

Addressing the Urgency of More Stringent Climate Change Policy

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1. Introduction

Over time, the consensus scientific findings about the potential extent of future climate changes and their biophysical consequences have become increasingly ominous. Climate scientists often focus on the associated potential biophysical outcomes given the increases (relative to preindustrial levels) in global average surface temperature. One focal point has been an increase of 2 degrees Celsius. Twelve years ago, a synthesis report from the Intergovernmental Panel on Climate Change (IPCC, 2007) indicated that a 2-degree increase would lead to substantial climate change and very serious associated biophysical impacts. This was the consensus finding from results derived from more than 1,000 peer-reviewed studies.¹ The most recent comparable report (IPCC, 2018) indicates that the impacts from a 2-degree increase would be considerably more severe. A 1.5-degree increase is now considered sufficient to produce climate-related damages of comparable magnitude to those previously attributed to a 2-degree increase.

If CO₂ emissions continue at current rates, how soon might a 1.5-degree increase in temperature occur? A key parameter that influences the answer is the transient climate response to cumulative emissions of carbon (TCRE), which stipulates the ratio of global average surface temperature to the stock of CO₂.² The recent IPCC report supplies the 33rd, 50th, and 67th percentile estimates from the probability distributions for the TCRE. These three values imply that, with 50 percent probability, the atmospheric concentrations that would produce a 1.5-degree temperature increase would be reached in 20, 14, or 10 years, respectively, if the current rate of emissions of CO₂ were to continue. Notwithstanding the uncertainties, these and other scenarios (some considered later in this paper) suggest that delay in addressing the climate change problem would pose substantial risks to human welfare.

For decades, economists have identified the climate change problem as an externality problem that leads to a market failure and a potential role for government intervention.³ Their analyses have influenced policy debates and helped support climate policy action in the US and elsewhere. Yet economists can expand their

¹ The report involved 498 authors from 28 countries.

² For any given amount of cumulative emissions, it indicates the temperature that would prevail over time, assuming no further changes to the stock.

³ William Nordhaus's "How Fast Should We Graze the Global Commons?" (Nordhaus, 1982), published several decades ago in *American Economic Review*, was a seminal contribution.

influence in important ways by giving greater attention to the urgency of more stringent climate policy action and the associated costs of delay. I will present four ways that economists can more satisfactorily address these issues.

A key implication of urgency is that the political feasibility takes on great importance in the evaluation of alternative climate policy options. Political feasibility connects with the likelihood of delay, and delay is costly. Thus, giving greater weight to considerations of political feasibility can affect the cost-rankings of policy alternatives.

The next section offers a brief account of distinguishing features of the climate change problem and some recent scientific findings. Together, the features and findings suggest that stronger policy action is urgent. I turn in Section 3 to the ways that economists can address urgency by focusing more on the timing of policy action—specifically, the prospects for near-term implementation—in evaluating competing policy alternatives. Section 4 suggests how greater attention to the prospects for near-term implementation can alter the rankings of climate policy options. Section 5 offers conclusions.

2. The Costs of Delay

2.1. Distinguishing Characteristics and Urgency

Three characteristics of the climate change problem make timing especially important. One is the mounting nature of the problem. Most of the greenhouse gases have very long atmospheric effective residence times. If anthropogenic emissions of CO₂, the most significant greenhouse gas in terms of radiative forcing, were to cease permanently starting today, it would take 1–3 centuries for atmospheric concentrations of this gas to return to preindustrial levels.⁴ The atmospheric residence time of nitrogen oxide is about 120 years.⁵ These long effective residence times imply that annual emissions of these greenhouse gases continually increase the atmospheric concentrations. Since climate change damages are an increasing function of these concentrations, annual emissions imply continually higher damages, even if the flow of emissions remains constant or declines.

A second characteristic is the irreversibility of climate-related damages. Some key impacts from climate change—for example, sea level rise and the loss of biodiversity—are irreversible within the relevant time horizon. Irreversibility raises the human-welfare stakes: once concentrations are sufficiently high as to cause serious damages, the damages will continue for a long time. Thus, policy makers face the prospect of extremely persistent damages. Thus, irreversibility makes timely action more important than would be the case if the atmospheric lifetimes of CO₂ were shorter.

