2000s. The respondents who completed the survey were more likely to hold a faculty position and more likely to work at a research university than "noncompleters." Additionally, respondents who completed the survey were more likely to have taught an environment-related economics course for 6 or more years. There is, however, no statistical difference between the two groups in the likelihood that they teach a climate-related economics course or for how long they taught that course.

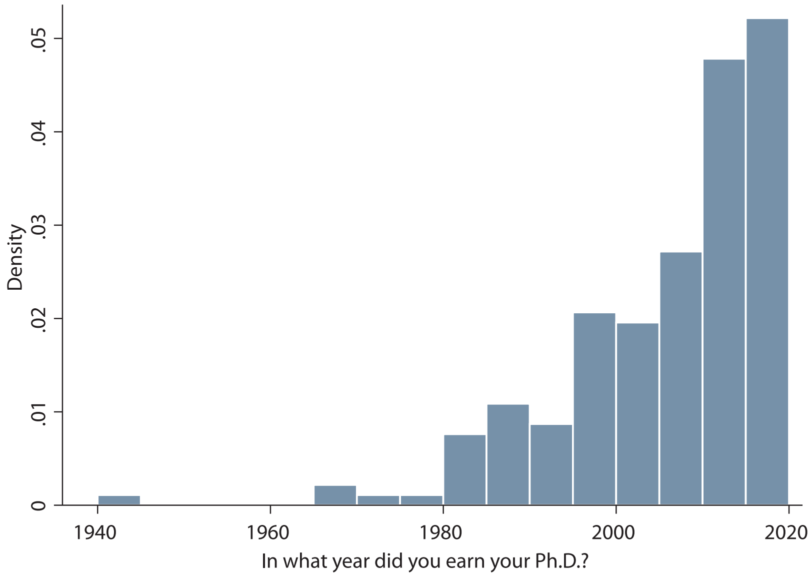

Figure 1: Year of PhD for survey respondents.

We asked when the respondent earned their PhD and the responses ranged from 1944 to 2020, with a mean of 2005 and median of 2009.[5] Twenty-four respondents did not report their year of PhD; these respondents are predominantly current graduate students. In Figure 1, we plot the distribution of year PhD was received across all our survey respondents. Figure 1 shows the majority of respondents earned their PhD in the last 10–15 years, although many respondents earned their PhDs in the 1980s and 1990s as well. This distribution suggests we have good coverage of recent PhDs and economists who have been in the profession for many years.

3.2 How Many People Are Teaching Climate Change Economics?

All but 8 (96%) of our respondents have taught some form of an economics course related to the environment at either the undergraduate

[5]Although we cannot be certain, we suspect the 1944 date is a typo for the date of PhD. This respondent, however, has provided reliable and believable repsonses to other survey questions.

or graduate level, broadly defined.[6] Considerably fewer respondents teach or have taught a course solely focused on the economics of climate change and policy. We observe that only 38 respondents (20%) in our sample teach or have taught a climate-specific economics course. An additional 44 respondents (22%) do not currently teach a climate-specific course, but they report that they plan to teach one. The remaining 134 respondents claimed that they do not teach a climate-specific course, nor do they plan to.

In Figure 2, we show the length of time respondents have taught (in the left panel) a course related to the economics of the environment and (in the right panel) a course on the economics of climate change. More than 60 respondents (32%) have been teaching a course related to the economics of the environment for more than 10 years, which decreases monotonically toward one year, with fewer than 20 respondents (10%). In contrast, only 3 out of 36 respondents (8%) who teach a course focused on the economics of climate change have taught it longer than

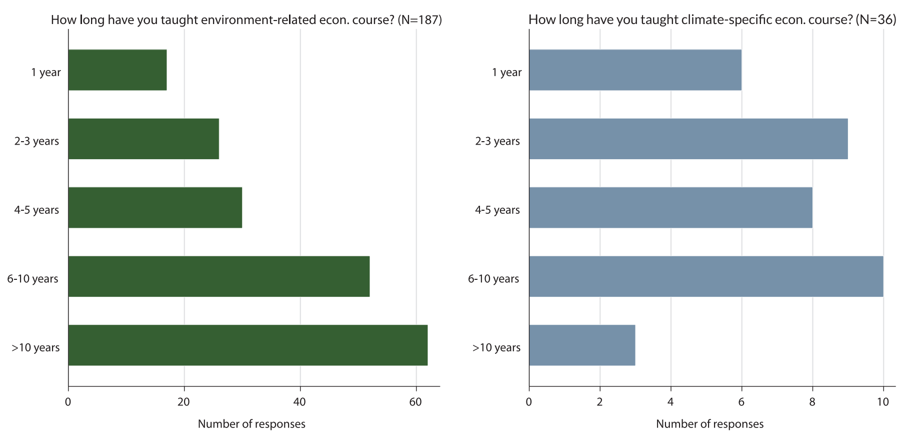

Figure 2: Length of time teaching an environment-related economics course or a climate-specific economics course.

[6]In the survey, we explicitly defined "related" courses as: Environmental Economics, Natural Resource Economics, Environmental and Resource Economics, Benefit–Cost Analysis, Energy Economics, as well as a write-in field, which garnered many additional responses than the ones we used as prompts.

10 years. The majority of respondents who teach climate change have been teaching it for fewer than 5 years (58%).

