Policy Study No. 252

CLIMATE CHANGE

BY KENNETH GREEN, D.ENV., RICHARD MCCANN, STEVE MOSS, AND ROY CORDATO

Executive Summary

In November 1998, President Clinton signed the Kyoto Protocol, moving the United States one step closer to implementing a sweeping set of new measures to combat what is posited by some to be the looming environmental threat of our time: manmade climate change. While debate ranges over the impacts that the Kyoto Protocol on Climate Change might have, the sheer magnitude of potential implementation impacts, both intended and unintended, suggests that careful scrutiny should precede actions to reduce the risk of climate change. In signing the Kyoto Protocol, the President did more than signal a concern over manmade climate change: he put the United States on a course toward a specific set of strategies and tactics that proponents claim will head the risk of climate change off at the pass.

But there are many reasons to question the wisdom of the Kyoto Protocol's approach to climate change policy, including questions about the scientific grounding of the protocol; questions about the feasibility of the proposed implementation mechanisms; questions about the efficacy of those measures; questions about the adverse consequences of diverting resources to address highly uncertain risks using tools with uncertain impacts; and questions about the impacts of proposed climate interventions on people's standard of living and freedom of choice. This study examines these questions in three chapters.

In the face of claims that the Kyoto Protocol will make present and future generations safer and provide a healthier environment, Chapter 1 explores what should be the bottom-line question: Is the Kyoto Protocol likely to provide a real, net improvement in the environmental safety of present or future generations? Chapter 1 examines the scientific uncertainties in our understanding of climate change. These uncertainties also limit the effectiveness of measures aimed at forestalling such change. After reviewing the meager promise of the Kyoto Protocol to reduce greenhouse gas concentrations, stacking it up alongside the protocol's impacts upon people's health as it is tied to the economy, and examining the opportunity costs of premature or inappropriate resource allocation, Chapter 1 builds a balanced risk ledger which demonstrates that the near-term benefits of the Kyoto Protocol are scant while the long-term benefits are highly uncertain. Such benefits pale when compared to high near-term negative impacts and opportunity costs. At the bottom line, this risk ledger includes both pros and cons of protocol implementation, suggesting the protocol is likely to do far more harm than good.

Chapter 2 explores the most commonly discussed mechanism for implementing the Kyoto Protocol, namely emissions trading. The administration, and numerous proponents of the Kyoto Protocol's approach to climate change policy, portray emission trading as a no-pain implementation mechanism that will let us have our cake and eat it too. But other analysts, notably those most experienced with the development and evaluation of emission-trading programs, point out that emission trading is not the panacea it is made out to be. Chapter 2 explores the factors which make emission trading less likely to work for greenhouse gases than for traditional air and water pollution problems. These factors include: 1) confusion over the “stock” and “flow” effects of air pollutants; 2) uncertainties about the influence of individual greenhouse gases; 3) uncertainty about forecasts; 4) uncertainty about outcomes; 5) problems with establishing and enforcing property rights; 6) and problems of high transaction costs. Emission trading, as an approach to climate change, is plagued with difficulties that cast serious doubt on its reputation as a no-pain approach to climate change.

Chapter 3 explores the ramifications of imposing carbon taxes, the most likely alternative to emission trading, an alternative looking more and more likely as developing countries stymie attempts to even study implementation of emission-trading regimes. The main claim of those promoting carbon taxes as an approach to forestalling climate change is that the known adverse economic impacts of a present-day tax will be offset by far-future benefits. But such claims do not stand up to scrutiny, and Chapter 3 demonstrates that uncertainties about the impacts of climate change; uncertainties about future climate benefits; uncertainties about a more economically fragile society to deal with other pressing risks; and the risks of allowing for a return to centrally planned energy policy all undermine the claims that carbon taxes are either an equitable, effective, or efficient way to forestall the risks of climate change.

Chapter 1

Evaluating Climate Change Policy

BY KENNETH GREEN, D.ENV.

I. The Challenge

In November 1998, President Clinton signed the Kyoto Protocol, moving the United States one step closer to implementing a sweeping set of new measures to combat what is posited by some to be the looming environmental threat of our time: manmade climate change. While debate ranges over the impacts that the Kyoto Protocol on Climate Change might have, the sheer magnitude of potential implementation impacts, both intended and unintended, suggests that careful scrutiny should precede actions to reduce the risk of climate change.

Like most of the actions we take to improve our safety, actions intended to reduce environmental health risks are rarely pure in their effects. We know that choices have consequences, and it is a true Pollyanna who thinks that any significant action, risk-reducing or otherwise, can have purely positive consequences. While some safety improvement may be wrought through the impact of a given risk-reduction measure, we know that, in many cases, the unintended consequences of the measure can produce countervailing impacts which erase some or all of the perceived benefit.

A recent example of such countervailing impacts gained visibility in the debate over automobile air bag requirements.[1] Studies have confirmed that rather than being "pure" in its risk-reducing impacts, the airbag requirement created new risks for a significant part of the population (smaller women) and posed a particular threat to children, the physically fragile, and the elderly. The additional risk posed by airbags may not eradicate all of the safety gains stemming from their use, but logic dictates that this increased risk be taken off the bottom line of claims about increased safety stemming from airbag use to create, in effect, a "net-benefit" assessment of increased safety.

We also know that our available risk-reduction actions are not unlimited, but are constrained by the resources available to us as individuals and societies over a given span of time. We might like to pursue all risk-reduction measures at all possible speed at all times, but we know that such an approach is simply not

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1 National Motor Vehicle Safety Act, 15 USC 1381 *et seq;* Federal Motor Vehicle Safety Standard 208 as amended, 58 FR. 46551 (September 2, 1993). Standard 208 was recently revised in order to address this concern, allowing for the installation of an airbag deactivation switch.

possible in a constrained world. Constraints require that we make choices regarding where to invest our risk-reduction resources.

Some individuals may prefer simply to make choices based on sentiment rather than a careful weighing of risk information. However, decisions made in the public-sector regarding mitigation of commonly faced indivisible risks, of which climate change policy is but a specific example, require an easily understood framework for choosing a strategy, whether that strategy is intended to head off a specific risk in a specific way, or is intended to help society and its members prepare for suspected, but poorly defined risks looming in the distance. We must evaluate available policy options using a net-benefit framework for portraying both the nature of environmentally conveyed health risks and the consequences of proposed actions.

This chapter will explore, first, what basis we might use for selecting a basic strategy with regard to climate change, and second, how we might assess available policy options within a given strategy.

II. Picking a Basic Strategy

We have many available risk-reduction interventions that move us toward a bottom line goal of decreased risk to ourselves and our children as conveyed through the environment, whether climate-related or not. These available interventions vary widely in terms of degree of intervention, public and private-sector roles, and amount of information needed for successful implementation.

At the most generic level of classification, the options range from the resilient to the anticipatory. Resilient strategies are largely decentralized and non-regulatory, maximizing society's ability to cope with risks through research, and through the naturally risk-reducing function of a dynamic, market-based, knowledge-building social structure. Anticipatory strategies are those designed to prevent a risk from occurring. Generally, anticipatory strategies are implemented through regulations which require certain actions and prohibit or restrict others.[2]

But how do we decide, for any given risk, whether an anticipatory approach is more likely to provide us with a good return for our safety investment than a resilient approach? A framework developed by risk-policy analyst Aaron Wildavsky provided a useful strategy selector based on levels of knowledge and predictability of change (for example, predictability of future harms):

Figure 1: Appropriate Strategies for Different Conditions

		Amount of Knowledge About What to Do	
		Small	**Large**
Predictability of Future Change	**High**	More resilience, less anticipation	Anticipation
	Low	Resilience	More resilience, less anticipation

Source: Adapted from Aaron Wildavsky's *Searching For Safety*, Transaction Press, 1991.

2 Aaron Wildavsky, *Searching for Safety* (New Brunswick: Transaction Publishers, 1991).

Wildavsky observed that it is not our knowledge but our *uncertainties* which most strongly constrain the probability of success with a given strategy.

A. Why Resilience is the Default Strategy

Resilient strategies are often wrongly characterized as “do nothing” by environmental agencies or advocacy groups with a “regulation first” orientation. However, there is a difference between “do nothing” and adopting a resilient strategy.

First, “do nothing” is mostly a canard. Research regarding risks will not cease. People will not stop tracking climate change, because people are now, and always have been concerned with the dangers of changing climate, and with developing tools to help them anticipate that change.

Second, resilient strategies are responsive, constantly addressing specific problems as knowledge about those problems develops. Third, resilient strategies are dynamic: they emphasize building knowledge and resources so people are better able to cope with real problems as they materialize. Numerous studies show that there is an unmistakable linkage between a society’s prosperity and its safety, and its environmental cleanliness.[3] People instinctively seek to reduce risks as they perceive them using their own local knowledge of their own particular situation.

Fourth, resilient strategies often include very specific deregulatory strategies that remove obstacles to the natural resilient process of a market-based society. Regulations put in place which favor or disfavor various fuels or technologies can stand in the way of actions that would decrease the risk of climate change by harnessing the natural processes of decarbonization and dematerialization that are hallmarks of competitive market economics.[4] Such strategies often fall into that category called “no regrets strategies.”

Resilient approaches that maintain a market-based, knowledge-building, and dynamic investment strategy enhance our ability to respond over time to risks and to reduce risks. Reducing people’s ability to procure safety through resilient strategies poses a risk liability in itself. Therefore, departure from that default should require a demonstration, based on an assessment of evidence, that a proposed intervention reliably outperforms the default path of resilience sufficient to warrant overriding people’s individual choices.

