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The Science, Economics, and Politics of Global Climate Change: A Review of *The Climate Casino* by William Nordhaus[†]

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The problem of global climate change presents overwhelming factual, analytical, and normative challenges. Nordhaus surveys this terrain bravely and mostly successfully. He explains the scientific/economic consensus that the planet is warming, that people are responsible, that the consequences are bad, and that immediate action is benefit/cost justified. He also discusses the efficient policy response, and the challenges of achieving coordinated global action. His approach is mostly that of standard neoclassical economics, and some of the limitations of that paradigm in this context are not addressed. But overall, The Climate Casino *provides an excellent self-contained introduction to the subject.* (*JEL* D61, H23, Q51, Q54, Q58,D72)

1. *Introduction*

Economists and other scientists who work on issues related to climate change live in a strange psychological space. Like any other research area, we have our mix of relatively settled issues, frontier areas of controversy, and fascinating research puzzles. But this normal science proceeds in a highly charged political atmosphere, and the consequences of the choices at stake are somewhere between serious and potentially catastrophic. Many climate change experts respond to this environment in one of two ways. Either they engage in polemics that are cheered by those of similar views, or they focus primarily on technical analyses of small aspects of the problem, avoiding as much as possible the larger debates.

We are most fortunate that William Nordhaus has taken the time and trouble to rise above the technical debates. *The Climate Casino* is not polemical, and some environmental advocates will certainly chafe at its fundamentally dispassionate, anthropocentric economic approach. But neither is it dry nor overwhelmed with technical minutiae. Rather, starting from a base of no assumed knowledge of either the science or economics, it slowly, carefully, thoroughly analyzes each piece of the climate puzzle

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and builds systematically towards the large, overall conclusion:

> A fair verdict would find that there is clear and convincing evidence that the planet is warming; that unless strong steps are taken, the earth will experience a warming greater than it has seen for more than a half million years; that the consequences of the changes will be costly for human societies and grave for many unmanaged earth systems; and that the balance of risks indicates that immediate action should be taken to slow and eventually halt emissions of CO_2 and other greenhouse gases (p. 325).

Nordhaus is one of our leading scholars of climate change, and the book makes extensive use of his and his colleagues' and students' research, including results from the Yale *Dynamic Integrated Climate-Economy* (DICE) family of models—dynamic computable general equilibrium models that combine simple relationships from climate science with standard economic behavior to model the evolution over time of the climate/energy/economy system. But it also draws from others' work in economics, other social sciences, and climate science. There is little here that is new, but in about 300 pages of text and figures, combined with fifty pages of smaller-print notes, the book provides a complete, self-contained analysis of what climate change is, why it is happening, what we know about the range of possible consequences, and what we should do about it. The main text is written for a well-educated general reader, but the professional economist will find most of her more technical questions answered in the endnotes.

There is also a special online version of the book on the website inkling.com. It contains additional color pictures and all of the charts and graphs appear in brightly colored, easily readable form. The main text is flanked by two additional "panes," whose use can be toggled among the table of contents with live links, a glossary of terms, notes on key points provided by the site, and notes that the student can enter herself and save. While we hesitate to state what twenty-somethings will find attractive in a technology product, this version does seem to have a number of features that would make it useful if the book is to be used in an undergraduate course.

2. *The Climate Science*

The book progresses roughly from climatology and ecology, through economics, and ends with politics. Nordhaus distinguishes two broad categories of impacts of climate change. The first is impacts on economic activities. These are likely to be significant, but it is the nature of these activities that they are "managed," and this means that over time, and at some cost, they will largely adapt to a changing climate. As a result, the magnitude of the harm to economic activity is large in absolute terms, but small relative both to world GDP and the growth in global incomes that is likely to occur over the same period.

The other category of damages will occur in "unmanaged and unmanageable human and natural systems." Because these systems are not managed, the scope for adaptation is much more limited. Sea-level rise, hurricane intensification, ocean acidification, and loss of biodiversity will cause harm that, quite literally, we don't know how to deal with. Not coincidentally, these threats to unmanaged systems are also the ones whose magnitude is most difficult to quantify, so they are typically left out of economic calculations of the cost of climate change. But as Nordhaus concludes, ". . . to say they are hard to quantify and control does not mean they should be ignored. Quite the contrary, these unmanaged or unmanageable systems are the ones that should be studied most carefully because they are likely to be the most dangerous over the longer run."

