

COST-BENEFIT ANALYSIS AND THE PRECAUTIONARY PRINCIPLE: CAN THEY BE RECONCILED?

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I. INTRODUCTION

Conventional wisdom teaches us that cost-benefit analysis (CBA) conflicts with the precautionary principle.¹ Proponents of the precautionary principle criticize CBA as an effort to defeat sensible precaution.² Proponents of CBA criticize precaution as a hopelessly incoherent threat to the enhanced rationality available through CBA.³ The conventional wisdom associates the precautionary approach with environmental extremism and CBA with careful balancing.⁴ CBA's fans emphasize quantitative calculation whilst precaution's advocates stress qualitative judgment. CBA's critics see CBA as an enemy of environmental progress; precaution's detractors see the precautionary principle as a threat to our economy.⁵

Recent experience seems to vindicate the conventional wisdom maintaining that the two ideas conflict. The Obama administration has committed itself to CBA, through an executive order that generally reaffirms the centrality CBA has enjoyed since Ronald Reagan and the appointment of Cass Sunstein—a leading academic supporter of CBA—as the head of Office of Information and Regulatory Affairs (OIRA) at the Office of Management and Budget.⁶ At the same time, the Obama administration has enacted standards designed to address global climate disruption.⁷ Recognizing that its ongoing

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¹ See, e.g., RICHARD A. POSNER, *CATASTROPHE: RISK AND RESPONSE* 140 (2004) (portraying precaution as an unsatisfactory alternative to CBA).

² See, e.g., John S. Applegate, *Embracing a Precautionary Approach to Climate Change*, in *ECONOMIC THOUGHT AND U.S. CLIMATE CHANGE POLICY* 171, 186 (David M. Driesen ed. 2010) [hereinafter *ECONOMIC THOUGHT*] (characterizing the precautionary principle as avoiding the “need to resort to” questionable quantification).

³ See Stephen Charest, *Bayesian Approaches to the Precautionary Principle*, 12 *DUKE ENVTL. L. & POL'Y FOR.* 265, 266 (2002) (stating that precaution's opponents “view it as . . . unscientific” and radical).

⁴ See, e.g., Christopher D. Stone, *Is There a Precautionary Principle?*, 31 *ENVTL. L. REP. (Envtl. L. Inst.)* 10790, 10790 (2001) (highlighting a version of the principle as a directive not to do anything).

⁵ See Frank B. Cross, *Paradoxical Perils of the Precautionary Principle*, 53 *WASH. & LEE L. REV.* 851, 859 (1996) (stating that critics of precaution charge its advocates with ignoring jobs and wealth).

⁶ Rena Steinzor, *The Case for Abolishing Centralized White House Regulatory Review*, 1 *MICH. J. ENV'TL & ADMIN. L.* 209, 254-56 (2012) (discussing the Sunstein appointment and the continuation of the Clinton and Bush era executive orders demanding CBA).

⁷ See generally Lisa Heinzerling, *Climate Change at the EPA*, 64 *FLA. L. REV.* 1 (2012). I use the term “climate disruption” instead of the more conventional terms “climate change” or “global warming”, because it better captures the phenomenon's core. The term climate change is quite accurate, but empty, saying nothing about the change's nature. The term “global warming” conveys scientists' expectation of an increase in average mean surface temperature, but conveys nothing about the consequences of such

rulemaking in this area would, in light of the executive order, repeatedly raise issues about how to value greenhouse gas abatement's benefits, the Obama administration convened an interagency working group (IWG) to evaluate the "social cost of carbon"—the dollar value of the harms associated with a ton of carbon dioxide emissions.⁸ The IWG, building on economic analyses that ignored or slighted many of climate disruption's risks, provided a central estimate of the social cost of carbon as \$21 per ton, a very small number.⁹ Predictably, environmental groups decried the estimate as too low and likely to lead to actions inconsistent with precaution.

This Article uses a case study of climate disruption CBA, including the IWG's recent work, to question the widely shared conventional wisdom. CBA is impossible without either a precautionary or anti-precautionary approach to incompletely understood risk. This means that precaution might prove possible *within the CBA framework*.

CBA can justify very vigorous action to address climate disruption, or doing next to nothing.¹⁰ It all depends on how analysts and policymakers approach the myriad assumptions needed to carry out a CBA.¹¹ Analysts employing conservative assumptions about damages and pessimistic assumptions about policy's influence on technological progress come up with CBA "showing" that we should not do very much, whilst analysts using more pessimistic assumptions about damages and optimistic assumptions about costs "show" that we should act very vigorously.¹²

This new understanding that precaution and CBA might prove reconcilable has enormous implications for environmental policy.¹³ With respect to environmental policy generally, we need to recognize that CBA does not provide a means of mechanically calibrating appropriate standards.¹⁴ This is not to say that CBA is meaningless. But its

warming. See DAVID M. DRIESEN, ROBERT W. ADLER, & KIRSTEN H. ENGEL, ENVIRONMENTAL LAW: A CONCEPTUAL AND PRAGMATIC APPROACH 25 (2011) (noting that science advisor John P. Holdren finds the term global warming misleading because it implies "something gradual, uniform, and benign").

⁸ Interagency Working Group on Social Cost of Carbon (IWG), Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866 2 (2010), <http://www.epa.gov/oms/climate/regulations/scc-tsd.pdf> (explaining that the IWG convened to estimate carbon's social cost under E.O. 12866).

⁹ See *id.* 1 (presenting \$21.4 as the central estimate in 2010).

¹⁰ See Frank Ackerman, *Cost-Benefit Analysis of Climate Change: Where it Goes Wrong*, in ECONOMIC THOUGHT, *supra* note 2, at 61-62 (contrasting the Stern Report's finding that the costs of inaction greatly exceeded the costs of "dramatic" greenhouse reductions, with analyses concluding that compliance with the Kyoto Protocol would generate costs exceeding benefits).

¹¹ See Baptiste Perrissin Fabert, Patrice Dumas, & Jean-Charles Hourcade, *What Social Cost of Carbon? A Mapping of the Current Debate* 7-8, 11-14 (2012) (discussing how various "world views" shape the social cost of carbon estimates); see generally Cass R. Sunstein, *Legislative Foreword, Congress, Constitutional Moments, and the Cost-Benefit State*, 48 STAN. L. REV. 247, 290 (1996) (characterizing CBA as "very close to empty" since "everything depends" on how valuation is carried out).

¹² See Ackerman, *supra* note 10, at 62-74 (discussing key assumptions in climate disruption damage estimates); Thomas O. McGarity, *The Cost of Greenhouse Gas Reduction*, in ECONOMIC THOUGHT, *supra* note 2, at 213, 215 (finding that estimates of U.S. Kyoto Protocol compliance cost varied from a 3% GDP loss to a 2% GDP gain).

¹³ Cf. Stone, *supra* note 4, at 10791 (faulting the precautionary principle literature for not connecting much with the literature on uncertainty, CBA, and risk management).

¹⁴ See Douglas A. Kysar, *Climate Change, Cultural Transformation, and Comprehensive Rationality*, 31 B.C. ENVTL. AFF. L. REV. 555, 570 (2004) (noting that CBA seeks to allow policymakers "to determine optimal policy" by running "a spreadsheet").

meaning stems more from the underlying normative commitments reflected in the approach and its practitioners' attitudes than from mechanical calculation of costs and benefits. We also need to understand the precautionary principle in a more precise way, as indicating an attitude to uncertainty, not necessarily as a complete guide to setting abatement levels. This Article sheds light on what the precautionary principle says, and just as importantly, what it does not say, about abatement levels. Hence, the inquiry into whether CBA and precaution conflict illuminates both concepts.

This understanding of CBA as providing a framework that generates results corresponding to its practitioners' attitudes and that precaution primarily addresses uncertainty suggests a pathway for addressing precaution within CBA addressing global climate disruption and other crucial environmental issues. Analysts can embrace precautionary assumptions to addressing uncertainties underlying CBA. Questions about how to estimate the benefits of ameliorating significant environmental problems like global climate disruption are both too political and too scientific to be left solely to economists. This Article therefore develops a set of methodological and institutional recommendations designed to appropriately resolve these questions in ways that minimize potential tension between precaution and CBA. This approach takes into account the locus of appropriate expertise within the government and relevant international law.

These ideas about making CBA precautionary may have an immediate payoff. Analysts with divergent views of climate policy and CBA have united in condemning the IWG's effort to estimate carbon's social cost.¹⁵ The Obama administration has committed to updating the IWG's work and could substantially improve its approach to uncertainty when it does.¹⁶ The ideas set out here show how the United States could proceed, making a case for the new precautionary CBA as consistent with international law. These ideas can also inform environmental policy in other contexts.

A word about this Article's limits will help avoid confusion. This Article does not attempt to assess the overall merits of CBA or the precautionary principle. A substantial literature addresses these topics and I have contributed to this literature in the past.¹⁷ My objective here is more limited: to explore the possibility of precautionary

¹⁵ See, e.g., Jonathan Masur & Eric Posner, *Climate Change and the Limits of Cost-Benefit Analysis*, 99 CAL. L. REV. 1557, 1577 (2011) (characterizing the IWG's product as suffering "from a variety of problems that render its conclusions unconvincing"); William Nordhaus, *Estimates of the Social Cost of Carbon: Background and Results from the RICE-2011 Model*, Cowles Foundation Discussion Paper No. 1826, 24 (2011), <http://nordhaus.econ.yale.edu/documents/CFDP1826.pdf> (criticizing the IWC's work for "ad hoc" adjustment of underlying models and assumptions based on "a hodge-podge of scenarios").

¹⁶ See EPA, Draft Regulatory Impact Analysis: Proposed Rulemaking for 2017-2025 Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards 7-4 (2011) [hereinafter CAFE II RIA] (noting the IWC's acknowledgment of weaknesses in its work and its intention to update its estimate).

¹⁷ See, e.g., David M. Driesen, *Is Cost-Benefit Analysis Neutral?*, 77 U. COLO. L. REV. 335 (2006) [hereinafter Driesen, *Neutral*] (questioning CBA's neutrality); FRANK ACKERMAN & LISA HEINZERLING, *PRICELESS: ON KNOWING THE PRICE OF EVERYTHING AND THE VALUE OF NOTHING* (2004) (arguing that some things are "priceless" and analysts' attempts to assign dollar values to everything are methodologically flawed); David M. Driesen, *Getting Our Priorities Straight: One Strand of the Regulatory Reform Debate*, 31 ENV'T'L L. REP. (Env't'l L. Inst.) 10003 (2001) [hereinafter Driesen, *Priorities*] (questioning the notion that CBA aids priority setting); David M. Driesen, *The Societal Cost of*

CBA and that possibility's implications. Accordingly, this Article will assume that the "cost-benefit state" is here to stay and that the United States should also exercise precaution in light of its statutory and treaty commitments to that principle, which this Article describes. This Article will necessarily draw on the critical literature, but for the narrow purpose of establishing the conventional wisdom positing these two concepts as opposites and to clarify the nature of CBA and the precautionary principle.

Part two explains CBA, the precautionary principle, and the conventional wisdom setting them in opposition. Part three analyzes the question of whether CBA and precaution must conflict using a critical case study of the IWG effort to estimate carbon's social cost to help establish, by negative implication, the possibility of precautionary CBA. Part four explores precautionary CBA's implications for environmental policy generally and for climate disruption policy in particular. It describes what precautionary CBA might look like methodologically and institutionally.

II. CBA, PRECAUTION, AND THE CONVENTIONAL WISDOM

This part develops the background necessary to understand the view that precaution conflicts with CBA. It begins with an account of CBA that emphasizes its dependence on quantitative risk assessment and its use to oppose environmental protection in practice. It continues with some discussion of the precautionary principle, emphasizing its role in catalyzing action and its emphasis on qualitative risk assessment. Finally, this part explains the conventional wisdom placing CBA and precaution at war.

A. CBA and its Dependence Upon Risk Assessment.

A CBA compares a proposed action's expected costs to its projected benefits. In the context of proposals to abate carbon emissions, the relevant benefits involve avoided damage to the environment and public health. These damages include deaths,¹⁸ injuries and loss of land from predicted sea level rise;¹⁹ illness and death from the spread of tropical diseases;²⁰ damage to life and property from more violent weather events;²¹

Environmental Regulation: Beyond Administrative Cost-Benefit Analysis, 24 *ECOLOGY L. Q.* 545 (1997) (arguing that CBA does not adequately address key societal concerns about regulation's costs); Cross, *supra* note 5, at 862-63 (finding the precautionary principle "paradoxical" because it does not take risk/risk tradeoffs into account); THOMAS O. MCGARITY, *REINVENTING RATIONALITY: THE ROLE OF REGULATORY ANALYSIS IN THE FEDERAL BUREAUCRACY* (1991) (critiquing the idea of "comprehensive rationality" that lies behind CBA).

¹⁸ CLIMATE CHANGE 2007: IMPACTS, ADAPTATION AND VULNERABILITY. CONTRIBUTION OF WORKING GROUP II TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE 393 (M.L. Parry et al. eds., 2007) [hereinafter FAR: IMPACTS] (stating that climate disruption will increase death).

¹⁹ *Id.* at 317 (discussing risks to coasts from sea-level rise); CLIMATE CHANGE 2001: IMPACTS, ADAPTATION AND VULNERABILITY. CONTRIBUTION OF WORKING GROUP II TO THE THIRD ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE 5 (J. McCarthy et al. eds., 2001) [hereinafter TAR: IMPACTS] (discussing flooding from sea level rise).

²⁰ TAR: IMPACTS, *supra* note 19, at 5, 43 (discussing increased incidence of diseases such as malaria, cholera, dengue, and heat stroke mortality).

hunger,²² crop loss,²³ and harms to livestock from drought;²⁴ and the loss of endangered species and their habitats.²⁵

CBA proponents develop methodologies for converting as many of climate disruption's consequences as possible into dollar terms. Much of the angst that CBA engenders involves concerns about these monetization methodologies' morality and technical merits.²⁶ For example, in the climate disruption context, some analysts use lifetime per capita income to estimate the value of a life saved from carbon abatement measures.²⁷ Since on average people living in developing countries have less per capita income than people living in developed countries, this approach treats human life in developing countries as less valuable in dollar terms than life in developed countries, which some see as morally objectionable.²⁸ And, of course, many people object on principle to valuing human lives in dollar terms.²⁹

This Article, however, focuses primarily on a prior step in the calculation of carbon abatement's benefits—quantitative risk assessment.³⁰ In order to determine the value of human lives saved through carbon abatement, an economist must multiply a dollar value for each human life by the number of deaths the carbon abatement measure will avoid.³¹ That first step, figuring out the number of lives saved through carbon abatement, requires assessment of the risk that climate disruption poses to human life.³² In order to come up with an actual number, this risk assessment must be quantitative. That is, it is not enough to understand that floods, droughts, more intense hurricanes, and

²¹ See FAR: IMPACTS, *supra* note 18, at 12 (discussing “increased deaths, disease and injury due to heat waves, floods, storms, fires, and droughts”).

²² ID. at 414 (discussing increased hunger risk from climate disruption).

²³ ID. at 12 (explaining that more droughts and floods will reduce crop yields “especially in subsistence sectors at low latitudes”).

²⁴ ID. at 18, 287 (discussing drought leading to “livestock loss”).

²⁵ See ID. at 792 (expressing “high confidence that climate change will result in the extinction of many species and reduction in the diversity of many ecosystems”); TAR: IMPACTS, *supra* note 19, at 69 (explaining that climate disruption will threaten “critically endangered species”).

²⁶ See Mark Geistfeld, *Reconciling Cost-Benefit Analysis with the Principle that Safety Matters More than Money*, 76 N.Y.U. L. REV. 114, 116-119 (2001) (discussing widespread aversion to quantifying the value of health and safety); ACKERMAN & HEINZERLING, *supra* note 17 (critiquing monetization methodologies).

²⁷ F. Bosello, R. Roson, & R. Tol, *Economy-wide Estimates of the Implications of Climate Change: Human Health*, 58 ECOLOGICAL ECON. 579, 585 (2006) (valuing a premature death at 200 times per capita income).

²⁸ See generally Matthew Adler, *Risk Death and Harm: The Normative Foundations of Risk Regulation*, 87 MINN. L. REV. 1293, 1397 (2003) (finding lost wages an inappropriate metric for measuring death's value).

²⁹ See Geistfeld, *supra* note 26, at 116-17 (discussing the widespread belief that “life is priceless” and therefore that sacrificing life in order to save money is unethical).

³⁰ See generally Symposium, *Risk Assessment in the Federal Government*, 3 N.Y.U. ENVTL. L. J. 251 (1995); NATIONAL RESEARCH COUNCIL, *RISK ASSESSMENT IN THE FEDERAL GOVERNMENT: MANAGING THE PROCESS* (1983); QUANTITATIVE RISK ASSESSMENT IN REGULATION (Lester Lave ed., 1982)

³¹ See Mark Geistfeld, *Implementing the Precautionary Principle*, 31 ENVTL. L. REP. 11326, 11326 (2001) (noting that risk assessment choices define regulatory benefits).

³² See generally EPA, *Guidelines for Preparing Economic Analysis* 1-5 (2010) [hereinafter EPA Guidelines] (noting that risk assessors provide the information needed to translate information about changes in pollution levels into health or other outcomes).

more widespread infectious diseases will cause death. Rather, one must estimate the number of deaths each of these rather capricious phenomena will produce. The point that CBA depends upon quantitative risk assessment applies not just to estimates of the value of lives saved through carbon abatement, but also to the estimation of the monetary value of any proposal's health and environmental benefits.

Quantitative risk assessment poses many problems for CBA. Often, science does not generate data sufficient to support a responsible quantitative estimate of predictable and serious consequences, even qualitatively well-understood ones.³³ As a result of this frequent inability to quantify qualitatively well-understood impacts, the CBA calculations used to formulate environmental policies simply leave out information about important abatement benefits. CBA supporters recognize that important nonquantifiable benefits exist and say that policymakers should consider nonquantifiable benefits, but they have been silent about how policymakers should do this.³⁴ And no evidence exists that OIRA, CBA's principal advocate within the federal government, has followed academic advice to give weight to nonquantifiable benefits, even when the nonquantifiable benefits matter much more than the quantifiable ones.