B. Running Climate Change Through The Strategy Selector

At the heart of climate change theory is a relatively simple relationship between gases in an atmosphere and temperature of a closed system. That relationship is called the greenhouse effect. Scaling that relationship up to the globe as a whole gives us the theory of global warming. Trying to figure out what’s going to happen with global climate based on one particular cause or change (such as manmade gas emissions) is what is

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[3] Ralph L. Keeney, “Estimating Fatalities Induced by the Economic Costs of Regulations,” *Journal of Risk and Uncertainty*, Vol. 14, pp. 5–23, 1997; Ralph L. Keeney and Kenneth Green, *Estimating Fatalities Induced by the Economic Impacts of EPA’s Proposed Ozone and Particulate Standards*, Policy Study No. 225, Reason Public Policy Institute, June 1997; Aaron Wildavsky, “Richer is Safer,” *The Public Interest*, Vol. 60, pp. 23–29, 1980; William Kip Viscusi, “Mortality Effects of Regulatory Costs and Policy Evaluation Criteria,” *Rand Journal of Economics*, Vol 25, pp. 94–109, 1994.

[4] Jesse H. Ausubel, “The Liberation of the Environment,” *Daedalus* Issue 125(3), pp. 1–17, Summer 1996. Also available at URL: http://phe.rockefeller.edu/Daedalus/Liberation/

generally meant by "climate change" when used in a public policy context. Climate change policy refers to proposed actions to prevent or mitigate harms from manmade climate change.

To understand the differences in certainty and predictive ability at each step toward greater complexity, consider this analogy: If you have a small vacuum chamber, and you drop ten different colored feathers, they fall straight down and land at the same time. Predicting the path, and intercepting say, the red feather is a simple task. That's like the greenhouse effect, a simple cause / effect relationship.

But if you drop the same ten feathers out of an airplane, they don't fall straight down, and they don't land at the same time. Some of them, in fact, won't land at all, because they'll stay aloft for so long that they'll get brittle and disintegrate or be sucked into jet engines and destroyed. Still, one can assume that some of them do land eventually, since gravity is still a force in play. Global warming and the various potential causal factors, like greenhouse gases, embody a similarly complex set of interactions among many variables over time.

Consider another example. If you released ten different colored birds into the wild with all the other birds in the world, then tried to figure out where each of your birds would lose its feathers; where and when a specific feather would land; what damage the feather might cause; and how you might avoid that damage by preventing the growth of the food that fed the bird that produced the feather, you'd be in a similar realm of complexity to climate change theory.

Between our incomplete understanding of the climate system and the difficulty of scaling up what we do know to the level of global climate effects, including effects involving oceans, ecosystems, mountains, rivers, groundwater, solar variation, greenhouse gas emissions, clouds, aerosols, water vapor, and historical variation, then trying to scale the impacts back down to the local and regional level, we are left with a view best characterized as "through a glass, darkly."

This is not an extreme or "skeptical" view: one need not look beyond the landmark 1995 reports of the Intergovernmental Panel on Climate Change (IPCC) themselves (the often-thumped but rarely read bible of climate change) for expressions of that uncertainty. Even a cursory review of the accepted uncertainties surrounding climate change show that we are clearly in a state of limited knowledge, not only about what to do, but about the nature of the risk itself:[5]

> *Impacts are difficult to quantify, and existing studies are limited in scope. While our knowledge has increased significantly during the last decade and qualitative estimates can be developed, quantitative projections of the impacts of climate change on any particular system at any particular location are difficult because regional scale climate change projections are uncertain; our current understanding of many critical processes is limited; and systems are subject to multiple climatic and non-climatic stresses, the interaction of which are not always linear or additive. Most impact studies have assessed how systems would respond to climate changes resulting from an arbitrary doubling of equivalent atmospheric carbon dioxide concentrations. Furthermore, very few studies have considered greenhouse gas concentrations; fewer still have examined the consequences of increases beyond a doubling of equivalent atmospheric carbon dioxide concentrations, or assessed the implications of multiple stress factors.*
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> *— p. 346 of the 1995 IPCC Impacts volume*

[5] Intergovernmental Panel on Climate Change (IPCC), *Climate Change 1995, The Science of Climate Change* (Cambridge, MA: Cambridge University Press, 1996), pp. 44, 439.

> *Tides, waves, and storm surges could be affected by regional climate changes, but future projections are, at present, highly uncertain*
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> *—p. 41 of the 1995 IPCC Science volume*

> *The global climate models used for future projections are run at fairly coarse resolution and do not adequately depict many geographic features (such as coastlines, lakes and mountains), surface vegetation, and the interactions between the atmosphere with the surface which becomes more important on regional scales.*
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> *— p. 44 of the 1995 IPCC Science volume*

Uncertainties about potential impacts that we wish to see averted and uncertainties as to whether any given action will have a reasonable probability of succeeding indicate appropriateness of a resilient strategy rather than an anticipatory strategy. Such resilient strategies might include additional research to reduce uncertainties in the predictive elements of climate change study; regional and local responses to regional or local manifestations of climate change (regardless of cause); "no regrets" energy policies; deregulation to remove barriers which inhibit better environmental performance; and so on.

III. Evaluating Proposed Anticipatory Measures

Though a resilient strategy might be sensible, currently proposed policies are largely anticipatory, including those emerging from the Kyoto Protocol.

Environmental advocacy groups, international commissions, and various state and federal agencies generally favor an anticipatory strategy to dealing with climate change policy. Proposals focus on heading possible problems off at the pass through what might be called a "fast-drive / fixed-target" approach. These proposals advocate the selection of a series of fixed targets for greenhouse gas reductions and then a rapid drive toward those targets through aggressive use of industrial policy, taxation, marketable permit trading, regulations, or a combination of these approaches. The Clinton administration's signature of the Kyoto Protocol, in November 1998, whether implemented through ratification or by executive action, has placed the United States on an anticipatory pathway. The various tactics mentioned by the administration and supporters of the Kyoto Protocol give us a set of plans to evaluate as public policy options. How do we evaluate the proposed anticipatory approaches to determine their likely impacts? How do we assess the likelihood that these approaches will achieve in practice what they are postulated to achieve in theory?

Unlike selecting a basic strategy, which depends largely on one's state of knowledge about a potential risk, evaluating specific tactics within a given strategy is more complex. However, some guiding principles should control the overall evaluation process:

1) There must be a valid framework of risk / benefit evaluation that is: scientifically rigorous, properly holistic, includes risk trading and shifting; and

2) There must be a valid framework for evaluating alternative interventions in terms of: 1) their likelihood of providing real, quantifiable, net risk-reduction benefits; 2) the information constraints that shape implementation of any anticipatory measure; and 3) the behavioral complexities that may result in a gap between the ideal and the actual.

To a very large extent, various environmental agencies and advocacy groups advance these principles as necessities in assessing not only environmental risks, but the efficacy of proposed compliance measures for dealing with various environmental policies.

A. Evaluating the Anticipatory Kyoto Approach

While portrayed as a “step in the right direction” by many environmental agencies and advocacy groups, scientists involved in climate change research have characterized the impacts of the actual accord reached in Kyoto as negligible in terms of near-term risk-reduction benefit. Yet, this 15-year step will span nearly a third of many people’s 47-year working lifetime. Given that longer-term benefits from future steps are highly speculative, while present-day impacts are more concrete, we should view the pros and cons of this first step on its own merits. Various analysts, agency researchers, and environmental advocacy group representatives claim a variety of benefits from greenhouse gas reduction measures that are either unrelated to risk-reduction, including amenity values and species protection, or are only indirectly related, as co-benefits of other existing air quality measures. But the justification for climate-change programs is almost exclusively future-generational risk reduction. The ancillary benefits that are offered in defense of climate change policies could be produced directly through specific resource-use policies if those goals are valued by enough people to allow their enactment.

B. Assessing Risk-Reduction Benefits

The belief that fully implementing the Kyoto Protocol by itself is unlikely to provide meaningful risk reduction benefits is widespread among those people cited as experts by proponents of the protocol at the 1997 Kyoto conference on climate change:

Jerry Mahlman, Director of the Geophysical Fluid Dynamics Laboratory at Princeton University, told the *Washington Post* that, “The best Kyoto can do is to produce a small decrease in the rate of increase.”[6] In a post-Kyoto *Science* news brief, Mahlman says that “it might take another 30 Kyotos over the next century” to cut global warming down to size.[7]

Bert Bolin, outgoing chairman of the United Nations Intergovernmental Panel on Climate Change, assessed the impact of Kyoto as a 0.4 percent reduction in greenhouse gas emissions compared to a no-protocol alternative and concluded: “The Kyoto conference did not achieve much with regard to limiting the buildup of greenhouse gases in the atmosphere.”[8]

Robert Repetto at World Resources Institute acknowledges that the Kyoto accord is little more than a tiny step toward a distant end rather than a significant step in itself: “Nobody thought in their wildest dreams that Kyoto would solve the climate problem….If implemented, the achievement at Kyoto will be to get nations off a business-as-usual trajectory, and onto a path that peaks, and then starts going down.”[9]

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6 Joby Warrick, “Reassessing Kyoto Agreement, Scientists See Little Environmental Advantage,” *Washington Post*, February 13, 1998.

7 David Malakoff, “Thirty Kyotos Needed to Control Warming,” *Science*, Vol. 278, December 19, 1997, p. 2048.

8 Bert Bolin, “The Kyoto Negotiations on Climate Change: A Science Perspective,” *Science*, Vol. 279, January 16, 1998, p. 330.

9 Warrick, “Reassessing Kyoto Agreement,” *Washington Post*.

As Tom Wigley, a climate researcher at the National Center for Atmospheric Research in Colorado, puts it, "A short-term target and timetable, like that adopted at Kyoto, avoids the issue of stabilizing concentrations [of greenhouse gases] entirely."[10]

In other words, benefits of the Kyoto Protocol, at least in the short term, are described more in political terms—as initiating a shift in energy-use patterns—than in terms of tangible environmental or risk-reduction benefits.

C. Assessing Risk-Reduction Liabilities

1) Accounting for the income-risk relationship

Although regulatory costs and job losses are not often considered risk-relevant in themselves, they should be. The idea of a linkage between income and risk may be subtle, but it is also intuitive. We know, for example, that people with large families face lower risks of suffering from severe depression or of becoming homeless due to economic dislocation. Having a large family seems to lessen one's risk of serious depression or homelessness. We know that people with many friends are in less danger of becoming mentally ill than are "loners." Thus, having a strong social network lessens one's risk of mental illness. Likewise, we know that people's safety is related to people's income. Those with less income are proportionately less able to take the safety measures that higher-income earners can. Families with high income levels can better withstand short-term health problems than those with less income. Families with higher incomes eat higher quality foods, drive safer cars, live in safer neighborhoods, train their children for safer jobs, and so on.