While the distinction between manageable and unmanageable impacts is a useful one, it

is not absolute. Some of the consequences of hurricane intensification or sea-level rise can, in fact, be managed and adapted to. Conversely, although agriculture is a managed system, it is not known what kind of adaptation climate change will require for agriculture or the feasibility of such adaptation throughout the global agricultural system. Nordhaus's analysis assumes that the application of capital and technology will allow farmers to adapt to changing climate conditions so as to permit global food production to keep up with growing demand at modest increased cost. This projected adaptability is predicated on historical experience that comes largely from advanced economies in temperate climates. There is significant risk of food shortage and potential famine in some developing countries, and it is at best unclear that these systems can be "managed" to forestall those risks. This means that even if global agriculture mostly adapts, there could be large unmanageable consequences for some of the most vulnerable populations.

3. *Economic Evaluation of the Harm of Climate Change (Benefits of Greenhouse Gas Emissions Reductions)*

Having identified the predicted consequences of climate change, the next logical step is to decide what actions to take to mitigate those consequences. There is much attention in the public sphere to the agreement reached in Copenhagen in 2009 that the world should commit itself to limiting greenhouse gas emissions sufficiently to ensure that the long-term rise in the global average temperature should not exceed 2° Celsius. The UN Intergovernmental Panel on Climate Change (IPCC) released its Fifth Assessment Report after this book went to press. That report presents estimates that achieving this target would require limiting cumulative carbon emissions to slightly less than 1 trillion metric tons, a milestone that will be reached under current projections by the middle of the century, with continued emissions and temperature increases likely to continue thereafter. Some commentators have begun to talk about this trillion tons as a carbon "budget" that needs somehow to be allocated over uses, places, and time so that it is not exceeded.

Of course, economists tend to take the view that we cannot figure out what goal to set for emission reduction (called "mitigation" in the climate change policy world) without weighing the benefits of such mitigation against the cost. Nordhaus takes on this difficult task in part III. A frequent topic of informal discussion at climate meetings is whether it is the natural science or the economics that generates the greatest uncertainties about climate modeling. In the end, there is no alternative to sensitivity analysis, and the range of plausible conclusions based on current models and data is wide.

3.1 *Methodological Issues*

The use of economic methods to draw normative conclusions about climate mitigation is beset by both conceptual and practical difficulties. Conceptually, most economic analyses of this kind are predicated on the idea that we can estimate a monetary equivalent value for all of the consequences of the different choices we face for all of the different parties who will bear those consequences, and then logically recommend that society choose the course of action with the greatest net benefits, aggregating across people and across time. Such aggregation sidesteps the impossibility of interpersonal utility comparisons using the "compensation" or Kaldor–Hicks criterion, which states that policy actions are justified if and only if those who gain from the action could compensate those who lose, in such a way that no one is worse off and some are better off.

Cost–benefit analysis based on monetary values for all impacts ensures that

the compensation criterion is satisfied. Of course, hypothetical compensation is not the same as actual compensation, so a normative policy conclusion derived in this way begs the question of the distribution of costs and benefits. Economists typically leave distributional considerations for others to worry about, or else make qualitative observations about which direction such considerations might shift decision making.

The distributional implications of climate policy are gargantuan. Indeed, in the later "politics" section of the book, Nordhaus notes that an estimate of the consequences of a benchmark global mitigation policy yields costs to rich countries of $1 trillion from 2010–2050, with (discounted) benefits to those same countries of $1.3 trillion from 2050 onward; the costs to poor countries is estimated at about $200 billion before 2050, with benefits of about $3.5 trillion thereafter (figure 44, p. 319). Nordhaus comments on these numbers in the context of the political difficulty of a global agreement, but does not consider them in the context of the fundamental validity of the cost–benefit approach in this context. As discussed further below, the practical implications of this omission for optimal global mitigation are limited, because the narrow economic analysis points towards the need for action now and distributional considerations would only reinforce that conclusion. But if the book is to be used in an economics course, the issue of the fundamental conceptual difficulty of applying cost–benefit analysis to situations with large distributional consequences should be addressed.

