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Climate Policy in the Age of Trump

ABSTRACT. The Trump administration is in the process of undoing what were the two central planks of President Obama's climate policy: First, Trump has called for a review of how the social cost of carbon is calculated in used in analyses of regulatory rule making and, second, Trump has announced that the United States is withdrawing from the Paris Agreement. In this paper I examine some of the conservative critics' objections to the first plank: calculations of the social cost of carbon in climate cost benefit analyses. I argue that while some of these criticisms are justified, the criticisms end up strengthening arguments for the importance of the second plank: the urgent need for an ambitious climate policy, in accord with the Paris Agreement, as precaution against exposing others to the risk of catastrophic harms.

1. INTRODUCTION

As the record-breaking heat of 2016 continues into 2017, making it likely that 2017 will be the second hottest year on record just behind the El Niño year 2016, and as Arctic heat waves pushing the sea ice extent to record lows are mirrored by large scale sheets of meltwater and even rain in Antarctica—the Trump administration is taking dramatic steps to undo the Obama administration's climate legacy.

In its final years, the Obama administration pursued two principal strategies toward climate policy. First, by signing the Paris Accord it committed the U.S. to contribute to global efforts to hold "the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels" (United Nations Framework Convention on Climate Change 2017, Article 2a). The Paris agreement in effect commits its signatories to reduce carbon emissions to levels close to zero by mid century. The Environmental Protection Agency's 'Clean Power Plan' was intended as the U.S. government's initial effort to work towards this ambitious goal.

Second, the Obama administration attempted to put a price on carbon emissions by charging an Interagency Working Group (IWG) to calculate the social cost of carbon (which is the cost associated with emitting an additional ton of carbon dioxide, or its equivalent, into the atmosphere). The IWG's results were used in cost–benefit analyses of regulatory actions (Interagency Working Group on Social Cost of Carbon 2010).

The two strategies presuppose two starkly different conceptual frameworks for arriving at a climate policy. The Paris temperature goals are motivated by broadly precautionary thinking. Temperature increases of 2°C or more would take us outside of the temperature band that we humans have experienced in our 200,000-year history (Jaeger and Jaeger 2011). Moreover, there is evidence that many climate tipping points are located at around 2°C above pre-industrial levels or slightly above 2°C (Schellnhuber, Rahmstorf, and Winkelmann 2016) (Knutti et al. 2016). Thus, limiting the temperature increase to well below 2°C promises significantly to reduce the risk of catastrophic climate change. By contrast, the IWG's calculations are situated within the framework of expected utility theory. The cost of carbon is calculated by running so-called *optimization*

Integrated Assessment Models (IAMs) that balance the costs of mitigation measures against their future benefits to determine the optimal climate policy.

The Trump administration is dismantling both strategies. In an executive order signed March 28, 2017, Trump ordered a review of the Clean Power Plan, with the aim to "suspend, revise, or rescind" the Plan (Sec. 4a). He also called for a review of the social cost of carbon and ordered that the IWG be disbanded and all documents issued by the IWG pertaining to the calculations of the social cost of carbon "be withdrawn as no longer representative of governmental policy" (Sec. 5). And on June 1, 2017 Trump announced that the United States would withdraw from the Paris Agreement, claiming that "the Paris Accord is very unfair at the highest level to the United States." (Trump, 2017)

With his executive order, Trump is following the advice of Thomas Pyle, head of the Department of Energy transition team, who has advocated that the use of the social cost of carbon in federal rulemaking be ended: "The Obama administration aggressively used the social cost of carbon (SCC) to help justify their regulations. During the Trump administration the SCC will likely be reviewed and the latest science brought to bear. If the SCC were subjected to the latest science, it would certainly be much lower than what the Obama administration has been using."[1] Pyle here echoes criticisms made by Robert Murphy, a senior economist at the Institute for Energy Research (EIR), who in written testimony before the Senate Committee on Environment and Public Works has argued "that the 'social cost of carbon' is not an objective empirical feature of the world, but is rather a very malleable figure dependent on modeling assumptions, and can be made

[1] In a memo leaked to the press. See https://cleantechnica.com/2016/12/08/leaked-transition-team-memo-outlines-trumps-catastrophic-energy-agenda/ accessed 17. Feb 2017, 1 pm EST.

large, small, or even negative depending on parameter choices" (Murphy 2013). The basic criticisms Murphy and others make of the IWG's use of integrated assessment models to calculate a social cost of carbon are, first, that scientific uncertainties are too large to permit any reliable estimate of the SCC and, second, that some of the assumptions going into the construction of IAMs are normative assumptions and, hence, that any model output cannot serve as an objective basis for climate policy decisions (see also Johnston 2016).