Moreover, significant uncertainties about future consequences' magnitude make quantification problematic, even when some information exists that can permit quantitative risk assessment.³⁵ In the case of climate, one key variable involves climate sensitivity—a measure of the amount of global warming a given quantity of greenhouse gas emissions will produce. Scientists express confidence that greenhouse gas emissions have caused global climate disruption and that they will produce more of it in the future.³⁶ But they express much less faith in their ability to accurately predict future temperature increases' magnitude, and, in practice, employ a wide variety of models, which include varying estimates of climate sensitivity.³⁷ Frank Ackerman and Elizabeth Stanton have shown that assumptions about climate sensitivity can have a huge influence on estimates of carbon abatement benefits.³⁸

Climate scientists have long warned policymakers not to place too much faith in their models, which good scientists tend to view as our best guesses about subjects whose

³³ See Matthew D. Adler & Eric A. Posner, *Rethinking Cost-Benefit Analysis*, 109 YALE L. J. 165, 175 (1999) (stating that a lack of data frequently hampers CBA).

³⁴ See, e.g., Cass R. Sunstein, *From Consumer Sovereignty to Cost-Benefit Analysis: An Incompletely Theorized Agreement?*, 23 HARV. J. L. & PUB. POL'Y 203, 206-07 (1999) (calling for consideration of qualitative information in regulatory processes).

³⁵ See Lisa Heinzerling, *Political Science*, 62 U. CHI. L. REV. 449, 460-63 (1995) (discussing scientific uncertainty and how the response to it skews CBA).

³⁶ See IPCC, FOURTH ASSESSMENT REPORT: CLIMATE CHANGE 2007: THE PHYSICAL SCIENCE BASIS 10 (2007) (stating that observed increases in temperatures are "very likely" due to the observed increase in greenhouse gas concentrations). The IPCC also warns that continued greenhouse gas emissions will "very likely" cause further warming. *Id.* at 13.

³⁷ See IPCC, REPORT: CLIMATE CHANGE, THE IPCC SCIENTIFIC ASSESSMENT XII (1990) (finding many "uncertainties" in predicting climate change with regard to "timing, magnitude, and regional patterns"). See also IPCC, *supra* note 36, at 13 (using a large number of climate models to determine "likely" ranges for global average surface air warming).

³⁸ Frank Ackerman & Elizabeth A. Stanton, *Climate Risks and Carbon Prices: Revising the Social Cost of Carbon* 6 ECON. E-JOURNAL 2012-10, 2 (2012) (explaining that plausible assumptions about climate sensitivity can generate social cost estimates of \$900 a ton).

complexity and intrinsic variability rules out reliable quantitative prediction.³⁹ IPCC reports regularly admonish readers to expect “surprises.”⁴⁰ And surprises have materialized. Current temperature measurements reflect more warming than the worst case models predicted.⁴¹ Ice melting contributing to sea level rise has proceeded at a much quicker pace than many scientists expected.⁴² And new research suggests a greater acceleration of the hydrological cycle than anticipated, which may lead to a higher potential for extreme weather than global climate models predict.⁴³

The relationship between temperature and actual damages suffers from even more uncertainty. Climate models may predict more intense hurricanes and sea level rise, but that does not mean they can predict how much increased wind and flooding will occur or precisely in what place and at what time.⁴⁴ Moreover, physical impacts do not translate directly into economic damages. A large increase in wind speed of a hurricane in a sparsely populated area could produce much less damage than a smaller increase in the wind speed of a hurricane hitting a heavily populated area at a time when a lot of people are out in the streets. Furthermore, the amount of damages can depend heavily on how well governments plan to help people escape injury and death from hurricanes, an example of “adaptation” to climate disruption (measures taken that do not ameliorate warming, but reduce the damage it causes).⁴⁵

One of the key uncertainties in the climate arena involves feedback loops. For example, scientists have long warned that a warmer earth might start to melt permafrost

³⁹ See IPCC, MANAGING THE RISKS OF EXTREME EVENTS TO ADVANCE CLIMATE CHANGE ADAPTATION 130 (2012) (warning that limitations in computing power and the scientific understanding of some physical processes hinder the quantitative assessment of projected climate change); see generally Wendy Wagner, Elizabeth Fisher, & Pasky Pascual, *Misunderstanding Models in Environmental and Public Health Regulation*, 18 N.Y.U. ENVTL. L. J. 293, 318 (2010) (explaining that models illuminate dynamics and uncertainties rather than generate answers); ORRIN H. PILKEY, & LINDA PILKEY-JARVIS, USELESS ARITHMETIC: WHY ENVIRONMENTAL SCIENCE CANNOT PREDICT THE FUTURE (2007).

⁴⁰ See IPCC, FOURTH ASSESSMENT REPORT: CLIMATE CHANGE 2007: IMPACTS, ADAPTATIONS, AND VULNERABILITY 407 (2007) [hereinafter IPCC, 2007] (stating that “surprises should be anticipated” and are of great concern); IPCC, SECOND ASSESSMENT REPORT: IMPACTS, ADAPTATIONS AND MITIGATION OF CLIMATE CHANGE, SCIENTIFIC-TECHNICAL ANALYSES, 5 (1995) [hereinafter IPCC, SECOND ASSESSMENT] (characterizing surprises as “likely”).

⁴¹ Press Release, Climate Change Cong., Key Messages from the Cong. (Mar. 12, 2009), http://climatecongress.ku.dk/newsroom/congress_key_messages (indicating that worst case IPCC scenarios (or even worse) are being realized, creating an increased risk of abrupt or irreversible climate shifts).

⁴² See IPCC, *supra* note 36, at 819 (stating “rapid reactions” of ice sheet systems raise new concerns about the collapse of the West Antarctic Ice Sheet, which would trigger a five to six meter sea level rise).

⁴³ See Justin Gillis, *Study Indicates a Greater Threat of Extreme Weather*, N.Y. TIMES A5 (April 27, 2012).

⁴⁴ See Robin Kundis Craig, *A Public Health Perspective on Sea-level rise: Starting Points for Climate Change Adaptation*, 15 WIDENER L. REV. 521, 535 (2010) (scientists remain uncertain about the “extent” of sea level rise).

⁴⁵ See THE LAW OF ADAPTATION TO CLIMATE CHANGE 3 (Michael B. Gerrard & Katrina Fisher Kuh eds. 2012) (defining adaptation as efforts to “moderate, cope with, and prepare for” climate change impacts); Damien Leonard, *Raising the Levee: Dutch Land Use Law as a Model for U.S. Adaptation to Climate Change*, 21 GEO. INT’L ENVTL. L. REV. 543, 554-556 (2009) (discussing the possible impacts of storm and flooding on Boston, New York, and other cities and the need to plan to mitigate the damages).

in Siberia, which traps methane, a potent greenhouse gas.⁴⁶ If this occurs, they explained, the released methane would produce more warming, melting yet more permafrost and releasing still more methane.⁴⁷ Thus, scientists have understood qualitatively that a chain reaction creating runaway warming could occur. They have never, however, built this possibility into models estimating warming's magnitude, because they never had sufficient information to predict the probability of this nightmare scenario occurring or the effect's magnitude.⁴⁸ It has, however, begun to occur.⁴⁹ We are now seeing methane escaping from beneath melted permafrost at rates that have astonished many scientists.⁵⁰ Although we now know that the probability of some methane release is 100%, we still do not know how much methane the melting permafrost will release and how quickly the released methane will accelerate warming that melts more permafrost to release yet more methane.⁵¹

All of this uncertainty means that the quantitative risk assessment at the base of an estimate of carbon abatement's benefits involves an incomplete and unreliable estimate. CBA analysts have some techniques for dealing with uncertainty, or more precisely, risk.⁵² The simplest and most common involves calculates the expected value of harm—by quantifying the value of a harm that might occur as best one can and then multiplying that value times the probability of its occurrence. So, for example, if economists estimated the value of a climate catastrophe at \$2 trillion and knew the probability of the catastrophe was 50%, they could multiple these two figures and estimate the expected value of the damages from catastrophic climate disruption at \$1 trillion. Unfortunately, in this particular example, and in many other ones, scientists do not know how great the probability of the feared outcome would be, nor do they have a complete understanding of the harm's magnitude should the worst occur.⁵³ In practice, CBA tends to either leave

⁴⁶ IPCC, *supra* note 37, at 7-15 (warning of the release of “significant quantities” of trapped methane as a result of permafrost melting in western Siberia).

⁴⁷ *Id.* at 110 (explaining the runaway greenhouse effect due to permafrost melting).

⁴⁸ *See id.* at 797 (stating release of methane from permafrost has yet to be accounted for in projections); *see also* IPCC, SECOND ASSESSMENT, *supra* note 40, at 348 (stating that the release of methane from permafrost has never been incorporated into “climate models”). *Cf.* Justin Gillis, *As Permafrost Thaws, Scientists Study the Risks*, N.Y. TIMES, Dec. 17, 2011, at A1 (stating “informal projections” made by scientists predict gases released from permafrost could eventually equal “thirty-five percent of today’s annual human emissions”).

⁴⁹ *See Arctic Melt ‘Bubbling Out’ Ancient Methane*, ASIAN NEWS INT’L, May 21, 2012, available at 2012 WLNR 10693080 (stating scientists have discovered “thousands of sites in the Arctic” where trapped methane is seeping out from melting permafrost).

⁵⁰ *See* Steve Connor, *Shock as Retreat of Arctic Sea Ice Releases Deadly Greenhouse Gas; Russian Research Team Astonished After Finding ‘Fountains’ of Methane Bubbling to Surface*, INDEPENDENT (London), Dec. 13, 2011, at 2 (describing scientists’ shock after witnessing “plumes of methane” being released from permafrost and the Arctic seabed).

⁵¹ *See* IPCC, *supra* note 40, at 249 (characterizing feedbacks from permafrost melting as “key uncertainties” in need of further research); *see also* IPCC, *supra* note 36, at 77 (characterizing the “large scale magnitude” of released methane as not well quantified).

⁵² *See generally* Jonathan B. Wiener & Michael D. Rodgers, *Comparing Precaution in the United States and Europe*, 5 J. RISK REG. 317, 320 (2002) (distinguishing risk from uncertainty based on the idea that risk involves probabilities); FRANK KNIGHT, *RISK, UNCERTAINTY AND PROFIT* 19-21 (1921) (same).

⁵³ *See* Charest, *supra* note 3, at 268 (pointing out that true uncertainty, where probabilities cannot be calculated, characterizes “many environmental problems”).

out very important uncertain consequences or to deal with them using fairly arbitrary assumptions about unknowns like the magnitude of the effect and the probability of its occurrence.

CBA practitioners, however, have developed elaborate, impressive-looking methods to generate arbitrary quantitative answers to questions bedeviled by true uncertainty (*i.e.* where probabilities are unknown). One technique, called Monte Carlo, analysis, merely pushes the uncertainty one step farther back: it assumes that although the true values of key parameters are unknown, the probability distribution is known. Then the calculations can be performed repeatedly, drawing different values of uncertain parameters from their probability distributions. For example, if you roll two dice once, the sum of the resulting numbers is uncertain; if you roll them many times, the sum of the two numbers averages seven. Monte Carlo analysis is the appropriate technique in cases where, as with a roll of the dice, the specific outcome is uncertain but the probability distribution is known with certainty. Unfortunately, such cases are quite rare; more often, Monte Carlo analysis hides the arbitrary judgment below the surface of the analysis, in the selection of a probability distribution.

Another technique, called Bayesian probability, is, like Monte Carlo analysis, appropriate under narrowly defined circumstances, but vulnerable to abuse when used more broadly. Bayesian analysis begins with the important observation that the best available estimate of the probability of an uncertain event often depends on the extent of relevant prior knowledge, and goes on to develop methods for revising probability estimates as knowledge changes.⁵⁴ In practice, however, it has often been used to incorporate ad hoc estimates from experts in the field.⁵⁵ Here the potential for arbitrary judgment enters in the construction of what is called the "Bayesian prior."⁵⁶ At its best, this technique is part of a sophisticated statistical methodology; at its worst, it can amount to relabeling idle prejudice or uninformed guesses as "data."⁵⁷

This Article refers to many simple applications of the Bayesian approach as arbitrary for several reasons. Absent good data or a solid basis for extrapolation from data, expert judgment is unlikely to be very good.⁵⁸ Indeed, some economists and a mathematician have argued that for some important types of uncertainty, the Bayesian theory of decisionmaking may be neither realistic nor necessarily rational.⁵⁹ All too often,

⁵⁴ See *id.* at 272-74 (explaining this approach in more detail).

⁵⁵ See David E. Adelman, *Two Models for Scientific Transparency in Environmental Law*, in *RESCUING SCIENCE FROM POLITICS: REGULATION AND THE DISTORTION OF SCIENTIFIC RESEARCH* 193, 198 (Wendy Wagner & Rena Steinzor eds., 2006) [hereinafter *RESCUING*] (describing Bayesian methods as based on "subjective" judgment).

⁵⁶ See *id.* at 201 (pointing out that environmental scientists often differ substantially in judgments about the appropriate Bayesian priors).

⁵⁷ See Charest, *supra* note 3, at 276 (pointing out that many believe that the Bayesian approach, as applied to true uncertainty is arbitrary). Charest does not dispute this characterization of the Bayesian approach as arbitrary, but essentially argues that such arbitrariness is inevitable when confronting uncertainty. *Id.* at 277.

⁵⁸ See Timothy M. Lenton *et al.*, *Tipping Elements in the Earth's Climate System*, 105 PNAS 1786, 1791 (2008) (characterizing the criticism of expert belief as not adding to scientific knowledge when not verified by data or theory as a "general criticism" from a natural science perspective).

⁵⁹ Itzhak Gilboa, Andrew W. Postlewaite, & David Schmeidler, *Probability and Uncertainty in Economic Modeling*, 22 J. ECON. PERSP. 173 (2008).

the economists employing Bayesian techniques in regulatory analyses average the results of different experts' uninformed judgments. Averaging can generate a number that cannot possibly be right, because it conforms to none of the plausible but inconsistent underlying assumptions that generated the individual estimates.⁶⁰ These methods make uncertainty appear to disappear while potentially generating scientifically implausible predictions.

Hence, quantitative estimates of the magnitude of health and environmental benefits are not facts. They are guesses about the future highly dependent on the assumptions those constructing the estimates choose to employ.

The entire process of quantifying benefits in dollar terms produces a number or, in a scientifically honest benefits estimate, a broad range of numbers.⁶¹ Supporters of CBA demand the production of this dollar value in order to compare the benefits of greenhouse gas abatement to its costs.

Estimates of greenhouse gas abatement's cost also vary widely with methodological assumptions.⁶² Although this variation is troubling, this particular problem has less to do with risk assessment potentially implicating the precautionary principle than with the difficulty of forecasting the pace of cost saving innovation.

In principle, a completed CBA provides guidance on the question of how strictly to regulate. In the environmental realm, OIRA typically demands a CBA when EPA sets a standard demanding a reduction in pollution. The analysis, at least in principle, can inform judgments about whether to demand small or large amounts of pollution reductions.

The question of which pollutants to regulate at all (as opposed to how strictly to regulate chosen pollutants), however, typically gets made on the basis of science, not economics.⁶³ This dichotomy between the triggers for regulation (science-based) and decisions about how strictly to regulate (often influenced by economics) stems from the need to choose which pollutants matter enough to warrant serious government attention.⁶⁴ Yet since CBA results vary with the stringency of the measures chosen, CBA generally does not provide a rational basis for deciding which pollutants to regulate, especially in

⁶⁰ See Wendy Wagner, *The Science Charade in Toxic Risk Assessment*, 95 COLUM. L. REV. 1613, 1623 (1995) (noting that science defines the scientifically plausible default options governing extrapolations from data).

⁶¹ See *id.* at 1637-38 (discussing the National Research Council's opposition to "single point estimates" of risk in light of scientific uncertainty); Jonathan Remy Nash, *The Supreme Court and the Regulation of Risk in Criminal Law Enforcement*, 92 B.U.L.REV. 171, 208 (2012) (pointing out that limited data imply benefit ranges, rather than a benefit number).

⁶² See Kysar, *supra* note 14, at 562 (reporting estimates of the benefits of greenhouse gas abatement that vary between \$5 and \$125 per ton).

⁶³ See Wagner, *supra* note 60, at 1681 (noting that "agencies tend to be 'science-based' in choosing toxic substances to regulate"); see also Driesen, *Priorities*, *supra* note 17, at 10006-7 (discussing science-based criteria in the Clean Air Act, Clean Water Act, and RCRA); John Dernbach, *The Unfocused Regulation of Toxic and Hazardous Pollutants*, 21 HARV. ENVTL. L. REV. 1 (1997) (discussing the law governing selection of toxic pollution for regulation).

⁶⁴ See SIDNEY A. SHAPIRO & ROBERT L. GLICKSMAN, *RISK REGULATION AT RISK: RESTORING A PRAGMATIC APPROACH* 31-35 (2003) (distinguishing triggers from criteria for establishing levels of risk reduction).

the typical context of many different actors with varied abatement technology possibilities and therefore disparate costs emitting the same pollutant.

OIRA, the principal advocate of CBA within the federal government, consistently acts as a one-way ratchet, often working to weaken proposed standards, but almost never to strengthen them.⁶⁵ This practice, however, reflects policy choices of CBA advocates within the government, and does not appear to be an inevitable result of CBA itself.⁶⁶ The Reagan executive order⁶⁷ established the custom of using CBA in conjunction with environmental regulation as a one-way ratchet by demanding that regulation's costs not exceed its benefits. Accordingly, the terms of the order itself, in keeping with its stated purpose, aims to decrease regulation's burdens.⁶⁸ But the Reagan order and the similar orders that Presidents Clinton and Obama put in place also call for maximization of net benefits.⁶⁹ That criterion in principle would require strengthening of regulation when marginal benefits exceed marginal costs.⁷⁰ Yet OIRA has never acted to strengthen regulation to maximize net benefits under the Clinton order.⁷¹ On the contrary, it has called for weakening regulation even when CBA indicates that a stricter regulation than the one proposed would maximize net benefits.⁷² And OIRA has often supported weaker regulation than EPA proposed when EPA could not carry out a CBA at all, presumably because it could not quantify any of the regulation's benefits.⁷³ OIRA's frequent opposition to strict regulation stems more often from its economists' general policy views than from CBA itself.⁷⁴ Thus, CBA in practice often functions as a device legitimating anti-regulatory actions, rather than as a determinate guide to policy.

This means that CBA could, in principle, play a different role than it has in the past. But making it serve a different role requires something more than a shift in the political party controlling the executive branch. OIRA has acted as a one-way ratchet

⁶⁵ See Driesen, *Neutral*, *supra* note 17, at 379-80 (describing OIRA review as a one way ratchet). Accord Nicholas Bagley & Richard L. Revesz, *Centralized Oversight of the Regulatory State*, 106 COLUM. L. REV. 1260, 1269 (2006).

⁶⁶ See Daniel Farber, *Rethinking the Role of Cost-Benefit Analysis*, 76 U. CHI. L. REV. 1355, 1364 (2009) (describing "the push to apply CBA to environmental regulation" as a product of "antiregulatory fervor").