3.2 *The Mechanics of Applying Cost–Benefit Analysis to Climate Change: Valuation of Nonmarket Benefits*

Nordhaus presents a good summary of the controversy over the use of "contingent valuation" methods to place a dollar value on nonmarket values such as species extinction. He takes seriously both what can be learned from such methods and the tremendous methodological difficulties they present. In the end, he chooses to largely exclude mitigation benefits associated with protecting ecosystems and species diversity from his aggregate cost–benefit analysis. Given the effort he devotes to discussing the methods for monetizing these effects, this seems a peculiar choice. He repeatedly emphasizes how important these effects are, so perhaps he feels that the available estimates of their dollar value do not do them justice.

3.3 *The Mechanics of Applying Cost–Benefit Analysis to Climate Change: Choice of Discount Rate*

The climate change economics issue that has probably generated the widest debate is the choice of discount rate. In particular, Nicholas Stern published a report commissioned by the UK Treasury that found large positive net benefits from climate mitigation actions, due largely to its use of a discount rate for future mitigation benefits of 1.4 percent per year (Stern 2007). This was quickly hailed by environmentalists as an eminent economist agreeing that significant mitigation efforts were called for. But it was criticized by some economists, particularly for its choice of discount rate.[1] Nordhaus discusses this controversy, and explains the justification for what he calls the "prescriptive (normative)" approach of Stern and others who advocate the use of a relatively low discount rate for cost–benefit analysis of climate change policy choices. He ultimately comes down, however, on the side of the "descriptive" approach, which sets the discount rate equal to the market opportunity cost of capital: "We need to use a discount rate that reflects the actual market opportunities that societies face, not

[1] For an extensive discussion of the economics of the Stern Report, see the articles in this journal, Nordhaus (2007), and Weitzman (2007).

an abstract definition of equity taken out of context of market realities."

Of course, the whole point of the cost–benefit analysis is to make a normative judgment, i.e. what *should* society do about climate change, so it is strange to reject a "normative" approach to the choice of discount rate in favor of a "descriptive" approach. But the use of net benefits as a normative criterion rests squarely on the Kaldor–Hicks compensation criterion, and the hypothetical compensation would presumably be paid through markets and bear the market interest rate, so the analytically consistent discount rate is, indeed, the market interest rate. What is normatively problematic about this conclusion is *not* that the discount rate should be less than r; what is normatively problematic is that it justifies harm flowing from today to tomorrow when no *actual* investment is going to be made to compensate those in the future for the consequences of our choices. But of course this problem does not flow from the choice of discount rate; it is intrinsic to the Kaldor–Hicks formulation.

The use of a "low" discount rate responds to our discomfort over justifying harm to the future on the basis of hypothetical compensation that is never paid, because it shifts the analysis qualitatively in favor of the future. But it is important to acknowledge that it does not solve the inherent problem that, as economists, we really do not have an analytically consistent method for adding up costs and benefits across different generations and income groups. This doesn't mean that we should not attempt to measure, tabulate, and compare costs and benefits. But it does mean that we should always recognize that *any* attempt to add them all up and maximize net benefits is intrinsically arbitrary in the way in which it weights the consequences for different groups.

In any case, one of the interesting results Nordhaus presents (and describes as surprising) is that if participation in a global agreement is relatively low (covering only 50 percent of emissions), the optimal target is not very sensitive to discounting (rising from 3.8°C to 4.0°C as we move from no discounting to market-rate discounting). This results because the damage function in Nordhaus's model is highly nonlinear around 4°C, so that discounting of future damages would have to be very high to drive the optimal target much higher.

3.4 *The Mechanics of Applying Cost–Benefit Analysis to Climate Change: Uncertainty and "Tipping Points"*

Given all of the uncertainties around climate change costs and benefits, the cost–benefit analysis has to start from maximizing the expected value of net benefits. But the range of possible outcomes makes most people uncomfortable with a naïve maximization of expected net benefits. Perhaps the greatest difficulty with predicting the benefits of mitigation is that there are certain discrete events whose occurrence would dramatically increase climate damages. These potential risks include the disintegration of the ice sheets covering Greenland or West Antarctica, which would trigger rapid (and hence difficult to adapt to) sea-level rise much greater than otherwise projected. They also include possible reinforcement effects, such as the release of greenhouse gases currently trapped in the arctic permafrost, such that if the permafrost melts, global warming would be accelerated.