Peer-reviewed studies over two decades have examined the question of such economic risk modifiers and generally concluded that people use their disposable income to weave a personal safety net around themselves and their loved ones. The more disposable income they have, the tighter the weave of their personal safety net. The less disposable income they have, the looser the weave.[11]

As systems engineer Ralph L. Keeney points out in *Estimating Fatalities Induced by the Economic Costs of Regulations*:

> *Regulatory costs are paid by individuals, which leaves them with less disposable income. Since individuals on average use additional income to make their lives safer and healthier, the regulatory costs lead to higher mortality risks and fatalities. Based on data from the National Longitudinal Mortality Study relating income to the risk of dying, approximately each $5 million of regulatory cost induces a fatality if costs are borne equally among the public. If costs are borne proportional to income, approximately $11.5 million in regulatory costs induces a fatality.*[12]

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[10] Malakoff, "Thirty Kyotos Needed to Control Warming," p. 2048.

[11] Ralph L. Keeney, "Estimating Fatalities Induced by the Economic Costs of Regulations," *Journal of Risk and Uncertainty*, Vol. 14, pp. 5-23, 1997; Ralph L. Keeney and Kenneth Green, *Estimating Fatalities Induced by the Economic Impacts of EPA's Proposed Ozone and Particulate Standards*, Policy Study No. 225, Reason Public Policy Institute, June 1997; Aaron Wildavsky, "Richer is Safer," *The Public Interest*, Vol. 60, p 23–29, 1980; William Kip Viscusi, "Mortality Effects of Regulatory Costs and Policy Evaluation Criteria," *Rand Journal of Economics*, Vol 25, pp. 94–109, 1994.

[12] Ralph L. Keeney, "Estimating Fatalities Induced by the Economic Costs of Regulations," *Journal of Risk and Uncertainty*, Vol. 14, pp. 5–23, 1997

Though environmental advocacy groups and agencies generally dismiss such ideas as being unconventional, the implications of this understanding are straightforward: less income, less safety. Nor is this relationship inherently unquantifiable. We can estimate the impact by determining how much a proposed action will cost an individual in terms of disposable income and then correlating that loss of disposable income with personal safety.

The costs of the Kyoto Protocol may be significant. Most moderate economic analyses with moderate assumptions show economic impacts of around a two percent reduction in U.S. gross domestic product (compared to a no-protocol scenario) in order to bring U.S. greenhouse gas emissions to 1990 levels by the time frame called for in the Kyoto Protocol.[13]

But for the sake of this analysis, let us make a few more optimistic assumptions. The Kyoto Protocol actually obligates the United States to cut its greenhouse gas emissions seven percent below that of 1990. Moreover, most studies showing a two percent reduction in GDP estimate costs exceeding $200 billion annually. However, let us assume that the full cost of compliance with the Kyoto Protocol might only cost $100 billion annually to present a conservative estimate of impacts.

Using a model of induced fatality developed by Ralph Keeney at the University of Southern California, we can model the impact of taking $100 billion out of people's own risk-reduction budgets and spending it elsewhere on anticipatory actions such as those needed to reduce the emission of greenhouse gases. Depending on whether one assumes that regulatory costs are borne equally by all households (the high end of the range), or proportionally with household income (the low end of the range), $100 billion (in 1990 dollars) spent each year to comply with the new standards will lead to induced fatalities of 9,000–22,000 Americans each year.[14]

2) Opportunity cost of investment: accounting for missed opportunity to save lives through alternative risk-reduction investments

As Harvard risk-researcher Tammy Tengs demonstrated in her study of cost-effectiveness of risk-reduction regulations, all investments in risk-reduction do not yield equal results.[15] Table 1-1 shows the median cost of intervention for five regulatory agencies, each charged with reducing risk within its sphere of authority. To date, saving lives through environmental regulations has been, in the aggregate, more expensive than saving lives through other types of safety regulation, though some individual environmental measures may be highly cost-effective ways to reduce risk.

As discussed earlier, the costs of the Kyoto Protocol will likely amount to at least $100 billion dollars per year. The same amount of money spent on some of the demonstrated, cost-effective health and safety risk reduction measures could, hypothetically, save the lives of many people if we would get comparable return on our investment to historically proven interventions. Of course, such high returns on risk-reduction investments are rare. Furthermore, high returns are not likely to be maintained over time as the low-hanging fruit of any given risk-reduction is plucked and as more marginal risk-reduction measures are pursued. And one should not think of saving lives as one would think of toting up the cost of preserving oranges. Still,

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[13] Ibid.

[14] The lower value in the range represents the assumption that regulatory costs will be divided among the population proportionately with household income, while the higher value in the range represents the assumption that regulatory costs will be borne equally by households regardless of income.

[15] Tammy O. Tengs, et al., "Five-Hundred Life-Saving Interventions and Their Cost-Effectiveness," Draft, Harvard Center for Risk Analysis, Harvard University, Boston, MA, 25 July 1994.

even if we break a given risk group into thirds, such as the roughly 41,000 people who die in automobile accidents each year, and assume that saving the second third is five times more expensive than the first, and saving the final third is five times more expensive than that, we could save all 41,000 for about $33 billion, while inducing between 3000 and 7,300 fatalities, for a net benefit of 33,700–38,000 lives saved annually.[16]

Table 1-1 —Median Value Of Cost/Life-Year Saved For Five Regulatory Agencies.

Regulatory Agency	Median cost/ life-year saved
Federal Aviation Administration	$23,000
Consumer Product Safety Commission	$68,000
National Highway Traffic Safety Administration	$78,000
Occupational Safety and Health Administration	$88,000
Environmental Protection Agency	$7,629,000

Source: Tammy O. Tengs, et al., "Five-Hundred Life-Saving Interventions and Their Cost-Effectiveness," Draft, Harvard Center for Risk Analysis, Harvard University, Boston, MA, July 25, 1994.

If policy makers are unwilling to allow people to retain all their earned resources to procure safety for themselves, they should consider whether we are getting better value for our governmentally administered safety investments than that which can be obtained by people on their own. They should also consider whether we're getting the biggest risk-reduction available through established intervention pathways.

D. Balancing the Ledger

When we account for the lack of demonstrable near-term, risk-reduction benefits from the Kyoto Protocol approach to climate change policy, the risk-reduction liabilities of the income-risk relationship, and lost opportunities to use proven risk-reduction interventions, we find that a net-benefit assessment shows considerably higher liabilities than benefits for the near term. And given the long-term uncertainties involved, even putting the speculative long-term range of benefits into the risk-ledger doesn't contribute much more information to facilitate evaluating whether we're on the right track.

IV. Conclusions

People do not face risks in isolation. Rather, at any given moment, each individual has a portfolio of risks and faces a constant challenge in managing that portfolio and in selecting from the various risk-altering actions available individually or through collective action. Man-made climate change may well be a risk in that portfolio, to ourselves, or to future generations.

But to empower individuals to make informed personal and public-policy risk-management choices, we need a method of selecting a risk-reduction strategy and a method of portraying risk and potential benefits of risk-reduction measures that retain the complexities that reality imposes, while providing an understandable basis for decision making.

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16 Calculations by author. Highway fatality estimate was for 1994, from "National Transportation Statistics, 1996," U.S. Department of Transportation, Bureau of Transportation Statistics, Washington DC. Cost for first third saved was $78,000/life-year saved, $390,000/life year saved for the middle third, and $1,950,000/life-year saved for the final third of the 41,000 automobile fatalities listed for 1994, the last year available at time of writing.

Table 1-2

KYOTO PROTOCOL RISK-REDUCTION BENEFITS —NEAR TERM[a]	
• Reduced risk of harm from changing weather patterns:	NONE
• Reduced risk of harm from extreme weather events:	NONE
• Reduced risk of harm through famine avoidance:	NONE
• Reduced risk of harm through disease prevention:	NONE
• Reduction in other proposed climate change hazards:	NONE
• Reduced risk of harm through avoided economic impacts of climate change:	NONE
KYOTO PROTOCOL RISK-REDUCTION BENEFITS —LONG TERM[b]	
• Reduced risk of harm from changing weather patterns:	NONE – HIGH
• Reduced risk of harm from extreme weather events:	NONE – HIGH
• Reduced risk of harm through famine avoidance:	NONE – HIGH
• Reduced risk of harm through disease prevention:	NONE – HIGH
• Reduction in other proposed climate change hazards:	NONE – HIGH
• Reduced risk of harm through avoided economic impacts of climate change:	NONE – HIGH
KYOTO PROTOCOL RISK-REDUCTION LIABILITIES —NEAR TERM[c]	
• Induced fatalities from income-risk relationship:	Approx. 9,000 – 22,000/yr.
KYOTO PROTOCOL OPPORTUNITY COSTS —NEAR TERM[c]	
• Lives not saved through other risk-reduction investments:	Approx. 0 – 3.5 million/yr.
• Resources not available for other social uses:	$100-200 billion/yr.

NOTES:

a) These values derive from the consensus scientific view that Kyoto compliance, of itself, will produce no environmental benefit, as discussed above.

b) This range of values flows from the consideration that if the pessimistic scenarios of climate change as discussed in the IPCC reports on climate change are true, and if the anticipatory approach is effective, averted risks could be significant.

c) Induced fatality values calculated by author using income-risk relationship as modeled in Keeney & Green, 1997. “Lives not saved” values calculated by author from values in Tengs, et al., 1994.

Based on uncertainties about the impacts of climate change, our analysis suggests that, pending improved understanding of the probable impacts of climate change, policymakers should reconsider their selection of an anticipatory strategy, as exemplified by the Kyoto Protocol. Instead, while keeping a wary eye out for more precise information about the risks posed by man-made climate change, our analysis suggests that policymakers should explore more proven, more resilient risk-reduction strategies.

