Feature

Timing Is Everything: How Economists Can Better Address the Urgency of Stronger Climate Policy

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Introduction

The scientific consensus about the potential extent of future climate changes and their biophysical consequences has become increasingly ominous over time. Climate scientists often focus on the potential biophysical outcomes associated with given increases (relative to preindustrial levels) in global average surface temperature. About 12 years ago, a synthesis report from the Intergovernmental Panel on Climate Change (IPCC, 2007) indicated that a temperature increase of 2°C would lead to substantial climate change and very serious associated biophysical impacts. This consensus finding was based on the results of more than 1,000 peer-reviewed scientific studies[1] and has become a main focal point in policy discussions. The most recent comparable IPCC report (IPCC, 2018) indicates that the impacts of a 2°C increase would be considerably more severe than the estimates in the 2007 report. Indeed, a 1.5°C increase is now considered sufficient to produce climate-related damages of similar magnitude to those previously attributed to a 2°C increase.

If carbon dioxide (CO_2) emissions continue at current rates, when might the 1.5°C threshold be reached? The answer to this question depends on a key parameter, the "transient climate response to cumulative emissions of carbon" (TCRE), which stipulates the ratio of global average surface temperature to the atmospheric stock of CO_2.[2] The 2018 IPCC report presents the 33rd, 50th, and 67th percentile estimates from a probability distribution for the

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[1]The report involved 498 authors from 28 countries.
[2]For any given amount of cumulative emissions, the TCRE indicates the temperature that would prevail over time, assuming no further changes to the stock of CO_2.

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TCRE. These three values imply that if the current rate of emissions of CO_2 continues, the atmospheric concentrations that would produce a 1.5°C temperature increase will be reached in 20, 14, or 10 years, respectively.[3] Notwithstanding all of the uncertainties, these and other scenarios (some of which I will discuss here) suggest that a delay in addressing the climate change problem poses substantial risks to human welfare.

For decades, economists have characterized the climate change problem as reflecting the external costs associated with emissions of CO_2 and other greenhouse gases. The externality implies a market failure and an associated potential role for government intervention.[4] Economic analyses have informed policy debates and helped support climate policy action in the United States and elsewhere. Nevertheless, economists can expand their influence in important ways by making clearer the urgency of more stringent climate policy action. I will argue that they can do this by focusing more sharply on the timing of policy implementation in their policy assessments and by revealing more clearly the environmental damages and economic costs that stem from delayed implementation. This article presents four ways that economists can better capture the environmental and economic costs associated with delay. It also shows how focusing more attention on the prospects for near-term implementation can alter the cost rankings of U.S. climate policy alternatives, increasing the attractiveness of some climate policy approaches that economists might otherwise tend to dismiss.

The rest of the article is organized as follows. The next section summarizes the recent scientific findings and indicates why these findings imply that stronger climate change policy is urgent. Then I present four ways that economists can more effectively address the urgency of stronger action through a sharper focus on the timing of policy implementation and the environmental and economic costs associated with delay. The section that follows shows how greater attention to timing and the costs of delay can alter the cost rankings of climate policy alternatives, arguing that with this change of focus, policy alternatives frequently dismissed by economists now deserve closer consideration. The final section provides a brief summary and presents the key conclusions.

Why Stronger Policy Is Urgent

Three characteristics of climate change make the timing of policy action especially important. First is the mounting nature of the problem, which stems from the fact that most greenhouse gases have very long effective atmospheric lifetimes.[5] Even if anthropogenic emissions of CO_2 — the most significant greenhouse gas in terms of the contribution to the greenhouse effect— were to cease permanently starting today, it would still take 1–3 centuries for

[3]While acknowledging uncertainties, the IPCC report expresses "medium confidence" in the predicted temperature changes it associates with the future CO_2 concentrations referred to here.

[4]William Nordhaus's "How Fast Should We Graze the Global Commons?" (Nordhaus, 1982) is a seminal contribution.