⁶⁷ Exec. Order 12,291, 3 C.F.R. 127 (1981) (revoked by Exec. Order 12,866 § 11, 3 C.F.R. 638, 649 (1993)).

⁶⁸ *Id.* (preamble, § 2(b)).

⁶⁹ *Id.* § 2(c); Exec. Order 12,866, § 1, 3 C.F.R. 638 (1993) (stating that agencies should select approaches that "maximize net benefits"); Exec. Order 13563, § 1(b)(3), 76 Fed. Reg. 3821 (January 18, 2011).

⁷⁰ See Stone, *supra* note 4, at 10794 (noting that an optimal level of pollution occurs when marginal benefits equal marginal costs).

⁷¹ See Driesen, *Neutral*, *supra* note 17, at 384 (citing the example of a lead abatement rule from the Reagan administration as the only case where CBA has led to stronger regulation than EPA had proposed). Cf. Cass R. Sunstein, *Lessons from Ronald Reagan*, N. Y. TIMES, November 11, 2012, opinion, p. 4 (suggesting that CBA of ozone depletion led to stronger regulation).

⁷² See Driesen, *Neutral*, *supra* note 17, at 369-70 (noting that in the cases studied OMB supported weaker regulation even when the benefits of the proposed regulation exceeded the costs).

⁷³ See *id.* at 376-78 (showing that OMB regularly supported lax regulation where no CBA existed to guide its views).

⁷⁴ Cf. Farber, *supra* note 66, at 1400 (noting that no evidence supports the supposition that EPA has a bias in favor of regulation, which might otherwise explain OMB's consistent opposition).

regardless of the party in power.⁷⁵ Although Democratic and Republican administrations frequently differ on environmental policy, OIRA's general tendency to support weaker but not stronger regulation than EPA proposes has been remarkably consistent over time.

B. *The Precautionary Principle*

Environmental scholars often trace the precautionary principle to *Ethyl Corp. v. EPA*, an *en banc* decision of the District of Columbia Circuit approving EPA's first rule reducing lead concentrations in gasoline.⁷⁶ This case addressed the question of what sort of information acts as a sufficient *trigger* to justify regulation of a substance, not the question of how strictly government should regulate a harmful substance.⁷⁷ The panel decision that preceded the *en banc* ruling held that EPA had failed to show that lead in gasoline "will endanger" public health, as the Clean Air Act (Act) requires, and therefore lacked authority to regulate lead in gasoline.⁷⁸ This decision makes perfect sense if one understands the Act's endangerment standard as requiring proof of harm. At the time, EPA did not know how much of the lead burden in bodies came from gasoline related emissions, so it had no hard proof that gasoline emissions harmed human health.⁷⁹ Nevertheless, the *en banc* court reversed, interpreting endangerment as "precautionary."⁸⁰ The court allowed EPA to regulate based on a "significant risk" of harm.⁸¹ Furthermore, it allowed EPA to use a *qualitative* risk assessment as the basis for finding a significant risk.⁸² More specifically, it allowed EPA to infer significant risk from evidence that lead was known to be very harmful at higher doses than gasoline was known to provide.⁸³ The court did not require a quantitative estimate of the number of illnesses lead in gasoline would cause as a basis for finding endangerment.⁸⁴ Nor did it engage in any

⁷⁵ See *id.* at 1366 (noting that "*regardless of the presidential administration*" OIRA mainly undercut regulations) (emphasis added).

⁷⁶ See *Ethyl Corp. v. EPA*, 541 F.2d 1 (D.C. Cir. 1976) (*en banc*). Environmental lawyers also sometimes trace the principle back to a prior decision employing very similar reasoning under the Clean Water Act, *Reserve Mining Co. v. EPA*, 514 F.2d 492 (8th Cir. 1975) (*en banc*). See PUBLIC HEALTH AND THE ENVIRONMENT: IMPLEMENTING THE PRECAUTIONARY PRINCIPLE, 5 (Carolyn Raffensperger & Joel Tickner, eds. 1999) [hereinafter PROTECTING] (discussing *Reserve Mining* as an example of precaution).

⁷⁷ *Ethyl*, 541 F.2d at 6 (defining the issue as whether the administrator could regulate lead based on a finding of significant risk of harm).

⁷⁸ See *Ethyl Corp. v. EPA*, 5 ENVTL. L. REP. (Env'tl L. Inst.) 20096, 20099 (D.C. Cir. 1975) (requiring a factual showing that lead emissions from gasoline cause a significant health hazard).

⁷⁹ See *Ethyl*, 541 F.2d at 9 (finding it impossible to isolate the effect of lead in gasoline on the human body, because lead comes from multiple sources and the extent of its entry into the human body is disputed).

⁸⁰ See *id.* at 13 (characterizing the statute's endangerment criterion as "precautionary").

⁸¹ See *id.* (agreeing with the EPA administrator that the statute allows regulation based on a "significant risk of harm").

⁸² See *id.* at 28 (allowing EPA to carry out a risk assessment described as including drawing conclusions from suspected relationships between facts, preliminary data, trends, and "theoretical projections").

⁸³ See *id.* at 38 (noting petitioners' apparent agreement that lead at high levels is harmful).

⁸⁴ See *id.* (never mentioning a demand for quantification).

review of the level of reduction EPA had demanded.⁸⁵ Thus, *Ethyl* allowed a qualitative, rather than a quantitative, risk assessment to serve as the trigger for regulation.

This same endangerment standard, by the way, governs the question of whether EPA must regulate greenhouse gases under the Act. Accordingly, when the Supreme Court demanded that EPA make a decision about whether to regulate greenhouse gas emissions by making a finding about endangerment, rather than through a freewheeling political judgment, EPA felt obliged to list greenhouse gases for regulation under *Ethyl*'s precautionary approach.⁸⁶ Thus, under current law, EPA must regulate greenhouse gas emissions, but the agency has only just begun to grapple with the question of how strict those regulations must be.⁸⁷

In the years since *Ethyl*, the world's nations have affirmed the precautionary principle through state practice and frequent mention in international legal instruments, leading many experts to characterize precaution as a customary principle of international law.⁸⁸ International law's articulations of the precautionary principle, however, vary in some respects.⁸⁹

The core of the international legal principle addresses this question of triggers for regulatory action.⁹⁰ The most widely cited version of the principle comes from the Rio Declaration on Environment and Development (Rio Declaration)⁹¹ a statement of principles agreed to by 165 nations in 1992. It states:

⁸⁵ Id. (never reviewing the level chosen).

⁸⁶ See *Massachusetts v. EPA*, 549 U.S. 497, 532-34 (2007) (rejecting a host of policy arguments against regulating greenhouse gases and directing EPA to simply determine whether these gases endangered public health or the environment); *Coalition for Responsible Regulation v. EPA*, 684 F.3d 102, 114, 116-126 (D.C. Cir. 2012) (upholding EPA's finding that greenhouse gases endanger public health and the environment).

⁸⁷ See *Coalition for Responsible Regulation*, 684 F.3d at 115-116 (detailing EPA's regulatory actions through June 26, 2012).

⁸⁸ See Jonathan Remy Nash, *Standing and the Precautionary Principle*, 108 COLUM. L. REV. 494, 499 (2008) (stating that many characterize the precautionary principle as customary international law); John O. McGinnis, *The Appropriate Hierarchy of Global Multilateralism and Customary International Law: The Example of the WTO*, 44 VA. J. INT'L L. 229, 269 (2003) (noting that many, but not all, scholars consider the precautionary principle a customary principle of international law); Geistfeld, *supra* note 31, at 11326 (noting that the European Union considers the precautionary principle a "full-fledged and general principle of international law"); see, e.g., Owen McIntyre & Thomas Mosedale, *The Precautionary Principle as a Norm of International Environmental Law*, 9 J. ENV. L. 221 (1997). Cf. Wiener & Rodgers, *supra* note 52, at 343 (arguing that the claim that precautionary is becoming a tenet of customary law "needs qualification" in light of inconsistent state practice); Richard B. Stewart, *Environmental Regulatory Decisionmaking under Uncertainty*, 20 RES. L. & ECON. 71, 75 (2002) (noting that critics and skeptics deny precaution's customary status); Stone, *supra* note 4, at 10799 (arguing against accepting the precautionary principle as customary international law because of its vagueness).

⁸⁹ See THE PRECAUTIONARY PRINCIPLE IN THE 20TH CENTURY: LATE LESSONS FROM EARLY WARNINGS, 6 (Poul Harremoës et al. eds. 2002) [EARLY WARNINGS]; James E. Hickey, Jr. & Vern R. Walker, *Refining the Precautionary Principle in International Environmental Law*, 14 VA. J. ENVTL. L. 423, 432-36 (1995) (collecting statements of the principle in international legal instruments); see generally, Stone, *supra* note 4, at 10790-91 (finding a muddle in statements of the precautionary principle and attributing this to "diplomacy").

⁹⁰ See Wiener & Rodgers, *supra* note 52, at 320-21 (finding that the core of the principle does not answer the question of what action to take given uncertainty).

⁹¹ United Nations Conference on Environment and Development, U.N. Doc. A/CONF.151/26/Rev.1 (Jun. 14, 1992) [hereinafter Rio Declaration].

In order to protect the environment, the precautionary approach should be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.⁹²

The statement that “scientific uncertainty shall not be used as a reason for postponing” prevention simply takes away scientific uncertainty as an excuse for inaction, in a manner congruent with *Ethyl Industries*’ acceptance of lead abatement without firm proof of harm.⁹³ And it only takes away this excuse when a qualitative risk assessment indicates a “threat [] of serious or irreversible damage,” leaving open the possibility of letting scientific uncertainty defeat regulation to diminish minor reversible damage.⁹⁴ Since a number of international agreements contain very similar language and this version comes from a very general and widely accepted listing of international legal principles, leading scholars of the precautionary principle identify this lowering of the burden of proof attached to regulatory triggers as the core meaning of the precautionary principle.⁹⁵

The principle also addresses measures’ *timing*.⁹⁶ As the Rio Declaration’s admonition against “postponement” suggests, the precautionary principle supports action in advance of full scientific certainty regarding regulated substances’ environmental effects.⁹⁷

The precautionary principle, at least as stated in this leading articulation of it, does not provide an answer to the question of how to set appropriate regulatory levels. It does not appear to take a position on whether society should establish safe levels regardless of cost, employ all feasible technology to reduce emissions (a cost sensitive criterion), or balance costs and benefits at the margin.⁹⁸ By only taking scientific

⁹² Id., Principle 15.

⁹³ Cf. PROTECTING, *supra* note 76, at xxi.

⁹⁴ See Applegate, *supra* note 2, at 182 (stating that the precautionary principle applies only when a threat of serious or irreversible harm exists).

⁹⁵ See Charest, *supra* note 3, at 266-67 (suggesting that the precautionary principle may be viewed as shifting the burden of proof); Geistfeld, *supra* note 31, at 11326 (stating that the Rio Declaration “merely states that uncertainty does not justify inaction, but does not specify a regulatory objective”); see, e.g., Cartagena Protocol on Biosafety to the United Nations Convention on Biological Diversity, art. 10 ¶ 6, opened for signature May 15, 2000, 2226 U.N.T.S. 208, 261 (entered into force Sept. 11, 2003) (stating that lack of full scientific certainty shall not prevent parties from making decisions about importation of modified organisms); United Nations Convention on Biological Diversity, preamble, June 5, 1992, 31 I.L.M. 818 (1992) (stating that “lack of full scientific certainty” should not be used to postpone measures addressing threats); see also Commission of the European Communities, Communication from the Commission on the Precautionary Principle, Feb. 2, 2000, at 30.

⁹⁶ Applegate, *supra* note 2, at 184-85 (discussing the principle of prevention by acting *before* harms occur).

⁹⁷ See Wiener & Rodgers, *supra* note 52, at 320 (associating more precaution with earlier action).

⁹⁸ See David M. Driesen, *Distributing the Costs of Environmental, Health, and Safety Regulation: The Feasibility Principle, Cost-Benefit Analysis, and Regulatory Reform*, 32 B.C. ENVTL. AFF. L. REV. 1, 9-16 (2005) (describing the “feasibility principle” governing many environmental regulations). Cf. Stewart,

uncertainty off the table, it leaves open questions about whether and how to consider costs.⁹⁹

Yet, the idea that precaution has something to say about levels of regulation enjoys a strong following among scholars.¹⁰⁰ And the idea that scientific uncertainty should not justify rejection of *measures* protecting us from environmental harms does suggest something about how a precautionary approach should influence decisions about abatement levels. This wording suggests not just that governments eschew the use of scientific uncertainty as a basis for rejecting listing of a pollutant for regulation, but also that scientific uncertainty play no role in rejecting any particular proposed measure to ameliorate an environmental harm.

For example, if a government rejected a proposal to reduce a pollutant by 90% because of scientific uncertainty, this arguably violates the precautionary principle, even if the same government simultaneously demanded a 70% reduction of this pollutant. This reasoning would supply the missing link between precaution's proponents' tendency to characterize the principle in the narrow terms of a trigger, and the common assumption that it does have something to say about abatement levels.¹⁰¹

If one goes beyond this core meaning of the principle, one can find other language that, at first glance, appears to implicate this question of stringency, but this language varies from statement to statement. (By contrast, all statements of the principle share a core meaning of taking scientific uncertainty off the table as a basis for inaction for serious and irreversible harms).¹⁰²

The Rio Declaration's statement of the precautionary principle goes beyond triggers and timing in its language calling for cost effective regulation. This statement on

supra note 88, at 78 (describing margin of safety and best available technology precautionary principles as different “versions” of the precautionary principle).

⁹⁹ See *Telstra Corp. v. Hornsby Shire Council* (2006) 133 N.S.W. L.E.Ct. ¶ 154 (stating that the precautionary principle does not require giving “overriding weight” to environmental damages compared to “. . . social and economic factors”). Cf. *INTERPRETING THE PRECAUTIONARY PRINCIPLE* 206 (Timothy O-Riordan & James Cameron eds. 1994) (suggesting that regulatory approaches that minimize the need for information about the precise causal relationships between activities and environmental harm are precautionary).

¹⁰⁰ See, e.g., Stewart, *supra* note 88, at 78 (characterizing several approaches to calibrating abatement as implementing the precautionary principle); Applegate, *supra* note 2, at 185 (stating that the precautionary principle addresses “the question of response”).

¹⁰¹ See, e.g., Applegate, *supra* note 2, at 182-83, 185 (defining the principle mostly in terms of a trigger, but then characterizing it as speaking to “the question of response”). One might object that the prohibition against using scientific uncertainty to reject “measures”—in the plural—allows the rejection of any single measure as long as some “measures” are accepted. This reading could justify confining the precautionary principle to the question of triggers only, requiring that at least one measure be taken in the face of scientific uncertainty while saying nothing about the abatement level. Although this is verbally plausible it contradicts the widely accepted idea that precaution has something to say about abatement levels. And it is at least equally verbally plausible to read the plural form here as simply forbidding the scientific uncertainty as the basis for rejection of any measures.

¹⁰² See *id.* at 172 (identifying the willingness to act “in the absence of scientific certainty” as the “minimal core” of the precautionary principle).

its face, however, still says nothing about abatement levels. It just suggests that countries should try to achieve whatever abatement level they choose as cheaply as possible.¹⁰³

This cost effectiveness principle does not demand a balance between costs and benefits. If it did, the cost effectiveness principle would make CBA a mandatory element of the precautionary principle (or at least the leading version of the principle).¹⁰⁴ The United National Framework Convention on Climate Change's (Framework Convention's)¹⁰⁵ very similar statement of the precautionary principle (adopted, like the Rio Declaration, at the 1992 "Earth Summit") shows even more explicitly than the Rio Declaration that cost effectiveness has nothing to do with abatement levels. Article 3 of the Framework Convention calls for "cost effective" measures "so as to ensure global benefits at the lowest possible cost."¹⁰⁶ Furthermore, the overall goal of the Framework Convention, the avoidance of dangerous levels of climate disruption, implicitly rejects balancing, at least over the long-term on a global scale.¹⁰⁷ The Framework Convention's cost effectiveness principle responds to the U.S. demand for international environmental benefit trading. Later, in the Kyoto Protocol, this U.S. lobbying led to incorporation of no less than three environmental benefit trading programs into the climate disruption regime, foreshadowed by language in the Framework Convention authorizing "joint implementation" of reduction commitments.¹⁰⁸ In this context, the cost effectiveness principle demands, not a balance between costs and benefits, but an effort to minimize the costs of whatever abatement targets countries agree to adopt. The principle tends to support global environmental benefit trading, as this approach minimizes the cost of meeting any given target, whether established by CBA or some other approach to specifying environmental goals.

Properly understood, this cost effectiveness principle has nothing to say about abatement levels. One can cost effectively achieve ambitious or unambitious reduction levels. This principle addresses regulatory technique, not regulatory stringency.

The Framework Convention's precautionary paragraph goes on to say a little more about how to regulate greenhouse gas emissions.¹⁰⁹ It demands comprehensive

¹⁰³ *Accord id.* at 185; Geistfeld, *supra* note 31, at 11327 (the Rio Declaration's reference to "cost effective measures" requires attainment of a "given environmental objective at lowest cost") (emphasis added). *Cf.* Stone, *supra* note 4, at 10790 n. 8 (recognizing this interpretation of cost effectiveness, but arguing that absent elaboration the meaning of the phrase is unclear).

¹⁰⁴ *Cf.* INDUR M. GOKLANY: THE PRECAUTIONARY PRINCIPLE: A CRITICAL APPRAISAL OF ENVIRONMENTAL RISK ASSESSMENT 6 (2001) (interpreting similar language in the Framework Convention on Climate Change as mandating reliance on CBA).

¹⁰⁵ May 29, 1992, S. Treaty Doc. No. 102-38, 1771 U.N.T.S. 164 [hereinafter Framework Convention].

¹⁰⁶ *Id.* art. 3.

¹⁰⁷ *See id.* art. 2.

¹⁰⁸ *See* David M. Driesen, *Sustainable Development and Market Liberalism's Shotgun Wedding: Emissions Trading Under the Kyoto Protocol*, 83 INDIANA L. J. 21, 35 (2008) (describing the Kyoto Protocol's three trading programs); David M. Driesen, *Free Lunch or Cheap Fix?: The Emissions Trading Idea and the Climate Change Convention*, 26 B. C. ENVTL. AFF. L. REV. 1, 28-30 (1998) (discussing the joint implementation idea's evolution).