3.3 How Much Is Climate Change Being Taught in Economics (and Related) Fields?

Because many courses related to the environment may focus on climate change for a portion of the course or, e.g., use climate change as an example of an externality that requires government intervention, we asked respondents how much of their related courses focus on climate change topics. We present these results in Figure 3. The results are relatively consistent across the first four panels, which include variants of environment, resource, and energy economics courses. Most respondents reported that they spend between 10% and 30% of their related environment/resource/energy course on climate change. In some cases, particularly for Environmental Economics and Environmental and Natural Resource Economics, respondents report dedicating upwards of 70–80% of course time to climate change. This pattern holds for the course that is not obviously environment-related (Benefit–Cost Analysis), although our survey is likely biased towards environmental economists who happen to teach such a class and thus use environmental examples. We received a diverse set of responses on "related" courses, ranging from the Economics of Climate Change to Money and Banking, and we continue to see large percentages of course time devoted to climate change. The "100% of time on climate change" responses are almost surely climate-focused classes, despite our best attempt at assuring the respondents that we would ask about a stand-alone climate course later in the survey.

We also asked the respondents how the coverage of climate change in related courses has changed over time. We present those results in the last panel in Figure 3. Only one person responded that they spend *less* time on climate in their related course, 98 respondents (59%) spend about the same amount on climate change, and 68 respondents (40%) reported spending *more* time on climate change in their related courses.

Collectively, we take this initial descriptive information to mean that climate change is discussed and taught as a nontrivial proportion of common environment-related courses, despite the fact that we see relatively few stand-alone climate courses in our sample. Additionally,

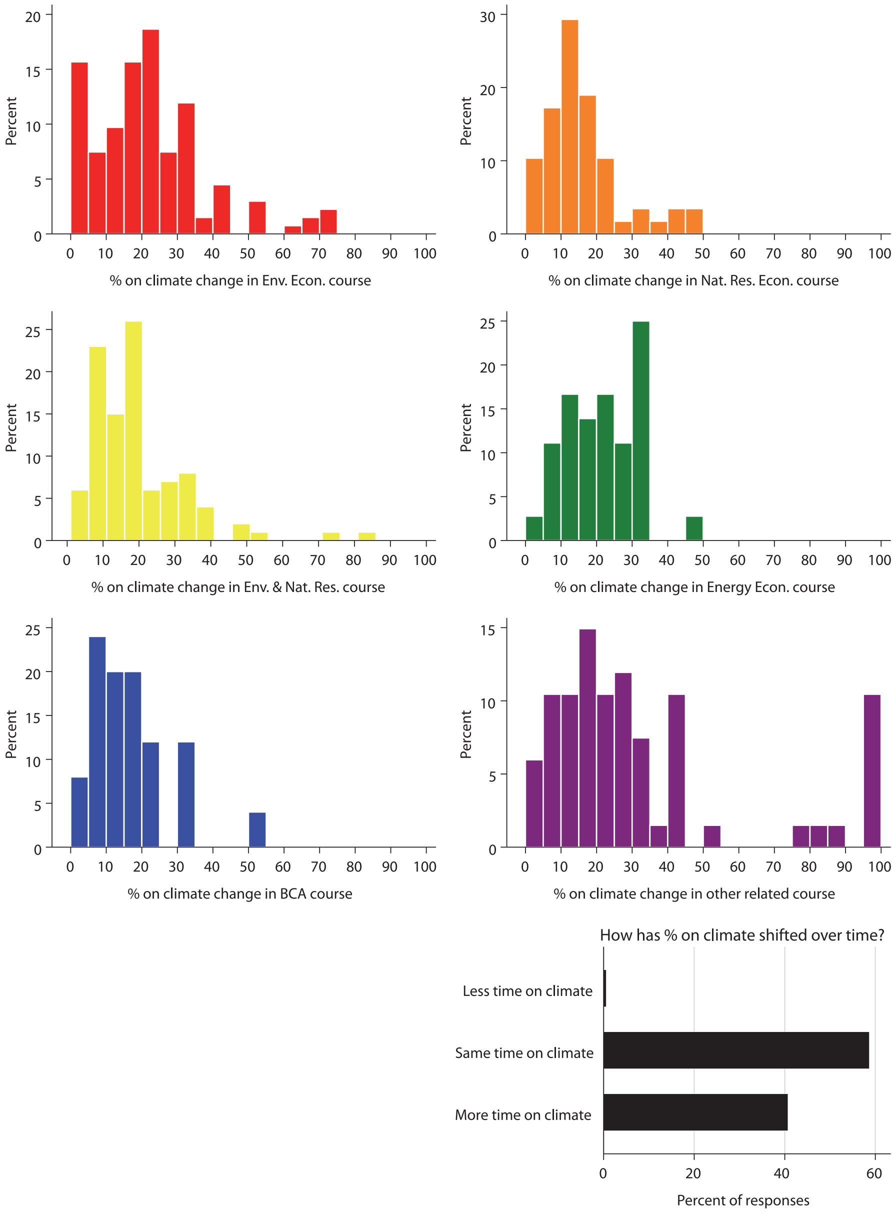

Figure 3: What percentage of course time in environment-related economics courses focuses on climate change, and how has that percentage changed over time?

the proportion of time spent on climate in related courses is increasing, potentially crowding out topics that would have otherwise be covered, although many of the methodological tools taught in environmental economics courses can be applied to climate examples. These trends suggest an increasing supply of climate content to economics students alongside the standard treatment of environmental and natural resource topics, presumably to match demand from students. Going a step further, we speculate that these trends indicate support for a climate-specific course in economics (and related) departments to complement the standard, and more common, environmental and natural resource curricula.