[5]I include the modifier "effective" here to account for the fact that the duration of the impact of an emitted molecule of a greenhouse gas depends on more than the atmospheric half-life of the molecule. Individual molecules of CO_2 have a short half-life: they remain in the air for only a few years. However, in keeping with the physical equilibrium between the ocean and atmospheric concentrations, the molecules that leave the atmosphere are replaced on close to a one-for-one basis by CO_2 from the oceans. This interaction implies that it takes centuries for permanent and significant reductions in CO_2 emissions to bring about significant reductions in the atmospheric stock of CO_2.

atmospheric concentrations of CO_2 to return to preindustrial levels. Nitrous oxide (N_2O) has an effective atmospheric lifetime of about 120 years.[6] The long effective residence times of these greenhouse gases mean that their annual emissions continually add to atmospheric concentrations. Because climate change damages are an increasing function of these concentrations, damages will continue to increase, even if the *flow* of annual emissions remains constant or declines.

A second important characteristic of climate change is the irreversibility of climate-related damages. Some of the key impacts from climate change—for example, sea level rise and the loss of biodiversity—are irreversible. This raises the human-welfare stakes: once concentrations have reached levels sufficient to cause serious damages, the damages will continue for a long time. The prospect of extremely persistent or irreversible damages makes timely policy action more important than would be the case if CO_2 had a shorter atmospheric lifetime.

These first two characteristics would be of intellectual interest, but perhaps not of great practical concern, if the current atmospheric stock of CO_2 were far below the stock levels that imply significant changes to the world's climate. But this does not appear to be the case. The third key characteristic of the climate problem, indicated by current scientific evidence, is the proximity of current CO_2 stock levels to levels that produce very large damages. The scientific findings summarized below indicate that in the absence of significant reductions in the rate of emissions of CO_2, temperature increases sufficient to cause very serious climate-related damages are likely to occur within a decade or two.[7]

Together, these three climate change characteristics— long atmospheric lifetimes, significant irreversibilities, and proximity of current concentrations to concentrations that would produce very high damages—imply that more stringent policy action is urgent. To avoid very significant costs, action is needed in the relatively near term.[8]

Number of Years to Reach Threshold CO_2 Concentrations

Uncertainties surround all three of the climate change characteristics just described, but the uncertainties are greater for some characteristics than for others. Climate scientists have a clear understanding of the atmospheric lifetimes of the principal greenhouse gases. Similarly, there is relatively little uncertainty concerning the irreversibility of certain key impacts such as sea level rise or biodiversity loss. The greatest uncertainties seem to concern the sensitivity of temperature to the concentration of CO_2 (as expressed by the TCRE, for example) and the climate-related biophysical impacts (sea level rise, for example) of given changes in temperature.[9]

[6] https://www.sciencedirect.com/earth-and-planetrary-sciences/nitrous-oxide. The atmospheric lifetime of methane, another important greenhouse gas, is much shorter: about 12 years. However, its radiative forcing (global warming) potential per ton in the atmosphere is 20 times that of CO_2.

[7] I am focusing on changes in temperature, a key dimension of climate change. However, climate change also involves changes in levels and patterns of precipitation.

[8] While other environmental problems share some of these characteristics, the three characteristics are especially significant for the climate change problem and make the timing of climate policy especially important. Many of the most important local air pollutants (such as sulfur dioxide, nitrogen oxides, and particulates) have much shorter atmospheric lifetimes; they are measured in days rather than centuries. In addition, although many other environmental problems involve irreversibilities, the irreversibilities associated with climate change seem especially significant. In the climate context, future generations will suffer damages long after emissions of the offending pollutant have stopped. This is not the case for emissions of local air pollutants.

[9] Biöschi and Montanari (2010) review the significant uncertainties in studies of the impacts of climate change.

Despite the uncertainties, the central tendencies of the scientific evidence support the conclusion that a delay in policy action poses a great risk of very serious climate-related damages and associated losses to human welfare. The 2018 IPCC report helps characterize the risks. It presents current scientific estimates of temperature change and the associated climate-related damages under a range of emissions scenarios. These estimates are based on the results of the Fifth Phase of the Coupled Model Intercomparison Project (CMIP5), which involved 20 modeling groups from around the world and more than 50 climate models incorporating a range of parameters and emissions scenarios.[10] Notwithstanding the range of models, scenarios, and parameters, the results yield a fairly consistent picture.