Michael Greenstone and Cass Sunstein, two of the architects of the Interagency Working Group, have defended the use of the SCC in regulatory analysis in *The New York Times*. Citing the central estimate of the IWG of $35 per ton of carbon dioxide they maintain that "this figure plays a central role in the cost–benefit analyses that agencies use in deciding whether to issue regulations to limit greenhouse gas emissions" and that "without it, such regulations would have no quantifiable benefits. For this reason, the social cost of carbon can be seen as the linchpin of national climate policy" (Greenstone and Sunstein 2016). Others share the view of the importance of the SCC. Thus, the climate journalist Andrew Revkin wrote that “there’s probably no more consequential and contentious a target for the incoming administration [as far as climate and energy policies are concerned] than an arcane metric called the ‘social cost of carbon’” (Revkin 2017).

I want to argue here that the conservative criticisms are to some extent correct: models contain deep uncertainties and they rely on normative assumptions. Yet the conclusions the critics want to draw do not follow and their criticisms do not justify Trump's decision also to undo the Obama administration's initial steps to satisfy U.S.

commitments under the Paris agreement. The models used by the IWG downplay uncertainties by making unjustifiably optimistic assumptions about the values of certain key parameters. Instead of trying to correct for this error by broadening the class of assumptions under investigation, the conservative critics reinforce the error further by cherry-picking predictions that lie at the optimistic end of the spectrum found in the peer-reviewed literature.

In addition, some of the normatively loaded assumptions have the consequence that potential harms to the populations most vulnerable to (and least responsible for) climate change are effectively ignored. Thus, a proper accounting of the uncertainties in our knowledge of how climate and economic systems interact and of the moral challenges of climate change puts us exactly in the epistemic and moral situation to which the Paris temperature targets are a response: in a situation in which we face scientifically plausible catastrophic harms; a precautionary approach is warranted, as embodied in the 2°C or 1.5°C targets. What is more, when many of these potential harms fall in the first instance upon the poorest populations and will do so as a result of our own activities, we have a moral duty to cease these activities and adopt policies that protect the most vulnerable populations from catastrophic harms.

Those associated with the Trump administration and with Republicans in Congress have offered a wide variety of criticisms of climate science and of the Obama administration's climate policies. Trump himself has famously called climate change a hoax perpetrated by the Chinese.[2] William Happer, an atomic physicist who at one point seems to have been under consideration for the position of Trump's science advisor, points to the fact that during the last 520 million years there have been periods when

[2] On Twitter: https://twitter.com/realDonaldTrump/status/265895292191248385?ref_src=twsrc%5Etfw

atmospheric CO_2 concentrations were much higher than at present, as reason for why the current increase in emissions presents no cause for concern ("Trump's Potential Science Adviser Will Happer: Carbon Dioxide Demonized Just Like 'Poor Jews Under Hitler'" 2017). As dangerous and as false as these views may be—Trump's claim is flat out wrong and Happer's claim while true is solace only for those who do not care about coastal cities or for a planet inhabited by the species with which we have coevolved in the last 100 million years—these views are not very interesting philosophically. Thus, I will here focus on what is arguably a more interesting criticism of at least one plank of the Obama administration's approach to climate policy: criticisms of the cost–benefit approach pursued by the Office of Management and Budget under Obama.

While some of the conservative criticisms of this approach are not without merit, the right conclusion to draw from the deep uncertainties that plague the IWG's calculations and from the ethical context of the climate problem is that we need to act even more aggressively on climate change than the Obama administration was prepared to do.

2. THE SOCIAL COST OF CARBON

According to expected utility theory, we should adopt the climate policy that maximizes expected utility. Calculating the expected utility associated with a climate policy requires as inputs, first, the costs and benefits of different policy choices, including the economic costs of mitigation measures as well as future benefits of reductions in temperature increases, and, second, a probability distribution over costs and benefits. In practice, the maximization calculation is performed with the help of so-called 'optimization integrated assessment models' (IAMs). These models couple an economic general equilibrium model to an extremely simplified climate model with the aim of representing the impacts of climate change on human welfare, the impact of changes in economic activity on GHG emissions, and the effect of mitigation measures on economic growth. The IWG considered three widely discussed IAMs in its calculation of the social cost of carbon: William Nordhaus's DICE model (Nordhaus 2008), which is one of the earliest optimization IAMs and remains one of the most influential models; the PAGE model used in the Stern Review (Stern 2007); and Richard Tol's FUND model (Tol 2002a; Tol 2002b).