3.4 What Climate Topics Are Being Taught?

In the survey, we presented a list of 40 topics related to climate change, with additional space for write-in comments, and asked respondents to rank the importance of inclusion in an environment-related economics course and a climate change economics course using the following scale: "Never include," "If time permits," "Always (lightly)," and "Always (in-depth)." We present the results, and the full list of topics, in Figure 4 for a related environmental course and in Figure 5 for a course on climate change economics. As shown, the percentages and shaded colors in each bar represent the percentage of respondents that chose a given importance option for that topic.

We first focus on the results of the environment-related course in Figure 4. An initial observation is that all of the topics had at least some positive percentage of respondents always including that topic in their course, suggesting our choice of topics was relevant. The topic with the most "Always include in-depth" responses was Public Goods and Externalities, which was included in nearly every course, either lightly or in-depth. The next most popular topics are also sensible: Discounting, Instrument Choice, Decision-Making, Abatement Costs, and Measuring Damages (both revealed and stated preference) were included in the vast majority of courses. This finding is intuitive, particularly because these topics are not specific to climate change. These topics would likely be included in an environmental economics course even if climate change was never mentioned.

Of topics that are more climate-specific, we see varied inclusion in a related environmental courses. Fat tails and tipping points are included

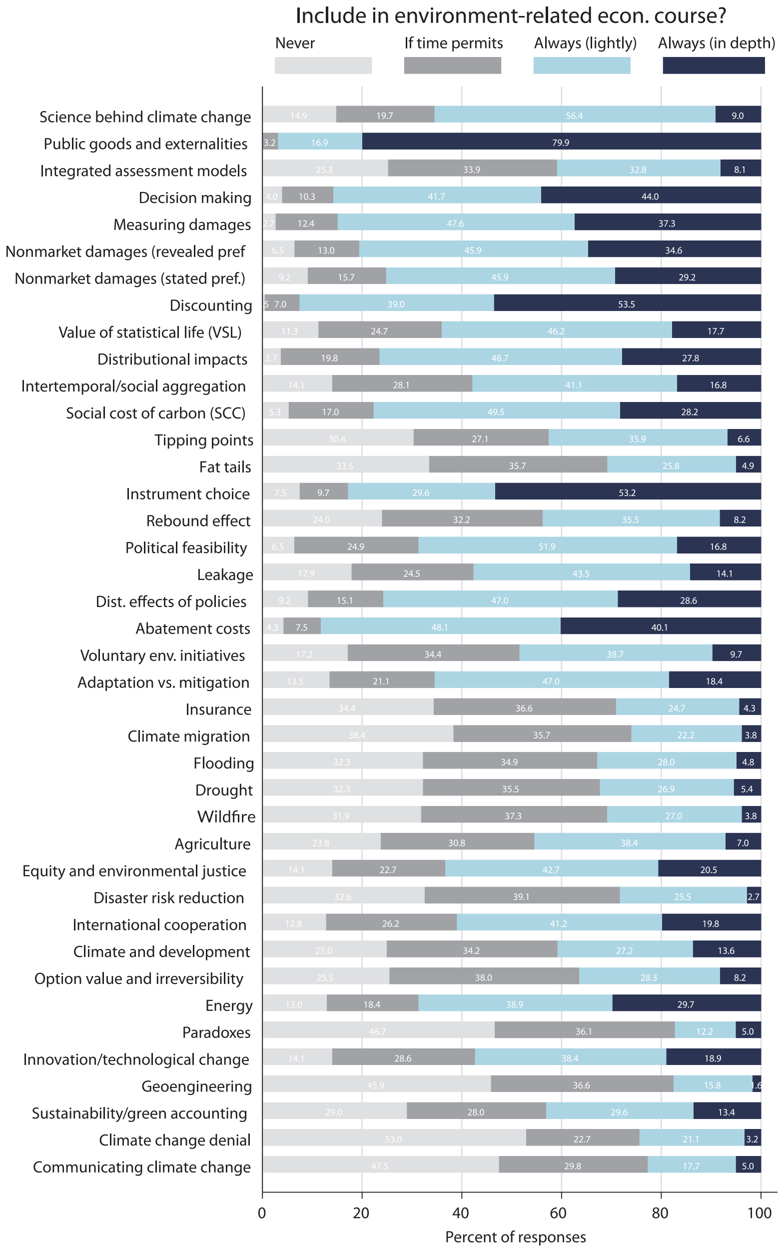

Figure 4: Responses for which topics would be covered in an environment-related economics course.