In a net-benefits framework, pursuing the Kyoto Protocol approach may well do more harm than good in the near term and offer only uncertain benefits in the longer term.

In the next chapter, we will examine the most frequently discussed tactics to be used in driving down greenhouse gases: emission credit-trading programs and carbon taxes. While potentially less problematic than carbon taxes, the credit-trading approach is fraught with unique difficulties and uncertainties which prevent us from making a meaningful assessment of potential benefits, but do suggest the potential for significant countervailing harms from either unanticipated, or unconsidered consequences of implementing a trading scheme.

Chapter 2

Markets and the Casino: Gambling on Greenhouse Gas Reductions

BY RICHARD J. MCCANN AND STEVEN J. MOSS

I. The Policy Setting

Concerns over the potential for global climate change caused by human activity began to arise in the late 1980s. Global climate models, made possible by advances in supercomputer technology, forecast large temperature increases not seen since the Age of Dinosaurs. These forecasts were corroborated, in the public's eye at least, by data showing a recent reversal of the global cooling trend that occurred from 1940 to 1975, and by the record heat experienced in the summer of 1988. These events led to the issuing of numerous international scientific and policy studies on global climate change.

These studies have prompted a series of international conventions, protocols, and treaties to control the emission of greenhouse gases. The initial agreement to establish emission control targets was signed in 1992 at the Earth Summit in Rio de Janeiro. After a series of conventions under United Nations sponsorship, a more specific protocol was negotiated in December 1997 in Kyoto, and signed by President Clinton in November 1998. This protocol more specifically assigns responsibility for reducing greenhouse-gas emissions and establishes rules and methods for crediting and trading such reductions.

The debate over global climate change, or "global warming" as it was called initially, has at least two foci. The first and primary focus has been over the scientific basis of the climate-change predictions and the level of risk posed by climate change given those forecasts. This debate has primarily taken place among scientists, with policy analysts entering the fray with their own take on the quality of the scientific process, and the possible socio-economic and ecological consequences from both climate change and policies undertaken to control greenhouse gas emissions. The second focus has been on the allocation of required emission-control responsibility among nations and industries. Because this debate has obvious "hard" dollar implications, it has been much more political in nature and has set the developed and energy-producing nations, which have historically had the highest rate of greenhouse-gas emissions, against the developing and transforming economies, which view such controls as serious constraints on their future growth. While the two debates often occur in separate forums, they are in fact intricately linked because of the wide disparity both in the expected impacts and risks from climate change and in the economic consequences of controlling emissions.

One of the centerpieces of the Kyoto Protocol is the establishment of an international mechanism to trade emission reductions. Trading programs have long been advocated by economists to solve a variety of environmental problems, and several such programs have been established around the world. The purported advantage of such a "market-based" approach is that reductions can be garnered at the least economic cost. Several so-called joint implementation trades have already taken place to reduce emissions in developing countries, where control costs are likely to be lower. However, such programs require a specific set of conditions to be successful, and in the case of global climate change, those conditions may not be met.

II. The Nature of the Climate Change Dilemma

The environmental risks and consequences of global climate change differ from the standard environmental problem in several ways. These differences can lead to important departures in how the threat of global climate change should be approached versus other environmental issues.

A. "Stock" Versus "Flow" Effects

For most environmental pollution, such as air emissions or water discharges, the damages are almost immediate and transient, i.e., the damages occur as the pollution arrives once emissions reach a certain threshold level. If the pollution ceases, the damages would end almost as quickly. Think about smog: if there were no more cars, air quality would improve rapidly within days. These types of relationships are known as "flow" effects because they are associated almost directly with the flow of pollutants. Global climate change theory, on the other hand, pertains to the total amount of greenhouse gases, or the stock, existing in the atmosphere.[17] The emissions in any one year have only a small impact on the potential effect—it is the accumulation of these gases which is the critical driver. As a result, reducing emissions will not lead to an immediate reduction in the risk. Nor are small annual reductions likely to have a substantial effect for some time. The focus of controlling greenhouse gases needs to be on the total stock in the atmosphere and the growth rate of that stock, not on the annual flow as in the case of air and water pollution.

B. Uncertainty About the Influence of Individual Greenhouse Gas Constituents

"Greenhouse gases" are a collection of various gases which have differing effects and half-lives. Most of these gases are released in large quantities by nature, but human activity appears to have added small increments that may lead to increased accumulations in the future for specific types of emissions. Carbon dioxide (CO_2) is usually claimed as the predominant source of the greenhouse effect. Its main anthropogenic sources are from burning fossil fuels and forestlands. However, human-induced emissions are dwarfed by the natural output of CO_2 from plant life and erosion.[18] Methane (CH_4) is considered the next largest source of greenhouse gases, and human sources of methane generally come from fuel use, cattle, and rice paddies. Other sources, including chloro-flurocarbons (CFC), which are now controlled by the Montreal Protocol, constitute smaller but significant sources.

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[17] Other examples of "stock" pollutants are toxic waste discharges into the groundwater or an embayment, and radioactive waste materials.

[18] Kenneth Green, *A Plain English Guide to the Science of Climate Change*, Reason Public Policy Institute Policy Study No. 237, December 1997.

Table 2-2: Exchangeable Flows of Carbon in the Environment

	Range (Gt/yr)	% of Total (out of 158 Gt/yr)
Natural Sources		
• Oceans	90–92	57–58
• Land biota	60–61	36–39
Natural Source Total	**150–153**	**93–97**
Human Sources		
• Burning fossil fuels	5.0–6.0	3.4–3.8
• Deforestation	0.6–2.6	0.01–0.02
Human Source Total	**5.6–8.6**	**3.5–5.4**
Total	**157–160**	**100%**

Notes: a) 1 Gt, or gigaton, is a billion metric tons. 1 Gt/yr is one gigaton of carbon moved from one pool to another over the course of one year. b) Land biota includes emissions from all plant life on the earth as well as soils and detritus.

Source: Data drawn from IPCC, *Climate Change 1995, The Science of Climate Change*, p. 77.

Table 2-3: Sources of Methane Found in the Atmosphere

	Range (M)	IPCC Value	Percent of IPCC Total
Natural Sources			
• Wetlands	100–200	115	22
• Termites	10–50	20	4
• Ocean/freshwater	6-45	15	3
• Methane hydrates	0–5	5	1
Natural Source Total	**117–325**	**150**	**30**
Human Sources			
• Energy use	70–120	100	19
• Rice paddies	20–150	60	12
• Enteric fermentation	65–100	80	15
• Human / Animal wastes	20–60	50	10
• Landfills	20–70	30	6
• Biomass burning	20–80	40	8
Human Source Total	**215–580**	**360**	**70**
Total	**332–905**	**515**	**100**

Notes: A) 1 Mt, or megaton, is one million metric tons. B) Column three shows the values deemed most likely by the IPCC. C)"Enteric Fermentation" constitutes gaseous emissions from animals. The IPCC considers all animal emissions as being caused by activities of mankind.

D) Calculations of percent contribution by Green, using IPCC 1992 data. The 1995 report did not break out the individual contributions, important information for understanding the relative contributors of methane to the atmosphere. Changes in the actual numerical assessment of the methane budget, however, are not substantial in the newer report.

Source: Data drawn from R.T. Watson, L.G. Meira Filho, E. Sanhueza, and A. Janetos, "Greenhouse Gases: Sources and Sinks," in *Climate Change 1992*, J.T. Houghton, B.A. Callander, and S.K. Varney, eds. (Cambridge, Mass: Cambridge University Press), p. 35.

The estimation of climate change potential of these gases is constantly changing as new information and modeling results are published. In some ways, the estimation method is an iterative process (not necessarily toward an equilibrium) between chemists and climate modelers. In addition, how emissions are released may influence climate change as well. For example, burning fossil fuels often releases sulfates which increase the albedo in the atmosphere and can create cooling that offsets the warming effect of CO_2. Also, the expected half-lives of these gases have changed with further analysis. This uncertainty is not surprising given our evolving understanding of atmospheric science and the inherent complexities of climate processes. Similar problems have arisen in studies of the formation of tropospheric ozone, which is both the prime constituent of smog and a greenhouse gas.[19] With any complex system, whether it's the climate or the national economy, we need humility in our understanding of how it works. To date, we simply do not know how changing one variable in the climate system will affect the Earth's climate.

C. Uncertainty About Forecasts

Economists and demographers universally acknowledge that long-term forecasts—of five years or more—are highly uncertain. Since most forecasts are based on historical patterns of behavior, when this underlying behavior substantially changes, and it almost always does, forecasts typically turn out to be inaccurate. The problem of forecasting error is particularly acute for climate change and associated economic models, for five primary reasons:

1. Global warming is projected to unfold over the next one to five hundred years, placing it well out of the range of typical forecasting accuracy. Even one-hundred year greenhouse gas forecasts may have forecasting errors exceeding 50 percent.[20]

2. Global warming forecasts are driven by a large number of independent variables, including population and economic growth, and energy use characteristics. All of these factors are subject to substantial forecasting error, with 10 percent swings in twenty-year population forecasts alone.[21] As Janet Yellen, Chair of the Council of Economic Advisors, stated, "Economists have a difficult time projecting the behavior of the economy over the next quarter or year, let alone over the next two decades."[22]

3. Although the developed world maintains reasonable long-term climate, demographic, and economic data, the developing world generally does not, making it extremely difficult to devise an accurate forecasting baseline, and to use past experience as an indication of future patterns.

4. Since emission forecasts will result in the need for potentially costly action, they are likely to be subjected to considerable scrutiny by entities with different interests. To the extent that the resulting adopted forecasts represent a political compromise, their accuracy is highly questionable.

5. Adopted emission-reduction strategies will directly influence baseline emission forecasts, and vice versa. However, there is large uncertainty as to the ability to identify these strategies and the prospect of determining long-term effectiveness of these strategies. Moreover, their cost-effectiveness will be partially determined by the amount of implementation time available.