These first two characteristics would be of intellectual interest but perhaps not great concern if the atmospheric stock of CO₂ today were far from the levels that imply significant changes to the world's climate. But this does not appear to be the case. Current scientific evidence suggests that in the absence of significant reductions in the emissions rate of CO₂, temperature increases sufficient to cause very serious climate-related damages would occur within a decade or two.⁶ The proximity of

⁴ I avoid referring to the “half-life” of atmospheric CO₂ because doing so can be misleading. Individual molecules of CO₂ have a short half-life: they remain in the air only a few years. However, the molecules that leave the atmosphere are replaced close to one-for-one by CO₂ from the oceans, in keeping with the physical equilibrium between the ocean and atmospheric concentrations. This interaction implies that it takes centuries for permanent and significant reductions in CO₂ emissions to bring about significant reductions in the atmospheric stock.

⁵ <https://www.sciencedirect.com/earth-and-planetary-sciences/nitrous-oxide>. The residence time of methane, another important greenhouse gas, is much shorter: about 12 years. However, its forcing potential per ton in the atmosphere is 20 times that of CO₂.

⁶ I focus here on changes in temperature as the key dimension of climate change. However, climate change also involves changes in precipitation levels and patterns.

current stock levels to levels producing very large damages is the third key characteristic of the climate change problem. Combined with the first two characteristics, this third characteristic yields the finding of *urgency*—that action in the relatively near term is needed to avoid very significant costs.⁷

2.2. Scientific Evidence Relating to the Costs of Delay

The conclusion of urgency is built on the assumption of good evidence for long atmospheric lifetimes, significant irreversibilities, and proximity of current concentrations to the concentrations that imply very high damages. Uncertainties apply to each of these elements, but they are greater in some cases than others. Climate scientists have a fairly clear sense of the atmospheric lifetimes of the principal greenhouse gases. Similarly, relatively little uncertainty is connected with whether certain key impacts, such as sea level rise or biodiversity loss, are irreversible.

The greatest uncertainties surround the sensitivity of temperature to the concentration of CO₂ (as expressed by the TCRE, for example) and the climate-related biophysical impacts of given changes in temperature. Despite these uncertainties, the central tendencies of the scientific evidence seem to justify the conclusion that delay poses a great risk of very serious climate-related damages and associated losses to human welfare.

The recent IPCC report offers current scientific estimates as to the extent of temperature change and associated climate-related damages under various emissions scenarios. The estimates reflect results from Fifth Phase of the Coupled Model Intercomparison Project (CMIP5), which involved 20 modeling groups and more than 50 models from around the world and incorporated a range of parameters and emissions scenarios. Despite the large numbers, the results are fairly consistent across models, and they provide a sense of the extent of risk.

⁷ While other environmental problems share some of these characteristics, in the climate-policy context, the long atmospheric lifetimes, irreversibilities, and proximity of current stocks to extremely damaging stock levels 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, not centuries. Also, although many other environmental problems involve irreversibilities, those associated with climate change seem especially significant. In the climate context, future generations can suffer damages long after emissions of the offending pollutant have stopped. For emissions of local air pollutants, this is not the case.

Table 1, adapted from Chapter 2 of the recent IPCC report, indicates the number of years it would take for global average temperature increase to reach 1.5 or 2 degrees with 50 percent probability, depending on assumed temperature sensitivity parameter (the TCRE) and the time path of global CO₂ emissions. The first numbered column shows the 33rd, 50th, and 67th percentile values from the distribution of temperature sensitivity. The second indicates the atmospheric stock of CO₂ on January 1, 2018. The third indicates, under alternative assumptions for the TCRE, the “threshold” stocks of CO₂; that is, the stocks that imply a 1.5- or 2-degree increase in temperature. The difference between the threshold stock and the stock on January 1, 2018 indicates the increase in the stock that would lead to the threshold stock. Current emissions rates are about 42 gigatons per year. Thus, dividing the number in column 4 by 42 yields the number of years to reach the threshold stock. As indicated in column 5, the scientific consensus is that (with 50 percent probability) a 1.5-degree increase would be achieved 10–20 years from January 2018 (fewer years from the present), depending on the assumed temperature sensitivity, if current emissions rates were to continue. A 2-degree increase would be realized within 11–22 years.⁸