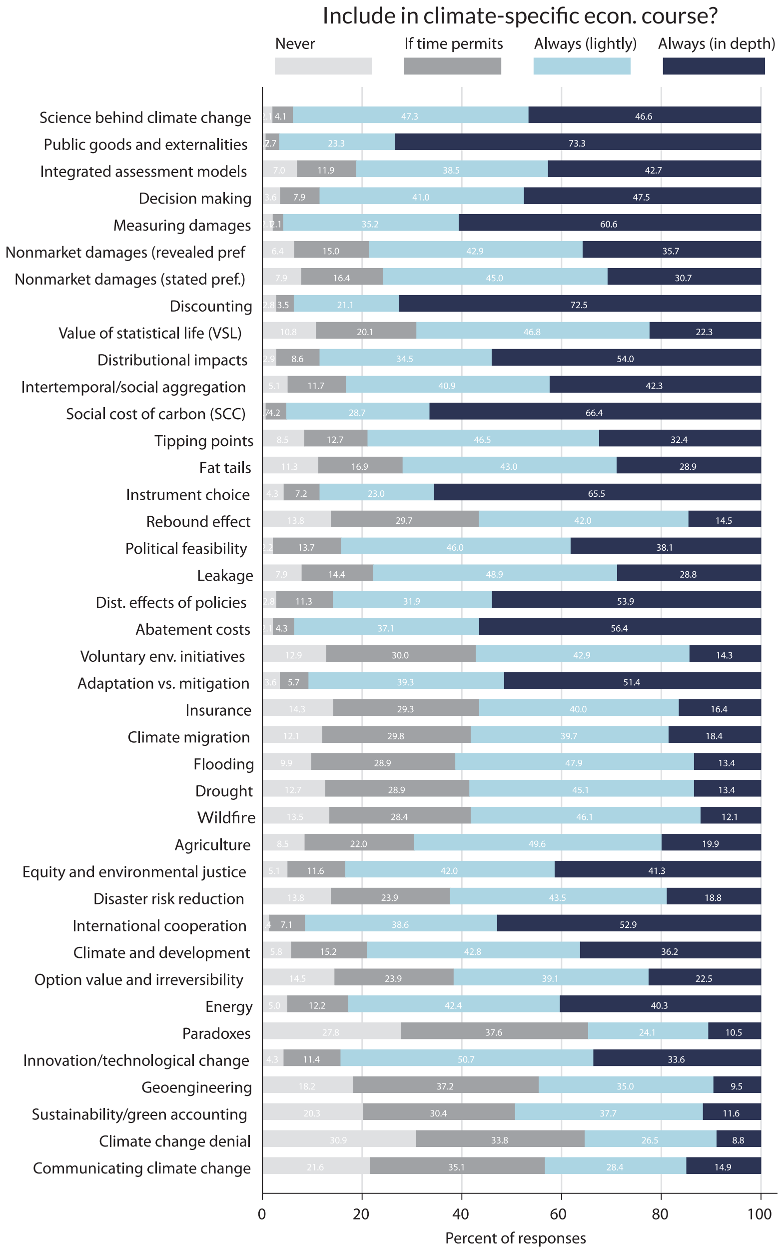

Figure 5: Responses for which topics would be covered in a climate-specific economics course.

at least lightly in 30–40% of environmental courses. Climate topics with relatively low inclusion rates include geoengineering, paradoxes, climate change denial, and communicating climate change, although these topics still appear in 20–25% of courses. Other topics that have inclusion rates (at least lightly) greater than 50% include adaptation vs. mitigation, international cooperation, innovation and technological change, distributional effects, and equity and environmental justice. Several of those latter topics, however, could apply more broadly to a different types of environmental problems.

Next, we examine the results of the same analysis, but for a course specifically focused on the economics of climate change. In Figure 5, we see nearly across-the-board increases in inclusion rates of all of the topics listed. Because the majority of respondents have not taught a climate-specific course, we asked explicitly to choose the topics that would be included if the respondent were to teach a course in the future. The following topics had inclusion rates (including 'lightly' and 'in depth') above 90%: Science behind climate change, public goods and externalities, measuring damages, discounting, social cost of carbon, abatement costs, adaptation vs. mitigation, and international cooperation.[7] Although the 90% threshold is arbitrary (and many additional topics exceed 80% inclusion rates), we take this list to be the core components of an economics course focused on climate change. On the other hand, the only topics that have inclusion rates (including 'lightly' and 'in depth' responses) less than 50% are communicating climate change, climate change denial, sustainability/green accounting, geoengineering, and paradoxes. But, even these topics have inclusion rates of at least 35%.

Additionally, we are interested in whether the characteristics of the respondent influence the climate topics that they teach. In Tables 1 and 2, we break up our sample by whether the respondent earned their PhD before/after 2010 and whether the respondent actually teaches a course on climate change (rather than developing a hypothetical climate course). We present means and standard deviation of the 1–4 inclusion score, and perform pairwise t-tests across groups. In Table 1, there is remarkably little difference across the responses from relatively junior and relatively senior instructors. Of the 40 topics, only 4 of the differences in means are significant at the 10 percent level. These

[7] Given their prevalence, these topics could be sensible section breaks in a syllabus.

Table 1: Mean survey responses for topics included in a climate economics course, segmented by when the respondent's PhD was received.