Greenhouse-gas emission uncertainty can be highlighted by comparing historical estimates, which in themselves display significant variation. Table 2-4 displays carbon dioxide emission data developed by different government agencies. As indicated in the table, there is over a 10 percent difference between the U.S. Environmental Protection Agency's (USEPA) and U.S. Department of Energy's Energy Information Administration (EIA) 1992 CO_2 emission estimate, even though these estimates were made in 1994, two

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19 National Research Council, *Rethinking the Ozone Problem in Urban and Regional Air Pollution* (Washington, D.C.: National Academy Press, Committee on Tropospheric Ozone Formation and Measurement, Board on Environmental Studies and Toxicology, Board on Atmospheric Sciences and Climate, 1991).

20 John T. Hougton, et al., *Stabilization of Atmospheric Greenhouse Gases: Physical, Biological and Socio-economic Implications*, Technical Paper of the Intergovernmental Panel on Climate Change, February 1997.

21 Steven J. Moss and Richard J. McCann, "The Use of Demographic and Economic Forcasts in Air Quality Policymaking: Addressing Issues of Uncertainty in California." *Environmental Regulation and Permitting*, 1998, pp. 45–57.

22 Janet Yellen, "Testimony before the House Commerce Committee on the Economics of the Kyoto Protocol," (Washington, D.C.: Council of Economic Advisors, March 8, 1998).

years after the estimating period, and they should be using common data sources. As discussed above, since emission forecasts to a large extent will determine actual dollar responsibility for emission reductions, it can be expected that forecast differences among nations will be even larger than those between U.S. agencies and departments.

Table 2-4: Differences in Historic CO_2 Emission Estimates (Million Metric Tons of Carbon or Carbon Equivalent)

	1989	1990	1991	1992	1993	1994
EIA, 1994	1,387	1,375	1,362	1,383	1,409	N/A
USEPA, 1994	N/A	1,335	1,319	1,339	N/A	N/A
USEPA, 1994	N/A	1,233	1,218	1,239	N/A	N/A
USEPA, 1995	N/A	1,336	1,320	1,340	1,369	1,390
EIA, 1996	1,384	1,372	1,359	1,380	1,405	1,481

Source: Energy Information Administration, *Emissions of Greenhouse Gases in the United States 1987-1992*, DOE/EIA-0573 (Washington, D.C.: U.S. Department of Energy, Energy Information Administration, Office of Energy Markets and End Use, October,1994); Energy Information Administration, *Emissions of Greenhouse Gases in the United States 1995*, DOE/EIA-0573(95) (Washington, D.C.: U.S. Department of Energy, Energy Information Administration, Office of Energy Markets and End Use, October,1996); U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks:1990-1993* (Washington, D.C.: U.S. Environmental Protection Agency, Office of Policy, Planning and Evaluation, September,1994); U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Has Emissions and Sinks:1990-1994* (Washington, D.C.: U.S. Environmental Protection Agency, Office of Policy, Planning and Evaluation, November,1995).

Because the potential effects of greenhouse gases devolve from the *stock* of gas rather than the *flow*, the forecast rate of emissions and their accumulation become important for policy making. Because mistakes in forecasting are also cumulative, choosing strategies that allow for mid-course corrections are paramount. Relying on today's forecast for setting reduction targets without a means to make mid-course corrections will guarantee large errors in the future. Because the errors are cumulative, corrections could require many years.

D. Uncertainty About Outcomes

The mechanism of "climate forcing" is still being understood and refined as illustrated by the repeated lowering of forecast temperature increases, which reflects the natural evolution of scientific investigations. As an example, a recent study has found that forests increase carbon dioxide uptake from the atmosphere with rising temperatures, contrary to the assumptions used in existing climate models.[23]

Yet there is another range of uncertainty in the linkage between climate change and the *consequences* of a change. We do not understand how dynamic and resilient either the earth's biosystem is or the world's economic system. However, scientists are finding precedents for rapid cooling and warming associated with the ice ages. The rapid transformation of the world's economy in this century probably is a testament to the adaptability of our societies to large changes. Nevertheless, it is the uncertainty over the *outcomes*, and how this uncertainty is compounded by the chain of scientific uncertainties back to human activities which should be the focus of policy responses.

A useful way to think about the distribution of possible outcomes is to examine two matrices relating emissions to potential warming, and warming to potential outcomes. These matrices can then be combined to link emissions to outcomes. Table 2-5 shows a hypothetical relationship between average annual emission growth (as a proxy for

[23] Christopher B. Daly, "Dr. Foster's Forest," *Harvard Magazine*, March-April 1998, pp. 40–47.

the stock of greenhouse gases in the atmosphere) and the probability of increased global mean temperatures. This relationship is the one most often conveyed to policymakers and the public, although the actual distribution is often ignored.

Table 2-5: Hypothetical Probability of Increased Mean Temp. (ºC) by 2100

Average Emission Growth/Year	0º	1º	2º	3º	4º	5º	6º
-2%	50%	30%	11%	5%	2%	1%	1%
0%	25%	40%	20%	10%	3%	1%	1%
1%	20%	25%	33%	15%	4%	2%	1%
2%	10%	20%	25%	30%	10%	3%	2%
4%	5%	15%	22%	25%	22%	8%	3%

Table 2-6 shows a hypothetical relationship between increased temperatures and potential outcomes. Economic and ecological analyses often present a range of outcomes, sometimes associated with different levels of temperature increase, but none has related the probability of an outcome given expected temperatures. Of course, making such an assessment is quite difficult and perhaps impossible, but we do know that the relative probabilities will change with changes in temperatures.

Table 2-6: Hypothetical Probability of Outcomes

Hypothetical Probability Increased Mean Temp.	Beneficial	Benign	Negative	Catastrophic
0º	13%	19%	6%	0%
1º	27%	16%	6%	0%
2º	20%	15%	12%	4%
3º	18%	14%	15%	8%
4º	13%	13%	18%	20%
5º	7%	12%	21%	29%
6º	1%	11%	24%	39%

With this these two matrices, a relationship between emission increases and outcomes can be developed, as shown in Table 2-7. This matrix is more informative to policymakers because it shows the direct linkages between policy decisions and potential outcomes. In this way, the policymaking can shift its focus from the process-oriented method used by scientists toward the outcome-oriented approach that politicians are more comfortable with.

Table 2-7: Hypothetical Probability of Outcomes

Average Emission Growth/Year	Beneficial	Benign	Negative	Catastrophic
-2%	52%	43%	5%	0%
0%	47%	45%	8%	0%
1%	33%	30%	32%	5%
2%	17%	26%	35%	22%
4%	6%	17%	34%	43%

As Table 2-7 shows, a 1 percent per year growth in emissions might have a 33 percent chance of producing negative effects; and a 5 percent chance of producing catastrophic effects.

E. Discrete Versus Continuous Outcomes

Although linking emissions to outcomes represents a necessary improvement, it does not convey one of the most important aspects of climate change uncertainty—the likelihood that the relationship between emissions and outcomes is probably highly nonlinear and perhaps even discontinuous, i.e., climate change will either be benign or catastrophic. That is, the geophysical system probably has substantial inertial balance which can accommodate large infusions of greenhouse gases. Such a system is likely to experience large discrete changes when that balance shifts. Such systems are more likely to have a "bimodal" (or double-peaked) distribution of outcomes rather than the classic single-peaked "normal" or bell-shaped curve.[24]

This bimodal distribution has an important implication for policymakers: global climate change could have rather benign implications or lead to catastrophic outcomes. For this reason, the appropriate measures also will vary significantly—in other words the optimal policy choices will be discrete and bimodal. If the outcome is likely to be benign, then little needs to be done.[25] However, if the outcome is likely to have severe consequences, worldwide emissions will have to be reduced dramatically and quickly—the Intergovernmental Panel on Climate Change (IPCC) estimates that annual emissions would have to be reduced by 50 percent to 70 percent to simply stabilize current atmospheric concentrations.[26]

While it might make sense on first impression to pursue the most risk-averse or "safety-first" (precautionary principle) strategy, such an approach is more likely to lead to disastrous results. First, the technology does not yet exist—nor will it be available in the next decade at least—to achieve these magnitudes of reductions and also to preserve a semblance of our way of life. We would simply have to stop using any type of energy in our daily lives. Even as new technologies come on line they would be quite expensive initially and would have significant economic consequences if forced into widespread use prematurely. Government expenditures might be able to accelerate dispersion, but such spending will have little influence on the creative process of inventing these technologies. The second problem is the irreversible nature of these type of investments.[27] Once committed to the draconian reduction path, turning back is extremely difficult. If the economy is forced to suffer such grave measures and then climate change turns out to be a benign outcome, we will not be able to return to our previous economic vigor for some time.

Nevertheless, a middle course of moderate reductions is unlikely to result in either the least economic disruption or adequate protection if the threat is serious. Unfortunately, the reduction targets laid out in the Kyoto Protocol fall into the moderate-course category. We can illustrate this conundrum by examining how the appropriate policy responses conflict with a moderate course chosen too early on:

- In the first case, moderate 5 percent to 20 percent annual reductions are pursued for a 10- to 20-year period in response to the threat of climate change. These actions reduce worldwide economic output due

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24 Such bimodal distributions are in fact quite common in climatological data. For example, both the Sacramento and Colorado Rivers in California show bimodal distributions in annual runoff events, i.e, "flood or drought."

25 One only needs to read Barbara Tuchman's *A Distant Mirror* to see the havoc created by the global cooling that occurred in the fourteenth century. Certainly the warming over the last century has not led to any catastrophic collapses and may have been beneficial in improving world agricultural output.

26 Intergovernmental Panel on Climate Change, *IPCC Second Assessment Synthesis of Scientific-Technical Information Relevant to Interpreting Article 2 of the UN Framework Convention on Climate Change* (New York City: United Nations Environmental Program, 1995).