It is clear that the probability of these catastrophic events increases with greenhouse gas concentrations, so mitigating climate change reduces the expected value of harm. But there are some models that suggest that the probabilities increase rapidly as global temperatures cross some threshold, leading to the idea of "tipping points" for climate change, corresponding to significant discontinuities in the net benefits of climate mitigation. If we knew where the tipping points were, it would be relatively

straightforward to incorporate them into design of an optimal mitigation strategy, but the models are not that precise. The consequence is that if we choose a mitigation strategy based on (our best estimates of) the expected value of benefits and costs, ex post we could find ourselves in a catastrophic scenario that could have been avoided by only modestly more aggressive (and hence modestly more costly) mitigation.

Nordhaus illustrates this issue with a sensitivity analysis of the net benefits of mitigation under different assumptions about where the tipping point falls. He then discusses the precautionary principle and the concept of a "minimax" strategy in game theory. But he notes that the empirical basis for applying these approaches does not exist: we do not know how many tipping points there are, where they are, or how rapidly damages rise as they are crossed. Rather, he suggests that the possibility of tipping points should be thought of as increasing the net benefits of mitigation, hence shifting the optimal mitigation upward. He characterizes this increase as an "insurance premium" against tipping points. Of course, this metaphor is not quite apt. The problem is precisely that we *cannot* get an insurance policy that will compensate us if the catastrophe comes to pass. Because we cannot insure against this risk, it is optimal to mitigate somewhat more than we would have otherwise done to reduce (by an unknown amount) the probability of the catastrophic outcomes. Once again, this approach is reasonably satisfactory for the purpose of showing that significant near-term mitigation is appropriate, but if the book is to be used in economics classes, there is an opportunity to take this issue further.

3.5 *Overall Conclusions from the Cost–Benefit Analysis*

Quite appropriately, Nordhaus does not attempt to identify a single cost–benefit analysis that gives "the" answer as to how much mitigation should be undertaken when. Rather, he looks at a number of different analyses and uses these to illustrate the important drivers of different conclusions about the appropriate level of mitigation to seek. In the end, he presents only a conditional summary of the implications of the cost–benefit analyses:

> If you really thought that only half of all countries would participate [in the mitigation regime], then aiming for 2°C is like hoping you can take Amtrak to the moon. On the other hand, if you thought you could induce all countries on board very quickly, with no free riding, and that the policy tools you could realistically deploy are efficient ones, then you might well aim for the Copenhagen target [i.e., 2°C]. (p. 218)

In the next section, where he turns to discussion of specific mitigation policies, he analyzes scenarios built around an assumed target of 2.5° (figure 33 and associated text, p. 228). Later in the book, he refers to a 3° increase as "indicated by economic cost–benefit analysis" (p. 248). This ambiguity about the bottom line is probably an appropriate reflection of the inherent imprecision of the tool, but it would be less confusing if the book were consistent in its approach to the range of "answers" generated by the many analyses.

4. *Choice of Policy Instruments to Mitigate Climate Change*

4.1 *Carbon Taxes and "Cap and Trade"*

Having analyzed the net benefits of climate mitigation, Nordhaus then turns to the issues around what policies are necessary to make mitigation efficient. He begins with the obvious-to-economists argument that efficient mitigation requires that the marginal cost of carbon reduction be equalized as widely as possible across sectors and countries,

and that the simplest way to achieve that is to make everyone face a common price for carbon emissions. This requires translating some target, such as 2.5°, into the carbon price trajectory necessary to achieve that target. He presents the range of estimates from different models of the necessary prices, which increase from $15–$50 in 2020 to $60–$200+ in 2050. For subsequent analysis, he uses the average of the model results, which implies a carbon price that starts at $25 and rises to over $160/ton in 2050.