	Year of PhD < 2010		Year of PhD >= 2010		
	Mean	SD	Mean	SD	Diff.
Science behind climate change	3.33	(0.74)	3.44	(0.58)	0.10
Public goods and externalities	3.67	(0.58)	3.72	(0.54)	0.05
Integrated assessment models	3.19	(0.92)	3.14	(0.88)	−0.04
Decision making	3.30	(0.77)	3.35	(0.78)	0.06
Measuring damages	3.57	(0.66)	3.51	(0.63)	−0.05
Nonmarket damages (revealed pref.)	3.03	(0.86)	3.14	(0.89)	0.11
Nonmarket damages (stated pref.)	2.95	(0.87)	3.03	(0.91)	0.08
Discounting	3.59	(0.74)	3.68	(0.63)	0.08
Value of statistical life (VSL)	2.80	(0.91)	2.82	(0.92)	0.02
Distributional impacts	3.43	(0.72)	3.35	(0.82)	−0.08
Intertemporal/social aggregation	3.11	(0.89)	3.31	(0.77)	0.20
Social cost of carbon (SCC)	3.59	(0.59)	3.62	(0.62)	0.03
Tipping points	3.03	(0.96)	3.03	(0.81)	0.00
Fat tails	2.85	(1.02)	2.94	(0.88)	0.09
Instrument choice	3.49	(0.83)	3.51	(0.79)	0.02
Rebound effect	2.58	(0.89)	2.56	(0.92)	−0.02
Political feasibility	3.19	(0.78)	3.21	(0.73)	0.02
Leakage	3.04	(0.85)	2.92	(0.89)	−0.12
Dist. effects of policies	3.35	(0.83)	3.39	(0.76)	0.04
Abatement costs	3.50	(0.69)	3.45	(0.68)	−0.05
Voluntary env. initiatives	2.53	(0.95)	2.65	(0.81)	0.12
Adaptation vs. mitigation	3.34	(0.83)	3.44	(0.66)	0.10
Insurance	2.46	(0.97)	2.73	(0.87)	0.27*
Climate migration	2.68	(0.89)	2.61	(0.95)	−0.06
Flooding	2.53	(0.78)	2.78	(0.88)	0.25*
Drought	2.45	(0.83)	2.75	(0.90)	0.30**
Wildfire	2.46	(0.86)	2.69	(0.87)	0.23
Agriculture	2.74	(0.84)	2.88	(0.86)	0.14
Equity/environmental justice	3.26	(0.79)	3.12	(0.88)	−0.13
Disaster risk reduction	2.66	(0.94)	2.69	(0.94)	0.03
International cooperation	3.45	(0.72)	3.41	(0.66)	−0.04
Climate and development	3.09	(0.89)	3.09	(0.83)	−0.00
Option value and irreversibility	2.68	(1.04)	2.72	(0.92)	0.04
Energy	3.08	(0.84)	3.29	(0.82)	0.21
Paradoxes	2.12	(1.01)	2.23	(0.90)	0.10
Innovation/technological change	3.03	(0.84)	3.26	(0.69)	0.23*
Geoengineering	2.40	(0.91)	2.31	(0.87)	−0.08
Sustainability/green accounting	2.29	(0.92)	2.54	(0.95)	0.25
Climate change denial	2.14	(1.00)	2.13	(0.91)	−0.01
Communicating climate change	2.42	(1.03)	2.30	(0.94)	−0.13
Observations	104		92		196

Notes: Each mean represents the average survey response (ranging from 1 = Never Include to 4 = Always include (in depth)) for the topic listed. Diff., in the final column, is the difference in mean. *, **, and *** indicate statistical significance from a pairwise t-test at the $p < 0.1$, $p < 0.05$, and $p < 0.01$ level.

Table 2: Mean survey responses for topics included in a climate economics course, segmented by whether the respondent teaches climate economics.

	Doesn't Teach Climate Econ		Teaches Climate Econ		
	Mean	SD	Mean	SD	Diff.
Science behind climate change	3.39	(0.66)	3.35	(0.71)	−0.04
Public goods and externalities	3.71	(0.53)	3.62	(0.66)	−0.09
Integrated assessment models	3.12	(0.95)	3.37	(0.61)	0.25
Decision making	3.38	(0.73)	3.13	(0.88)	−0.25
Measuring damages	3.55	(0.60)	3.53	(0.80)	−0.01
Nonmarket damages (revealed pref.)	3.17	(0.80)	2.74	(1.03)	−0.43**
Nonmarket damages (stated pref.)	3.09	(0.81)	2.61	(1.05)	−0.48***
Discounting	3.69	(0.62)	3.44	(0.88)	−0.25*
Value of statistical life (VSL)	2.94	(0.82)	2.31	(1.07)	−0.63***
Distributional impacts	3.45	(0.69)	3.19	(0.98)	−0.26*
Intertemporal/social aggregation	3.24	(0.82)	3.10	(0.91)	−0.14
Social cost of carbon (SCC)	3.61	(0.57)	3.59	(0.71)	−0.02
Tipping points	3.09	(0.81)	2.81	(1.12)	−0.28
Fat tails	2.94	(0.91)	2.75	(1.08)	−0.19
Instrument choice	3.49	(0.80)	3.53	(0.86)	0.05
Rebound effect	2.64	(0.87)	2.35	(0.98)	−0.28
Political feasibility	3.18	(0.73)	3.29	(0.82)	0.11
Leakage	2.98	(0.84)	3.00	(0.97)	0.02
Dist. effects of policies	3.38	(0.78)	3.34	(0.87)	−0.03
Abatement costs	3.48	(0.66)	3.48	(0.77)	0.01
Voluntary env. initiatives	2.63	(0.85)	2.44	(1.01)	−0.19
Adaptation vs. mitigation	3.45	(0.71)	3.16	(0.86)	−0.29*
Insurance	2.65	(0.84)	2.38	(1.18)	−0.27
Climate migration	2.72	(0.82)	2.41	(1.19)	−0.31*
Flooding	2.70	(0.75)	2.47	(1.08)	−0.23
Drought	2.65	(0.77)	2.38	(1.16)	−0.28
Wildfire	2.65	(0.76)	2.28	(1.14)	−0.37**
Agriculture	2.79	(0.78)	2.88	(1.07)	0.09
Equity/environmental justice	3.25	(0.74)	3.00	(1.11)	−0.25
Disaster risk reduction	2.79	(0.82)	2.27	(1.20)	−0.52***
International cooperation	3.41	(0.71)	3.48	(0.63)	0.07
Climate and development	3.13	(0.80)	2.97	(1.05)	−0.16
Option value and irreversibility	2.81	(0.92)	2.29	(1.07)	−0.52***
Energy	3.21	(0.80)	3.06	(0.96)	−0.15
Paradoxes	2.22	(0.91)	2.00	(1.11)	−0.22
Innovation/technological change	3.14	(0.79)	3.13	(0.76)	−0.01
Geoengineering	2.36	(0.89)	2.35	(0.91)	−0.00
Sustainability / green accounting	2.52	(0.89)	2.00	(1.00)	−0.52***
Climate change denial	2.21	(0.92)	1.87	(1.06)	−0.34*
Communicating climate change	2.38	(0.97)	2.32	(1.05)	−0.06
Observations	158		38		196

Notes: Each mean represents the average survey response (ranging from 1 = Never Include to 4 = Always include (in depth)) for the topic listed. Diff., in the final column, is the difference in mean. *, **, and *** indicate statistical significance from a pairwise t-test at the $p < 0.1$, $p < 0.05$, and $p < 0.01$ level.

significant differences suggest that relatively junior instructors are more likely to include the following topics: insurance, flooding, drought, and innovation and technological change.