27 Charles Kolstad, "Learning and Stock Effects in Environmental Regulation: The Case of Greenhouse Gas Emissions," *Journal of Environmental Economics and Management* 31, no. 1, 1996, pp. 1–18.

to increased costs.[28] However, after 20 years, the scientific forecasts show that the effects of global warming are likely to be de minimus or benign. Governments immediately respond by eliminating any programs that restrict greenhouse gas emissions. However, world economies have foregone a higher level of output for 20 years, and the now-unneeded energy infrastructure must still be paid off.

- In the second case, again moderate reductions are in place until scientific forecasts show that climate change is likely to be catastrophic to the world's biosystem and economy. Annual world emissions must be cut immediately by 70 percent or more to stabilize existing greenhouse gas concentrations. These levels of reductions require drastic restructuring of the world's energy infrastructure and economic order. Unfortunately, the moderate reductions had two effects: first, greenhouse gas concentrations are likely to be only 10 percent to 20 percent lower after 20 years than they would be without any restrictions—buying only a two- to four-year delay in the expected temperature increase. Second, the moderate reduction targets will have accelerated the replacement of long-lived energy infrastructure with technology that meets the moderate targets. Since this infrastructure is relatively "young" and the drastic reductions will now "strand" these investments, much of it, particularly for energy production, will now have to be replaced quickly.[29]

In the first scenario, the intermediate reductions provide no net benefits (at least beyond the so-called no regrets strategies which generate other non-climate change benefits) at substantial cost. In the second scenario, the accelerated turnover in capital stock actually makes it more costly (and probably more politically difficult) to institute further reduction targets because the capital stock is newer, with more outstanding investment. As an example, an electric utility could meet a 20 percent reduction target by replacing its 30-year old steam boiler that uses 10,000 British thermal units (Btus) of natural gas to generate a kilowatt-hour with a new combined-cycle turbine that uses 8,000 Btus per kilowatt-hour (kWh). However, if a further reduction is needed 20 years later, the combined-cycle plant would be only half-way through its expected service life, and the utility will be reluctant to replace it with the 4,000 Btu per kWh fuel cell needed to meet the new reduction targets. On the other hand, if the utility had simply extended the steam boiler's life by 20 years, the fuel cell probably would be an attractive option. *The net result is that the so-called moderate reductions provide only a costly sense of false security.*

The "irreversibility" of infrastructure investment, as with the draconian strategy, acts to penalize a middle course of action. The moderate reduction path does not prepare investors, producers, or consumers for the likely changes in that path that may be necessary. Similarly, investors are likely to perceive the increasing risk as more is learned about the potential for climate change, and this will tend to reduce the amount of investment in current technologies no matter what their emission-reduction benefit.[30]

One other drawback of the moderate-reduction approach is that it tends to push renewable, non-greenhouse-gas emitting technologies into the marketplace before they are ready. Virtually none of these technologies is cost-competitive with fossil-fueled choices, and most still have significant technical hurdles. American consumers already suffered through "not-ready-for-prime-time" alternative energy technologies in the 1970s

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[28] See Richard J. McCann and Steven J. Moss, *Nuts and Bolts: The Implications of Choosing Greenhouse-Gas Emission Reduction Strategies*, Policy Study No. 171, Reason Foundation, November 1993 for a least-cost analysis of potential greenhouse gas reduction measures available in the United States.

[29] This is the same problem that electric utilities in the United States now face in recovering "stranded assets" for investments in nuclear power and alternative energy resources which became uneconomic with correction and stabilization of world fossil-fuel markets.

[30] Avinash K. Dixit and Robert S. Pindyck, *Investment under Uncertainty* (Princeton, New Jersey: Princeton University Press, 1994).

and 1980s when federal and state governments offered tax incentives to install solar and conservation technologies. Many of these failed badly and consumers are still wary of using these systems. Renewable energy technologies could suffer the same fate if they are introduced too early. As a result, if advanced technologies are really needed at a later date to meet more-stringent reduction targets, consumers may be reluctant to adopt these technologies.

All of these uncertainties—component effects, climate forecasting, economic forecasting, the distribution of possible outcomes—combined with the stock effects of both greenhouse gases and infrastructure investment create a situation where a cautious approach to climate control policies is necessary. The year-to-year expected costs are not uniform and tend to rise as the impending event nears.[31] In addition, the uncertainty and stock effects combine to encourage delayed action.[32]

III. Turning to the "Marketplace" for a Solution

Politicians are cognizant that reducing greenhouse gas emissions could be quite costly and may lead to substantial change in the broad activities, such as fossil fuel use, on which our world society and economy are built. In this context, policymakers are looking to economists for a "quick fix" to limit the potential for catastrophic costs. Economists have long argued for the use of so-called market incentives or mechanisms either to obtain the greatest environmental benefits or to use the least cost to achieve an environmental goal.[33] Market incentives include:

- pollutant-specific charges, fees or taxes;
- beneficial technology subsidies;
- deposit-refund programs for harmful products; and
- tradeable permits or allocations of pollutants.

The economists' argument goes as follows:

> *The regulator may know the overall environmental objective to be achieved, and may even know the rate at which a particular pollutant is emitted and degrades the environment. However, the regulator does* not *and cannot know the costs for each individual and firm to meet those objectives. At a minimum, market incentives can be used to signal the "price" for using the environment as a sink for disposal of production and consumption by-products. Individuals and firms will then choose to reduce their pollution up to the point where the control costs equal the price. In this way, the marginal costs of meeting the environmental objective are equated across all parties and society's resources are efficiently allocated.*

Policymakers have only recently turned to using market incentives as the rising costs of meeting environmental objectives have become more apparent.[34]

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[31] Ita Falk and Robert Mendelsohn, "The Economics of Controlling Stock Pollutants: An Efficient Strategy for Greenhouse Gases," *Journal of Environmental Economics and Management* 25, no. 1, 1993, pp. 76–88.

[32] Charles Kolstad, "Learning and Stock Effects in Environmental Regulation: The Case of Greenhouse Gas Emissions," *Journal of Environmental Economics and Management* 31, no. 1, 1996, pp. 1–18.

[33] One of many excellent textbooks on this subject is by David W. Pearce and R. Kerry Turner, *Economics of Natural Resources and the Environment* (Baltimore: The Johns Hopkins University Press, 1990).

[34] Market-based approaches to allocating previously administered resources have been more commonly applied to non-environmental public goods, such as taxi cab quotas, milk pricing quotas, time-of-use electricity pricing, and transit pricing by

The Kyoto Protocol signed in November 1998 formally established means for participating nations to trade "emission reduction units" and to credit those trades toward each country's stated goals. The protocol clearly expects that such trading will greatly reduce the compliance costs with the reduction objectives specified in Annex A. Articles 3, 4, 6, 11, 12 and 17 specify rudimentary rules and responsibilities for participants in such trades. These rules make distinctions between trades among "Annex I" nations, which include those in the Organization for Economic Cooperation and Development (OECD) and the former Soviet Union states, and those between Annex I and nations with "developing and transforming economies."

A. The Advantages of Marketable Emission Permits

Among the various market-based instruments, technology subsidies and tradeable permits have probably been the more politically popular, and taxes the least:

- Subsidies are a quite prevalent form of government intervention, and, for example, are a substantial component of state and federal transportation policies (e.g., highway and railroad subsidies). Subsidies appeal to particular interest groups which gain them at the expense of the general public which pays the subsidies.[35] Subsidies also can increase pollution by actually encouraging the damaging activity.
- Taxes are unpopular for one immediate reason—they effectively confiscate the "rights" to pollute being currently exercised. Taxes are generally set for the entire pollutant output, and polluters are not compensated for the economic value they implicitly placed on their ability to freely dispose of their by-products.
- Tradeable permits provide a means of addressing this problem of confiscation. Individuals and firms are allocated "property" rights to their emissions at historical levels or by some other method. These rights can then be bought and sold with the "owners" retaining the economic rents rather than the government, as is the case with taxes. Under tradeable permits, a quantity target of pollutants can be established, which is done more easily than setting monetary targets for taxes that are expected to achieve certain levels of pollution reduction.

Under a tradeable permit scheme regulators establish an overall emissions reduction target, allocate emission "rights," and allow emitters to trade among themselves for the right to emit potential pollutants, with permits essentially sold to the highest bidder. Under the right circumstances, a well-crafted permit program can minimize overall pollution-reduction costs, for two primary reasons:[36]

1. *Trading programs can provide an incentive to those capable of making reductions at the least cost to do so*. The costs associated with reducing greenhouse gas emissions importantly depend on the emission source and the strategies employed to obtain the reductions. For example, conservation—at the most extreme, simply consuming no energy at all—may be the most cost-effective emission-reduction

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distance (e.g., Bay Area Rapid Transit; D.C. Metro). Note that the term "market based" should not be confused with "free market" or "open market" policy. The former relies on politically set goals and simply uses pricing to achieve those goals. The latter relies on private decision makers determining their own goals (consumption preferences) in a context of property rights, contract law, and privately traded goods and services.

35 Mancur Olson, *The Logic of Collective Action: Public Goods and the Theory of Groups*, Vol. 124, *Harvard Economic Studies* (Cambridge, Massachusetts: Harvard University Press, 1965), discusses the incentives in the democratic process which lead to these types of outcomes.

36 Marketable permit programs may also help create equitable outcomes, by empowering both polluters and non-polluters to participate in the market. See T.H. Tietenberg, *Emissions Trading: An Exercise in Reforming Pollution Policy* (Washington, D.C.: Resources for the Future, 1985) and Ian W.H. Parry, "Pollution Taxes and Marketable Emission Permits Under Endogenous Technological Progress," (Washington, D.C.: U.S. Department of Agriculture Economic Research Service, January 1994).

strategy, while use of ethanol in transportation may be the most expensive.[37] Trading enables those individuals who place a high value on using ethanol to pay others to conserve energy as a least-cost method of obtaining mandated reductions—the ethanol users pay less than it would cost them to make reductions in ethanol consumption, and the conservers obtain compensation for their voluntary actions.