He estimates the impact of the initial $25 tax on a range of activities; an economy-class transcontinental airfare would go up by about 6 percent, the cost of driving about 8 percent, and the average household's overall consumption bundle about 1 percent. He calculates that such a tax would generate $168 billion in revenue in 2020 and notes the superiority of revenue generation through this route, relative to distortionary taxes on income.[2]

Nordhaus turns next to explaining the fundamental equivalence between a carbon tax and the creation of a market for carbon emission allowances, generally designated as "cap and trade" in the recent debates. He summarizes the theoretical issues around uncertainty and information that have been the focus of the economics literature and also discusses the apparent political arguments in each direction. His bottom line is a personal preference for a carbon tax, which he then returns to at the end of the book in the context of making what he calls the political conservative's argument for mitigation. But he is quite clear that implementing one of these two economic mechanisms is much more important than the choice between the two.

4.2 *Other Domestic Policy Issues*

It is natural to an economist, but some noneconomist readers will be put off by the fact that Nordhaus titles his chapter about policy options other than a carbon tax or cap-and-trade as "Second Best and Beyond."[3] In this chapter, he discusses policies such as energy efficiency standards for appliances or motor vehicles and subsidies or regulatory preferences for zero-carbon technologies. Most of the chapter is devoted to a discussion of why these polices are inferior to carbon-price policies, and empirical estimates of the magnitude of the inefficiencies of some specific policies are presented. He then moves, however, to consideration of the considerable empirical evidence of "energy-cost myopia." In the same way that "behavioral finance" has in recent years changed the way finance economists think about efficient markets for financial instruments, empirical analysis of the markets for energy-consuming durables have shown a variety of apparently nonoptimizing behavior. This behavior manifests itself overall as energy-cost myopia. Nordhaus acknowledges that such myopia potentially challenges the first-best status of carbon price policies and provides a justification for other approaches such as efficiency standards, because myopic consumers will respond inadequately to carbon price incentives but can be forced to make the "right" choice by regulations. He provides some illustrative calculations based on

[2] It should be emphasized that this relatively modest carbon price scenario is based on an assumed globally efficient mitigation strategy. In the real world of incomplete participation, those who do participate will optimally take on themselves some (though not all) of the mitigation that would have been undertaken by the nonparticipants in the globally efficient scheme. Hence carbon prices imposed within the participating countries would have to be higher.

[3] In much of the environmental economics literature, policy instruments are grouped into "economic" instruments, and "command and control" instruments, and their advantages and disadvantages are discussed, with economic instruments usually being found to be superior. Naming the latter category "second best" is presumably a reference to the assumed theoretical inferiority of the regulatory approaches. But there is no formal analysis along the lines of the theory of the second best in economics.

hypothetical degrees of myopia, and shows that with modest myopia, some standards do yield a lower effective cost per ton of CO_2 removed, or even a negative "cost," an illustration of the "paid lunch" (rather than free lunch) that some efficiency advocates have claimed.

Unfortunately, the existing state of the behavioral economics of energy markets is not good enough to tell us the magnitude of the myopia in different circumstances. If it were, then there might be policy options that addressed the behavioral issues that would be superior to efficiency standards. Overall, Nordhaus's basic conclusion is probably right: the phenomenon of myopia does create some scope for efficiency regulations to improve outcomes relative to what would occur with carbon-price policies alone, but ideally they should not be used as a substitute for carbon-price policies. Of course, if one were to take as a given constraint that explicit policies to raise the cost of carbon are not available, then some otherwise inefficient policy interventions are likely to be normatively superior to inaction.

Nordhaus is much less sympathetic to subsidies (or policy preferences that amount to subsidies) for low-carbon technologies such as renewables. The concern about subsidies is easiest to see in a situation such as has emerged in recent years in Europe, which has both a cap-and-trade system for CO_2 emissions *and* a set of policies to encourage renewable electricity generation that are equivalent to significant subsidies. Given the cap-and-trade regime, the renewable subsidies *cannot* reduce overall CO_2 emissions; any reductions they stimulate will be offset by an increase somewhere else as firms buy and sell permits under the CO_2 cap. And that trading, on its own, should lead to efficient reduction, with everyone choosing a level of emissions based on the common price. This means that anything that moves the system away from this efficient outcome must increase cost. If the renewables policy "succeeds" in encouraging more renewable electricity generation than would have otherwise occurred, it can only do so by inducing renewable investment that is not efficient. Estimates are that the European renewables policy has increased costs by billions of euro.