¹⁰⁹ Article 3 of the Framework Convention on Climate Change, contains a very similar statement:

Parties should take precautionary measures to anticipate, prevent, or minimize, the causes of climate change and mitigate its effects. Where there are threats of serious or

regulation, covering all relevant economic sectors.¹¹⁰ This comprehensiveness phrase says nothing about how stringent governments should make their comprehensive regulations.

Another statement in this paragraph addresses abatement levels, but does so quite obliquely. It states that “policies and measures should take different socio-economic contexts into account.”¹¹¹ This statement certainly leaves room for the consideration of cost. Its core meaning, however, seems directed at the idea that developing countries, because of their socio-economic context, may regulate less strictly than developed countries, thereby reinforcing the Framework Convention’s principle of “common but differentiated responsibilities.”¹¹² It also embraces an idea later actualized in the Kyoto Protocol, that the level of reductions might vary among different *developed* countries, since every country has varying social and economic situations to consider.¹¹³

In short, the Framework Convention and Rio Declaration’s statements going beyond the principle’s core say almost nothing about regulation’s stringency, and what they do say addresses the topic at a very high level of generality. Far from stating that countries must ignore costs in order to regulate as strictly as possible, the Framework Convention at least potentially leaves the door open to CBA in the short run at the national level by indicating that countries should take economic context into account in addressing climate disruption. Furthermore, other international agreements embracing precaution provide language treating cost considerations as relevant information, further reinforcing the impression that the precautionary principle does not close the door on CBA.¹¹⁴ Finally, many commentators and government statements about the precautionary principle embrace the concept of proportionality, usually interpreted to require some CBA, but not a strict equalization of costs and benefits at the margin.¹¹⁵

irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures, taking into account that policies and measures should be cost-effective so as to ensure global benefits at the lowest possible cost. To achieve this, such policies and measures should take into account different socio-economic contexts, be comprehensive, cover all relevant sources, sinks and reservoirs of greenhouse gases and adaptation, and comprise all economic actors.

Framework Convention, *supra* note 105, art. 3(3).

¹¹⁰ *See id.*

¹¹¹ *Id.*

¹¹² *Id.* art. 3(1).

¹¹³ *See* Kyoto Protocol to the Framework Convention on Climate Change, FCCC/CP/1997/L.7/Add.1, Dec. 11, 1997.

¹¹⁴ *See, e.g., The Montreal Protocol on Substances that Deplete the Ozone Layer*, art. 9(c), Sep. 16, 1987, 1522 U.N.T.S. 3, 29 (requiring communication of information about the costs and benefits of measures to address stratospheric ozone depletion).

¹¹⁵ *See* ELIZABETH FISHER, RISK REGULATION AND ADMINISTRATIVE CONSTITUTIONALISM 222-23 (2007) (pointing out that the European Court of Justice applies proportionality but not CBA in interpreting the precautionary principle); IMPLEMENTING THE PRECAUTIONARY PRINCIPLE: PERSPECTIVES AND PROSPECTS 26-27 (Elizabeth Fisher, Judith Jones, Rene von Schomberg eds. 2006) (pointing out that EU guidelines calling for CBA do not contemplate a purely “economic weighing”); INTERPRETING THE PRECAUTIONARY PRINCIPLE, *supra* note 99, 238 (referencing the proportionality principle in the German and British versions of the principle); EARLY WARNINGS, *supra* note 89, at 4 (identifying the precautionary principle with “taking into account the likely costs and benefits” and “the proportionality principle”).

To conclude, the precautionary principle's agreed upon core addresses triggers and only addresses abatement levels, if at all, principally by withdrawing scientific uncertainty as a ground for a rejection of any proposed measure. When the Framework Convention says more about regulatory response in the midst of a discussion of precaution, it says very little about abatement levels. What little the Framework Convention's precautionary paragraph does say does not rule out CBA's use.¹¹⁶

C. *The Conflict Between CBA and Precaution*

Still, almost everybody seems to assume that CBA and precaution conflict.¹¹⁷ Indeed, David Weisbach, a CBA advocate, partially defines the precautionary principle as a demand to reduce harm more than CBA requires.¹¹⁸ This view may reflect his qualified acceptance of precautionary principle advocates' apparent position.¹¹⁹ Richard Stewart takes an even more radical stance, treating the principle as simply prohibiting potentially harmful activities altogether.¹²⁰ If all harmful activities must cease, clearly no room exists for any consideration of costs and therefore no room exists for CBA.

Cass Sunstein wrote an entire book attacking the precautionary principle and urging CBA as an alternative.¹²¹ Sunstein's main argument portrays CBA as a rational alternative to the precautionary principle's "incoherence."¹²² He sees the precautionary principle, or at least strong versions of the principle, as providing no useful guidance.¹²³ He sees the principle as leading to paralysis, because, in Sunstein's view "risks are on all sides"—meaning that actions taken to comply with regulations always create risks that a

¹¹⁶ See generally INTERPRETING THE PRECAUTIONARY PRINCIPLE, *supra* note 99, at 17 (linking the precautionary principle to ensuring that restraints are "not unduly costly").

¹¹⁷ See, e.g., Stone, *supra* note 4, at 10796 (claiming that the precautionary principle demands a curtailment of cost-benefit calculation once a harm threshold is reached). Cf. Geistfeld, *supra* note 31, at 11326 (stating that the precautionary principle's "least controversial version . . . must include evaluation of costs and benefits").

¹¹⁸ See David A. Weisbach, *Should Environmental Taxes be Precautionary*, 65 NAT'L TAX J. 453, 462 (2012) (identifying the precautionary principle with "reducing pollution . . . more than is required through the use of expected values, such as those in standard" CBA). Cf. *id.* at 463-64 (noting that "other interpretations" of precaution, including that found in the Rio Declaration, would not necessarily conflict with "expected value").

¹¹⁹ See Stone, *supra* note 4, at 10792 (presuming that precautionary principle advocates intend activity reduction "to a level lower than what the mathematically expected damages would warrant"). Cf. PROTECTING, *supra* note 76, at 6 (stating that "quantitative risk assessment" and CBA have "eroded the early precautionary" approach to environmental law).

¹²⁰ See Stewart, *supra* note 88.

¹²¹ CASS R. SUNSTEIN, *LAWS OF FEAR: BEYOND THE PRECAUTIONARY PRINCIPLE* (2005).

¹²² See *id.* at 4, 6 (suggesting that CBA overcomes precaution's "incoherence" because it uses a "wide . . . viewscreen" to evaluate risks).

¹²³ *Id.* at 4.

precautionary approach might want to avoid.¹²⁴ He notes CBA “is often urged as an alternative to the precautionary principle” and then proceeds to defend CBA.¹²⁵

John Applegate, likewise, views precaution as an “alternative” to an “approach predicated on cost-benefit analysis.”¹²⁶ And he is not alone among advocates of precaution in viewing it that way. Douglas Kysar places CBA in opposition to precaution when he suggests that the precautionary principle requires avoidance of a catastrophe regardless of cost.¹²⁷ And a group of activists defines it, in part, as a challenge to “the hegemony of cost-benefit analysis.”¹²⁸ Hence, analysts with very diverse views see precaution and CBA as at war with each other.

I have found only two scholars, Professors Mark Geistfeld and Daniel Cole, who clearly regard CBA and precaution as compatible.¹²⁹ Geistfeld reaches this conclusion on different grounds than those that this Article explores, finding an equitable principle embedded in precaution favoring pollution victims.¹³⁰ In order to operationalize his view of precaution he ends up departing from the optimality goal that animates CBA.¹³¹ This Article’s approach focuses more on precaution’s simple insistence that governments not rely on uncertainty as a ground for rejecting measures addressing serious risks.¹³² Daniel Cole assumes compatibility without defending this assumption, focusing on technical suggestions for making CBA precautionary, which this Article draws upon.¹³³

¹²⁴ ID. *Accord* Wiener & Rodgers, *supra* note 52, at 321-22 (seeing the real world as involving multiple risks that require tradeoffs). *Cf.* Samuel J. Rascoff & Richard L. Revesz, *The Biases of Risk Tradeoff Analysis: Towards Parity in Environmental Health and Safety Analysis*, 69 U. CHI. L. REV. 1763, 1765-66 (2002) (pointing out that addressing one risk sometimes simultaneously reduces a corollary risk).

¹²⁵ See SUNSTEIN, *supra* note 121, at 129.

¹²⁶ See Applegate, *supra* note 2, at 171.

¹²⁷ See Kysar, *supra* note 14, at 565-67 (suggesting that the precautionary principle requires restricting greenhouse gas concentrations to “a level that would eliminate the plausible threat of catastrophic scenarios”). *Cf.* SUNSTEIN, *supra* note 121, at 109-15 (likewise endorsing precaution in the case of uncertain catastrophe, but arguing that even in such a case costs should be considered).

¹²⁸ See PROTECTING, *supra* note 76, at 16.

¹²⁹ See Geistfeld, *supra* note 31, at 11326 (arguing that “the least controversial version of the principle must include evaluation of costs and benefits”); Daniel Cole, Reconciling Cost-Benefit Analysis with the Precautionary Principle, <http://www.law.upenn.edu/blogs/regblog/2012/03/reconciling-cost-benefit-analysis-with-the-precautionary-principle.html> (March 4, 2012) (expressing the view that precaution and CBA “can be reconciled”). *Cf.* Wiener & Rogers, *supra* note 52, at 322 (finding the European Commission’s statement of the precautionary principle similar to the Clinton executive order on CBA). I do not agree that the least controversial version of the principle *must* include CBA, only that the principle can include CBA.

¹³⁰ See *id.* Geistfeld, *supra* note 31, at 11328 (finding that the precautionary principle implies a focus on the pollution victim’s welfare).

¹³¹ See *id.* (embracing CBA as a means of measuring “distributive effects” even though precaution often involves inefficiency); Mark Geistfeld, *supra* note 26, at 148-54 (arguing, in some contexts, for expenditures up to two times the value of damages measured by willingness to accept based on a distributive rationale that departs from optimality). *Cf.* INTERPRETING THE PRECAUTIONARY PRINCIPLE, *supra* note 116, at 104 (stating that the normal rule of CBA, that costs should equate with benefits at the margin, “does not apply to efforts to achieve public safety”).

¹³² *Cf.* DAVID M. DRIESEN, THE ECONOMIC DYNAMICS OF LAW 6-7 (2012) (arguing that systemic risk avoidance is much more important than economic efficiency).

¹³³ See Cole, *supra* note 129.

Scholars almost universally view precaution and CBA as at war. The next section questions that view.

III. IS CBA AT WAR WITH PRECAUTION?

The basis for this widespread belief in a conflict between CBA, understood merely as a comparison between costs and benefits, and mainstream precaution proves startlingly thin. This section will argue that the most simple natural reading of mainstream contemporary statements of the principle points to the conclusion that the two ideas might not conflict because they primarily address different subjects. It will then go on to point out that a reading of the precautionary principle as embracing radical precaution—the idea that all potentially harmful activity must cease outright—does create a conflict. But, we shall see, the international community has generally rejected radical precaution, so that this conflict proves more apparent than real.

Next, I will argue that precaution, properly understood, does have some implications for how we approach levels of abatement—by demanding a conservative approach to risk assessment in the face of uncertainty.¹³⁴ I will then argue that U.S. CBA practice, not necessarily the idea of CBA itself, conflicts with the precautionary principle, using a case study of the IWG's effort to establish the social cost of carbon as an illustration. This effort to separate contemporary U.S. practice from the basic idea of comparing costs and benefits will provide a predicate for envisioning precautionary CBA.

A. *Triggers and Levels: Talking Past Each Other*

I have already suggested that leading statements of the precautionary principle, may have little or nothing to say about abatement levels, in which case, they may not conflict with CBA. This point may need some elaboration. If one understands the precautionary principle as only (or primarily) taking scientific uncertainty off the table as an excuse for inaction, then the core of the principle does not appear to conflict with CBA's core. That is, if one *only* takes scientific uncertainty off the table as a basis for inaction, all other bases for inaction remain available. It remains acceptable to decline to take an action if taking action would cost too much.¹³⁵ It would follow that a society that chooses to decide which regulatory actions cost too much through CBA would be free to do so.

CBA advocates might object to this analysis on the grounds that the trigger for regulatory action, which, as pointed out previously, has traditionally been science-based, should be based on CBA. That is, CBA could be viewed not only as an influence upon abatement levels, but as an influence upon, or even determining factor, in decisions about

¹³⁴ *Accord* INTERPRETING THE PRECAUTIONARY PRINCIPLE, *supra* note 99, at 209 (finding that precaution could, as an alternative to wholly avoiding uncertain harm, demand conservative assumptions in bridging gaps in our knowledge of risk); *Bridgetown/Greenbushes Friends of the Forest, Inc. v. Executive Director of Conservation and Land Management*, (1997) 18 W.A.R. 102, 118 (interpreting the precautionary principle as requiring a “pessimistic” view of risk).

¹³⁵ *See Bridgetown/Greenbushes*, 118 W.A.R. at 199 (stating that the precautionary principle does not dictate a particular course of action).

whether to regulate at all. This, they might argue, would mean that CBA and the precautionary principle both address (or should address) triggers and so might conflict.

I have two responses to this. First of all, in a world of limited resources, the triggers must be based on science. Second, even if triggers can and should somehow be done through CBA, this would not create a conflict with the precautionary principle defined narrowly.

To see these points, consider the process for setting primary National Ambient Air Quality Standards under the Clean Air Act and how one might modify it to conform better to CBA proponents' desires. The Act requires EPA to list pollutants that endanger public health, the triggering step to which the precautionary principle applies.¹³⁶ One year later, EPA must publish a document linking various quantities of the listed pollutant to levels of health and environmental impacts, called a "criteria" document and a document discussing available technologies for controlling the pollutant.¹³⁷ Finally, comes the step that dismays CBA proponents: EPA must establish standards for the listed pollutant that protect public health and the environment with an adequate margin of safety.¹³⁸

One must identify pollutants based on science in step one, regardless of whether the final step involves setting standards aimed at protecting public health and the environment (as under current law) or standards based on cost-benefit balancing. Governments cannot analyze the costs and benefits of regulating a pollutant without identifying the pollutant first. Unless governments conduct CBA on every single substance released into the environment, they must select pollutants based on some kind of dangerousness assessment as a predicate for analysis. And no government possesses the resources or information that would permit CBA of every released substance, especially since the CBA would necessarily have to examine a variety of possible abatement levels for each pollutant, as costs and benefits vary with the abatement level. As long as one concedes that some assessment of dangerousness functions as a condition predicate to CBA, then it follows that a triggering step exists to which precaution can apply before one gets to the questions of levels.

Second, even if one imagines a Herculean regulator who somehow instantly performs CBA on every substance considering a variety of abatement levels and all the sources of the relevant pollution (and their varied abatement costs), this would not necessarily contradict the precautionary principle. If the regulator decided not to list a substance because any and all regulation would cost too much, this would not violate the mainstream precautionary principle, as long as the decisionmaker did not rely on scientific uncertainty as a ground for the decision.

B. *Radical Precaution*

If, however, one understands the precautionary principle much more broadly as demanding the cessation of all arguably environmental harmful activities, then precaution conflicts with the idea of taking CBA seriously. But leading precautionary principle

¹³⁶ 42 U.S.C. § 7408(a)(1).

¹³⁷ 42 U.S.C. § 7408(a)(2),(b).

¹³⁸ 42 U.S.C. § 7409(a),(b).

scholars reject this understanding of the principle,¹³⁹ castigating precaution's critics for focusing on a straw man by directing so much of their attention at radical precaution¹⁴⁰.

Sometimes the precautionary principle's supporters suggest that some statements of the principle seem to embrace radical precaution, although even that is debatable.¹⁴¹ But they point out that the more widely embraced and recently endorsed versions of the principle, such as those found in the Framework Convention, and above all, in the Rio Declaration, contain no such absolutes about levels.

Not all of those finding a conflict between precaution and CBA rely upon a distortion of the principle's most widely accepted contemporary meaning. David Weisbach relies upon a statement of the precautionary principle as a demand for action to avoid or diminish uncertain but morally unacceptable harm to bolster his contention that the two ideas must conflict.¹⁴² Yet, the language "avoid or diminish" suggests that regulators need not wholly avoid even "morally unacceptable" harms; they may instead choose to *diminish* those harms. Since actions to reduce serious harms likely generate some benefits, surely some action will usually be justifiable in cost-benefit terms. Certainly, this is true in the climate disruption context, since energy efficiency measures often pay for themselves, even apart from their environmental and health benefits.¹⁴³ This "avoid or diminish" statement functions more as a trigger for action than as a guide to calibration of abatement, except perhaps as it indicates a mood.¹⁴⁴

CBA proponents' grounds for finding a conflict between precaution and CBA turn out to be baseless. They rely too much upon a radical precautionary idea enjoying little if any support in international treaties or state practice and, like advocates of precaution, have no clear justification for even imagining that the principles speak to the same issue.

C. Precautionary Risk Assessment and Abatement Levels

Yet, the idea that precaution has something meaningful to say about levels persists among commentators on both sides, in spite of the thin support for this idea in the

¹³⁹ See, e.g., Nash, *supra* note 88, at 502 (claiming that the precautionary principle should not be read to demand bringing all potentially risky activity to a halt).

¹⁴⁰ See, e.g., Applegate, *supra* note 2, at 173-75 (describing the idea that the precautionary principle prohibits any activity that might harm the environment outright as "a caricature of the Precautionary Principle"); Elizabeth Fisher, *Review of Laws of Fear: Beyond the Precautionary Principle by Cass Sunstein*, 69 MODERN L. REV. 288 (2006) (finding Sunstein's evidence for the existence of radical precaution thin and heavily dependent upon exaggerated descriptions by the principle's most vociferous critics).

¹⁴¹ Compare Applegate, *supra* note 2, at 174-75 (suggesting the early versions of the principle, especially in the area of hazardous waste, were quite strong, but that these versions have been "tamed" over time) with Fischer, *supra* note 140, at 290 (calling radical precaution a "straw man" lacking any relationship to actual statements of the principle or the practice of governments applying it).

¹⁴² Weisbach, *supra* note 118, at 462 (citing this as an example of a principle demanding reductions "well above those required through the use of expected values.").

¹⁴³ See Applegate, *supra* note 2, at 187 (stating that many "forms of energy efficiency save more money than they cost" and therefore "should be welcomed regardless of their contribution to reducing climate change.").