In Table 2, we conduct a similar analysis broken up by whether the respondent has actually designed and taught a climate economics course.[8] Here, we see more statistical differences and, interestingly, all of the significant differences suggest that topics are included *less* frequently by instructors who have taught a climate economics course. These topics include nonmarket damages (revealed and stated preference), value of a statistical life, distributional impacts, adaptation vs. mitigation, climate migration, wildfire, disaster risk reduction, option value and irreversibility, sustainability/green accounting, and climate change denial. We propose two hypotheses for what is driving lower inclusion rates among these topics. First, instructors who have designed and taught a climate economics course before may have hit a constraint in the number of topics that they could feasibly include in a semester- or quarter-length course, whereas respondents who face no such constraints in their hypothetical course would rather include the kitchen sink. Second, we suspect that climate-change economics is often taught as a complementary course to an existing environmental and/or natural resource economics course within the department. So, some topics, like methods for measuring nonmarket damages (stated and revealed preferences), are not included in a climate economics course to reduce duplication and because of the time necessary to give those topics full treatment. Unfortunately, we did not ask about the suite of other environmental economics courses available in a respondent's department.

3.5 How Have Climate Topics Changed Over Time?

Our last piece of analysis regarding topics for inclusion asks whether there are any topics related to climate change that the respondent would include in a course now but would not have included 10 years ago. We include the results from that question in Figure 6. The topics

[8]We chose 2010 as a cut-off to (a) capture the hypothesis that more recent PhDs were likely more up-to-date on the fast-moving climate literature and (b) split our sample roughly evenly. We also calculated these results with a 2015 cut-off (60 respondents have earned PhDs since 2015). With this sample split, we find no statistical differences in the topics covered between the two groups, which suggests that both "older" and "younger" teachers cover similar climate topics.

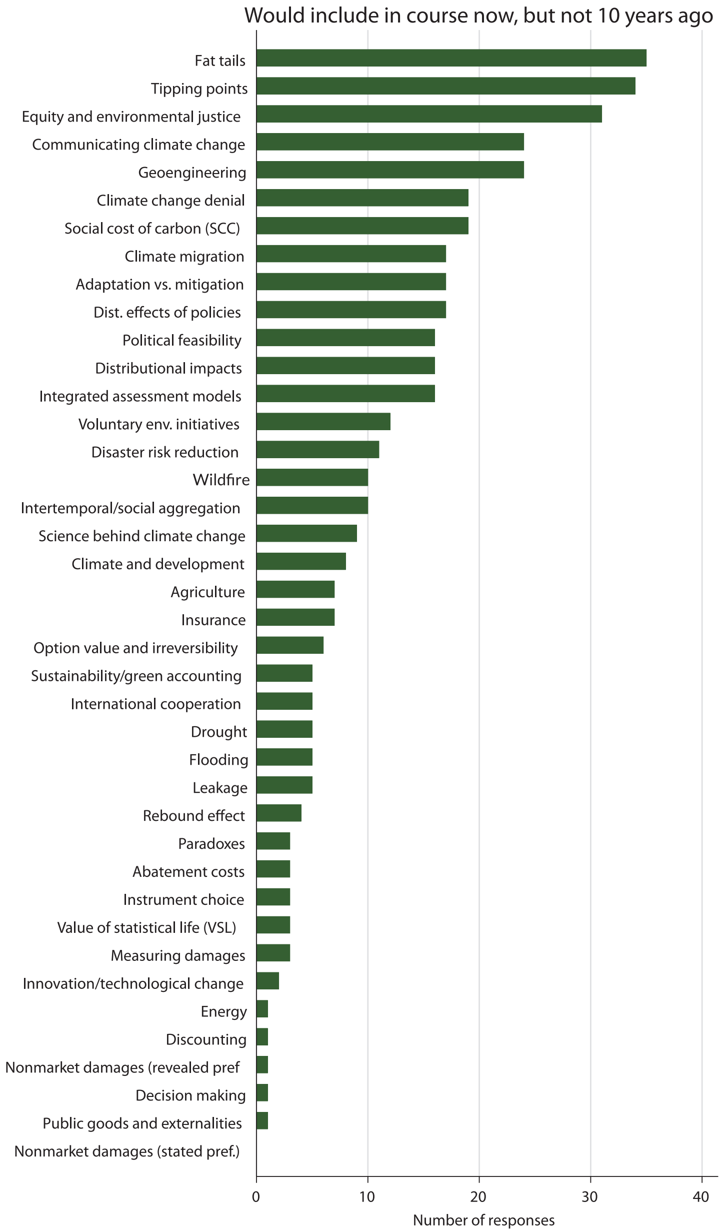

Figure 6: Responses for which topics would be included in a Climate-Specific Economics course now, but not 10 years ago.

with the greatest number of respondents reporting that they would include now, but not 10 years ago, include tipping points, fat tails, equity and environmental justice, geoengineering, and communicating climate change. These topics are sensible in that there has been an enormous shift in the frontier of our understanding in the last decade and/or importance of these topics in the research community.