This conclusion is correct, as far as it goes, but it ignores the argument that Nordhaus makes in the next chapter, which focuses on the importance of technological change in addressing climate change and the role of policy in facilitating technological change. Just as polluters generate negative externalities, those who create or diffuse new technologies create *positive* externalities. The public good nature of knowledge means that its creation and spread creates benefits that can only imperfectly be captured by the party that acts to advance technology. This means that public policy should be designed to encourage the creation, development, and adoption of new technologies.

This is the standard argument for government funding of research, particularly basic research, but the argument is actually broader. Commercial development and adoption by users of new technologies also generate externalities, and the historical record is quite clear that many important technologies now in wide commercial use were supported in their infancy by government policy. From this perspective, policies in support of renewables and other low-carbon technologies should not be evaluated in terms of their efficiency in reducing CO_2 emissions today. That is not their purpose. Their purpose is to increase the rate at which new low-carbon technologies are developed and diffused. Now, one might still conclude that particular policies—be they those supporting renewable electricity in Europe or those supporting hybrid cars in the United States—are ineffective or inefficient in fostering technological change. But they should be evaluated on that basis, not

on the basis of the cost at which they reduce CO_2 emissions today.

Another issue is that efficient carbon-price policy assumes that the carbon price is perceived as generated by a stable policy and hence fully incorporated in efficient investment decisions. Recent policy history suggests that investors would be unwise to assume this. Policy uncertainty could generate another role for promotion, though not necessarily subsidies, of specific investments.

Finally, it should be noted that Nordhaus remains squarely within the standard economic model that treats preferences as exogenous and makes normative recommendations based solely on maximizing (in some sense) consumption-derived utility. But there is increasing evidence from behavioral economics that preferences are endogenous, and survey evidence shows consistently that reported happiness or satisfaction does not actually increase with income above some subsistence level. While the overall implications of these findings for normative economics are beyond the scope of this review, when combined with the magnitude of the climate risks, they suggest we might consider policies aimed explicitly at shaping the evolution of preferences and practices towards lower-emission consumption or even lower total consumption of material goods. It is not clear how to think about these issues from an economic perspective, but it seems likely that discussions of this kind will be more productive with input from economists than if economists leave them entirely to others.

4.3 *Global Climate Policy*

The economics of global mitigation policy are basically a reprise of the discussion of carbon taxes and cap-and-trade. One way or another, we need global carbon prices to rise; efficient mitigation requires that carbon emitters in different places face the same carbon price. Nordhaus describes how the Kyoto Protocol of 1997 would have committed the high-income countries to limit their emissions to 5 percent below their 1990 levels by 2008–12. A mechanism was created to trade off emissions of different greenhouse gases. The "Clean Development Mechanism" was created whereby the rich countries subject to a cap could get credit for reductions brought about by investments they financed in poor countries that were not subject to the cap.

The countries subject to emissions limits under Kyoto represented about two-thirds of global emissions in 1990, but then the United States and Canada declined to ratify the agreement and the emissions from China and other countries that were not limited by Kyoto grew rapidly, so that by the time the agreement was formally terminated in 2012, only about 20 percent of global emissions were subject to restriction. As Nordhaus notes, "global actions lag far behind the steps that would be necessary to limit global warming to the 3°C increase indicated by economic cost–benefit analysis, while the ambitious 2°C target announced at Copenhagen is probably infeasible" (p. 248).

It is important in this context to remember that no one ever expected the Kyoto Protocol to solve the problem. It was generally regarded as a small first step towards a more ambitious regime. It has been successful in improving the science and infrastructure for monitoring emissions credibly, which is a prerequisite for any formal enforcement regime or for informal cooperation among states or among citizens of different countries. It motivated the creation of emissions trading systems in Europe, New Zealand, and Australia and has led to active climate policy discussion more broadly. Unfortunately, the state of those discussions does not yet point towards the needed next steps.