Table 1, which is adapted from chapter 2 of the 2018 IPCC report, summarizes the consensus. It indicates the number of years it would take for the global average temperature to increase 1.5°C or 2°C with 50 percent probability, depending on the assumed value of the temperature sensitivity parameter (the TCRE) and the assumed time path of global CO_2 emissions. Column 1 shows the values for the TCRE at the 33rd, 50th, and 67th percentile in the distribution of this parameter. The "threshold stock" in column 3 is the CO_2 stock that implies a 1.5°C or 2°C increase in temperature. The difference between that stock and the stock on January 1, 2018 (column 2) is the increase in the stock that would lead to the threshold stock (column 4). Dividing the number in column 4 by 42—the current CO_2 emissions rate (in gigatons) per year (IPCC, 2018)—yields the number of years to reach the threshold stock. As indicated in column 5, the consensus is that if current emissions rates continue, there is a 50 percent probability that a 1.5°C increase in global temperature will be achieved in 10–20 years (from January 2018), depending on the assumed temperature sensitivity. A 2°C increase will be achieved within 28–48 years.[11]

If instead we assume a CO_2 emissions path consistent with the pledges from the December 2015 Paris Accord, then the 1.5°C threshold would still be achieved in 11–22 years and the 2°C threshold would be achieved in 31–54 years (column 6). The lower emissions rates associated with the Paris Accord lengthen the amount of time to reach the two temperature thresholds by about 10 percent. Even with fulfillment of the Paris pledges, the length of time to reach the 1.5°C threshold can still be viewed as relatively short.

Damages Associated with Threshold Concentrations

To judge the seriousness of the results in table 1, we need to assess the climate–change–related damages associated with the two temperature changes.[12] Figure 1 summarizes the conclusions in the 2018 IPCC report concerning the severity of impacts for various natural,

[10]The project was meant to provide a framework for coordinated climate change experiments, whose results could then be used and interpreted by the IPCC and scientific organizations. See https://www.wcrp-climate.org/wgcm-cmip/wgcm-cmip5.

[11]I would have liked to extend table 1 to include the number of years to reach threshold stocks for a 3°C or greater temperature increase, but the necessary information was not provided in the 2018 IPCC report.

[12]Again I rely on the conclusions from IPCC (2018). While some readers may be skeptical of these conclusions, it is important to note that the IPCC's findings are based on the results of more than 1,000 peer-reviewed studies and reflect the consensus of more than 600 authors from 32 countries.

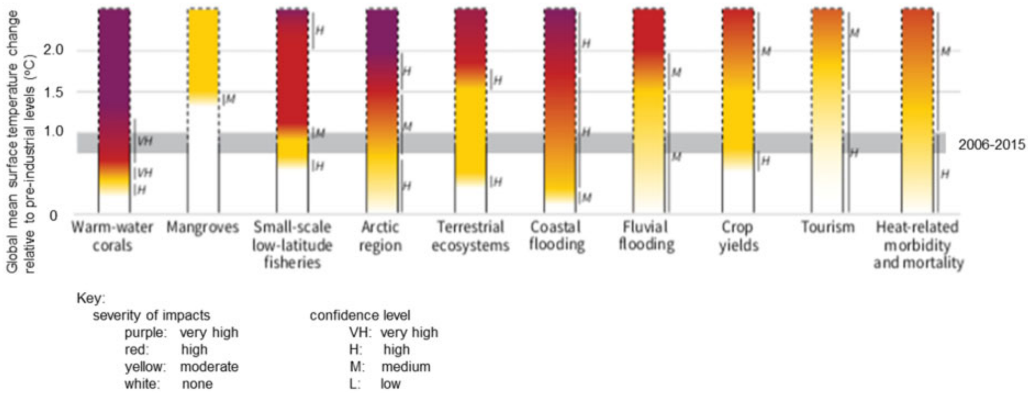
Table 1 Number of years to reach threshold CO_2 stocks under alternative assumptions for emissions rates