The sixth numbered column employs similar calculations, this time assuming that from January 1, 2018 forward, the time path of CO₂ emissions is consistent with the pledges from the December 2015 Paris Accord. These emissions paths were estimated based on the Climate Action Tracker.⁹ The lower emissions rates estimated to be associated with the Paris Accord extend the length of time to reach the two temperature thresholds. The time window expands by about 10 percent. The length of time to reach the 1.5-degree threshold can still be viewed as relatively short: 11–22 years.

To judge the seriousness of the results in Table 1, one needs to consider the extent of the climate-change-related damages associated with the two temperature changes.¹⁰ The IPCC’s conclusions about the severity of impacts are summarized in Figure 1, which is adapted from a figure in Chapter 2 of the IPCC report. The figure shows the severity of impacts for various natural, managed, and human systems, as a function of the global average temperature increase.

⁸ I would have liked to extend Table 1 to include the number of years to reach threshold stocks for a temperature increase of 3 degrees or higher, but the necessary information was not provided in the recent IPCC report.

⁹ <https://climateactiontracker.org>.

¹⁰ Again I rely on the conclusions from the recent IPCC report. Some readers might be skeptical of these conclusions. However, the IPCC’s findings reflect the results from more than 1,000 peer-reviewed studies, and the findings represent a consensus of more than 600 authors from 32 countries.

According to the figure, a 1.5-degree increase implies very severe impacts for warm-water corals, whose viability is compromised by CO₂-related ocean acidification. Severe and widespread impacts are predicted for small-scale low-latitude fisheries, whose fish stocks are harmed as a result of CO₂-related impacts on coastal ecosystems; significant losses of arctic sea ice and significant coastal flooding are also predicted. A 1.5-degree increase is also expected to have “moderate” impacts in terms of heat-related morbidity and mortality. A temperature increase of 2 degrees implies considerably more severe consequences in several impact categories. In particular, the heat-related morbidity and mortality impacts approach the “high” classification.

Notwithstanding the uncertainties, the information in Table 1 and Figure 1 implies a very significant probability of quite serious climate change if more aggressive action to reduce CO₂ emission—beyond what is implied by the Paris Accord—is not taken.

Delay in initiating the needed additional reductions increases the risk of very serious damages. If delay is prolonged, accelerated future reductions in emissions would be necessary to prevent atmospheric concentrations from reaching levels associated with very significant and costly temperature increases. Assuming rising marginal costs of abatement, the accelerated reductions might be extremely costly.¹¹ Politicians and the public might be unwilling to undertake these (higher) abatement costs.¹² In that event, the world would resign itself to very serious climate change. These considerations suggest the importance of focusing sharply on the costs of delay and incorporating attention to delay in the assessment of alternative policy options. The next section considers how economists can offer such a focus.

¹¹ One offsetting benefit from delay is that it allows time to discover new and lower-cost methods for emissions abatement. On this, see, for example Jaffe et al. (2003). It seems impossible to quantify the extent to which this benefit offsets the additional risks posed by delay. Still, the potential for severe climate-related costs from delay seems to justify the assumption that delay is quite costly overall.

¹² Indeed, some commentators seem to be adopting the perspective that atmospheric concentrations of CO₂ had already reached a level that makes the economic costs of avoiding serious climate change too high to justify the necessary emissions reductions.

3. Incorporating Timing in Economic Assessments of Policy Alternatives

3.1. The Externality is Global, but Domestic Policies Matter

The focus here is on integrating considerations of timing into the evaluation of *domestic* climate policy alternatives. At first blush, this focus might seem inappropriate: climate change depends on the total contributions to atmospheric stocks by all world nations, so any single nation's climate policy might seem to have little impact on the extent of climate change or the associated impacts. However, the policies of an individual nation can still have substantial global consequence through strategic effects. Although US domestic policy, in particular, might have little *direct* impact on the future path of climate change, it still can have a significant effect by influencing the extent to which other nations follow along.¹³ Delay in introducing significant US climate policy poses global risks to the extent that it reduces the potentially beneficial strategic impact.¹⁴