Nordhaus places this failure in the context of the global commons problem and then goes on to discuss some of the complexities that would need to be addressed

if a new agreement is to be reached. This is perhaps the least satisfying section of the book. One reason is that no one has figured out how to formulate a global agreement that would bring the bulk of world emissions under control. But the book's discussion also suffers from the common economist weakness of stressing analytical simplicity while failing to really address the complex human, organizational, and political motivations that drive negotiations. Nordhaus emphasizes that it would greatly simplify the negotiations if, instead of trying to agree to greenhouse gas quotas for each country, the negotiators simply tried to agree on a minimum global carbon price. But each country cares about its own compliance cost and its perception of the fairness of the allocation of compliance costs around the world, where "fairness" is a complicated multidimensional construct. A minimum carbon price, in and of itself, cannot, except by accident, achieve a distribution of burdens perceived to be fair. Hence, an agreement on a minimum carbon price would have to be accompanied by some kind of side payments in order to be widely accepted. A single minimum carbon price accompanied by (lump sum?) side payments is an attractive outcome in terms of efficient mitigation, but it would be no simpler to formulate or negotiate than a set of emissions quotas.

The gap between theory and reality is illustrated by Nordhaus's discussion of the division of the mitigation burden among countries of different wealth. Currently, approximately half of world CO_2 emissions come from "high income" countries—those with per capita income of about US$20,000 or more. But as Nordhaus notes, an effective regime will require participation of all but the poorest countries in the world; to achieve participation of countries accounting for 90 percent of world emissions, essentially all of the "middle income" countries such as China and India and almost all of Latin America will need to participate. Nordhaus observes ". . . the prospects of India and China joining a Kyoto-like agreement in the near future seem remote. The range of institutional structures and integration in the global economy and in international institutions differs greatly among these countries, but they need to be persuaded to join a global agreement if it is to be effective, and the agreement needs to be designed in a way that is not overly burdensome for middle-income countries. A minimum carbon price regime does that." The truth of the concluding sentence seems transparent to Nordhaus, but convincing the middle-income countries themselves that a minimum carbon price would result in an equitable sharing of the mitigation burden remains a major task.

Nordhaus also oversells the administrative simplicity of a harmonized carbon tax regime relative to a global agreement on greenhouse gas quotas by country. A country may have a carbon tax on its books, but to know if it is implemented, an outsider would need to observe emissions and tax revenues. And there are a host of implementation issues, as with any tax, spelling out what is covered, and what needs to be explicitly measured versus estimated. Which of these implementation issues would be specified in the global agreement, and which left to countries' discretion? For those left to discretion, would there be some mechanism to ensure that discretion does not gut the effectiveness of the regime? Given political pressures, there would be huge incentives to offset the effects of the tax with explicit or implicit subsidies for particular groups. Would that be prohibited, and if so, how would that prohibition be monitored and enforced?

Recognizing these difficulties does not undercut the desirability of moving as much as possible towards international harmonization of the price of carbon; it just means that a global carbon tax is not a panacea that somehow "solves" the problem of reaching

a global agreement. Indeed, other scholars have argued that addressing a complex global problem like climate change requires a complex or polycentric effort (Keohane and Victor 2011; Ostrom 2010). This work suggests we might best evolve a suite of complementary institutions with high-quality transparent monitoring of a range of proxies for mitigation effort as a coordinating mechanism. The suite of institutions would allow for experimentation, evaluation, and evolution. This is not an elegant solution like one global cap-and-trade or one globally harmonized tax system, but it might be robust and would allow progress without universal agreement.

In this context, it is worth noting the number of jurisdictions that have taken independent action to reduce carbon emissions despite the absence of a global agreement. Under the logic of the global commons, this is a puzzling phenomenon: unilateral mitigation imposes costs without delivering any significant benefits in terms of climate change mitigation. Yet states (California), countries (New Zealand), and regions (the European Union) have all acted. It is not clear to what extent this represents action in anticipation of a global agreement—and hence may fade if that agreement continues to recede—or a fundamentally different way of thinking about individual groups' mitigation policy choices. To an economist, it seems unlikely that these policies could survive indefinite postponement of a global agreement, but since we would not have predicted their emergence to begin with, we should be cautious about predicting their future.