Temperature change	Transient climate response to cumulative emissions of carbon (TCRE)	Atmospheric CO_2 stock on January 1, 2018 (gigatons)	Threshold CO_2 stock yielding given temperature increase (gigatons)[a]	Difference [(3) − (2)]	Number of years to reach threshold stocks: if current emissions rates continue	Number of years to reach threshold stocks: if emissions rates follow Paris pledges[b]
	(1)	(2)	(3)	(4)	(5)	(6)
1.5°C increase	0.35°C per 1000 Gt CO_2	2200	3040	840	20.0	22.5
	0.45°C per 1000 Gt CO_2	2200	2780	580	13.8	15.5
	0.55°C per 1000 Gt CO_2	2200	2620	420	10.0	11.2
2°C increase	0.35°C per 1000 Gt CO_2	2200	4230	2030	48.3	54.3
	0.45°C per 1000 Gt CO_2	2200	3700	1500	35.7	40.1
	0.55°C per 1000 Gt CO_2	2200	3370	1170	27.9	31.3

[a] All the numbers in the table are for CO_2 only.

[b] Estimated using the average annual CO_2-only emission rates over the interval 2018–2100 implied by the Paris pledges, based on emissions paths reported in the Climate Action Tracker (https://climateactiontracker.org). The actual Paris pledges are commitments regarding all greenhouse gases. To obtain the figure in column 6, the Paris greenhouse gas emission rates were converted to CO_2-only emission rates, assuming the ratio of CO_2 emissions to total greenhouse gas emissions would remain equal to the ratio in 2010, I applied a ratio of .76, based on what was reported in IPCC AR5, *Mitigation of Climate Change*.

Sources: Information in all columns except the far-right column is from IPCC (2018), chapter 2. Emissions time profiles underlying the results in column 6 were calculated from the Climate Action Tracker (https://climateactiontracker.org).



Source: Adapted from IPCC (2018)

Figure 1. Climate impacts and risks for selected natural, managed, and human systems.

managed, and human systems as a function of the global average temperature increase. The figure indicates that a 1.5°C increase will have very severe impacts on warm-water corals, whose viability is compromised by CO_2-related ocean acidification. Severe and widespread impacts are also predicted for small-scale, low-latitude fisheries, whose fish stocks will be harmed as a result of CO_2-related impacts on coastal ecosystems. In addition, significant losses of Arctic sea ice and significant coastal flooding are predicted. A 1.5°C increase is also expected to have "moderate" impacts on heat-related morbidity and mortality. A temperature increase of 2°C implies considerably more severe consequences in several categories, including heat-related morbidity and mortality.

The Cost of Delay

Notwithstanding the uncertainties, the findings in table 1 and figure 1 imply a very significant probability of quite serious climate change and associated damages unless more aggressive action is taken to reduce CO_2 emissions—beyond what is implied by the Paris Accord. Moreover, delaying such additional reductions heightens the risk of very serious damages. If there is a prolonged delay, accelerated future reductions in emissions would be needed in order to prevent atmospheric concentrations from reaching levels associated with very significant and costly temperature increases. Assuming rising marginal costs of abatement, these accelerated reductions could be very costly.[13] Politicians and the public may be unwilling to bear these (higher) abatement costs,[14] in which case the world would likely suffer severe climate change.

These findings bring out the importance of focusing sharply on the significant costs of delay and the associated urgency of stronger policy action. The next section articulates how economists can achieve this much needed sharper focus.

[13]One offsetting benefit of delay is that it allows time for discovery and development of new and lower-cost methods for emissions abatement (see, e.g., Jaffe et al. 2003). It is not possible to quantify the magnitude of this offsetting benefit, but it seems reasonable to assume it yields only a partial offset to the costs of delay.

[14]Indeed, some commentators claim that atmospheric concentrations of CO_2 have already reached a level that makes the economic costs of adequately reducing emissions to avoid serious climate change too high.

How Economists' Policy Assessments Can Focus More Effectively On Timing and the Costs of Delay

Here I focus on incorporating timing and the related costs of delay into the evaluation of *domestic* (i.e., U.S.) climate policy alternatives. At first glance, such a focus may seem misconceived. Since climate change depends on the total contributions to atmospheric stocks by all countries, any one country's climate policy might appear to have little impact on the extent of climate change or the associated impacts. However, the policies of an individual country can still have substantial global consequences by influencing what other countries decide to do. U.S. domestic policy, in particular, may have little *direct* impact on the future path of the climate, but it can still have a significant effect through its influence on other countries.[15] This suggests that delaying the implementation of a significant U.S. climate policy effort poses global risks by foregoing this potentially beneficial near-term strategic impact.[16]