The two core components of optimization IAMs—the climate model and the economy model—are coupled through two different channels: economic activity is assumed to affect climate change through the emission of greenhouse gases (GHGs); and economic activity is modeled as being affected by climate change through a so-called 'damage function.' Optimization IAMs are used to determine what the optimal emission abatement strategy would be by maximizing the present value of overall utility, which consists in an aggregate of utilities across time. Any such cross-temporal aggregation faces the problem as to what relative weight to assign to utilities at different times. It is common practice to discount future utilities with respect to the present. The IWG calculated values for the SCC for three different discount rates, 2.5%, 3%, and 5%. The results, reported on the EPA website, are $56, $36, and $11.[3]

[3] https://www3.epa.gov/climatechange/Downloads/EPAactivities/social-cost-carbon.pdf accessed on 2/25/2017

In what follows I want to briefly discuss three areas in which uncertainties arise: an IAM climate model, the discount rate chosen in the economy model, and the damage function that models climate impacts.[4]

2.1. *Climate Sensitivity*

The climate model of an IAM consists of a small number of equations with parameters, whose values need to be calibrated with the help of more complex climate models. One central parameter is the so-called 'equilibrium climate sensitivity' *ECS*, which is defined as the equilibrium mean surface temperature response to a doubling in atmospheric CO_2. The IPCC report (AR5) reports probability density functions for the value of *ECS* derived from complex climate models or paleo-climate data (Bindoff et al. 2013, Figure 10.20a). Now the first thing to note is that the basic physical mechanism by which an increase in atmospheric CO_2 concentrations affects the Earth's energy balance is extremely well understood and that climate scientists know a lot about the value of the climate sensitivity. According to the (AR5) "there is *high confidence* that *ECS* is *extremely unlikely* less than 1°C and *medium confidence* that the *ECS* is *likely* between 1.5°C and 4.5°C and *very unlikely* greater than 6°C." (Bindoff et al. 2013, 10.8.2) Thus, we know a range of values within which the climate sensitivity is very likely to fall. The second thing to note is that the climate sensitivity is much better constrained on the lower end—it is, with high confidence, extremely unlikely to be less than 1°C, but that it is only *very likely* less than

[4] For additional criticisms of IAMs and their use by the IWG see (Masur and Posner 2010; Frisch 2013; Pindyck 2013).

6°C and this statement is made with only medium confidence.[5] The third thing to note is that even though we know a lot about the value of the climate sensitivity, what we know is not enough to perform a cost–benefit analysis or welfare maximization analysis. In order to calculate the optimal emissions policy we would need to know the probabilities with which different consequences would occur. But in order to derive a single probability distribution for *ECS* we would have to know what the probabilistic dependencies between the different models are from which the IPCC distributions for *ECS* are derived. And these dependencies are unknown. Thus, despite the fact that we know quite a bit about the value of *ECS*, we are in a situation of *deep uncertainty* with respect to its value—that is, not only is the exact value of *ECS* unknown but we do not even have grounds for associating a specific probability distribution with *ECS*.

IAMs 'solve' this problem by simply positing a probability distribution that is peaked at the center of the IPCC range, but no formal justification for this procedure is given. Moreover, the probability distributions posited by different IAMs are symmetric and do not have fat upper tails and hence ignore the possibility of extreme runaway climate change, which according to some models has a low but non-negligible probability of occurring.[6] Hence, IAMs turn deep uncertainties into precise probabilities and do this in a manner that skews uncertainties towards less serious threats.

There is a fourth point to note. The different probabilities for *ECS* summarized by the IPCC are derived within the frameworks of various climate models and are not adjusted for any idealizations or factors left out in the models. The IPCC probabilities for

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[5] For an explanation of how the two axes along which the IPCC report expresses confidence, see the IPCC Guidance Note (Mastrandrea, M. D., C. B. Field, T. F. Stocker, O. Edenhofer, K. L. Ebi, D. J. Frame, H. Held, E. Kriegler, K. J. Mach, and P. R. Matschoss, G.-K. Plattner, G. W. Yohe, and F. W. Zwiers 2010)

[6] The consequences of fat-tailed distributions for climate policy are explored in (Weitzman 2012).