¹⁴⁴ Cf. PROTECTING, *supra* note 76, at (identifying the precautionary principle with a "mood of distrust" over the introduction of risky technologies and products without studying their risks).

leading statements of the principle.¹⁴⁵ And surely the word “precaution” itself does suggest choosing abatement levels that reflect some caution about the dangers they aim to address. I have already suggested that the language demanding that governments not rely on scientific uncertainty to reject specific measures supplies some justification for this belief. It remains to spell out this language’s implications for efforts to establish levels and therefore, potentially for CBA. Specifically, I will argue below the precautionary principle demands that policy-makers choosing abatement levels that take health and environmental impacts into account must base their benefits evaluation on conservative risk assessment assumptions.¹⁴⁶

As many commentators have suggested, precaution can inform decisions designed to fully protect public health—including decisions about what abatement level to require.¹⁴⁷ Thus, many scholars describe the requirement that standards designed to protect human health (or the environment) incorporate a “margin of safety” as precautionary.¹⁴⁸ This idea of a margin of safety refers to the practice of setting levels of pollution below the levels where serious health effects are actually observed to take into account potential effects that we have not yet observed, but may well exist. This accounts for a common situation where data exist only for high-level exposure, but that data show the existence of serious problems. For lower levels of exposure that often typify environmental insults, insufficient data exist. This approach takes uncertainty into account by making some expert judgment about safe levels, even when nobody has produced data that would answer the question of exactly where this safe level lies. Furthermore, the idea of an adequate margin of safety implies that in making this assessment of risks at levels for which we have inadequate data, regulators should err on the side of caution, rather than on the side of optimism.¹⁴⁹ This approach implies an attitude of precaution in risk assessment.¹⁵⁰

¹⁴⁵ See, e.g., Wiener & Rodgers, *supra* note 52, at 319 (interpreting a statement that European regulation has become stricter since the mid-1980s as indicating that Europe has become more precautionary); Cross, *supra* note 5, at 856-58 (associating precaution with action based on conservative risk assessment).

¹⁴⁶ See Cross, *supra* note 5 at 856-58 (suggesting as much).

¹⁴⁷ See *id.* at 855.

¹⁴⁸ See *id.* and n. 23 (citing 42 U.S.C. § 7409(b)(1) (1994) and 33 U.S.C. § 1317(a)(4) (1994)); Cass Sunstein, *The Precautionary Principle*, 151 U. PA. L. REV. 1003, 1005 & n. 9 (2003) (citing the Clean Air Act’s ample margin of safety requirement as an example of implementing precaution by requiring “regulation on the basis of conservative assumptions”); see also Thomas Lundmark, *Principles and Instruments of German Environmental Law*, 4 J. ENVTL. L. & PRAC. 43, 44 (1997) (finding that precaution supports building “a margin of safety into all decisionmaking”); INTERPRETING THE PRECAUTIONARY PRINCIPLE, *supra* note 116, at 204 (citing the margin of safety requirements in the Clean Air Act as examples of the precautionary principle at work in U.S. environmental law).

¹⁴⁹ See *Lead Ind. Ass’n v. EPA* 647 F.2d 1130, 1155 (D.C. Cir. 1980) (interpreting the adequate margin of safety requirement as requiring EPA to “err on the side of caution”).

¹⁵⁰ Cf. Nicolas de Sadeleer, *The Precautionary Principle in EC Health and Environmental Law*, 12 EUR. L. J. 139, 147-48 (2006) (agreeing that the precautionary principle is a risk assessment tool, not just a risk management tool).

Notice that this argument does not locate the precautionary principle in the health protection principle itself.¹⁵¹ Rather, a decision to protect health regardless of cost involves a particular value choice that by itself says nothing about scientific uncertainty. One could imagine a health protection principle that applies only to extremely well understood environmental risks. This principle in isolation would violate the precautionary principle, as it would use scientific uncertainty as a basis for inaction.

Furthermore, the literature identifies precaution with a very different principle, that of feasibility. This principle, which animates technology-based rulemaking, does not directly take risk into account at all; yet many countries consider a feasibility-based approach to be synonymous with the precautionary principle.¹⁵² This approach conforms to the precautionary principle, because it does not use scientific uncertainty to postpone action. This analysis suggests that precaution must influence risk assessment whenever levels of risk influence actions.

Yet, as we have seen, risk assessment underlies not just efforts to establish safe levels, but also efforts to quantify regulatory benefits for purposes of CBA. And questions about “margins of safety” and other indicia of precaution enter into risk assessment to establish regulatory benefits. For example, suppose that one wants to establish the benefits of a proposed regulation diminishing levels of a hazardous pollutant to 5 parts per million (ppm). Assume that we have solid data showing that at 10 ppm the pollutant causes 10,000 deaths per year, but we have no data at all about the number of deaths below 10 ppm. How many deaths should an analyst claim will occur at 5 ppm for purposes of CBA?

One approach to this question goes under the name of “sound science” and is much in vogue among regulated companies and conservative think tanks.¹⁵³ Under this approach, the regulator would assume that at 5 ppm, the regulation will avoid only 10,000 deaths, the number of deaths associated with a 10 ppm level, since no proof exists that levels below 10 ppm will kill anybody.¹⁵⁴ This approach, in spite of its technocratic sounding moniker, enjoys little support from scientists not receiving industry funding.

Typically, scientists, absent some contrary evidence, will assume that if levels of 10 ppm kill 10,000, then levels of 5 ppm will kill people as well, albeit at numbers less than 10,000. Many scientists would be very uncomfortable with making claims about how many people will die at 5 ppm, because no data exist to answer that question scientifically. Yet, techniques of quantitative risk assessment exist, which risk assessors

¹⁵¹ Cf. Geistfeld, *supra* note 31129, at 11328 (suggesting that the precautionary principle does not “impose any additional requirements” on regimes emphasizing safety and environmental protection over cost considerations).

¹⁵² See INTERPRETING THE PRECAUTIONARY PRINCIPLE, *supra* note 99, at 241 (pointing out that the precautionary principle is often seen as synonymous with basing regulation on what is technically achievable).

¹⁵³ Donald T. Hornstein, *The Data Wars, Adaptive Management and the Irony of “Sound Science”*, in RESCUING, *supra* note 55, at 103, 114 (describing the “sound science narrative” as demanding a “high level of confidence” about the “precise dimension of the risk”); EARLY WARNINGS, *supra* note 89, at 43 (discussing industry support for an approach that “call for scientific certainty” as a prerequisite to the regulation of benzene).

¹⁵⁴ See INTERPRETING THE PRECAUTIONARY PRINCIPLE, *supra* note 99, at 74 (associating sound science with a demand for proof of harm).

can use to make guesses about how many people will die at a 5 ppm level, at least in some cases.¹⁵⁵

These extrapolation techniques, however, create controversy, since science often cannot identify the correct extrapolation technique.¹⁵⁶ The fact that science often cannot tell us how to estimate risks in the absence of data has significant implications for CBA. It means that human beings cannot discover correct answers about the magnitude of environmental and health benefits.¹⁵⁷ In this case (i.e. just about every case), the answer given in a quantitative analysis will depend upon the analysts' assumptions.¹⁵⁸

The need for assumptions in risk assessment underlying CBA implies that analysts conducting CBA can choose precautionary assumptions in estimating the magnitude of consequences where the data tail off. Or they can choose anti-precautionary assumptions—like the sound science assumption that no firm proof of harm with data implies no harm at all.

Use of antiprecautionary assumptions in the risk assessment underlying a CBA would violate the core of the precautionary principle. To see how antiprecautionary CBA could offend even a modest view of precaution's implications, a return to our "sound science" example will help. Suppose that a regulatory agency rejects a proposal to regulate at 5 ppm on the grounds that the costs of doing so outweigh the benefits. The agency calculates the benefits as 10,000 lives saved (based on the sound science assumption) and multiplies this number by \$6 million (an estimated value for a life saved), thus reaching the conclusion that the 5 ppm regulation generates \$60 billion worth of benefits. It estimates the cost of compliance with a 5 ppm standard at \$61 billion and declines to promulgate the regulation as unjustified in cost-benefit terms. Its conclusion that the benefits outweighed the cost depended on assuming that scientifically uncertain benefits, i.e. those stemming from harms occurring at levels below 10 ppm, do not exist at all. Accordingly, the agency has implicitly used scientific uncertainty to justify rejecting a measure protecting the environment, in violation of the precautionary principle.

According to Rena Steinzor, in practice OIRA uses CBA "to combat precaution."¹⁵⁹ She cites an effort by OIRA economists to change the risk assessment guidelines that the National Academy of Sciences has created to guide government agencies conducting quantitative risk assessments. Although this effort failed, OIRA has

¹⁵⁵ See Wagner, *supra* note 60, at 1619-1627 (discussing the difficulties of making these extrapolations).

¹⁵⁶ See *id.* at 1622-27 (discussing the policy judgments necessary to choose among different models when science does not tell us which one is correct); Eric Biber, *Which Science? Whose Science? How Scientific Disciplines can Shape Environmental Law*, 79 U. CHI. L. REV. 471, 478-79 (2012) (discussing the problem of constructing a "dose-response curve" to govern extrapolation of high dose laboratory experiments to low dose real world human exposures); see, e.g., EARLY WARNINGS, *supra* note 89, at 44 (discussing unresolvable debates about the proper dose-response model for benzene).

¹⁵⁷ See Wagner, *supra* note 60, at 1619 (claiming flatly that "contemporary science is incapable of" specifying the precise level of risk to humans a chemical poses at a given concentration).

¹⁵⁸ See *id.* at 1626-27 (discussing the numerous policy judgments necessary in assessing risk quantitatively and their "profound policy implications").

¹⁵⁹ Steinzor, *supra* note 6, at 250 (stating that John Graham's predecessors as head of OIRA used CBA to combat precaution and that John Graham tried to alter agency risk assessment practices).

long enjoyed a reputation for second-guessing precautionary assumptions embedded in agency CBA.

This gravitation toward anti-precaution may not be deliberate. Generally, CBA practitioners see themselves as choosing middle-of-the-road assumptions. But the middle of the road is not a fixed place. It depends on one's view of where the edges of the road are, i.e. which worst and best cases one finds credible. And one's view of that may be influenced by one's predilections. Furthermore, knee jerk moderation is not necessarily more accurate than any other response in the face of true uncertainty. True uncertainty makes reliable identification of the middle impossible.

One finds this same tendency of CBA supporters to resist precautionary assumptions in risk assessment among commentators. In a notable example, Robert Hahn, who has made a career of promoting CBA, sought (with a coauthor) to downplay the risks arsenic posed in drinking water by challenging the assumptions EPA and the National Academy of Sciences had used in assessing that risk.¹⁶⁰ Tom McGarity's rebuttal showed that Hahn's assumptions lacked scientific justification.¹⁶¹ Perhaps more tellingly, he pointed out that Hahn, as an economist, lacked adequate credentials for making scientific judgments.¹⁶² This point suggests something intriguing for the potential practice of precautionary CBA: CBA of environmental measures requires scientific, not just economic, expertise.¹⁶³

Not all CBA supporters, however, use CBA as a pretext to undermine precautionary risk assessment. Cass Sunstein responded to Hahn's article by accurately noting that the science of arsenic supports a wide range of scientifically plausible estimates of the magnitude of the harms arsenic would cause.¹⁶⁴ Accordingly, he recognized that a CBA based on the plausible benefits range would not provide agency policymakers with clear guidance about what to do.¹⁶⁵

Whether or not today's CBA proponents would accept precautionary risk assessment, it is an analytical possibility. Therefore, it is possible to imagine a benefits assessment that estimates benefits using precautionary risk assessment assumptions. I now move to a case study of anti-precautionary CBA, which will inform, by negative example, our understanding of what precautionary CBA might look like.

D. *The Social Cost of Carbon*

Recently, the Obama administration (an administration not particularly hostile to environmental protection) engaged in an effort to estimate carbon's social cost. This

¹⁶⁰ Jason K. Burnett & Robert W. Hahn, *EPA's Arsenic Rule: The Benefits of the Standard do not Justify the Costs* (2001), http://aei.brookings.org/admin/pdffiles/reg_analysis_01_02.pdf.

¹⁶¹ See Thomas O. McGarity, *Professor Sunstein's Fuzzy Math*, 90 GEO. L. J. 2341, 2357-64 (2002) (critiquing Hahn and Burnett).

¹⁶² See *id.* at 2357 (noting that both lack expertise in toxicology or dose response modeling).

¹⁶³ Accord EPA Guidelines, *supra* note 32, at 7-3 (stating that collaboration with scientific experts is necessary to evaluating environmental benefits).

¹⁶⁴ See Cass R. Sunstein, *The Arithmetic of Arsenic*, 90 GEO. L. J. 2255, 2283 (2002) (characterizing the range of plausible numbers of lives saved through EPA's arsenic regulation as "exceedingly wide").

¹⁶⁵ See *id.* at 2257 (finding that a wide benefits range "does not do a great deal to discipline judgment").

estimate of the value of harms caused by carbon emissions is in effect an estimate of carbon abatement benefits, since the principal benefit of abatement is that it avoids a quantity of emissions and the consequent harms. This exercise's results have already been used in CBA of carbon abatement measures, and will presumably influence future standards.¹⁶⁶

An understanding of this process will show that climate disruption CBA requires either precautionary or anti-precautionary assumptions. The Obama Administration's Interagency Working Group's (IWG's) conclusion pegging carbon's social cost at \$21 per ton (as its central estimate) was not inevitable. Indeed, economists' estimates of the dollar value of a ton of greenhouse gas emission reduction vary from as little as \$5.00 a ton to close to \$3,000 a ton (although most estimates lie in the \$5-\$125 range).¹⁶⁷ The IWG's conclusions reflect the anti-precautionary assumptions of the academic economists whose work it selected as the basis for its estimate. Showing the anti-precautionary nature of existing practice provides a predicate for understanding the shape of a potential precautionary alternative.

1. *Anti-Precautionary Damage Functions* - The IWG arrived at its \$21 number by averaging results from three commonly used integrated assessment models, FUND, PAGE, and DICE.¹⁶⁸ All three of these models rely on inadequate representations of climate damages, failing to reflect current scientific understandings of likely climate impacts, let alone precautionary assumptions about the remaining uncertainties.

DICE calculates expected damages as a function of temperature increases. This "damage function" is calibrated to estimates of the value of a few categories of potential damages at 2.5°C, partially offset by a large subjective benefit expected from warmer weather. In all, DICE projects losses of less than two percent of world GDP due to the first 2.5°C of warming. That estimate is quite incomplete and conjectural; other analysts have estimated much larger damages at the same temperature.¹⁶⁹ Based on the 2.5°C estimate, the DICE damage function is extended to other temperatures by assuming a simple, unproven algebraic formula (involving the square of the temperature increase). The DICE damage function implies that half of world output will not be lost to climate

¹⁶⁶ See, e.g., Masur & Posner, *supra* note 15, at 1572-1577 (discussing regulations employing the IWC's estimates of carbon's social costs).

¹⁶⁷ See Tiffany Stecker, *Administration Grossly Underestimated Carbon Costs, Says Study*, (July 14, 2011), <http://www.nytimes.com/cwire/2011/07/14/14climatewire-administration-grossly-underestimated-carbon-69396.html> (stating that estimates vary from \$5 to \$3,000 a ton); Frank Ackerman & Elizabeth A. Stanton, *Climate Risks and Carbon Prices: Revising the Social Cost of Carbon 2* (2011); Frank Ackerman & Elizabeth A. Stanton, *The Social Cost of Carbon: A Report for the Economics for Equity and the Environment Network* 9 (2010) [hereinafter 2010 *Social Costs*]; Douglas Kysar, *Some Realism About Environmental Skepticism: The Implications of Bjorn Lomborg's The Skeptical Environmentalist for Environmental Law and Policy*, 30 *ECOLOGY L. Q.* 223, 263 (2003) (discussing these numbers, given in 1990 U.S. dollars); Richard S.J. Tol, *The Social Cost of Carbon: Trends, Outliers and Catastrophes*, *ECONOMICS E-JOURNAL* 2, article 2008-25 (2008) (reviewing many studies published through 2006); see also Farber, *supra* note 66, at 1386-88 (noting that some models find climate disruption causes positive economic effects up to about 4° C, but that others anticipate losing 5 to 20% of GDP or more).

¹⁶⁸ See IWG, *supra* note 8, at 28 (explaining that the damages were calculated by combining outputs of DICE, FUND, and PAGE model runs).

¹⁶⁹ See, e.g. W.M. HANNEMAN, *WHAT IS THE ECONOMIC COST OF CLIMATE CHANGE?* (2009).

damages until the temperature has increased by almost 19°C, far beyond the temperatures at which many observers anticipate catastrophic climate changes.¹⁷⁰

PAGE uses a slightly more complex treatment of damages, separately estimating the costs of several major categories of climate impacts. The overall results are calibrated to roughly match other models such as DICE – and indeed, PAGE and DICE produce very similar estimates of the social cost of carbon under IWG assumptions (\$30 and \$28, respectively). PAGE assumes that developed nations will adapt to most impacts of climate disruption at near-zero cost.¹⁷¹ This seems like wishful thinking, in light of our failure to protect the people of New Orleans from the widely anticipated threat of a major hurricane such as Katrina.¹⁷² The developer of the PAGE model has indicated that he is exploring alternatives to this assumption (along with other improvements) in the next version of the model; his preliminary results from that version suggest a much higher social cost of carbon.¹⁷³

The FUND model offers the lowest estimate of the social cost of carbon of the three models used by the IWG, a mere \$6 per ton of carbon dioxide. (As a rule of thumb for interpreting such numbers, every \$1 per ton of carbon dioxide is roughly equivalent to \$0.01 per gallon of gasoline. Thus the IWG's FUND results suggest that the climate damages caused by using a gallon of gasoline are worth about \$0.06, compared to a larger but still modest \$0.28 - \$0.30 per gallon inferred from the DICE or PAGE results.)

A recent article analyzed the damage estimates in the FUND model.¹⁷⁴ Although FUND distinguishes 15 different categories of damages, many of the category estimates are close to zero in practice. Cooling and heating costs, driven by the fact that a warmer world will lead to increases in air conditioning expenditures, are by far the largest category of climate impacts in FUND. The increased costs of air conditioning, combined with smaller climate disruption costs in other areas, are partially offset by a substantial projected benefit of climate change in agriculture. The supposed agricultural benefit is supported by citations to a handful of studies published in the mid-1990s, and rests on calculations that are both empirically and theoretically problematical.¹⁷⁵ In the IWG's FUND analysis, the world as a whole experiences net benefits from warming until about 3°C.¹⁷⁶

In short, each of these models relies on assumptions about the extent of climate damages, and/or the ease of adaptation, which serve to minimize the threat of climate change. Climate science, meanwhile, has run far ahead of such economic analyses,

¹⁷⁰ F. Ackerman, E.A. Stanton, & R. Bueno, *Fat tails, exponents, extreme uncertainty: Simulating catastrophe in DICE*, 69 ECOLOGICAL ECON. 1657, 1660 (2010) (noting that DICE's "leisurely" damage function implies that "less than half of world output" is destroyed until temperature rises to 19°C).