Thus the issue of timing is clearly relevant to assessments of U.S. climate policies. Yet among the very large number of economic assessments of U.S. climate policy, relatively few focus on timing. When these analyses evaluate policy alternatives, the benefits and costs are usually estimated *conditional on implementation*, and implementation of the alternative policies is assumed to occur at a single common point in time (perhaps the present or a few years in the future).[17] This approach biases against climate policies that have greater prospects for near-term implementation. It ignores the fact that a policy with a greater chance of near-term implementation actually has a cost *advanta*ge over one with little chance of near-term implementation, all else being equal. To illustrate, suppose that, conditional on implementation at a given point in time, policy A achieves some given emissions reduction target at a lower cost than policy B, but policy B has a much greater chance of implementation in the near term. In this case, the *expected* cost of policy B could in fact be lower than the expected cost of policy A.[18] This is because policy B's earlier implementation would avoid some of the costs of delay.

A recognition of the urgency of stronger policy action gives greater importance to considerations of political feasibility in the evaluation of policy options, because the timing of policy action depends on political feasibility. Some readers might believe that considering political feasibility is beyond the purview of economics. In particular, they might think that economists should not seek to incorporate the relative likelihood of near-term implementation in

[15]The U.S.–China agreement on CO_2 emissions reductions illustrates the potential strategic impact of U.S. action. This agreement is recognized as having played a critical role in bringing about the multinational Paris Agreement (see, e.g., Stavins 2018).

[16]This helps explain why many U.S. states and cities, as well as many countries, have been taking significant steps to reduce CO_2 emissions, despite the fact that the *direct* climate benefits from their doing so are almost certainly smaller than the economic sacrifices involved. Clearly there are other factors, including the significant local air quality benefits that stem from reductions in other pollutants that are correlated with emissions of CO_2. These other pollutants include sulfur dioxide, nitrogen oxides, and particulate matter.

[17]Exceptions are studies by Clarke et al. (2009), Luderer et al. (2012), McKibbin et al. (2014), and Daniel et al. (2018).

[18]An alternative accounting method yields the same result. Instead of viewing policy A as having a greater cost because of its higher environmental damage, we can view both policies as having the same (narrowly defined) cost and policy B as yielding larger environmental *benefits* (avoided climate damages). In this case, policy B is still preferred over policy A because its net benefits are greater.

their assessments of policy alternatives, viewing such efforts as being within the purview of political science, not economics.

I am not suggesting that economists become political scientists. However, economists can nevertheless incorporate considerations of political feasibility into their analyses. While leaving it to political scientists or politicians to assess the political feasibility of specific policy options, economists can develop frameworks that allow for alternative assumptions about political feasibility. The different assumptions would imply different prospects for near-term implementation, the likely extent of delay, and the associated costs of delay.

In the remainder of this section I suggest four ways that economists can better account for the urgency of stronger climate policy action and the associated issues of timing and political feasibility.

Emphasize that Earlier Action Reduces Costs

The first way simply involves economists emphasizing that earlier action reduces costs. Toward this end, they can highlight (in workshops, conferences, and published work) the relevance of the probability of near-term implementation to the overall evaluation of domestic policy alternatives.

A related and specific point—and one that deserves greater recognition—is that emphasizing the importance of nearer-term implementation gives rise to a different perspective on policy "add-ons" that might otherwise appear to sacrifice cost-effectiveness or efficiency. Some climate policy designs include "add-on" features (such as compensation payments to certain stakeholders) aimed at addressing distributional concerns or enhancing political feasibility. Oftentimes these add-ons are viewed as liabilities, in keeping with the view that they raise policy costs relative to simpler policies. However, to the extent that these add-ons reduce political opposition and increase the probability of earlier implementation (relative to a simpler policy), they may in fact *lower* climate damages and thus *reduce* overall costs.

Identify Policy Impacts on Key Stakeholder Groups

A second way is to develop and apply economic models that provide detail on the distribution of policy impacts on important stakeholder groups. Relevant stakeholders include politically mobilized and influential industry groups, household groups, labor groups, and consumer groups. Such models would provide policy makers and political scientists with information that could then be used to make judgments about political feasibility and the prospects for near-term implementation. Although some studies already offer this type of information, further modeling of this type would help clarify what is needed to overcome political constraints and achieve nearer-term implementation.