ECS are *model-based probabilities* and not yet decision-relevant probabilities. Sophisticated climate models offer an increasingly fine-grained representation of the climate system and include more and more factors that are believed to be relevant to the overall state of the system. Even so, many potentially important factors are omitted. These include melting of the Greenland and Antarctic ice sheets; melting of the permafrost and large-scale release of methane from Siberian methane clathrates; and release of seabed methane. The factors not represented in the models tend to be *positive feedback factors* that are likely to exacerbate the rate of warming and could even result in 'tipping point' behavior. Indeed, Previdi et al. (2013) argue that *ECS* would be between 4°C and 6°C if the ice sheet and vegetation albedo feedback were included. As Sir Nicholas Stern puts it, quoting Sir Brian Hoskins: climate models predict "the climate we get if we are very lucky" (Stern 2013, 842). Decision-relevant probabilities would have to take into account the probabilities of futures in which we might not be so lucky, but these probabilities are unknown.

2.2. *Future Discounting*

The second core component of an IAM is an economy model with a welfare function representing overall global welfare at a time. In principle, the concept of welfare equivalent consumption is meant to be broad and include not only consumption but also environmental goods and other goods that are not marketable. Thus, Nordhaus says: "Economic welfare should include everything that is of value to people, even if those things are not included in the market place" (Nordhaus 2008, 13). In practice, however non-marketable goods are simply ignored and IAMs measure welfare equivalent consumption in terms of GDP.

IAMs aggregate welfare across time. The discount rate allows us to calculate the net present value of future welfare. There is widespread disagreement in the literature not only on what choice of discount rate is appropriate but even on what the proper methodology for choosing a discount rate ought to be. What makes matters worse is that predictions derived from IAMs are extremely sensitive to the choice of discount rate, as is evident from the different values for the SCC derived by the IWG.

Here I want to focus on one aspect that highlights both the uncertainties affecting IAMs and the normative import of some of their assumptions. There are at least two normative issues that affect the discount rate.[7] First, the value of the *pure rate of social time preference* captures to what extent present welfare should be valued more highly just because it occurs in the present. Second, it is common to posit the law of diminishing marginal utility and assume that marginal utility declines. If we adopt a temporally egalitarian position (as many philosophers and economists argue we should) and set the pure rate of social time preference equal to zero, the discount rate becomes a measure of inequality aversion.

Standard IAMs posit a representative consumer at each time and consider the wealth transferred between representative consumers at different times. If we take the rate of pure time difference to be zero and assume positive worldwide economic growth, then we are justified to discount future welfare just in case the future will be richer than the present. But as Fleurbaey and Zuber(2012) show, this assumption changes

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[7] For discussions to what the choice of discount rate is a normative or 'descriptive' issue, see (Posner and Weisbach 2010), which is critically discussed in (Fleurbaey and Zuber 2012; Frisch 2012).

dramatically if we adopt a slightly more complex model and allow for different populations at each time with different levels of wealth. If in modeling the transfer of wealth we distinguish between the transfer between different populations at different times the overall inter-temporal discount rate will in the long run be mathematically dominated by the discount rate governing the transfer from the worst-off population in the present to the worst-off population in the future.

The effect of this is that discount rates may very well be negative. If the costs of a climate policy are carried by the high emitters of greenhouse gases, who also tend to be among the most affluent, and the beneficiaries include many of the future poor, then such a policy will have a negative discount rate. What is more, if we make the not implausible assumption that there will be climate change losers among the poorest populations, wealth transfer from the present poor to the future poor will be transfer from a comparatively richer population to even poorer populations in the future. Thus, even a climate policy that asks the present-day poor to contribute to mitigation costs could have a negative discount rate.

The overall discount rate reflects normative assumptions and has a large effect on the value of the SCC. Does this show that the Institute for Energy Research (IER) economist Murphy is correct when he says that the overall SCC is "a very malleable figure dependent on subjective modeling assumptions" (Murphy 2013)? This does not follow. First, for many scientific predictions it will be the case that they are "very malleable figure[s] dependent on modeling assumptions," as Murphy says. Quite generally, scientific predictions are derived by constructing a model of a phenomenon. That predictions are sensitive to modeling assumptions, which invariably will include idealizations and abstractions, is to be expected. The crucial question is how well supported the modeling assumptions are.