This makes timing relevant to US policy assessments. Yet, among the very large number of economic assessments of US climate policy, very few focus on timing. In general, when the analyses consider policy alternatives, the benefits and costs are considered *conditional on implementation*, and implementation of the various alternatives is assumed to occur at a common point in time.¹⁵ This approach biases against policies that have greater prospects for near-term implementation. Indeed, given the costs of delay, a policy with greater chance of near-term implementation has a *cost advantage* over one with little chance, other things equal. Suppose that, conditional on implementation at a given point in time, Policy A achieves some given emissions reduction target at lower cost than Policy B. But suppose that Policy B has a

¹³ An example of potential strategic influence: the US–China agreement on CO₂ emissions reductions is recognized as having been critical to bringing about the multinational Paris Agreement. See Aldy and Stavins (2010) and Stavins (2018) for assessments of the international impacts from US domestic climate-policy efforts.

¹⁴ This helps explain why many US states and cities, as well as many countries of the world, have been taking significant steps to reduce CO₂ emissions, despite the fact that the *direct* climate benefits from their doing so are almost certainly smaller than the economic sacrifices involved. Of course, other factors exist, including significant “local” benefits that stem from reductions in the local pollutants correlated with emissions of CO₂.

¹⁵ McKibbin et al. (2014) and Kotlikoff et al. (2019) are exceptions.

much greater chance of implementation in the near term. Then the *expected* cost of Policy *B* could be lower than that of Policy *A*.¹⁶ Policy *B*'s earlier implementation would avoid some costs of delay.

3.2. How Economists Can Give Greater Focus to Timing

As noted, recognizing the urgency of stronger climate policy action gives greater importance to considerations of political feasibility in evaluating policy options. Greater prospects for near-term implementation imply lower costs by reducing expected costs of delay.

Readers might feel that political feasibility is beyond the purview of economists, and that, accordingly, economists should not aim to incorporate the relative likelihoods of near-term implementation when assessing policy alternatives. I do not mean to suggest that economists become political scientists. However, economists can nevertheless integrate considerations of political feasibility in their analyses. They can develop frameworks that reveal the implications of political feasibility for expected climate damages and leave it to other experts to assess the political feasibility of given policy options. More generally, economists can consider prospects for near-term implementation in their rankings of the costs of policy alternatives. I suggest four ways.

The first is largely conceptual. It simply involves emphasizing that earlier action reduces costs, by economists giving greater attention, in workshops, conferences, and published works, to the relevance of the probability of near-term implementation in the overall evaluation of domestic policy alternatives.

A particular idea worthy of emphasis is that considerations of timing yield a different perspective on policy “add-ons” that might otherwise seem to sacrifice cost-effectiveness or efficiency. Some climate policy designs include elements (such as compensation payments to certain stakeholders) that aim to address distributional concerns or enhance political feasibility. Oftentimes, these add-ons are viewed as liabilities because they raise policy costs relative to simpler policy designs. However,

¹⁶ An alternative accounting method yields the same result. Instead of referring to the higher environmental damage as a greater cost of Policy *A*, we can view both policies as having the same (more narrowly defined) cost yet indicate that Policy *B* yields larger environmental benefits (avoided climate damages). In this case, Policy *B* is again preferred because its net benefits are higher.

to the extent that the add-ons reduce political resistance and raise the probability of earlier implementation relative to a simpler policy, they can imply *lower* climate damages and thereby *reduce* overall costs. The point deserves greater recognition.

A second contribution involves developing and applying economic models that reveal in some detail the distribution of policy impacts on important stakeholder groups. The stakeholders can include household, labor, and consumer groups and politically mobilized production sectors. These studies would provide useful information to politicians and political scientists, who can then judge political feasibility and the prospects for near-term implementation. Although some studies already offer this sort of information, additional work along these lines would have significant payoffs.