Attention to stakeholder groups and political feasibility can influence the relative cost rankings of policy alternatives. Environmental economists tend to regard CO_2 emissions pricing as the preferred option for federal climate policy. Apart from the timing issue, there are indeed very strong reasons to prefer such pricing.[19] However, it is not clear *a priori* that

[19]These reasons include (1) giving firms greater flexibility (compared with technology mandates) regarding their choice of production methods, which facilitates their ability to select the lowest-cost way to reduce emissions; (2) promoting equality of marginal abatement costs across firms, with such equality being a

emissions pricing would remain the best approach once the differing prospects for near-term implementation (and associated cost savings or avoided damages from earlier implementation) are included in the analysis. To the extent that other climate policy options offer greater prospects for near-term implementation, the advantages from nearer-term implementation would offset disadvantages these policies might have along other dimensions. I will return to this issue later in this article, when I consider how considerations of timing can affect the rankings of some specific policy alternatives.

Include Attention to the Timing of Implementation When Comparing the Costs of Policy Alternatives

A third contribution is for economists to perform analyses that, in comparing policy alternatives, incorporate the cost savings from nearer-term implementation. In such analyses, a policy that has a higher probability of being implemented in the nearer term would have lower costs than a policy with a lower probability, other things being equal. Delay is costly either because it necessitates a costly acceleration of future emissions reductions in order to avoid exceeding a given future concentration target or because it implies higher cumulative emissions and climate damages than would be the case if the delay were avoided.

To assess the potential savings that policy A might have over policy B (due to policy A's better prospects for near-term implementation), economists should consider (1) subjective probabilities of implementation at various points of time in the future and (2) estimates of the differences in expected climate damages of the two policies, with these estimates being a function of the differences in the implementation probabilities. The subjective probabilities (element 1) could be elicited from politicians and political scientists. The differences in expected damages (element 2) would be based on information from climate scientists or from economists' integrated assessment models (IAMs).[20]

Clearly, different experts and models will offer different estimates, reflecting the substantial uncertainties about both the probabilities of implementation and the climate damages associated with different implementation dates. Nonetheless, this framework would provide valuable information by making explicit what needs to be assumed about implementation probabilities and avoided climate damages to make one policy's overall costs lower than the costs of another policy. This would help focus the debates about the relative attractiveness of alternative policies. I would emphasize again that although this framework considers political feasibility, it is fundamentally *economic*, relying on the expertise of economists, not political scientists.

Use IAMs to Help Quantify the Costs of Delay

Finally, economists can help address the urgency of stronger climate action through research that applies IAMs to assess the costs of delay. Although IAMs have made substantial

condition for maximizing cost-effectiveness; (3) encouraging more demand-side conservation than conventional regulations that lead to similar production methods; and (4) having the potential to raise revenues that can be used to finance cuts in the rates of preexisting distortionary taxes, thereby producing efficiency benefits. See Parry and Oates (2000), Fullerton and Metcalf (2001), and Goulder and Parry (2008) for discussions of these issues.

[20]See the discussion of IAMs in the next subsection.

contributions to our understanding of the benefits and costs of a range of climate policy options,[21] current applications of these models often do not fully separate the impacts of timing or delay from other factors that affect overall outcomes in terms of damages or income.

Two experiments using IAMs would help quantify the costs of delay. One would compare emissions paths that begin to undertake emissions reductions at different points in time but lead to the same cumulative emissions reductions over a given time interval. This experiment would isolate the cost of delay by holding overall stringency (cumulative emissions) constant. For the paths in which the initiation of significant emissions reductions is delayed, larger emissions reductions would need to be achieved in later years of the given time interval in order to achieve the same cumulative reductions as the other paths. As noted earlier, under the reasonable assumption that marginal abatement costs increase with the extent of abatement, delay would increase the overall costs during the time interval considered, because speeding up abatement to catch up on cumulative reductions increases costs.