I have argued above that any choice of probability distribution for *ECS* cannot be fully supported by predictions from climate models and our physical understanding of the climate system and is to some extent unprincipled. But not every modeling assumption that is not underwritten by the relevant science is subjective in the sense of being arbitrary. There may be principled and legitimate reasons supporting an assumption even when it is not justified empirically. Normative assumptions are a case in point. While normative assumptions might not be objective in the same way as physical assumptions are they might be intersubjective and reflect widely shared commitments. Thus, just as we can hope that our choice of climate parameters represents the climate system adequately (for a given purpose), so we can hope that normative parameters adequately represent either our actual intersubjectively held ethical values or the values we ought to have (given our other shared ethical commitments). Moreover, just as uncertainties concerning the value of *ECS* do not imply that there exist no scientific facts about how the climate system responds to anthropogenic changes in atmospheric GHG concentrations, uncertainties in the value of the discount rate do not imply that there are no normative facts about how inequalities among and between different generations should affect climate policy.

The problem with the IWG's calculation of the social cost of carbon is not, as Murphy charges, that it is based on moral or ethical assumptions. The climate problem is a moral problem just as much as it is a scientific problem, and any adequate discussion of climate policy has to engage with the moral challenges raised by climate change. Rather among the problems are the following:

First, existing deep uncertainties concerning both normative and scientific assumptions—that Murphy correctly highlights—undermine our ability to apply expected utility theory to the climate problem in a principled manner. Second, as Fleurbaey and Zuber's argument shows, by considering only discount rates greater than or equal to 2.5%, the IWG's calculations ignore climate risks for the future poor. And, third, the choice of the expected utility framework restricts the type of ethical considerations that can be brought to bear on our policy choice. Not only do our choices for some of the models' parameters have normative implications but also the choice of modeling framework itself is not ethically neutral.

By modeling each generation in terms of a single representative consumer IAMs ignore inequalities among each generation with significant consequences for the choice of discount rate. But the problem runs deeper than that and points to the limitations of treating climate change within the framework of expected utility theory in that the utilitarian framework within which the IGW's calculations are performed is blind to considerations of justice and harm, which arguably are at the core of the moral problem posed by climate change.

There are strong intuitions, I take it that Fleurbaey and Zuber's result gets at something important: a model allowing for different contemporaneous populations with an overall discount rate that is dominated by that between the worst-off at different times seems to get something right. I want to submit that this intuition has less to do with the fact that the model takes inequality aversion more comprehensively into account than models with a single representative consumer do. Rather, the intuitive appeal of the result lies in the fact that it is sensitive to the needs of those who *both* are the most threatened by climate change *and* are the least responsible for climate change. Fleurbaey and Zuber themselves hint at this when they support their analysis by saying that "mitigation efforts, when they are well conceived, should put the burden on the high emitters who are typically among the affluent members of the present generation" (Fleurbaey and Zuber 2012, 15). But that well-conceived mitigation measures should put the burden on high emitters is not an obvious consequence of a cost–benefit analysis, which at best can favor a redistribution of welfare from the rich to the poor. Instead, that high emitters should carry the main costs of a climate policy is suggested by principles of fairness or justice (Shue 2014a). We, as high emitters, are harming future generations, and in particular the future poor in less developed countries, by threatening to deprive them of an environment in which they can support themselves and thrive. A cost–benefit analysis is blind to this fact.

2.3. *The Damage Function*

IAMs couple a climate model to a welfare function in two ways: first, consumption is taken to affect GHG emissions and, second, climate change is taken to affect consumption through a damage function. Nordhaus's DICE model assumes that the effects of climate change on the economy can be represented in terms of a single temperature-dependent quadratic function—a choice that has become particularly influential in IAM modeling. The PAGE and FUND models contain more complex treatments of damages, aggregating several sector- and region-specific damages. Climate damages are significantly more uncertain than the climate system's response to GHG emissions. While IAM modelers point to climate impact studies in support of their treatment of damages, the empirical constraints are much weaker than in the case of climate models.