3.6 What Did We Learn about Learning Goals?

Finally, we asked respondents to list up to three learning goals for a course that they considered most important. The inclusion of learning goals on a syllabus is relatively new for economists. The sample of syllabi we collected was very mixed on whether learning goals were listed and some of those that did include them did not have learning goals specific to climate change, but were more broadly about the tools of environmental economics.

We received a total of 301 unique "learning goals." We put this term in quotation marks since a significant number of these were not written as learning goals per se, but were simply a list of the most important topics to cover. Those topics are illustrated in the word cloud in Figure 7. In this figure, the words that showed up most frequently appear larger and bolder. Interesting, with respect to learning goals, only the less cognitively challenging words "understand" and "understanding" show up most frequently.

Word clouds have visual appeal and allow for some casual observation and insights on the importance of certain topics. They provide a useful visualization of the qualitative data we collected. The word cloud's appeal as a useful qualitative tool and a visual tool stems from its ability to show patterns in the data that perhaps calls for further exploration. Because the "learning goals" we received via the survey were so diverse and somewhat rudimentary, the word cloud gives a first look at possible themes and allows us to visualize what types of assessment words are chosen, if any.

A keyword frequency analysis can also offer a quantitative catalog of the information contained in the word cloud by showing the number of times a word or phrase was mentioned. We present a frequency table of words found in the reported learning goals in Table B.1 in the online Appendix B for words that occurred at least five times. For example,

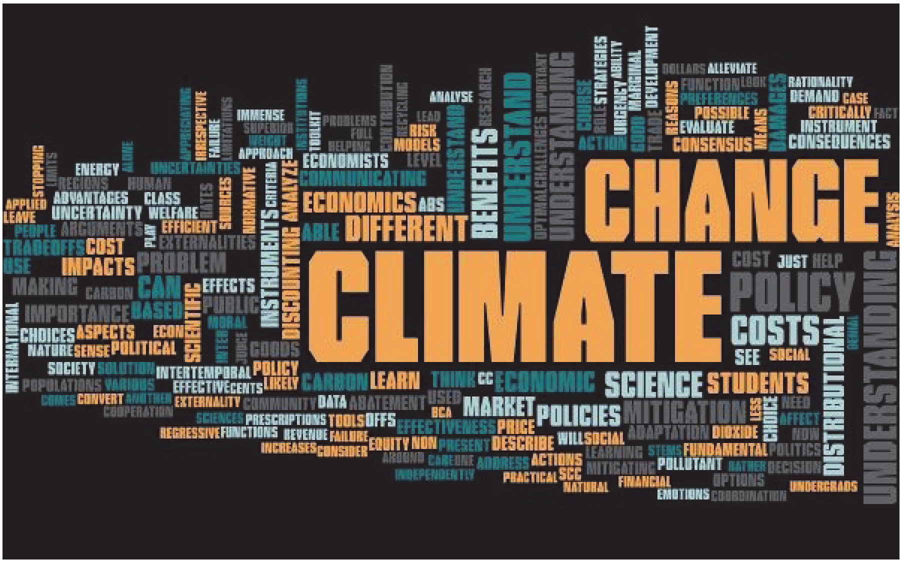

Figure 7: Word cloud using answers to the question, "In your opinion, what is the most important learning goal or goals for students taking an undergraduate course in climate change economics. (Please list up to 3)."

"climate" was mentioned 118 times, "policy" or "policies" 63 times, and "cost(s)" 44 times.

What about the mechanics of what it is about the topic we want students to come away with? Is it a simple understanding or a more sophisticated ability to use models or perform benefit–cost analysis? Do we want students to apply their knowledge or to just know the basics? The word cloud (and frequency table, online Appendix B) highlights very clearly the words "understand' and "understanding" but otherwise shows very few active learning words. The next most used is "analyze," but that is used very infrequently. Bloom's Taxonomy is a commonly used framework for the development and assessment of learning goals. Originally developed by Bloom *et al.* (1956) and revised by Anderson and Bloom (2001), the taxonomy organizes learning objectives and goals in a hierarchical fashion by complexity and cognitive function utilized in achieving those goals.

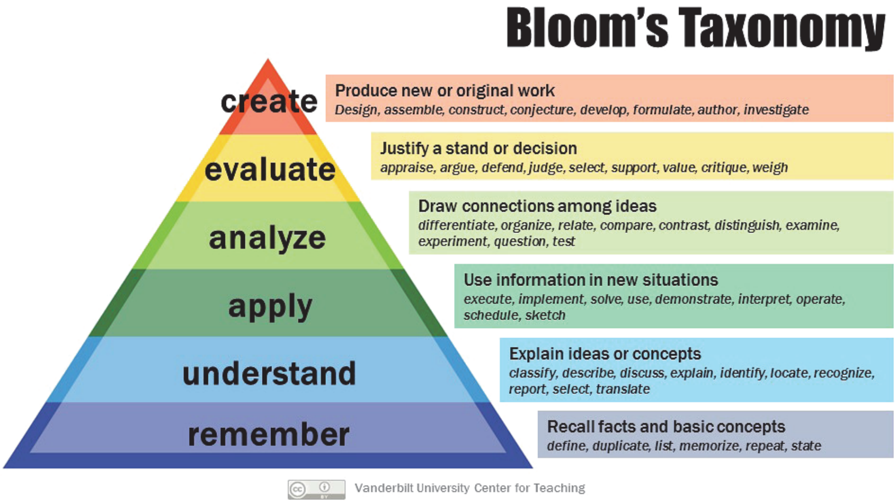

Figure 8: Bloom's taxonomy with descriptions.
Source: Vanderbilt University Center for Teaching.