In making this second contribution, economists should be open to a wide range of policy approaches, including but not limited to putting a price on CO₂ emissions. This is very important. Environmental economists tend to regard CO₂ emissions pricing as the preferred approach to federal climate policy, if not the only option worthy of serious consideration. Apart from the timing dimension, there are indeed very strong reasons to prefer such pricing.¹⁷ However, it is not clear a priori that emissions pricing would remain the most attractive approach once the timing dimension (and associated cost-savings or avoided damages from earlier implementation) is included in the analysis.

A third contribution would be to offer analyses that, in comparing policy alternatives, consider quantitatively the cost-savings (reductions in environmental damages) from nearer-term implementation. In these analyses, a policy with greater prospects for nearer-term implementation would involve lower costs than a policy with weaker prospects, other things equal.

To assess the potential savings that Policy A might have over Policy B as a result of better prospects for near-term implementation, economists can consider, for each policy, (a) subjective probabilities of implementation at various points of time in the future and (b) estimates of the two policies' differences in expected climate damages, with these estimates a function of the differences of the implementation probabilities

¹⁷ Attractions include (a) 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; (b) promoting equality of marginal abatement costs across firms, such equality being a condition for maximal cost-effectiveness; (c) encouraging more demand-side conservation than is motivated by conventional regulations that lead to similar production methods; and (d) 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 related discussions.

referred to as elements of (a). The subjective probabilities could be elicited from politicians and political scientists; the differences in expected damage would be based on information from climate scientists' or economists' integrated assessment models (IAMs). Obviously, different experts are likely to offer different numbers, reflecting the substantial uncertainties along both dimensions. Nonetheless, the resulting framework would provide valuable information by making explicit what needs to be assumed about implementation probabilities and avoided climate damages to make a given policy's overall costs lower than another's. This would help focus the debates about the relative attractiveness of the policies under consideration. Note that although this framework considers political feasibility, it is fundamentally *economic*; it exploits the expertise of economists.

A fourth way that economists can help address urgency is through focused work to assess the costs of delay. The IAMs referred to in the previous paragraph are the appropriate tool for assessing such costs. IAMs have made substantial contributions to our understanding of the benefits and costs of a range of climate policy options.¹⁸ However, current applications of these models often do not fully isolate the impacts of timing or delay from other factors influencing overall outcomes in terms of damages or income.

Two experiments with IAMs would be especially useful. One would compare emissions paths that lead to the same cumulative emissions reductions over a given time interval but differ in timing: the paths begin to initiate significant emissions reductions at different points in time. This would isolate the cost of delay by holding overall stringency (cumulative emissions) constant. For the paths in which the initial significant reductions are delayed, larger emissions reductions must be achieved in later years in order to achieve the same cumulative reductions as the other paths over the given interval involved. Assuming that marginal abatement costs increase with the extent of abatement, delay raises the overall costs during the interval involved, because speeding up abatement to catch up on cumulative reductions raises costs.

A second useful experiment would compare benefits and costs of "time-displaced" emissions paths. We can call Path *B* a "time-displaced" transform of Path *A* if its emissions reductions are the same as those of Path *A* but delayed *j* years: that is, if

¹⁸ Leading IAMs include the Page Model (Dietz et al., 2007), Fund Model (Waldhoff, 2011), and DICE Model (Nordhaus, 2018). Results from these models formed the basis of the Obama administration's estimate of the social cost of carbon—the external cost of a ton of CO₂ emissions at the margin. Other IAMs include the DSICE Model (Cai et al., 2012) and MAGICC (Meinshausen et al., 2011).

$e_{t+j}^B = e_t^A$, where t refers to the time and e denotes emissions. Here, delay is costly because it implies higher concentrations and greater expected climate damages at each point in time within any given interval.

These experiments would help quantify the costs of delay. They would offer what was given as element b in the discussion earlier of the potential “third contribution” of economists: narrowing the range of disagreement over the answers to questions like, “How much does the risk of serious damages increase, if we wait X years to begin substantial emissions reductions?”

I believe economists in general have not offered sufficient attention to the urgency of the climate change problem. In the four ways just outlined, they can give this issue the focus it deserves.