Moreover, damage estimates on which the IWG draws appear extremely optimistic. For a difficult-to-fathom 8°C increase in global temperatures, the DICE and PAGE models predict 'only' damages of roughly 15% global GDP—a loss that would correspond to taking the 2016 U.S. GDP back to its 2004 level—while the FUND model predicts even smaller damages of roughly 6% GDP.[8] Indeed, a recent study (Burke, Hsiang, and Miguel 2015) reaches dramatically different conclusions about climate damages: Burke et al. consider economic data from 166 countries in the years 1960–2010 to determine how changes in economic activity are coupled to annual fluctuations in temperature. They project that under business as usual, damages in 2100 will be an entire order of magnitude higher than those predicted by standard IAMs even when ignoring sea-level rise. Moreover, damages are extremely unequally distributed and will lead to an extreme widening of global income inequalities. While damages in North America or Central Europe may be small enough to allow overall economic growth, Sub-Saharan Africa or South Asia are projected to see a catastrophic 75% decrease in GDP per capita. Thus, as in the case of the discount rate, we find that standard IAMs do not adequately represent the uncertainties associated with climate change and underestimate the threats to the poorest and most vulnerable populations.

3. UNCERTAINTY AND PRECAUTION

[8] See (Interagency Working Group on Social Cost of Carbon 2010).

Our brief survey of some of the core features of IAMs used by the IWG to calculate the social cost of carbon suggests that some of the conservatives' criticisms of the IWG's approach are warranted. In particular, the IWG posits precise values for some parameters and probability distributions for the values of other parameters even though the values of the parameters in question are deeply uncertain and we do not know what appropriate probability distributions associated with their values would be. Thus, the critics are right in contending that the IWG's estimates depend on scientifically not sufficiently constrained modeling assumptions and that the IWG treats climate change as a problem of risk with known probabilities rather than as a problem of deep uncertainties. We have also seen that at least some of the modeling choices in IAMs reflect normative assumptions.

One might argue that the IWG is aware of the uncertainties and responds to it by not just calculating a single value for the SCC, but by proposing three different values. In fact, one response to the problem of deep uncertainties might be to run IAMs under a whole range of different assumptions exploring the space of scientifically (and normatively) plausible values for its key parameters and thereby derive a range of value for the SCC. But, first, this is not really what the IWG is doing, since the only quantity varied in their three estimates is the discount rate, and the IWG dramatically underestimates the range of plausible values of this quantity. On the one hand, one of Murphy's complaints is that the IWG does not also calculate a SCC for a discount rate of 7%, even thought the U.S. Office of Management and Budget instructs that a 7% rate should be used for regulatory analysis in addition to a 3% rate. On the other hand, as we have seen, there are compelling arguments for using a negative discount rate.

Second, IAMs were intended to enable us to calculate the optimal climate policy. If we were to use IAMs merely to explore the space of plausible values for the SCC, we still need an additional decision strategy that tells us what climate policy to adopt given a range of plausible values for the SCC.

We can glean two different decision strategies that policy advisors associated with the Trump administration appear to endorse. The first strategy, which has more or less explicitly been advocated by Trump's Secretary of State Rex Tillerson, is that in situations of deep uncertainty we should ignore any uncertain costs (or benefits) associated with our policy decisions. Thus Tillerson has said: “It is a judgment of balance between future climatic events which could be catastrophic but are unknown, by the IPCC’s own acknowledgement, and more immediate needs of humanity today to address poverty, starvation, broad-based disease control, and the quality of life that billions of people are living in today, which is unacceptable to many of us.”[9]

The current poor, Tillerson claims, are energy-poor. They rely on energy—and, hence presently still on carbon emissions—not only to escape poverty but as a means of survival. On this point Tillerson will find broad agreement. But while some would argue that the energy needs of the current poor are a constraint on climate policy just as much as the threats associated with unabated emissions are (see, e.g., Shue 2014b), Tillerson suggests that, because of the deep uncertainties in climate predictions we ought to focus exclusively on the needs of the present poor (and on the value associated with maintaining our "quality of life"!). The deep uncertainties associated with precise

[9] https://thinkprogress.org/exxons-ceo-just-won-his-shareholders-rejected-climate-change-proposals-573d12dde5e7#.h7xpxfs4x . Accessed 2/28/2017

predictions of climate impacts are sufficient to trump any concern about climate damages, no matter how catastrophic they might be.