¹⁷¹ Frank Ackerman, *et al.*, *Did the Stern Review Underestimate U.S. and Global Climate Damages?*, 37 ENERGY POL'Y 2717, 2719 (2009) (explaining that PAGE2002 assumes "nearly costless adaptation").

¹⁷² See Farber, *supra* note 66, at 1390 (pointing out that the history of federal flood control does not generate optimism about our capacity to optimally adapt to climate disruption).

¹⁷³ See Chris Hope, *The Social Cost of CO2 from the Page09 Model* 8-9 (2012), available at <http://www.economics-ejournal.org/economics/discussionpapers/2011-39> (presenting new assumptions and noting that they respond to Ackerman's criticism of the earlier version's overoptimism about adaptation).

¹⁷⁴ F. Ackerman & C. Munitz, *Climate Damages in the FUND Model: A Disaggregated Analysis*, 77 ECOLOGICAL ECON. 219-224 (2012).

¹⁷⁵ See *id.*

¹⁷⁶ IWG, *supra* note 8, at 9 (showing this result graphically with a green line).

identifying numerous threats to economies and ecosystems that are expected to occur at relatively low temperatures.¹⁷⁷ Even worse are the “known unknowns” – crucial issues such as climate sensitivity, discussed above, for which scientific research has not resolved the fundamental uncertainty, and may not be able to do so (at least until it is too late to act on this information and prevent worst-case outcomes).

Perhaps the biggest challenge to conventional CBA of climate change involves the problem of catastrophic risk mentioned earlier. The IWG analysis minimizes this problem. Of the three chosen models, PAGE includes a Monte Carlo analysis of assumed risks of a medium-sized catastrophe; DICE includes the expected value of the same size of event (i.e., DICE damage estimates include the value of catastrophic losses multiplied by the probability of occurrence); FUND simply omits catastrophic risk. Yet one of the key results in the economic theory of climate change is Martin Weitzman’s “dismal theorem.”¹⁷⁸ Weitzman demonstrates that because we know so little about the risks of disastrously high climate sensitivity, the marginal benefit of emission reduction, and hence the social cost of carbon, could literally be infinite. This, suggests Weitzman, underscores the need for a precautionary response to climate change.¹⁷⁹ The IWG recognized that the models it relied upon downplayed or ignored the potential for catastrophic risk, and identified it as an area for future research. To the extent that CBA does not adequately address catastrophic risk it egregiously violates the precautionary principle.

2. *Zero Value for Nonquantifiables.* - The Stern Review, a widely discussed report on the costs and benefits of greenhouse gas abatement by a noted British economist, criticizes the studies the IWC relied upon for focusing exclusively on “a small subset of the most well understood, but least damaging, impacts.”¹⁸⁰ This report lambastes earlier efforts at quantifying climate disruption’s social costs for ignoring the most damaging impacts because they are “surrounded by the greatest scientific uncertainty.” Analysts conducting CBA face a choice: They can confine themselves to cases where good data exist to estimate benefits, or they can go beyond that and look at cases where data about the magnitude of an effect are sparse. Confining themselves to professionally relatively safe cases where good data exist leads to effective, albeit unintentional, use of the lack of scientific certainty to justify rejecting measures to abate serious harms—i.e. to a cold violation of the precautionary principle.

Even Nicholas Stern, however, has been unable to fully quantify some of climate disruption’s most serious effects—such as the loss of endangered species.¹⁸¹

¹⁷⁷ F. Ackerman & E.A. Stanton, *Climate Economics: The State of the Art* (Stockholm Environment Institute, 2011).

¹⁷⁸ Martin Weitzman, *On Modeling the Economics of Catastrophic Climate Change*, 91 REV. OF ECON. & STAT. 1, 10 (2009).

¹⁷⁹ See id. at 12 (linking his dismal theorem to “a very strong form of a ‘generalized precautionary principle’” for climate disruption and other cases with fat tails).

¹⁸⁰ NICHOLAS STERN, THE ECONOMICS OF CLIMATE CHANGE: THE STERN REVIEW 149-151 (2007)

¹⁸¹ See Wayne Hsiung & Cass R. Sunstein, *Climate Change and Animals*, 155 U. PA. L. REV. 1695, 1697 (2007) (noting that Stern makes “little effort” to monetize species loss); see generally WILLIAM D. NORDHAUS & JOSEPH BOYER, WARMING THE WORLD: ECONOMIC MODELS OF GLOBAL WARMING 4-20 (1999) (discussing the difficulties of economically quantifying species loss and characterizing existing economic valuations as “wild”); cf. Hsiung & Sunstein, *supra*, at 1708, 1734 (estimating a value); Jason Scott Johnson, *Desperately Seeking Numbers: Global Warming, Species Loss, and the Use and Abuse of*

Unfortunately, many of the harms that cannot be quantified are likely to occur. The Intergovernmental Panel on Climate Change, the primary source for peer reviewed consensus science on climate disruption, has a high degree of confidence that climate disruption will produce widespread species loss.¹⁸² The frequent coexistence of good qualitative evidence indicating a likely environmental or health effect with a dearth of good data about the effect's magnitude, however, does pose a problem for the project of constructing precautionary CBA.

3. *High Discount Rates.* - Economists conducting CBA discount future costs to reflect the time value of money. So, for example, if a regulator enacts a rule that requires a \$1 million compliance expenditure three years from now, the regulator will calculate the cost of that regulation as being somewhat less than \$1 million today, because a company could set aside less than \$1 million today and earn sufficient interest on the balance to pay the \$1 million cost three years hence. The expected rate of interest determines the discount rate that would apply to future costs.

More controversially, economists generally discount future health and environmental benefits as well.¹⁸³ The IWG selected models using higher discount rates than the models generating far higher social cost of carbon numbers. It applied a range of discount rates, but used 3% as a central estimate.

Selection of discount rates implicates the analyst's policy judgment.¹⁸⁴ Scholars have made reasonable arguments for rejecting discounting of deaths and illness, especially when the discount rates apply to harms threatening future generations.¹⁸⁵ Some economists, notably Nicholas Stern, accept arguments that this generation's preferences should not determine the scope of allowable harms to future generations, and therefore use close to a zero discount rate for the rate of pure time preference, a component of the discount rate.¹⁸⁶ Others, such as William Nordhaus, however, think that discount rates should reflect the current generation's self-interested preferences and

Quantification in Climate Change Policy Analysis, 155 U. PA. L. REV. 1901 (2007) (showing that Hsiung & Sunstein's analysis is not credible).

¹⁸² FAR: IMPACTS, *supra* note 18, at 792 (expressing "high confidence that climate change will result in the extinction of many species").

¹⁸³ See EPA Guidelines, *supra* note 32, at 6-20 (stating that costs and benefits should be "discounted in the same manner").

¹⁸⁴ See Daniel H. Cole, *The Stern Review and Its Critics: Implications for the Theory and Practice of Cost-Benefit Analysis*, 48 NAT. RES. J. 53, 81-82 (2008) (explaining that policy judgment is unavoidable in discount rate selection); DISCOUNTING AND INTERGENERATIONAL EQUITY 4-5 (Paul R. Portney & John P. Weyant eds. 1999) (reporting "unease" among economists about discounting because of discounting's "ethical ramifications" and technical complexity).

¹⁸⁵ See Farber, *supra* note 66, at 1390 (pointing out that scholars have questioned discounting's legitimacy and that no professional consensus exists about appropriate discount rates); see, e.g., Kysar, *supra* note 14, at 578-81 (questioning the moral basis for intergenerational discounting); Lisa Heinzerling, *The Temporal Dimension in Environmental Law*, 31 ENV'T L. REP. (Env'tl. L. Inst.) 11055 (2001); Richard L. Revesz, *Environmental Regulation, Cost-Benefit Analysis and the Discounting of Human Lives*, 99 COLUM. L. REV. 941 (1999); Lisa Heinzerling, *Discounting Life*, 108 YALE L. J. 1911 (1999) (questioning the notion that future lives have less value than present lives); see also Geistfeld, *supra* note 31, at 11328 n. 18 (finding no persuasive economic or ethical justification for intergenerational discounting).

¹⁸⁶ See EPA Guidelines, *supra* note 32, at 6-18 (explaining that Stern's discount rate reflects a view that the "current generation has an ethical obligation to place similar weights on the pure rate of time preference for future generations.").

therefore come up with a much higher discount rate. The question of whether this generation's preferences should govern the valuation of benefits accruing to future generations is normative.¹⁸⁷ A thorough review of the discounting debate will not serve this Article's purpose. It brings up the policy judgments embedded in discount rates primarily to discuss discounting's potential relationship to the precautionary principle.

The discount rate appears to implicate the precautionary principle insofar as it influences regulation's timing. Recall that the precautionary principle has an ambition of anticipating and preventing serious negative consequences before they occur, especially irreversible consequences.¹⁸⁸ Greenhouse gases once emitted remain in the atmosphere for many decades, in some cases for centuries, so failing to act in advance of dangerous warming makes it impossible to address the problem effectively with carbon abatement.¹⁸⁹ Our emissions today will influence the climate many decades hence, even if we cease emitting tomorrow. The very word precaution appears to prefer early rather than late action.

Discounting of abatement benefits, however, favors delay over prompt action, because benefits often occur many years after companies pay out abatement costs.¹⁹⁰ For climate disruption, many of the worst effects occur 100 years or more in the future, so that discount rates have an enormous effect.¹⁹¹ An analysis applying a high discount rate to benefits occurring far in the future makes them dwindle to a fraction of their dollar value, thereby allowing the nearer term costs to greatly exceed them.¹⁹² By contrast, a decision not to discount future environmental and health benefits or to discount them only modestly makes the early timing favored by precaution appear more attractive in cost-benefit terms.

¹⁸⁷ See *id.* at 6-12 (stating that the “fundamental choice of what moral perspective should guide intergenerational social discounting . . . cannot be made on economic grounds alone”).

¹⁸⁸ See de Sadeleer, *supra* note 150, at 139 (describing the precautionary principle as a “philosophy of anticipated action”).

¹⁸⁹ See Cass Sunstein, *Irreversible and Catastrophic*, 91 CORNELL L. REV. 841, 842 (2006) (pointing out that since greenhouse gases remain in the atmosphere for “up to a century . . . global warming may be irreversible, at least for all practicable purposes”).

¹⁹⁰ See Christian Gollier, *Debating about (sic) the Discount Rate: The Basic Economic Ingredients*, 11 PERSPEKTIVEN DER WIRTSCHAFTSPOLITIK 38, 38 (2010) (pointing out that discounting at Nordhaus' preferred rate of 5% suggests that none of the big projects reducing emissions are socially desirable, whilst discounting at Stern's preferred rate of 1.4% suggests immediate actions to fight climate disruption).

¹⁹¹ See Christian Gollier & Martin L. Weitzman, *How Should the Future be Discounted When Discount Rates are Uncertain*, 107 ECON. LETTERS 350, 350 (2011) (stating that small differences in discount rates can have an enormous influence on valuation of climate disruption's cost).

¹⁹² See Ackerman & Stanton, 2010 *Social Costs*, *supra* note 167, at 11 (pointing out that with discounting “the farther into the future that costs take place, the less these costs are assumed to matter”); see, e.g., Amy Sinden, *The Abandonment of Justice*, in ECONOMIC THOUGHT, *supra* note 2, at 120 (pointing out that application of a 5% discount rate to a dollar value for the death of a billion people 500 years from now produces a present value equivalent to the death of one person today); Kysar, *supra* note 14, at 578 (pointing out that one million lives discounted over 145 years at 10% is “worth” less than a single life today).

Economists have criticized the IWG for selection bias in choosing the models and data runs to employ in estimating carbon's social cost.¹⁹³ The analyses that the IWG chose to rely upon employed much higher discount rates than other analyses, such as the Stern Report, that generated much higher social cost of carbon numbers.¹⁹⁴ A choice of high discount rates appears to exacerbate the tension between CBA and the precautionary principle.

Yet, selection of a high discount rate does not appear to contradict the Rio Declaration's literal language. It only rejects use of scientific uncertainty as a reason for postponement. By its terms, it does not take delay motivated by a desire to make environmental policy mirror the current generation's market preferences off the table.

Yet, some arguments against high discount rates depend upon precaution. Daniel Cole, relying on work by the economists Christian Gollier and Martin Weitzmann, has argued that at least one assumption common in constructing discount rates may literally violate the precautionary principle. A frequently employed equation for generating a discount rate, the Ramsey equation, makes the discount rate depend, in part, on an estimate of the future economic growth rate, something economists have been notoriously bad at predicting.¹⁹⁵ Economists employing this equation in climate CBA have usually assumed that economic growth would remain positive and more or less as robust as it has been in the past.¹⁹⁶ This assumption neglects the possibility that climate change or an oil shortage may disrupt the economy so severely that economic growth diminishes or even reverses.¹⁹⁷ Cole, Gollier, and Weitzmann suggests that a precautionary approach to discounting would require consideration of discount rates based on assumptions of declining or negative economic growth.¹⁹⁸ To the extent that calculations of discounting rates assume away scientific uncertainty about climate's disruption of the economy and oil reserves, they implicitly generate results using scientific uncertainty to justify inaction (or less vigorous action).

A high discount rate tends to produce results in tension with the idea of precaution generally, especially as it applies to irreversible problems like climate disruption. And some aspects of current discounting practice directly contradict the principle.

¹⁹³ See Ackerman & Stanton, 2010 *Social Costs*, *supra* note 167, at 8-10 (explaining how the IWG selected its models and how they differ from models that received short shrift); see also Nordhaus, *supra* note 15, at 22-23 (criticizing the meta-analysis underlying the IWC's work).

¹⁹⁴ See Cole, *supra* note 184, at 60-62 (discussing the *Stern Review*'s choice of discount rate).

¹⁹⁵ See Christian Gollier, *Discounting with Fat-Tailed Growth*, 37 J. RISK & UNCERTAINTY 171, 173 (2008) (pointing out that the "Ramsey rule" derives the "socially efficient discount rate" from "the product of the real growth rate . . . times the marginal utility of consumption"); Farber, *supra* note 66, at 1389 (noting that nobody could have predicted the growth of personal computers, the internet, or the invention and implosion of financial derivatives, all of which influenced economic growth).

¹⁹⁶ See *id.* at 173 (noting that concerns about natural resource scarcity lead some to forecast negative economic growth).

¹⁹⁷ See, e.g., EPA Guidelines, *supra* note 32, at 6-17 (noting that an assumption of declining economic growth, perhaps due to resource constraints, leads to "declining discount rates").

¹⁹⁸ See Cole, *supra* note 151 (noting that the value for "g", which measures economic growth, could be a negative number in light of "catastrophic climate change"); Christian Gollier, *On the Underestimation of the Precautionary Effect on Discounting*, 2, CESifo working paper: Energy and Climate Econ. No. 3536, <http://hdl.handle.net/10419/49477> (2011) (uncertain economic growth produces a precautionary effect reducing the discount rate); Gollier & Weitzman, *supra* note 191, at 353 (arguing for a discount rate that declines over time toward its lowest possible value).

E. Lessons about Prospects for Reconciliation

Thus far, we have found that conceptually CBA and precaution need not be at war. In doing so, we discovered some valuable things about environmental law. The argument advanced here suggests that precaution by itself has relatively little to say about how to consider costs. It has something to say, however, about how to treat uncertainty, not wanting it to be used as a reason for “postponing” measures addressing serious environmental harms. But the social cost of carbon case study suggests that current U.S. CBA practice is deeply anti-precautionary, employing methods that effectively use uncertainty as a rationale for postponing measures that a different approach to benefits valuation would justify.

Conversely, the mere idea of CBA has very little to say about normative judgment in addressing uncertainty. Its practitioners, however, address uncertainty, both in coming up with quantitative estimates through analytical techniques (such as Monte Carlo analysis and Bayesian probabilities) and in leaving significant information out of their analysis. And policymakers, to the extent that they employ antiprecautionary CBA as a guide to policy, will implicitly, and probably unwittingly, use scientific uncertainty to justify postponing measures addressing serious, and sometimes irreversible, environmental problems.

The analysis of this anti-precautionary practice suggests that precautionary CBA will, at a minimum, have to employ conservative risk assessment assumptions and take nonquantifiable benefits into account. The spirit of precaution, and in some contexts the letter, would also counsel against steeply discounting future benefits. I will develop these principles into more concrete suggestions in the next part. Although these ideas are easily stated, many of them excite controversy and their implementation raises difficult issues.

IV. TOWARD PRECAUTIONARY CBA

The previous section shows that an analytical possibility of precautionary CBA exists and provides a rudimentary picture of what precautionary CBA might look like. I begin this section by motivating interest in implementing precautionary CBA, primarily by arguing that the executive order requires CBA and that our obligations under international law support precaution: *i.e.* that existing law may require some sort of blending. I will then develop a fuller picture of what precautionary CBA might look like, building on the core ideas mentioned in the Introduction and in Part III.

A. Why Precautionary CBA?

This exploration of precautionary CBA illuminates both the precautionary principle and CBA, and therefore proves worthwhile theoretically, even if nobody had any interest in adopting it. And, in truth, a lot of analysts will oppose its adoption. CBA proponents may well resist precautionary CBA, because they see little or no value in

precaution. Conversely, precaution's advocates tend to find CBA wrongheaded and will see no value in continuing its use.¹⁹⁹

The law, however, suggests that we need precautionary CBA. The United States, for better or worse, has operated under an executive order for some time that requires CBA of major rules. On the other hand, international law, including treaties that the United States has ratified, supports implementation of the precautionary principle.

Environmental advocates' actions in recent years suggest that they do not see much opportunity for dislodging CBA in the near term. Even at the outset of President Obama's first term, no environmental group urged him to repeal the Clinton executive order requiring CBA of major rules to the extent required by law. Accordingly, some environmental advocacy groups have begun to follow Richard Revesz and Michael Livermore's advice: to become more active in seeking to shape CBA's methodologies.²⁰⁰ Indeed, environmental groups filed comments seeking to influence the IWC's approach to the social cost of carbon, and these comments, at least implicitly, addressed precautionary CBA.