A second experiment would compare benefits and costs of two emissions paths, where one of the paths is a "time-displaced" transformation of the other. I categorize path B as a "time-displaced" transformation of path A if its emissions reductions are the same as those of path A, but delayed j years; that is, if $e^B_{t+j} = e^A_t$, where t refers to the time period and e denotes emissions. In this case, delay is costly because it implies higher concentrations and greater expected climate damages at each point in time within any given interval of time.

These two experiments would help quantify the costs of delay and narrow the range of disagreement over answers to questions like, "How much does the risk of serious damages increase if we wait x years to begin substantial emissions reductions?"

Implications of the Timing of Implementation for Rankings of U.S. Policy Alternatives

How might accounting for the potential for near-term implementation affect the rankings of U.S. climate policy alternatives?

Carbon Tax Packages

Let's first consider a carbon tax. I define a "carbon tax package" as a combination of a given carbon tax time profile and a particular use of the tax revenues. Among the various packages, the one that most economic analyses consider to be the most cost effective is one in which the revenues are used to finance across-the-board cuts in preexisting distortionary taxes such as the marginal rates of individual or corporate income taxes.[22] However, this policy package is

[21]Leading IAMs include the PAGE (Policy Analysis of the Greenhouse Effect) model (Dietz et al. 2007), the FUND (Framework for Uncertainty, Negotiation and Distribution) model (Waldhoff et al. 2011), and the DICE (Dynamic Integrated Climate–Economy) model (Nordhaus 2018). Results from these models formed the basis for the Obama administration's estimate of the social cost of carbon—the external cost of a ton of CO_2 emissions at the margin. Other IAMs include DSICE (Dynamic Stochastic Integrated Model of Climate and Economy; Cai et al. 2012) and MAGICC (Model for the Assessment of Greenhouse Gas Induced Climate Change; Meinshausen et al. 2011).

[22]See, e.g., Goulder and Hafstead (2017) and Fawcett et al. (2018).

likely to continue to face particularly stiff political resistance. Most of this policy's economic benefit comes from the decrease in economic distortions that results from the lowered marginal income tax rates that are financed by the carbon tax. This benefit is not highly visible, however, and this lack of salience limits political support for this option. Moreover, this type of carbon tax package is often viewed as regressive, although recent economic analyses find that such a package in fact is likely to be slightly progressive.[23]

Alternative carbon tax packages may have more promising political prospects. One option, which has received considerable attention and is the approach endorsed by the Climate Leadership Council,[24] would return the tax's revenues in the form of rebates of an equal amount to every U.S. household. This policy package is more progressive than the first tax package described: low-income households would receive a larger income boost from the rebate than from across-the-board cuts in income tax rates. The greater progressivity of this option is attractive in terms of distributional equity, which might also give it the edge in terms of political feasibility, an attribute that is especially closely connected to the issue of urgency. When cost-effectiveness is measured in the narrower, conventional way—that is, when it ignores the expected cost savings associated with greater prospects for near-term implementation—the tax rebate package is less cost effective than the tax cut package. However, to the extent that the tax rebate package, by virtue of its greater political feasibility, increases the likelihood of earlier implementation, the expected costs (net of the avoided environmental costs) are reduced. Thus this alternative package could emerge as the *more* cost-effective option when the broader measure of cost-effectiveness is applied.

Carbon-intensive industries have been a key source of opposition to a carbon tax, and the recycling of carbon tax revenues through rebates to households does not directly address these industries' concerns. The opposition from carbon-intensive industries can be addressed via a carbon tax package in which some of the tax revenues are used to finance corporate tax credits to firms in particularly vulnerable carbon-intensive industries. Goulder and Hafstead (2017) examine how such an approach would prevent a carbon tax from causing profit losses in the 10 industries that otherwise would suffer the greatest percentage reductions in profit. Under this tax package, less revenue would be available to finance cuts in marginal income tax rates, because some of the tax revenue would be devoted to finance the industry tax credits. Thus, according to the standard measure of cost-effectiveness, this package would be more costly than the first carbon tax package. However, this package has a potentially significant advantage in terms of political feasibility. To the extent this implies greater prospects for near-term implementation, it also implies offsetting cost savings that could make this option more attractive than the first package in terms of cost-effectiveness.