Now, one might think that it is obviously a mistake to ignore threats simply because they are associated with deep uncertainties. Yet there is an argument that suggests that not ignoring deeply uncertain threats can result in paralysis. Take a situation in which uncertain threats suggest a certain policy response, perhaps based on precautionary considerations. In many such cases we can imagine highly speculative chains of events, according to which the proposed policy would itself result in catastrophic consequences. And while the chain of events we are imagining might be utterly implausible, the more outlandish the scenario we are imagining is, the less likely it might be that we can give a precise, albeit small probability for the scenario's occurrence. Now, if we could associate probabilities with various catastrophic outcomes, expected utility theory would tell us how serious we ought to take these outcomes. The worry is that under conditions of deep uncertainty—that is, without being in possession of probability distributions—we have to treat all catastrophic threats on a par. But then we may frequently find ourselves in situations of paralysis in which a decision strategy will counsel both for and against a given policy. In effect, Tillerson's strategy responds to the problem of paralysis by proposing that deeply uncertain threats ought to be ignored in decision making.

But do we really need to consider all uncertain threats? Just as considering uncertain purely speculative threats may lead to paralysis, ignoring threats just because we cannot associate precise probabilities with them may strike us as reckless. A more promising reply to the argument is the following. Allowing that some uncertainties cannot be represented in terms of precise probabilities does not imply that all deeply uncertain outcomes have to be treated equally. It may be possible to introduce yet more fine-grained non-probabilistic distinctions, but at the very least we should distinguish between threats that have at least some minimal plausibility and arise as the result of reasonably well-understood mechanisms and threats that are outlandish and purely speculative. We have to consider only the latter in decision problems. That is, threats only have to be taken into account if they do not violate what Henry Shue has called an "anti-paranoia requirement" (Shue 2010, 49).

Climate threats clearly satisfy Shue's requirement. Recall our discussion of the climate sensitivity above. The basic physical mechanisms behind anthropogenic climate change are well understood. Even though no precise probability distribution for *ECS* can be given, we know that it is likely to be between 1.5°C and 4.5°C (at least under climate models' idealizing assumptions). And while the science of climate damages is much less settled than basic climate science is and, hence, for example Burke et al.'s estimate of the damage function is a lot more uncertain than estimates of *ECS*, their study is based on a wealth of historical data and suggests a robust relationship between temperature changes and economic activity.

Tillerson's strategy is to completely ignore threats in situations characterized by deep uncertainty. A second decision strategy is implicit in the claims by Murphy and by Trump's advisor Perry that the SCC ought to be close to zero. Murphy and Perry's strategy amounts to cherry-picking data and modeling assumptions in the face of uncertain predictions. As Murphy and others correctly point out, there does exist a selective body of evidence that jointly appears to support the view that climate change poses no serious threat. Thus, there are some studies that arrive at a value for the climate sensitivity at the lower end of the IPCC range (e.g., Otto et al. 2013) the FUND model posits that the effects of climate change will be positive up to a temperature increase of 2.5°C and, some argue, still overestimates damages (see Johnston 2016) and the OMB instructs that a discount rate of 7% be one of the values used in regulatory analysis. Combining these assumptions may indeed result in a value for the SCC that is close to zero or even negative.

Yet Murphy and Perry's cherry picking of assumptions appears even less justified than Tillerson's strategy. While some climate models predict a value for the *ECS* of only 1.5°C, others allow for a value of up to 6°C (see Previdi et al. 2013). While the FUND model predicts that economies will be relatively resilient in the face of rising temperatures, Burke et al. (2015) predict damages an order of magnitude higher than standard IAMs and catastrophic declines in economic activity in many regions of the world. And while the OMB instructs that a discount rate of 7% also be used, taking the threat to poorer populations seriously suggests that we use a negative discount rate.[10] Now, there may be scientific reasons to trust some of these predictions more than others. But if, as Murphy himself argues, our knowledge of the relevant parameters ultimately remains deeply uncertain, proposing to base policy decisions on a combination of the

[10] Murphy refers to the OMB Circular A-4 of September 17, 2003 (Regulatory Analysis), which states that discount rates of 3% and 7% be used in cost–benefit analysis. Trump's executive order from March 28, 2017, also refers to this circular, instructing that "agencies shall ensure, to the extent permitted by law, that any such estimates are consistent with the guidance contained" in that circular (Sec. 5c). It is worth pointing out that Circular A-4 has a separate discussion of intergenerational discounting, which explicitly recommends using lower rates (as low as 1%) for benefits and costs across generations reaches the following conclusion: "If your rule will have important intergenerational benefits or costs you might consider a further sensitivity analysis using a lower but positive discount rate in addition to calculating net benefits using discount rates of 3 and 7 percent."

most optimistic assumptions suggests a reckless preference for an extremely risk-seeking decisions strategy.