Since the disparity in emission sources and reduction strategies grows as the universe of sources expands, trading becomes potentially most effective at a global level. For example, perhaps three-quarters of China's and India's energy production is derived from coal, while it is less than one-third for the United States and Canada.[38] The use of inefficient technologies in India and China exacerbates this problem.[39] Exchanging coal-based energy production for compressed natural gas or renewable sources provides one of the least-cost methods of obtaining emission reductions and would be much less expensive than almost any approaches related to transportation emissions, the dominant source of greenhouse gases in North America. Use of a trading scheme would enable mobile sources in the United States to compensate Chinese electricity generators for taking responsibility for some portion of U.S. emission-reduction goals. Again, both parties are better-off as a result of the trade.

2. *Trading programs can encourage technological innovation if well-designed.* This feature is quite similar to the examples discussed above, except that the action being traded is improved energy-use efficiency or other methods to reduce emissions. That is, trading enables innovators to be compensated for their efforts, thereby instilling a significant profit motive to pursue effective advancements.

Tradeable permit programs have gained popularity among global policymakers because of their ability to combine strict emission-reduction standards with decentralized decision-making related to how the emissions can be reduced. This feature bypasses the need to estimate the value of fees, taxes, or charges, which otherwise have been viewed by some as attractive alternatives to command and control policies. Tradeable permits are also more operationally flexible than fees. For example, if emission regulations are tightened within a trading market, permits will become scarcer, and permit prices will "automatically" rise. If higher prices act to accelerate technological innovation, control costs will ultimately fall, as will prices. Under the same circumstance, using a fee approach, regulators would have to explicitly act to change the fee structure to meet air quality goals.

There are a number of tradeable permit variations, including cooperative or joint implementation schemes, in which one party can gain the rights to an environmental resource—air pollution credits or water rights—by subsidizing the adoption of more efficient or cleaner production processes by the entity that initially owns the rights. Recent examples of joint implementation approaches include the Metropolitan Water District-Imperial Irrigation District investment in water conservation, and the Sacramento Municipal Utility District-Sacramento County Rapid Transit District purchase of natural gas-fueled buses.

Although marketable permit programs have been demonstrated to be more efficient in achieving pollution-reduction goals than command and control policies in the economic literature, real-world experience with these programs has been limited. As indicated in Table 2-8, only a dozen environmental marketable permit programs appear to have been implemented to date, none of which operates on a worldwide, or even multinational, basis.[40]

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[37] McCann and Moss, *Nuts and Bolts*, 1993.

[38] The World Resource Institute, *World Resources* (New York: Oxford University Press, 1990).

[39] Madhu Khanna, "Technology adoption and the abatement of greenhouse gasses: the thermal power sector in India" (Dissertation, University of California, 1995) found that the fuel efficiencies at Indian coal-fired electricity generators average 24,000 Btus per kilowatt-hour. In North America, these plants typically average 10,000 Btus per kilowatt-hour or less.

[40] This estimate—which cannot be considered comprehensive—is based on a review of the economic and policy literature, as well as Radian Corporation, "Summary of Innovative Regulatory Strategy Programs Found in the Literature and Popular Press," US EPA Contract 69-DO-0125, 1992.

Table 2-8: Past and Existing Marketable Permit Programs for Environmental Protection

Type of Program	Program Structure/Location
US EPA Acid Rain Emission Allowance Trading Provision of the Clean Air Act Amendments	Nationwide SO_2 trading by electric utilities and industrial facilities.
US EPA New Source Review—Emission Reduction Credits Trading	Nationwide ROG, NOx, PM, SOx, CO netting or internal trades; offsets.
US EPA Leaded Gasoline Phase-Down	Nationwide limited trading among oil refineries
SCAQMD RECLAIM	Southern California NOx and SOx trading.
SMUD-RTC Natural Gas Bus Purchases	Joint implementation program for air pollution credits in Sacramento, California
US EPA Chloroflurocarbon Fee Program	Nationwide quota trading and escalating fees on CFC emissions, with revenue dedicated to the U.S. Treasury.
Home Fireplace Devices	Two permits must be purchased from existing stock to install a fireplace in Telluride, Colorado.
Vehicle Scrappage Programs	Purchases of high-emitting older cars
Water Discharge Permit Trading	Wisconsin
Point and Non-Point Water Pollution Trading	Colorado and North Carolina
Water Rights and Use Transfers	Sale and lease of legal rights to divert streams in Rocky Mountain states and California.
MWD-IID Water Conservation Investment	Joint implementation to acquire Colorado River water rights in California
TRPA Property Development Rights	Tradeable permits for developing property in the Lake Tahoe Basin

B. The Messy World Meets The Ideal Market

While tradeable permits appear to be an attractive option for reducing the expected costs of controlling worldwide greenhouse gas emissions (assuming such a goal has been embraced), use of such a program is likely to encounter a wide range of problems. These problems could undermine the world's ability to achieve the ultimate policy goals of mitigating alleged climate-change risk while maintaining economic vitality.

Economists have long touted the theoretical advantages of markets over direct, prescriptive regulation in more efficiently meeting environmental objectives.[41] However, the comparative analyses generally have not been commensurate.[42] Most often, the comparison has been made between an existing regulatory framework, with its associated real-world imperfections, and an "ideal" market setting in which institutional and participant characteristics are glossed over or assumed to meet tightly defined economic assumptions. This problem arises from economists' tendency to focus on a narrow set of traits in economic activity, such as individuals' behavior, technological production processes, and physical resource characteristics. These analyses do not address directly the most critical issue in establishing such markets: What types of institutions are needed to facilitate efficient trades? The failure of the profession to anticipate these issues was demonstrated by the initial lack of relevant advice to Eastern European nations after the fall of the Communist regimes. As Robert Young wrote, "the choice of institutions to coordinate economic activity is among the most fundamental of social decisions."[43]

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41 The seminal article on applying tradeable permits to air emissions is W. David Montgomery, "Markets in Licenses and Air Pollution: Efficient Pollution Control Programs," *Journal of Economic Theory* 5, 1972, pp. 345–418.

42 A more detailed discussion of these issues is contained in Richard J. McCann, "Environmental Commodity Markets: 'Messy' Versus 'Ideal' Worlds," *Contemporary Economic Policy* 14, no. 3, 1996, pp. 85–97.

43 Robert A. Young, "Why Are There So Few Transactions among Water Users," *American Journal of Agricultural Economics* 68, no. 5, 1986, pp. 1143–1159.

Market-formation issues can be divided into three sets. First are those generic to establishing any new market, particularly in environmental commodities such as air emissions and water rights. These mainly relate to defining property rights, establishing trading mechanisms, and accommodating the physical attributes of the resources being managed. Second are those which arise from the international nature of controlling greenhouse gases. These are generally a subset of the more generic issues and include problems of devaluation and free ridership. Third are those particular to the problem of climate change, including the difference between flows and stocks, the problem of investment irreversibility, and the need to adjust policy goals in the future. The first two issues can be discussed in the context of the common economic dialogue on market performance. The third requires a greater discussion about the nature of climate change and issues pertaining to developing appropriate policies.

IV. Basic Problems in Market Formation

We turn first to the problems that arise in creating any market for a commodity which previously was shared among individuals with no prices. These type of commodities are often called "public goods (or bads)." Essentially, the benefits from creating such markets may have been outweighed by the costs associated with initiating and transacting in these markets.[44] The types of market-formation costs that can hinder the creation of any market institution can be segmented into two categories:

1. *Risks to property rights* from uncertainty about legal and political institutional actions; and
2. *Transaction costs in trading* created by regulatory oversight and the structure of the market institutions.

Both of these issues are directly relevant to establishing tradeable permit markets in greenhouse gas reductions. Concerns by participants about the stability of property rights will arise from the necessity of having a global system involving separate sovereign nations and the uncertainty over the future policy course. Markets will likely experience transaction costs through the search and matching process and the need to monitor the consequences of the trades for a substantial period afterward.

A. Risks to Property Rights

The first requirement for any functional market is that property rights be assigned and enforceable, at least at some minimal level.[45] If these rights cannot be defined, controlled, monitored, or enforced effectively, participants will discount the potential benefits from any trades and turn to other avenues to meet their requirements. The trust that market participants place in these property rights can be measured to a certain extent by the apparent risk premium incorporated into the permit prices themselves. For example, empirical studies have found apparent premiums of 10 percent to 40 percent in the trading of agricultural production quotas and water rights.[46] The risk premium thus alters the price signal that policymakers hope will convey the path to the most cost-effective control measures. Instead, individuals may choose to use higher-cost

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44 Richard E. Howitt, "Malleable Property Rights and Smooth-Pasting Conditions," *American Journal of Agricultural Economics* 77, no. 5, 1995, pp. 1192–1198.

45 Harold Demsetz, "Some Aspects of Property Rights," *Journal of Law and Economics* 9, no. 2, 1966, pp. 61–68.

46 Richard R. Barichello, "Capitalized Government Program Benefits: Evidence of the Risk of Holding Farm Quotas," in *The Economics of Agriculture: Papers in Honor of D. Gale Johnson*, ed. John Antel and Daniel Sumner (Chicago, Illinois: University of Chicago Press, 1996), pp. 283-299; Richard Howitt, "Empirical Analysis of Water Market Institutions: The 1991 California Water Market," *Resource and Energy Economics* 16, no. 4, 1994, pp. 357–371.

measures over which they have substantially greater control and view as being less threatened by actions that might undermine or even eliminate the gains from a trade. In other words, the risk premium alters the net cost of what otherwise might have been a lower-cost control measure.