5. *The Politics of Climate Change and the Climate Skeptics*

The final section of *The Climate Casino* discusses the politics of climate change in the United States. It begins with a discussion of climate change denial from a scientific perspective. Nordhaus argues forcefully that if the phrase "scientific consensus" has any useful meaning, there *is* a scientific consensus that the earth is warming, that we are responsible, and that the consequences of continuing on our current course will be somewhere between costly and catastrophic. He summarizes thoroughly the ways in which those who argue otherwise are either focusing on small controversies that do not affect the broad conclusion, or are willfully ignoring the proven facts. It is true that there are some individual scientists who disagree, and it is also true that no one can say with 100 percent certainty what will happen. But neither science nor public policy has ever been governed by a requirement of unanimity, and only people who do not understand how science works would look for 100 percent certainty.

From the science, we move on to public opinion. If there truly is a scientific consensus, why is much of the public still skeptical? Nordhaus begins by pointing out that in general, the public does not understand science very well. The fraction that doubts that global warming is real is comparable to the fraction that doubts that the universe started with a big bang, and the fraction that believes that antibiotics kill viruses. But this is not the whole story, as climate doubt among the general public increased significantly after 2000 up until 2012. (There is a hint of a possible turnaround in this trend in 2013 poll numbers.) Nordhaus argues that many people do not invest much effort in understanding complex issues like climate change, but rather rely on elites to inform them. In effect, they start from an ideological perspective on the environment, the economy, and the political parties, and choose their climate beliefs to match, rather than forming climate beliefs based on facts about climate. To oversimplify only a little, for many people—on both sides—the fact that Al Gore is equated with climate activism

tells them all they need to know to decide what they think. From this perspective, the persistence of climate denial among the general public is inextricably intertwined with the overall political polarization of American society.

This takes the issue back to the question of why the "elite" on the political right is so resistant to the scientific consensus. No one, including Nordhaus, can provide a complete answer to this question. But he makes two observations. First, even the elites are greatly affected by ideology, and the kind of government intervention in markets that has dominated proposed policy responses to climate change is anathema to them. Second, the parties who have the most to lose in a transition to a low-carbon world have spent a lot of money on doubt creation: "In the doubt-creating process, groups undermine, distort, or create facts and theories in an attempt to refute mainstream science, confuse the public, and prevent political action." He goes on to draw an analogy to the decades-long campaign by the tobacco companies to raise doubt about the scientific link between smoking and disease. He concludes this section with the ominous observation that the economic stakes for the fossil fuel industries are even greater than they were for the tobacco companies, so that "the battle for hearts, minds and votes will be fierce" (p. 323).

While the eventual success of antismoking policy might seem an encouraging example of democracy's overcoming doubt creation, it is important to note that the tobacco doubt-creation campaign only ended when several billion-dollar losses in liability litigation induced the major tobacco companies to negotiate a settlement that involved new, higher taxes on cigarettes and limitations on their marketing efforts. Absent some clever lawyers finding a successful tort liability theory against fossil fuels, that route will not be available for climate change.

6. *Conclusion*

Despite its reputation as the dismal science, in practice, most economists are fundamentally optimists. We believe that economics gives us the tools to identify efficient and effective public policy, and that our patient and persistent explication of such findings eventually penetrates and affects public decision making (though the empirical evidence for this last proposition is anecdotal at best). Nordhaus shares this occupational predilection. Having traced the public resistance to climate action to opposition from conservative elites, he formulates the conservative's perspective on climate policy. His conservative begins by studying the science and concluding that we are in danger. He thinks about policy and comes to the standard conservative conclusion that regulations on light bulbs and cars or emission permits allocated to special interests are exactly the kind of government meddling that he hates. But he notices that many economists, including the vast majority of the professional economists who work for Republicans (again, consensus if not unanimity) favor a tax on carbon. He is at first repelled by a new tax, knowing that taxes discourage investment . . . .

But then the metaphorical light bulb goes on. On reflection, Nordhaus's conservative realizes that this is the wrong way to think about a carbon tax, that those who emit CO_2 are actually being subsidized by the rest of us, and true conservatives hate subsidies as much as they hate taxes. ". . . [C]arbon taxes are an ideal policy for true conservatives who care about preserving our beautiful planet but want to do so with well-tuned economic incentives and with minimal government intrusion into people's lives and business decisions." We might be tempted to argue that this vision of conservative thinking is stronger analytically than it is empirically. But we are optimists, so we won't.

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