There is, of course, another approach to decisions under conditions of severe uncertainty that provides an alternative to the strategies advocated by Tillerson and Murphy—an approach that in light of the severity of the threats posed by climate change seems significantly more prudent than its two rivals—and that is a precautionary approach. Henry Shue (Shue 2010) has identified three conditions under which prompt precautionary action is required. These conditions are: (i) we are facing the possibility of massive, catastrophic losses; (ii) the mechanisms by which these losses can occur are well understood and are scientifically plausible, even though we cannot give precise probabilities; and (iii) the costs for preventing these losses are not excessive. The second condition is the anti-paranoia requirement. The third condition, like the second condition, helps to prevent paralysis. If there were uncertain possible costs of preventing a catastrophe that are comparable to possible losses from the catastrophe, then a precautionary approach might recommend for and against taking preventive measures (see also Steel 2014). All three conditions are met in the case of climate change.

Now one might think that the choice between Murphy's or Tillerson's decision strategies and a precautionary approach is ultimately a matter of taste. Prudence might suggest a precautionary approach, particularly in light of the stakes involves, but those brave or reckless enough might favor a more risk-seeking strategy. But there is a further feature of the climate problem that implies that a precautionary approach may not only be prudent but is in fact morally required. What is morally odious about Tillerson's or Murphy's extreme risk-seeking approach to climate change is that they seek risks not for themselves, but that their strategy exposes future generations, and in particular the future poor, to grave threats. In deciding on a climate policy we are in the main not considering threats of possible harm to ourselves but threats to others—we are considering whether or not to engage in activities that threaten to expose others to grave harms. If future generations, and in particular future populations in less developed countries and in countries more exposed to climate risks, have a right to food, to water, to shelter, and, more generally, to an environment that sustains them and in which they can thrive, then we have a moral duty not to engage in activities that seriously put these rights in jeopardy. Moreover, as Shue has argued, our duty is not mitigated by the fact that the threats at issue are uncertain. As Shue says: "If I play Russian roulette with your head for my amusement as you doze and the hammer of the revolver falls on an empty chamber, I will have done you no physical harm. But I will have seriously wronged you by subjecting you to that unnecessary risk" (Shue 2010, 152). We wrong future generations by exposing them to the risk of serious harms as a consequence of our actions.

A broadly precautionary approach underlies the temperature goals of the Paris Agreement, the signing of which was at the core of the second plank of the Obama administration's climate policy. As Knutti et al. (2016) and others have argued, there is no purely scientific argument for the 2°C temperature limit. Rather it is an anchoring device that was agreed on based on a combination of scientific arguments, moral arguments, potential costs, and feasibility. Deep uncertainties, some of which I have discussed in this paper, imply that it is a mistake to think of 2°C as a guardrail or as a safe upper limit. Yet, there is evidence that suggests that various climate tipping-points will be reached at or above 2°C. Thus, limiting the increase in global average temperatures to well below 2°C above preindustrial levels promises significantly to reduce the risk of catastrophic climate change, but no precise calculation of expected damages associated with these tipping points has (or can) be given.

4. CONCLUSION

I have here argued that some of the conservative criticisms of the Obama administration's use of cost–benefit analysis to calculate the social cost of carbon are justified. The deep uncertainties characterizing our knowledge of the future climate and of climate damages make the exercise of trying to calculate a single well-supported value for the social cost of carbon impossible. Moreover, the framework of cost–benefit analysis used by the IWG is blind to important moral dimensions of the climate problem. At best, then, the type of calculations performed by the IWG could provide us with a range of possible climate costs associated with our emissions, which might inform but cannot determine a specific choice of climate policy.

I also argued that there are moral reasons to adopt a precautionary approach: unless we want to gamble immorally and recklessly with the lives and the wellbeing of future populations, the uncertainties to which Murphy, Tillerson and others point suggest the need for the U.S. to remain committed to the Paris agreement. Since even the final climate plan proposed by the Obama administration fell far short of the emissions reductions that likely will be needed to remain with the 2°C target (let alone within the 1.5°C target),[11] one might have hoped that those within the Trump administration, who understand both the basic science of climate change and the deep uncertainties

[11] See the 2016 Emissions Gap report by the United Nations Environmental Program: http://web.unep.org/emissionsgap/

concerning precise predictions of future damages, would advocate vocally and vigorously for an even more aggressive climate policy than the Obama administration was prepared to adopt.

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