A fourth carbon tax option combines elements of the two previous tax packages: it recycles some revenues in the form of a rebate to households and some in the form of a tax credit to firms in carbon-intensive industries. This approach shares some features of British

[23]See Rausch et al. (2011) and Goulder et al. (2019).

[24]The Climate Leadership Council is an international research and advocacy organization whose purpose is to galvanize support for a low-cost, fair, and effective solution to the climate change problem. See https://www.clcouncil.org/our-plan/.

Columbia's carbon tax package, which "recycles" its revenues through both household rebates and tax cuts to producers.[25]

Alternatives to a Carbon Tax

Given the urgency of the climate change challenge, it is also important to consider some alternatives to the carbon tax, with an eye to their political feasibility and associated prospects for near-term implementation.

One alternative is a nationwide Clean Energy Standard (CES), which some analysts claim has better political prospects than a carbon tax. A possible political attraction is that the CES's costs may be less salient by virtue of the fact that the policy is not a tax.[26] Consequently, although studies suggest that a nationwide CES may have a disadvantage when evaluated using what I have referred to as the narrower cost-effectiveness measure, it has the potential to emerge as less costly once its potential for nearer-term implementation is considered and may, in fact, deserve a better ranking than it is often given.[27]

Likewise, the importance of political feasibility and the timing of implementation justifies serious consideration of achieving CO_2 emissions reductions through subsidies to CO_2 emissions abatement rather than through a tax on CO_2 emissions—despite the significant limitations of subsidies on narrow cost-effectiveness grounds.

Whether these alternatives will emerge as top choices based on a broader measure of cost-effectiveness remains to be seen. What is clear, however, is that they deserve close attention in light of the possibility that they may have greater potential for near-term implementation.

Summary and Conclusions

The consensus findings from climate scientists regarding potential future climate change and associated damages have become increasingly ominous over the last decade. These findings reveal that in the absence of significant reductions in CO_2 emissions, atmospheric concentrations of CO_2 stand a significant chance of causing increases in global average surface temperature that are large enough to produce very serious climate-related damages within a decade or two. They imply that stronger policy action—beyond what has been pledged in the 2015 Paris Accord—is urgently needed.

This article has indicated how economists can help reveal more clearly the urgency of stronger policy action. Such clarification requires policy evaluations that focus more sharply on the timing of policy action and the economic costs that result from delayed implementation.

[25]Currently about half of the revenues are devoted to business tax rate reductions and tax credits, 23 percent are devoted to personal income tax rate cuts, and about 25 percent are used for lump-sum rebates to households.

[26]Stock (2019) offers an insightful assessment of the advantages and limitations of the CES and other alternatives to a carbon tax.

[27]Goulder et al. (2016) find that if the probabilities of implementation are ignored, a CES that achieves moderate or large reductions in emissions is less cost effective than an equally stringent carbon tax. However, it is slightly more cost effective than a low-stringency carbon tax. This is due to the CES's ability to avoid the certain price increases that distort factor markets.

I have shown that economists can achieve this sharper focus in several ways. One is simply to place greater emphasis on the fact that earlier action reduces costs. A second is to expand the development and application of numerical models that reveal the economic impacts on key stakeholder groups. Such models provide information relevant to political feasibility and the prospects for near-term implementation. A third is to include attention to the timing of implementation in comparisons of the costs of policy alternatives. Other things being equal, a policy that is likely to be implemented sooner will have a cost advantage. A fourth is to apply IAMs to alternative emissions scenarios designed to isolate the costs of delay. These costs reflect either the additional climate damages from the higher future concentrations attributable to delayed emissions reductions or the extra abatement costs attributable to the future acceleration of emissions reductions that would be needed to avoid the future increase in concentrations that otherwise would result from delay.

As discussed here, greater attention to the prospects for near-term implementation can alter the cost rankings of U.S. climate policy alternatives, increasing the attractiveness of some climate policy approaches that economists might otherwise tend to dismiss. While carbon pricing has several advantages over other instruments for CO_2 abatement, I would argue that consideration of the prospects for near-term implementation justifies giving alternative approaches a closer look.

By bringing out more effectively the significance of the timing of policy implementation and the costs of delay, economists can provide better guidance to policymakers struggling to address what is arguably the world's most urgent and important environmental problem.

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