On the other hand, international law supports the precautionary principle. To the extent that the principle has become a part of customary international law, it binds us. As a general matter, the idea that international law forms part of our law is well established.²⁰¹ I put aside difficult issues about whether a U.S. duty to abide by the precautionary principle might be judicially enforceable, because even if it is not, the executive branch remains obligated to respect customary international law.²⁰²

Furthermore, the United States has ratified a number of treaties embodying the precautionary principle.²⁰³ Most importantly for this Article, it has ratified the Framework Convention, which contains a leading statement of the principle echoing the

¹⁹⁹ See, e.g., David Santillo, Paul Johnston, & Ruth Stringer, *The Precautionary Principle in Practice: A Mandate for Anticipatory Preventative Action*, in PROTECTING, *supra* note 76, 36, 48 (urging resistance to making the precautionary principle "subject to cost-benefit analysis").

²⁰⁰ RICHARD REVESZ & MICHAEL LIVERMORE, RETHINKING RATIONALITY: HOW COST-BENEFIT ANALYSIS CAN BETTER PROTECT OUR ENVIRONMENT AND OUR HEALTH 192 (2008) (calling on "proregulatory interests" to participate in improving CBA).

²⁰¹ See Harold Hongju Koh, *Is International Law Really State Law?*, 111 HARV. L. REV. 1824, 1831 (1998) (describing long standing precedent making international law part of our law); see, e.g., *The Paquete Habana*, 175 U.S. 677, 700 (1900).

²⁰² Cf. Curtis A Bradley & Jack L. Goldsmith, *Customary International Law as Federal Common Law: A Critique of the Modern Position*, 110 HARV. L. REV. 815, 870 (1997) (arguing that absent federal political branch authorization, customary international law does not count as federal law).

²⁰³ See, e.g., *Annex VI to the Protocol of Environmental Protection to the Antarctic Treaty* [hereinafter *Annex VI*], Preamble & art. 3, Jun. 14, 2005, S. Treaty Doc. No. 111-2; *International Convention on the Control of Harmful Anti-Fouling Systems on Ships* [hereinafter *Antifouling Convention*], art. 6.5, Oct. 18, 2001, S. Treaty Doc. No. 110-13; *Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean* [hereinafter *Fish Stocks*], art. 5, Sep. 5, 2000, T.I.A.S. No. 13,115, 2275 U.N.T.S. 43, 48-49; *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal* Preamble, Mar. 22, 1989, 1673 U.N.T.S. 57, 126 (regulating hazardous waste based on a "risk of damage to human health and the environment"); *Montreal Protocol*, *supra* note 114, Preamble, 1522 U.N.T.S. at 29 (declaring a determination to take "precautionary measures" to "protect the ozone layer"); *Convention on the Conservation of Antarctic Marine Living Resources* art. 2.3(c), Aug. 1, 1980, 1329 U.N.T.S. 47; see also *Vienna Convention for the Protection of the Ozone Layer*, Preamble, Mar. 22, 1985, T.I.A.S. No. 11,097, 1513 U.N.T.S. 293, 324 (acknowledging precautionary measures undertaken prior to enactment).

Rio Declaration (which we also signed). Although the Framework Convention states that the parties “should” rather than “must” take a precautionary approach, other treaties that the U.S. has ratified contain mandatory language.²⁰⁴ The object and purpose of the Framework Convention treaty—to avoid dangerous climate change—suggests that the United States must take this admonition to employ the precautionary principle seriously, as treaties must be construed to advance their object and purpose.²⁰⁵ Together, the likelihood that the precautionary principle already imposes a legal obligation under customary international law together with the U.S. agreement that it should employ the approach suggest that the President of the United States should see to it that U.S. actions, and U.S. practices under the executive order, conform to the precautionary principle.

The legal academy’s CBA advocates should, moreover, support precautionary CBA. For they have urged CBA as a way of fully informing decisionmakers about their actions’ consequences. To the extent that CBA does not comprehensively present information about all of the benefits, because it leaves out information about nonquantifiable benefits, CBA systematically undervalues benefits and misleads decisionmakers. That is why CBA advocates have always said that decisionmakers should take nonquantifiable benefits into account.²⁰⁶ Similarly, when CBA obscures the possible consequences of action, by hiding uncertainty through obscure and often arbitrary uses of statistical techniques, it does not perform its mission of informing decisionmaking. Scholars advocating CBA as a way of enhancing the rationality and transparency of government decisions should welcome the reforms proposed here.²⁰⁷

Hence, both the law and the ideals of CBA’s most thoughtful advocates support precautionary CBA. It remains to say a little more about how one might carry out precautionary CBA.

B. On Precautionary Cost-Benefit Analysis

This section develops and supports recommendations on how to carry out precautionary CBA. I begin with some institutional points, building on an earlier

²⁰⁴ Compare, *Framework Convention*, *supra* note 105, preamble with *Annex VI*, *supra* note 203, art. 3 (requiring “reasonable preventive measures . . . to reduce the risk of environmental emergencies” and their impacts); *Fish Stocks*, *supra* note 203, art. 5, T.I.A.S. No. 13,115 at 4, 2275 U.N.T.S. at 49 (requiring application of the precautionary approach); *Vienna Convention*, *supra* note 203, art. 2, 1513 U.N.T.S. at 326 (requiring parties to “take appropriate measures . . . to protect . . . against adverse effects . . . likely to result from” ozone modification) [emphasis added]; *Antifouling Convention*, *supra* note 203, art. 6(5) (stating that lack of certainty about irreversible damage will not prevent listing of an antifouling system in the treaty).

²⁰⁵ See Vienna Convention on the Law of Treaties, art. 31, § 1, May 23, 1969, 1155 U.N.T.S. 331, 340 (demanding that a treaty be interpreted “in light of its object and purpose”).

²⁰⁶ See, e.g., Robert W. Hahn & Cass R. Sunstein, *A New Executive Order for Improving Federal Regulation?: Deeper and Wider Cost-Benefit Analysis*, 150 U. PENN. L. REV. 1489, 1498 (2002) (arguing for CBA that takes qualitative information into account) Cf. Arden Rowell, *Partial Valuation in Cost-Benefit Analysis*, 64 ADMIN. L. REV. 723, 729-30 (2012) (arguing for only counting quantifiable benefits in CBA). Arden, however, concedes that decisionmakers should ultimately take non-monetizable outcomes into account. *Id.* at 741-42 (suggesting that CBA should not be “the sole determinant of legal policy” and that revealing nonquantifiable benefits aids transparency).

²⁰⁷ See Hahn & Sunstein, *supra* note 206, at 1498 (describing CBA as providing a “full accounting” of action’s consequences both quantitatively and qualitatively).

suggestion that CBA requires too much scientific and normative judgment to be left solely to economists. I then take up the question of how to take into account nonquantifiables. I flesh out a conservative approach to risk assessment that comports with the principle. And finally, I discuss the precautionary principle's potential implications for treatment of discount rates.

1. *Institutional Considerations*—I have already suggested that precautionary CBA may require scientific and normative judgments that ought not be left solely to economists. The IWC did not open up the black box containing the anti-precautionary assumptions I highlighted in my discussion of the models it relied upon. It simply averaged the model results it chose to consider. The IWC consisted mostly of economists. Although economists have expertise in monetization techniques, construction of risk assessments informing a model's damage functions is essentially a scientific task. For it requires assessment of scientific information to generate descriptions of climate disruption's outcomes and estimates of their magnitude. To be sure, the scientific data alone will rarely control such a damage functions. For creation of damage functions requires science policy judgment in making inferences from the data. Still, the people with the relevant expertise for these science policy judgments are scientists, not economists.²⁰⁸ And scientists should have the dominant role in constructing damage functions.²⁰⁹

In the case of climate disruption CBA the principle that scientists should have a dominant role in constructing damage functions, suggests a need for scientific review of models' damage functions. This role will enable the government to avoid relying on scientifically outdated or naive models. This implies, at a minimum, that scientists must participate in any future IWG revisiting the social cost of carbon issue. As a further safeguard, the National Academy of Sciences could review the IWC's estimate and the studies it relies upon for scientific integrity and completeness. Often climate disruption CBA has undergone peer review in the past, but peer review by economists does not suffice as a substitute for a current scientific review assessing the model's validity under the most up-to-date scientific information.

2. *Nonquantifiables*—Although the suggestion that nonquantifiables should count enjoys widespread support, the cost-benefit state has not been kind to information resisting quantification. Basically, soft variables—those lacking hard numbers—tend to get short shrift in CBA.²¹⁰

Government regulatory impact analyses (RIAs) mention nonquantifiable benefits' existence.²¹¹ Furthermore, they often comprehensively list pollutants' effects including

²⁰⁸ See Wagner, *supra* note 60, at 1627-28 (explaining that scientific expertise is needed to distinguish scientifically resolvable questions from policy questions embedded in risk assessment).

²⁰⁹ See EPA Guidelines, *supra* note 32, at 7-3 (stating that collaboration with scientific experts is necessary to evaluating environmental benefits). Cf. *id.* at 1634-35 (criticizing scientists who resolve policy questions embedded in risk assessment as if they were scientifically resolvable in isolation from "designated policymakers").

²¹⁰ See Laurence H. Tribe, *Policy Science: Analysis or Ideology?*, 2 PHIL. PUB. AFF. 66, 96-96 (1972).

²¹¹ See, e.g., Regulatory Impact Analysis for the Proposed Standards of Performance for Greenhouse Gas Emissions for New Stationary Sources: Electric Utility Generating Units [hereinafter NSPS RIA] 5-23

both quantifiable and nonquantifiable impacts (something called risk characterization in the risk assessment literature).²¹² Usually, however, these documents highlight CBA's quantitative conclusions and bury mention of nonquantifiable impacts deep in the documents, sometimes scattered about in different subsections.²¹³ This makes it almost impossible for a busy policymaker to get a clear picture of the importance (or unimportance) of the benefits left out of the quantitative analysis.²¹⁴

Government agencies should design RIAs to counteract the tendency to give soft variables short shrift. They should emphasize what is important, not necessarily what is quantifiable. The executive summary should include a list of significant benefits listed in order of importance, relying on the judgment of agency scientists. This list should include an indication of which benefits were quantified and which were not.²¹⁵ That way, a reader can easily see whether the quantitative portion of the CBA captured the most important benefits or not. EPA guidance endorses a template that would likewise list benefits and indicate whether they were quantified or not.²¹⁶ My recommendation builds on this suggestion by endorsing ordering information by importance and commending this approach for all agencies, not just EPA.²¹⁷

(2012) (discussing the limitations of the IWG's calculation of the social cost of carbon); CAFE II RIA, *supra* note 16, at 7-12 (describing the social cost of carbon estimates as incomplete and noting that non-carbon dioxide greenhouse gas related benefits have not been quantified); Final Rulemaking to Establish Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles: Regulatory Impact Analysis [hereinafter Truck RIA], 8-77 – 8-79 (2011) (listing the monetized and non-monetized benefits of reductions in toxics and criteria pollutants); Final Rulemaking to Establish Light-Duty Vehicle Greenhouse Gas Emissions Standards and Corporate Average Fuel Economy Standards: Regulatory Impact Analysis [hereinafter CAFE I RIA], ES-2 n. 4 (2010) (noting that the monetized greenhouse gas reduction benefit in the executive summary's table excludes non-CO₂ benefits)

²¹² See, e.g., CAFE II RIA, *supra* note 16, at 6-1 – 6-26 (qualitatively describing the impacts of criteria pollution and toxics limited by the rule); Truck RIA, *supra* note 211, at 8-1 – 8-32 (same); CAFE I RIA, *supra* note 211, at 7-1 – 7-13, 7-89 – 7-90 (describing effects of air toxics and criteria pollutants and then providing a table listing non-monetized benefits).

²¹³ See, e.g., CAFE II RIA, *supra* note 16 at vi (presenting a table early in the executive summary showing quantified costs and benefits with no mention of nonquantified benefits); Truck RIA, *supra* note 211, at ES-1 – ES-2 (same); Truck RIA, *supra* note 211, at ES 1CAFE I RIA, *supra* note 211, at ES-2 (presenting a table early in the executive summary showing quantified costs and benefits with only a brief and very incomplete mention of omitted benefits in a footnote).

²¹⁴ See, e.g., CAFE II RIA, *supra* note 16, at 6-43 – 7-10 (describing some benefits of reduced climate disruption qualitatively, but then presenting the monetized benefits with no clear or comprehensive indication of what is left out of the monetization).

²¹⁵ Cf. Truck RIA, *supra* note 211, at 8-78 – 8-79 (providing a table distinguishing between quantified and non-quantified impacts, but containing no indication of their relative importance).

²¹⁶ See EPA Guidelines, *supra* note 32, at 11-4 (presenting a table that indicates whether a benefit has been quantified and whether it has been monetized).

²¹⁷ EPA's guidance does not say anything about how to order the benefits within broad categories and even suggests putting nonquantifiables last in one summary table, whilst I endorse an ordering by importance. See *id.* at 11-4, 11-7 (using categories of health, environmental, and other benefits). Furthermore, EPA says nothing about where this table appears, whilst I endorse putting this before any summation of costs and benefits, except where all of the significant costs and benefits have been monetized. Cf. *id.* at 11-3 (presenting these tables as simply “templates for presenting information” albeit with a goal of communicating “full richness of benefit and cost information instead of focusing narrowly on what can be put in dollar terms”).

This recommendation demands that agency scientists make some judgments that go beyond merely reporting data. Moreover, these judgments will often prove difficult, for they require subjective judgments about the relative importance of very different types of impacts. They also require assessment of the relative weight to be given one impact that can be quantified and another where data do not permit quantification. In some cases, these judgments will prove easy. For example, when EPA evaluated the benefits of regulating runoff from construction projects, its scientists had an abundance of qualitative data indicating that runoff was causing serious water quality problems.²¹⁸ Only the relatively trivial benefit of saved water storage and treatment costs and avoided dredging, however, produced sufficient quantitative data to justify a benefits number.²¹⁹ Even when it is hard, however, some sort of expert qualitative judgment must be made when important impacts resist quantification, lest policymakers assume, often quite wrongly, that only the quantifiable items are real and important. If policymakers make that assumption, they will unintentionally end up using scientific uncertainty about the magnitude of effects, even with respect to qualitatively well understood effects, to justify inaction.

Furthermore, where important impacts cannot be quantified, a team of communication experts and scientists should describe the most important ones in ways that will make their significance apparent to policymakers.²²⁰ And this description should precede any mention of numbers in the introduction and follow any mention of numbers in the conclusion, if the nonquantifiables are more important than the quantifiables. The general principle is that the document should emphasize the important, whether the important is quantifiable or not.

RIA reform, however, makes a process that is already too time consuming and expensive even more so, even though much of the information needed to inform this judgment already appears in the RIA or is well known to the agency.²²¹ But as long as CBA is retained, some sort of reform is required to avoid letting CBA remain anti-precautionary.

This improvement of RIAs to emphasize the bottom line only when the bottom line reflects the most important information, however, may not suffice.²²² If OIRA's career officials see only quantitative information as credible and lack sufficient humility to accept scientific judgments that industry will tend to contest, the tradition of giving nonquantifiable variables short shrift may continue. This may then require changes in

²¹⁸ See Driesen, *Neutral*, *supra* note 17, at 365 (explaining that construction runoff is one of the largest known sources of bacterial contamination).

²¹⁹ See *id.* at 374 (explaining that EPA could not monetize recreational, biodiversity and health benefits, but did monetize the benefit of "avoided dredging and water storage and treatment costs").

²²⁰ Cf. EPA Guidelines, *supra* note 32, at 7-49 (stating that CBA should explain why non-quantified effects may be important).

²²¹ See, e.g., CAFE I RIA, *supra* note 211, at 7-1- 7-13, 7-89 – 7-90 (providing a basic description of pollutant's effects in one place and a list of the non-monetized effects in another).

²²² See OMB, Circular A-4, 47 (2003) (recommending a form of CBA reporting that requires listing of nonquantifiables in a key table); EPA Guidelines, *supra* note 32, at 11-3 (recommending assessment of whether non-monetized costs and benefits "would materially alter the net benefit calculation"). The apparent failure of these reforms to induce OIRA to give nonquantifiables substantial weight when justified by the science suggests that the further reforms I have proposed may not suffice.

OIRA's management and personnel to become effective, or OIRA's abolition.²²³ The President, by the way, could abolish OIRA without doing away with CBA. Currently individual agencies, not OIRA, prepare RIAs.²²⁴ OIRA reviews them. If OIRA's review continues to exhibit bias against nonquantifiable variables, and OIRA reform proves impossible, then its abolition would be important to making precautionary CBA real. Abolition would also free up resources and reduce the time and expense involved in government standard setting.

I do not claim that I have proven through this argument that precautionary CBA is possible. It may be that the tendency of quantitative analysis to crowd out realistic weighing of crucial qualitative information would survive all of the reforms suggested here.

One reason to suspect this might be the case has to do with the difficulty of giving qualitative information any particular weight in an optimality framework. It is not clear how one can reach conclusions about whether a qualitatively important environmental benefit outweighs a specific quantified cost. The principle U.S. environmental statutes, however, do not authorize optimal regulation anyway.²²⁵ At times, they require protection of health, thereby making the consideration of CBA illegal.²²⁶ More often, they authorize maximizing feasible reductions.²²⁷ In the feasibility context, the Supreme Court has sometimes considered CBA potentially relevant and sometimes not.²²⁸ Even where the Court has found CBA potentially relevant, it has only approved it as a

²²³ Cass R. Sunstein, *Constitutionalism After the New Deal*, 101 HARV. L. REV. 421, 458-59 (1987) (suggesting that concerns about antiregulatory bias at OMB could justify removing the regulatory review function from that institution); Lisa Schultz Bressman & Michael P. Vandenbergh, *Inside the Administrative State: A Critical Look at the Practice of Presidential Control*, 105 MICH. L. REV. 47, 74-75 (2006) (discussing the antiregulatory bias of OIRA's permanent staff).

²²⁴ EPA Guidelines, *supra* note 32, at 1-1 (noting that executive order 12866 "directs federal agencies" to prepare CBA).

²²⁵ The courts, however, have suggested that a true cost-benefit test governs the Toxics Substances Control Act (TSCA) and the Federal Insecticide Fungicide and Rodenticide Act (FIFRA). *See* Corrosion Proof Fittings v. EPA, 947 F.2d 1201, 1217 (5th Cir. 1991) (requiring consideration of each regulatory option's costs and benefits); *Environmental Defense Fund v. EPA*, 548 F.2d 998, 1012-18 (D.C. Cir. 1976) (holding that the proponent of pesticide registration must show that the pesticide's benefits outweigh the risks). By doing so they have thoroughly paralyzed these statutes' implementation. *See* Thomas O. McGarity, *supra* note 161, at 2343 (noting that CBA has "thoroughly stymied government action" under TSCA and FIFRA); *see, e.g.,* Jason Scott Johnston, *A Game Theoretic Analysis of Alternative Institutions for Regulatory Cost-Benefit Analysis*, 150 U. PENN. L. REV. 1343, 1392 (2002) (noting that EPA had only reregistered 2 of 19,000 older pesticides by 1992); Donald T. Hornstein, *Lessons from Federal Pesticide Regulation on the Paradigms and Politics of Environmental Reform*, 10 YALE J. ON REG. 369, 436-37 n. 395 (1993).