4. Some Potential Implications for US Policy Rankings

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

Consider first a carbon tax. Define a “carbon tax package” as a combination of a given carbon tax time profile and a particular specification for the use of the tax revenues. Among the various packages, the one deemed most cost-effective according to most economic analyses is one in which the revenues are devoted to financing across-the-board cuts in preexisting distortionary taxes, such as the marginal rates of individual or corporate income taxes.¹⁹ However, political resistance to this policy package is likely to continue to be particularly stiff. Most of its economic benefit comes from the lowered economic distortions that result from the lowered marginal income tax rates financed by the carbon tax. Salience counts, and this benefit is not highly salient. Moreover, this form of carbon tax package is often regarded as regressive (although recent economic analyses²⁰ find that, in fact, it would likely be slightly progressive).

Alternative packages could have better political prospects. One alternative would return the tax’s revenues in the form of rebates of an equal amount to every US household. This is the approach endorsed by the Climate Leadership Council.²¹ This policy package has gained considerable attention. It is more progressive than the tax package described earlier: low-income households receive a larger income boost from the rebate than they would as a result of across-the-board cuts in income tax rates. The greater progressivity has attractions in terms of distributional equity. It might also give this approach the edge in terms of political feasibility, which is especially relevant to the issue of urgency. When cost-effectiveness is measured in the conventional way (ignoring the expected cost-savings associated with greater prospects for near-term implementation) the policy package involving recycling via lump-sum tax rebates is less cost-effective than the one involving recycling through tax rate cuts. However, to the extent that this form of recycling, by virtue of greater political feasibility, increases the likelihood of earlier implementation, the expected costs net of the avoided environmental costs are reduced. This alternative package could emerge as *more* cost-effective according to the broader cost-effectiveness measure.

¹⁹ See, for example, Fawcett et al. (2018) and Goulder and Hafstead (2017).

²⁰ See Rausch et al. (2011) and Goulder et al. (forthcoming).

²¹ <https://www.clcouncil.org/our-plan/>

As noted, carbon-intensive industries have been another key source of opposition to a carbon tax. Recycling carbon tax revenues through rebates to households does not directly address this source of opposition. A carbon tax package that would do so combines a carbon tax with some revenues used to finance corporate tax credits to firms in particularly vulnerable carbon-intensive industries. Goulder and Hafstead (2017) explore how this approach can prevent a carbon tax from causing profit losses in the 10 industries that otherwise would suffer the largest percentage reductions in profit. Under this tax package, less revenue is available to finance cuts in marginal income tax rates because some of the tax revenue is devoted to financing the tax credits. As a result, according to the standard measure of cost-effectiveness, this package is more costly than the first package. However, this package has a potentially significant advantage in terms of political feasibility. To the extent that this implies greater prospects for near-term implementation, it will yield offsetting cost-savings. Overall, it could prove more attractive than the first package.

A third option is to combine elements of the two previous tax packages: recycle some revenues in the form of a rebate to households and some as a tax credit to firms in carbon-intensive industries. This approach has something in common with British Columbia's carbon tax package, which recycles its revenues as both household rebates and tax cuts to producers.²²

As suggested earlier, given the high stakes posed by the climate change challenge, it is reasonable to also 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). Some analysts claim that a nationwide CES has better political prospects than a carbon tax, in part because its costs seem to be less salient than the costs associated with a carbon tax. Consequently, although studies suggest it may have a disadvantage according to a narrower cost-effectiveness measure—one that did not account for prospects for near-term implementation—it could potentially emerge as less costly once such prospects are considered.²³ Given the very high stakes of the climate change problem in terms of future human welfare and the urgency of action, the potential political

²² Currently, about half the revenues are devoted to business tax rate reductions and tax credits, 23 percent to personal income tax rate cuts, and about 25 percent to lump-sum rebates to households.

²³ My paper with Marc Hafstead and Rob Williams (*American Economic Journal—Economic Policy*, 2016) finds that, ignoring probabilities of implementation, 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 at low stringency levels. This stems from the CES's ability to avoid the certain price increases that distort factor markets.

prospects of this policy deserve consideration as part of the overall cost assessment. This policy might deserve a better rating than it often receives. Likewise, it seems worth employing this framework to reinvestigate the overall costs of achieving reductions via subsidies to CO₂ abatement, despite the serious limitations of subsidies on narrow cost-effectiveness grounds.