Figure 8 illustrates those goals with brief descriptors of each.[9] Each of these tiers is easily applicable in economics courses with the lower levels of the pyramid, fitting lower-level courses or early in the semester/topic for other courses with the top of the pyramid being an undergraduate thesis or other independent research project.

Of the unique 301 learning goals we received (some respondents listed none, one, two, or three), 30.5% of them started with the word or phrase, "Understand," "Understanding," or "Students must/will Understand." Although these words suggest simply the explanation of ideas or concepts (classify, describe, explain, recognize, report, etc.), what follows the word understanding or understand varies widely in our sample. "Understand a bit of the science" versus "Understand complex systems aspects of climate: tipping points, irreversibility, deep uncertainty, path dependence, fat-tailed distributions" are significantly different as are "Understanding externalities" and "understand and analyze the effects of technical innovations on energy use and greenhouse gas emissions."

[9] Vanderbilt University Center for Teaching, https://cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy/

This is not to suggest that any of these are incorrect or one is better than another. Quite the opposite: they are all important, but we can be clearer in helping our students understand what is expected of them and what they can expect from us, their professors.

Using this taxonomy to develop learning goals could be helpful for climate economics courses especially since the topic is so complex, and fraught with politics and normative values about what is the appropriate policy response. Learning goals help students understand not only what they are expected to learn, but why they are expected to learn something. What is our purpose? Learning goals help educators clarify the course objectives for both themselves and their students. Finally, learning goals help instructors to develop assessments that reflect those goals.

Another interesting observation is that many of the topics included as answers to this question are likely covered in a typical environmental economics course (whether or not applied to climate change). These include a knowledge and understanding of externalities, market failure and public goods; benefit–cost analysis, discounting and distributional analysis. Interestingly, Table 2 illustrates that those respondents who do not currently teach a climate economics course may be more likely to emphasize those topics that are common to most environmental and natural resource economics courses such as nonmarket valuation (both stated and revealed preference), the value of a statistical life, and option values.

Using the data we collected, we present a set of learning goals that could be utilized in a climate-change economics (and/or policy) course. We assume students will have had a basic exposure to environmental economics and thus have a decent understanding of externalities and valuation techniques. Note that any of these goals could be scaled up or down, or dropped entirely, depending on the level and breadth of the course.

Upon completion of this course, students will be able to:

- *Understand* the (basic) science behind human-induced climate change along with the uncertainties involved.

- *Understand* the basics of risk and uncertainty, including tipping points, fat tails, and catastrophic risk, and be able to communicate the meaning of those terms.

- *Demonstrate* the ability to interpret the measurement of climate change damages.
- *Perform* (basic) benefit–cost analysis and exhibit proficiency with discounting.
- *Utilize* sensitivity analysis to account for fat tails, accelerated timing, and different discount rates.
- *Recognize* the limitations of benefit–cost analysis and integrated assessment models for low probability, high impact events and the normative decisions involved with choosing a discount rate.
- *Be comfortable applying* the Social Cost of Carbon to estimate the impacts of a policy change, especially for the estimation of benefits of reducing climate pollution.
- *Understand* the differences between adaptation and mitigation policy and that both are necessary.
- *Analyze* policy recommendations using knowledge about instrument choice and recognition of the distributional impacts. Make recommendations where necessary to account for environmental justice concerns and for political feasibility.
- *Evaluate* adaptation strategies.
- *Understand* the rationale for and *analyze* the implications of government intervention as a potential solution to market failures and global externalities.
- *Recognize* the importance and *analyze* the implications of international cooperation in achieving global solutions to climate change.
- *Evaluate* policy instruments using evidenced-based reasoning (only for more advanced students).

These learning goals were chosen from the set of topics for which at least 50% of respondents said they do or would cover in-depth and at least 80% of respondents said they cover in-depth or lightly. We also pay attention to those topics for which 25% of our respondents said they cover now, but did not (or would not have) 10 years ago. This last criterion reflects the rapid pace of the field changing over time as well as the rapid pace of climate change (and our understanding of it).

Clearly this set of goals might be too narrow or too broad depending on the goals of a particular class, but hopefully they provide some guidance on what the profession is choosing to emphasize and what environmental and resource economists think our students should be learning. Designing a course with clear and assessable learning goals helps clarify those goals to students and sets up clear communication between professor and students. Reiterating these goals as well as keeping them somewhat fluid, should something change, can also be helpful.

4 Concluding Thoughts

The old joke that if you laid all the economists end to end, they still would not come to an agreement is a not-so-unreasonable description of the diverging normative prescriptions about dealing with climate change. However, we have found there is remarkably strong agreement about what we *should* be emphasizing in courses on climate change and what we should be teaching our students. In this paper, we have attempted to highlight what a sample of environmental and resource economists currently teaches or thinks should be emphasized and what topics are emerging as important more recently. We have also offered a set of learning goals from which instructors may draw from that follow Bloom's taxonomy and that should be relatively easily assessable.

One important caveat that we note is how fast the science behind climate change is evolving and also how rapidly we are starting to see changes in the environment. Offering room for flexibility in syllabi for new material and for current events can ensure the most relevant material is getting covered and the course evolves over time.

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