²²⁶ *See, e.g.,* *Whitman v. American Trucking Ass'ns*, 531 U.S. 457, 465 (2001) (finding that the Clean Air Act precludes the consideration of cost in setting health protective National Ambient Air Quality Standards).

²²⁷ *See* Driesen, *supra* note 98, at 20-25 (providing numerous examples of feasibility-based statutory provisions).

²²⁸ *Compare* *American Textile Mfrs. v. Donovan*, 452 U.S. 490, 509 (1981) (interpreting the Occupational Safety and Health Act to require feasibility analysis and preclude CBA) *with* *Entergy Corp. v. Riverkeeper*, 556 U.S. 208, 219, 226 (2009) (interpreting the best technology available mandate in the Clean Water Act as not demanding maximum feasible reductions and permitting limited use of CBA).

somewhat marginal influence.²²⁹ Hence, the only legal role of CBA in many contexts involves motivating OIRA to advocate use of discretion to tilt results marginally in one direction or another based on cost-benefit considerations.²³⁰ One can imagine an ideal OIRA head asking EPA to temper regulatory action based on a CBA quantifying the most important variables and asking EPA to use its discretion to tighten regulations when an important nonquantifiable impact seems to indicate that vigorous action might be needed in spite of costs outweighing quantified, but qualitatively trivial, benefits.

Hence, precautionary CBA can only exist if government officials give weight to soft but important variables. Happily, its proponents favor this approach in principle; it remains to see whether government officials can put it into practice.

C. Toward Precautionary Risk Assessment

The previous analysis also suggests a precautionary approach to estimation of risk where sufficient data exist to ground some sort of quantitative estimate. Working out an approach to this issue and defending it thoroughly would require another Article. But this section will sketch some elements of possible precautionary approaches to risk assessment and provide at least some normative justification for them.

The most obvious way to comply with the precautionary principle involves employing a worst case as the basis for the risk assessment underlying CBA.²³¹ Advocates of this approach typically do not demand the worst case imaginable, but rather a scientifically plausible worst case. One might think of this as approximating a case at the 95th percentile in a probability distribution.

Regulations under the National Environmental Policy Act (NEPA), a statute sometimes treated as a source of demand for CBA, used to require a worst-case analysis.²³² The Council on Environmental Quality, however, changed its regulations out of concern about spending an inordinate amount of resources on an unlikely case.²³³ Policy professionals inclined to knee-jerk moderation frequently make the error of assuming that a worst case must always be unlikely. But this is not necessarily the case. Richard Posner recognized this when he rejected some economists' notion that catastrophic climate disruption is unlikely, since he noticed that the scientific literature treated catastrophic climate disruption as a quite plausible case with unknown

²²⁹ See *Riverkeeper*, 556 U.S. at 223-24 (approving CBA's use to avoid extreme disparities between costs and benefits, but leaving open the question of whether comparing total costs to total benefits more broadly is permissible).

²³⁰ See generally EPA Guidelines, *supra* note 32, at 1-2 (characterizing CBA as "but one component" of a decisionmaking process that also involves concerns about enforceability, technical feasibility, affordability, politics, and ethics).

²³¹ See Adam M. Finkel, *Who's Exaggerating*, 17 DISCOVER 48, 49 (1996) (pointing out that risk assessors traditionally focus on a reasonable worst case); PERSPECTIVES ON THE PRECAUTIONARY PRINCIPLE 41-42 (Ronnie Harding & Elizabeth Fisher eds. 1999) (arguing that the precautionary principle endorses or requires worst-case analysis).

²³² See generally Edward A. Fitzgerald, *The Rise and Fall of Worst-Case Analysis*, 18 U. DAYTON L. REV. 1, 9-10 (1992).

²³³ See *id.* at 2, 43.

probabilities.²³⁴ In any case, limiting worst case analysis to scientifically plausible worst cases addresses this concern about wasting resources studying very unlikely scenarios.²³⁵

This approach, however, will trouble believers in optimal regulation, for there usually is no particular reason to think that the worst case is more likely than other less drastic possibilities. And an optimization framework suggests trying to focus on the most plausible outcomes, not the worst ones. But optimizers face an enormous difficulty, as part two showed, when probabilities are not known, *i.e.* in the normal case. In such a case, Bayesian probabilities and Monte Carlo notwithstanding, there is no strong scientific basis for declaring any particular plausible case more likely than another.²³⁶ Accordingly, worst-case analysis becomes a reasonable option even within an optimizing framework.²³⁷ Furthermore, risks are not evenly distributed, so one might prefer a 95th percentile type case on distributional grounds to protect the most vulnerable in a reasonable way.

This approach also has an advantage in terms of analytical symmetry, at least in most cases. Economic analysis of regulatory costs often uses something resembling worst-case analysis. Usually, regulators base their analysis of regulatory costs on current market prices of known technological changes that will reduce relevant pollution. But in practice, regulation tends to lower compliance costs.²³⁸ Sometimes those subject to regulation innovate to escape high costs and they almost always employ competitive bidding to reduce equipment costs. The net result is that post-compliance studies, which unfortunately are in short supply, frequently show unexpected cost declines. It follows that cost estimates based on current market prices often constitute a worst plausible case

²³⁴ POSNER, *supra* note 1, at 52-53.

²³⁵ See, e.g., Cass R. Sunstein, *Probability Neglect: Emotions, Worst Case Analysis, and Law*, 112 YALE L. J. 61, 98 (2002) (linking worst case analysis to excessive alarm over highly improbable scenarios); Alan K. Simpson, "Worst Case" Analysis: A Study in Reckless, Wasteful Conjecture, 25 LAND & WATER L. REV. 99, 100 (1990) (complaining about worst case analysis focused on "scenarios that were unlikely to exist in the real world"); Allan D. Brock, *Abolishing the Worst Case Analysis*, 2 NAT. RESOURCES & ENV'T 22, 67 (1986) (objecting to worst case analysis as focused on "the worst possible consequences that can be imagined"); Melissa P. Corrado, Note, *The National Environmental Policy Act and the Revised CEQ Regulations: A Fate Worse than the "Worst Case Analysis?"*, 60 ST. JOHN'S L. REV. 500, 506 (1985) (complaining about "unlimited and . . . exaggerated speculation")

²³⁶ See Ackerman *et al.*, *supra* note 171, at 2720 (pointing out that we cannot learn enough to know how likely the worst-case possibilities are for climate disruption); see generally Weitzman, *supra* note 178, at 2 (claiming that even standard approaches to modeling climate change that employ Monte Carlo analysis probably do not adequately account for "fat-tailed" risk).

²³⁷ See CASS R. SUNSTEIN, WORST CASE SCENARIOS 119 (2007) (suggesting that in cases of true uncertainty regulators should act to avoid potential catastrophes, even when the probabilities of a catastrophe occurring are unknown); Sunstein, *supra* note 235, at 98 (suggesting that worst case analysis makes sense under conditions of uncertainty rather than risk); David Dana, *The Contextual Rationality of the Precautionary Principle*, 35 QUEEN'S L. J. 67, 75 (2009) (pointing out that people tend to be risk adverse in the sense of eager to avoid serious losses).

²³⁸ See Margaret R. Taylor, *Innovation Under Cap and Trade*, PNAS 3 (2013) (finding that regulators overestimated the costs of sulfur dioxide and nitrogen oxide regulations authorizing trading programs); Larry Dale *et al.*, *Retrospective Analysis of Appliance Price Trends*, 37 ENERGY POL'Y 597, 598-99 (2009) (finding that energy regulators forecast price increases from regulations improving energy efficiency, but that actual market data shows price declines); Winston Harrington, Richard D. Morgenstern, & Peter Nelson, *On the Accuracy of Regulatory Cost Estimates*, 19 J. POL'Y ANALYSIS & MGMT. 297, 306 (2000) (finding a consistent tendency to overestimate regulatory costs).

analysis for cost.²³⁹ This symmetry argument, however, does not apply when economists, as they sometimes do, use rate-of-progress ratios (estimates of past cost declines for a technology) to predict future cost saving innovation.²⁴⁰

The argument for worst-case analysis becomes especially strong when environmental effects prove irreversible, as in the climate disruption case.²⁴¹ Most greenhouse gases remain in the atmosphere for centuries. If we invest in greenhouse gas abatement based on a damage assessment that proves too low, we cannot correct the mistake. The temperatures will continue to rise based on past accumulations of greenhouse gases and any additions made even if we suddenly, decades hence, decide that we were wrong and therefore institute drastic abatement. By contrast, we can make up for overinvestment in abatement through economic growth and innovation if the threat proves less serious than imagined. This justifies some risk of overinvestment in abatement.

At the same time, worst-case analysis should apply to the environmental effects of technologies used to address environmental insults, not just the targeted insults. For example, if regulators are taking an action that addresses climate disruption by licensing nuclear power plants, they should look at scientifically plausible nuclear accidents and consider this possibility in their plans. This addresses the concern that Sunstein and others have expressed about the potential myopia of focusing on a targeted risk without considering risks associated with ameliorating the targeted risk.²⁴²

Even if regulators do not wish to base their decisions on the worst case, analysts should include one in their CBA.²⁴³ The National Academy of Sciences has long advocated the presentation of a *range* of regulatory benefits.²⁴⁴ It considers point estimates irresponsible scientifically, because the relevant science does not generally permit precise estimates of environmental consequences' magnitude. Accordingly, scientifically informative presentation of costs and benefits will present a range of benefits estimates that correspond to the full range of scientifically reasonable cases.

This approach also serves the goals of legal scholars advocating CBA. Few of these scholars accept preference-based optimization as the sole determinant of

²³⁹ Cf. Daniel A. Farber, *Probabilities Behaving Badly: Complexity Theory and Environmental Uncertainty*, 37 U.C. Davis L. Rev. 145, 171 (2003) (noting that uncertainty may not be symmetrical, as we may know more about the future price of reducing fossil fuel use than we do about the magnitude of future climate disruption).

²⁴⁰ See Bernardo Barreto & Socrates Kypreos, *Emissions Trading and Technology Deployment in an Energy-Systems "Bottom-up" Model with Technology Learning*, 158 EUR. J. OPERATIONAL RES. 243, 246-48 (2004) (estimating an 86% progress ratio for solar photovoltaics, representing the rate of cost decline per doubling of production).

²⁴¹ Cf. SUNSTEIN, *supra* note 237, at 181-82 (suggesting that irreversibility may justify special steps).

²⁴² See ID. at 151 (pointing out that efforts to avoid catastrophes can themselves have catastrophic consequences); see generally Cross, *supra* note 5, at 859-60 (pointing out that precautionary measures can create adverse health consequences).

²⁴³ Cf. SUNSTEIN, *supra* note 235, at 139 (suggesting consideration of a worst case's potential to create large secondary social, cultural, and economics losses)

²⁴⁴ Accord Richard Pildes & Cass Sunstein, *Reinventing the Regulatory State*, 62 U. CHI. L. REV. 1, 48 (1995) (suggesting that estimates of benefit ranges are appropriate to account for scientific uncertainty).

environmental standards.²⁴⁵ But they all agree that CBA should inform regulators, thereby, they claim, increasing transparency and rationality. But CBA that fails to at least inform regulators about very serious scientifically plausible consequences misinforms regulators by obscuring potentially important information.²⁴⁶

This principle of fully informing regulators also raises some concerns about CBA's approach to uncertainty. Academic CBA based on or including a worst case would reduce the dollar value of the worst case by an estimate of the probability of its occurrence, even when the probability is truly unknown. That may indeed be an appropriate procedure for an academic optimization exercise. But it poses some questions from the standpoint of precaution and with CBA advocates' professed goal of fully informing regulators.²⁴⁷

The claim that the precautionary principle rules out rejection of measures based upon scientific uncertainty leads to the following question: Does the practice of multiplying risks by the probability of their occurrence itself violate the precautionary principle? Suppose, for example, that an economist estimates that a 100 ton reduction of a pollutant would cost \$1 million, but might generate \$1.5 million of benefit. The economist estimates the likelihood of this benefit occurring as 50%. The standard economics would suggest that the benefit estimate be reduced to \$750,000 (\$1.5 million X .5).²⁴⁸ Doing so would lead to rejection of the measure on the ground that the \$1 million cost exceeds the \$750,000 benefit. It would seem that this standard approach to risk uses scientific uncertainty as a reason to forego a protective measure. For absent some consideration of uncertainty, the economist would conclude that the measure costing \$1 million would yield \$1.5 million worth of benefits and would recommend its adoption. Surely, scientific uncertainty here performs the function of justifying rejection of the measure.

One could resist this conclusion by drawing upon economics' distinction between risk and uncertainty.²⁴⁹ In economic terms, if the probabilities are known, as in the above hypothetical, this is not a case of true uncertainty. Rather it is a case of risk. Therefore, a treatment of the "scientific uncertainty" as a term of economic art would support the

²⁴⁵ See, e.g., Adler & Posner, *supra* note 33, at 196 (distinguishing their defense of CBA as advancing "overall well-being from an account based on preferences).

²⁴⁶ This position about fully informing regulators does not depend on a particular position about how regulators should respond to the information. In this respect, even though this Article relies heavily on Cass Sunstein in justifying CBA based on a worst case, this Article does not address many of his ultimate positions about what regulators should do in response to worst case analysis.

²⁴⁷ See generally, Cass R. Sunstein, *Incommensurability and Valuation in the Law*, 92 MICH. L. REV. 779, 841-42 (1994) (arguing that reducing all consequences to a dollar value without giving a good sense of the qualitative consequences underlying the numbers renders analysis obtuse and makes effects people care about invisible).

²⁴⁸ For the sake of simplicity I ignore the declining marginal utility of money, which would change the shape of the utility function.

²⁴⁹ Cf. FISHER, *supra* note 115, at 148-151 (discussing Australian cases interpreting the precautionary principle as requiring evaluation of the "risk-weighted consequences" of a proposed action).

conclusion that reducing benefits estimates on the basis of probabilities does not violate the precautionary principle.²⁵⁰

This term of art argument, however, would not justify benefit reduction in cases of true uncertainty. That is, when we really do not know the probabilities of a particular predicted harm coming to fruition, multiplying benefits estimates by some economists' guesses about the probabilities, whether arrived at through Monte Carlo analysis or Bayesian probabilities, would seem to violate precaution. In other words, the precautionary principle seems to rule out multiplying harms by the likelihood of negative outcomes in the normal case, that of true uncertainty, because doing so uses scientific uncertainty as a justification for rejecting measures.

Transparency concerns would suggest that CBA should at least include an unreduced worst case, even if economists want to include a diminished one as well. Regulators should know what a worst case would look like. Hiding that information from them, especially when the probability of its occurrence remains unknown, conflicts with the goal of transparently informing policymakers.

D. *Discounting*

I cannot in this space offer a thorough defense of any particular approach to discounting and doing so would implicate considerations going beyond precaution itself, such as inter-generational equity. But a brief mention of the some of the potential implications of the forgoing analysis for discounting does seem in order.

To minimize tension with the precautionary principle's timing goals policymakers might well choose to eschew discounting of future benefits or discount at a low rate. CBA employing discount rates for government consumption should, at a minimum show an undiscounted case and a low discount rate case, explaining the ethical questions involved in this. In addition, precaution requires discounting that does not assume continued economic growth.²⁵¹ That will lead to a reduction or elimination of positive discounting in analyses using the Ramsey equation. So, the precautionary principle requires at least the adjustment of the Ramsey equation and its spirit commends a more general reduction of discount rates.

E. *A Cultural Caveat*

This article's conclusion that the core ideas of CBA and precaution do not necessarily conflict and that therefore one can imagine precautionary CBA barely addresses cultural norms among communities supporting one or the other approach that may make adoption of these measures difficult. It may well be that supporters of precaution often start with the assumption that we have a right to a clean environment, which should be compromised, if at all, only upon a strong showing of serious economic

²⁵⁰ One might question the idea that the governments agreeing to the precautionary principle used the word "uncertainty" as a term of economic art. See Nash, *supra* note 61, at 194 (stating that the precautionary principle calls for a "cautionary approach" to both "risk and uncertainty").

²⁵¹ See Gollier, *supra* note 195, at 173, 185 (suggesting that uncertainty about economic growth rates casts doubt on large discount rates dependent upon assumptions of economic growth).

harm and perhaps not then. Conversely, many CBA supporters may start from a presumption of an entitlement to economic development through a free market, and require a strong showing to justify government “intervention.”²⁵² More subtle differences in cultural norms almost surely influence the methodologies these communities endorse to arrive at sound decisions. For example, CBA advocates tend to think in terms of a flat metric of overall welfare, whereas advocates of precaution see important qualitative differences between different effects.²⁵³

For that reason, this Article’s precautionary CBA recommendations necessarily serve as a starting point for debate, rather than as an endpoint. Cultural differences suggest the need for a more thorough understanding of the normative positions underlying the clashes between CBA and precautionary principle advocates. Hopefully, this Article will move the debate over appropriate environmental policy to a deeper level.

V. CONCLUSION

Precaution, understood narrowly as the principle that scientific uncertainty should not be used to avoid taking measures to address serious environmental problems, does not necessarily conflict with the basic idea of CBA—the idea that policy makers should take costs into account in deciding how vigorously to act in avoiding looming harms. Current CBA practice, however, often conflicts with precaution. So, precautionary CBA is imaginable.

By making use of worst-case analysis, paying close attention to nonquantifiable regulatory benefits, and avoiding deep discounting analysts can, in principle, harmonize CBA with non-radical precaution. I intend my specific recommendations along these lines as a starting point for discussion, not necessarily as the last definitive word on the subject that this Article has introduced—how to reconcile precaution and CBA.

²⁵² I am grateful to John Applegate for suggesting that I make these points explicit.

²⁵³ See, e.g., Rebecca M. Bratspies, *Regulatory Trust*, 51 ARIZ. L. REV. 575, 617 (2009) (criticizing CBA for treating all harms and benefits as “fungible”). Cf. Adam Finkel, *Protecting People in Spite of-or Thanks to-the Veil of Ignorance*, in GENOMICS AND ENVIRONMENTAL REGULATION: SCIENCE, ETHICS, AND LAW 290, 327 (Richard R. Sharp, Gary E. Marchant, & Jamie A. Grodsky, eds., 2008) (suggesting that we should protect people who face above average risks from environmental hazards).