I am not claiming these alternatives are better than the carbon tax, but I believe it is worth considering them, along with a carbon tax, with attention to their political prospects. The high human-welfare stakes of the climate change problem justify considering a wide range of options.

5. Conclusions

Earlier action to address environmental problems always has attractions, but in the context of the climate change problem, earlier action is especially important. This reflects three key features of the problem: the long residence times of CO₂ and other greenhouse gases, the irreversibility of important climate-change-related biophysical impacts, and (as indicated by recent scientific findings) the proximity of current atmospheric stocks of CO₂ to levels that would yield very serious climate change.

These features imply that significant delay in achieving more stringent climate change policy—beyond the extent implied by the Paris Accord—is likely to be very costly. Delay would necessitate accelerated future reductions in emissions to prevent atmospheric concentrations from reaching levels associated with substantial temperature change and the accompanying very serious climate-related impacts. Marginal costs of abatement tend to increase with the rate of abatement, which means that the accelerated reductions would raise costs relative to a scenario involving earlier implementation.²⁴ Delay also can increase the risk that atmospheric concentrations will reach the levels associated with very serious climate-related damages. This is because a significant delay might make politicians and the public reluctant to endure the (especially high) abatement costs associated with the more rapid future abatement that was made necessary because of nearer-term inaction. In that event, the consequence of delay is a world resigned to very serious climate change.²⁵ Either way, delay is costly.

Economists can help reduce the likelihood of these outcomes by giving greater focus to the urgency of more stringent climate policy action and the associated costs of delay. This essay presents four ways that economists can account for the significance of urgency in their assessments of climate policy alternatives. Doing so will yield very important policy-relevant information, lead to more adequate rankings of policy costs, and enable economists to provide better guidance to policymakers struggling to address a most urgent and important environmental problem.

²⁴ As noted earlier, technological change can mitigate the cost increase.

²⁵ Moreover, to the extent that delay increases the expected extent of climate change, it increases the expected amount of (costly) adaptation needed to maintain any given level of future well-being.

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Tables and Figures

Table 1. Time to Reach Threshold CO₂ Stocks Under Alternative Assumptions for Emissions Rates

	Transient Climate Response to Cumulative Emissions of Carbon (TCRE)	Stock on January 1, 2018 (gigatons)	Threshold Stock Associated with Given Temperature Increase (gigatons) ^a	Difference [3 – (2)]	Number of Years to Reach Threshold Stocks	
					If current emissions rates continue	If emissions rates follow Paris pledges ^b
	(1)	(2)	(3)	(4)	(5)	(6)
1.5-Degree Increase	0.35°C per 1000GtCO ₂ (33 rd percentile)	2200	3040	840	20.0	22.5
	0.45°C per 1000GtCO ₂ (50 th percentile)	2200	2780	580	13.8	15.5
	0.55°C per 1000GtCO ₂ (67 th percentile)	2200	2620	420	10.0	11.2
2-Degree Increase	0.35°C per 1000GtCO ₂ (33 rd percentile)	2200	4230	2030	48.3	54.3
	0.45°C per 1000GtCO ₂ (50 th percentile)	2200	3700	1500	35.7	40.1
	0.55°C per 1000GtCO ₂ (67 th percentile)	2200	3370	1170	27.9	31.3

Data sources: Information in all columns except far-right column is from IPCC SR1.5, Chapter 2. Emissions time profiles underlying the results in column 6 were calculated from Climate Action Tracker.

^a All the numbers in the table are for CO₂ only.

^b Estimated using the average annual CO₂-only emissions rates implied by the Paris pledges, with the average rate calculated over the interval 2018-2100. The actual Paris pledges are commitments regarding all greenhouse gases. To obtain the figures in column 6, the Paris greenhouse gas emissions rates were converted to CO₂-only emissions rates assuming the ratio of CO₂ emissions to total greenhouse gas emissions would remain equal to the ratio in 2010. We applied a ratio of 0.76, based on what was reported in IPCC AR5, *Mitigation of Climate Change*.

Figure 1. Impacts and Risks for Selected Natural, Managed, and Human Systems