The risks to such property rights in an international market for greenhouse gas emissions can arise along several avenues:

- The recognition of private property rights varies substantially from nation to nation, and often the viability of these rights can decline with a change in regimes, particularly in developing nations. Given that the most cost-effective trades are likely to be between industrialized and developing nations, and that the Kyoto Protocol places the responsibility of meeting reduction goals on the purchasing nation if the trade fails to generate the necessary reductions, the buyers of these reduction credits can be expected to heavily discount the value of acquired reductions in some developing nations.
- Developing nations' economic policies often undermine the value of internationally traded financial instruments, such as currency and debt. The deep discounting of debt that occurred in the "debt-for-nature" swaps popular in the late 1980s reflects this phenomenon. Often, the markets for a developing nation's currency and debt are quite "thin," i.e., there is little activity and few traders. This circumstance adds to the volatility of these financial markets. Because these international greenhouse-gas trades have similar financial characteristics, we can expect traders to hedge against these risks and volatility at a substantial premium.

B. Transaction Costs in the Market

Even after property rights are established, the next step in market formation is establishing the institutions for facilitating trades. These can be divided into three general categories: the search and matching process, the exchange process, and the monitoring and enforcement process.

The costs of search processes depend on the market activity level, the similarity of commodity characteristics, the means of transmitting price information, and the characteristics of the participants. Search costs tend to rise as commodity characteristics differ, price information is more difficult to acquire, activity level falls, and the participants become more spatially distant. For example, the residential housing market has substantially higher search costs than those for corporate shares because the characteristics differ more greatly among houses, price information often is not posted in a common place or format, only a small percentage of the housing stock turns over in a particular period, and most buyers and sellers only enter the market sporadically. The corporate share market has experienced traders who have ready access to price information on financial instruments described in common terms.

Three types of exchange systems are common. These often reflect the search and matching process. Brokers often bring together buyers and sellers in markets which have little activity or where commodity characteristics might differ substantially. Brokers never actually take possession of the commodity, but can facilitate the regulatory process of transferring property rights. Merchants or dealers prevail where the risks of holding a stock of a commodity are outweighed by the reduced transaction costs from quickly facilitating trades. Dealers buy and then sell the commodity, easing the process of transferring rights for the participants. Exchanges directly bring together pools of buyers and sellers and formally incorporate the property-right transfer process.

The monitoring and enforcement process ensures that the seller carries out the required tasks. When the trader actually passes physical control of the commodity, e.g., a house to a buyer, then this process has relatively low costs. However, if the trade requires continued performance by the seller, such as installing and maintaining an emission-reduction device, then the monitoring costs can be substantial. Even establishing a governmental certification or inspection process involves substantial costs.

V. The Mismatch of the Market with Policy Goals

As discussed previously, there are fundamental reasons to suppose that the reduction objectives laid out in the Kyoto Protocol will probably change substantially. As more information is acquired, it will become more apparent whether climate change will result in benign or catastrophic outcomes. In the former case, reductions will not be necessary and will become valueless. In the latter, such draconian measures will be needed in every nation that the reduction credits will have to be abrogated and the situation reevaluated after the new programs have been implemented. Due to the magnitude of these changes, participants are likely to assign significant uncertainty to the continued existence of the reduction credits. Such uncertainty over government policy is a common problem of such programs.[47]

A market in greenhouse gases can be expected to experience high costs in each of the transaction steps—search, matching, exchange, and enforcement. At least initially, the market will require that actual reduction programs be identified for each trade. This means that the characteristics are likely to differ among the offered reductions by gases to be controlled, the lifespan of the reduction, the nation in which the reduction occurs, and the price quoted for the reduction. A dealer almost certainly could not acquire and hold a stock of these reductions given the large risks, and likely trading activity will be relatively low compared to more traditional financial markets such as the Chicago Board of Trade or the New York Stock Exchange. Thus brokers probably will dominate this market, which will result in higher transaction costs.[48] Eventually, an international exchange akin to those in currencies might arise. However, currencies for developing countries see little trading now and are among the most volatile, implying a similar problem in trading greenhouse-gas reduction credits. Finally, monitoring and enforcement costs can be expected to be substantial. At least one of the parties will have to demonstrate annual compliance for many years to the relevant regulatory body. Yet the Kyoto Protocol fails to specify any enforcement actions, which probably means that the parties will have to create their own enforcement mechanisms at substantial costs.

Even beyond these issues of market risks and transaction costs, there is a more fundamental problem with using tradeable permits to address the potential risks from climate change. The underlying principle in the Kyoto Protocol is that controlling the annual *flows* of greenhouse gases at a constant rate equates to an optimal policy for mitigating climate change risk from the *stock* of gases in the atmosphere. However, as discussed previously, focusing on the flows rather than the stock of such gases is *not* the most economically beneficial approach. Tradeable permits are more appropriate for controlling flows instead of stocks. As a result, relying on permit trading can lead to an outcome far from what is probably preferable.

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47 Richard R. Barichello, "Capitalized Government Program Benefits: Evidence of the Risk of Holding Farm Quotas," in *The Economics of Agriculture: Papers in Honor of D. Gale Johnson*, ed. John Antel and Daniel Sumner (Chicago, Illinois: University of Chicago Press, 1996), pp. 283–299; Richard Howitt, "Empirical Analysis of Water Market Institutions: The 1991 California Water Market," *Resource and Energy Economics* Vol. 16, No. 4, 1994, pp. 357–371; Robert Hahn, "Economic Prescriptions for Environmental Problems: How the Patient Followed the Doctor's Orders," *Journal of Economic Perspectives,* Vol. 3, No. 2, 1989, pp. 95–114.

48 Steven C. Hackett, "A comparative analysis of merchant and broker intermediation," *Journal of Economic Behavior and Organization* Vol. 18, No. 2, 1993, pp. 300–315.

To be profitably traded, a property right usually is associated with flows of services, such as housing or corporate income, which occur on some regular basis. Certain commodities, such as debt in large infrastructure projects, may have large payouts at some future date, but these type of instruments are rare, and usually derivative financial instruments are developed to convert this economic stock into a monetary flow. The ability to receive a flow of services greatly reduces the monitoring costs of the trade by allowing the buyer to readily see the benefit of the purchase.

A financial option might be considered as a viable economic alternative for controlling the stock of greenhouse gas emissions. An option could be bought or sold, to be exercised if the reductions were needed at some specified future date. The entities that sold the option would have an incentive to develop new technologies that reduce or control greenhouse gas emissions, while those buying the option could use the option strike price as a measure for either developing their own control measures or balancing against the potential damages from climate change.

While options are probably the appropriate mechanism in theory, financial markets have little experience with options that can be exercised beyond one year. As with the bond market, the "yield curve" probably would show a rising discount rate that would quickly depreciate the value of any long-term option, particularly if it is 10 to 20 years before the option would be exercised. In addition, it would be difficult to insure that both parties actually perform their respective duties at that late date. Insurance might be issued for the purchase (or "put") side of the option, but a financial payout would be inadequate for the selling (or "call") side, given the magnitude of the problem. Only if there were sufficient options transacted and if a sufficient number of sellers were expected to perform could the insurance payment then be used to buy any surplus reduction credits available from other sellers. In addition, it would be difficult to determine what the "baseline" would be for emission reductions 10 or 20 years hence. Setting reduction targets against today's emission levels may lead to insufficient controls if forecasted emissions increase at a substantially greater rate. On the other hand, targets set against future levels introduce a large uncertainty around the forecasted levels.

Of course, research, design, and development (RD&D) is a form of an option.[49] The firm or agency conducting the research invests a certain amount with an expectation of some form of return. Usually though, RD&D projects have a high failure rate, so the entity conducting the RD&D must have a significant portfolio of research projects and must evaluate the expected return across this entire portfolio.

The nature of RD&D, however, is that a large share of the returns, particularly for energy and environmentally oriented projects, accrue to society in general.[50] Private investors will undervalue the expected returns on these projects because they cannot capture all of those returns. The only means of generating a socially optimal level of RD&D is to "pool" the social resources and subsidize the relevant private investors in proportion to the ratio of social to private returns.

Nevertheless, this structure does not bode well for a market in greenhouse gas-reduction options based on RD&D investments. Governments would need to be involved, both as buyers and sellers, due to the

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[49] Steven Moss, Richard McCann, and Robert Vergun, *The Economic and Environmental Benefits of Increased Natural Gas RD &D Investment in Southern California (With Technical Appendix)* (San Francisco, California: Prepared for the Southern California Gas Co. by Foster Associates Inc., November 1992); Steven J. Moss and Richard J. McCann, *Global Warming: The Greenhouse, Whitehouse and Poorhouse Effects*, Policy Study No.167, Reason Foundation, September 1993.

[50] Moss, McCann and Vergun, 1993.

importance of social returns to such investments. Unfortunately, governments by their nature are risk averse and not good participants in active markets.

VI. Conclusion and Policy Recommendations

In developing a policy to mitigate the risks associated with climate change, both to the environment and to the world's economy, several principles can guide policymakers:

- *Focus on the possible* outcomes *of climate change, not the* increase *in temperature.* Climate change may result in benign or even beneficial effects. No one would argue that the warming that might have occurred since the mid-eighteenth century has had a negative, much less a catastrophic, impact on the global environment or economy.
- *Focus on the stocks of greenhouse gases, not the annual flows.* Taking action to minimally reduce greenhouse gas emissions today will do little to affect the stock of greenhouse gases in the atmosphere even 20 years from now. Any policy actions should focus on how they will affect the stock of gases at some future date.
- *Gather more information on possible outcomes.* Because outcomes are what we are really interested in, and because our confidence in what we know is what should trigger action, we need to further resolve our scientific understanding about the possible outcomes and the likelihood of those outcomes.
- *Increase RD&D as an option on mitigating a potential catastrophic outcome.* If a catastrophic outcome becomes evident, the global economy will have to produce large reductions in emissions quickly. No technological means are currently available to do this, but some research projects, such as hydrogen fuels and other alternative energy sources, appear promising. RD&D may generate large social benefits, and private investors will tend to underinvest in these activities. As a result, public investment in technologies to control greenhouse gas emissions may be a prudent policy alternative.
- *Delay implementing any market-based trading program.* The time is not ripe for trading greenhouse gas emission reductions, either internationally or within the United States. Markets require a specific set of conditions to operate smoothly and efficiently, as the Eastern European nations have discovered. The lack of adequate market institutions, the transaction costs inherent in these types of trades, and the risks that participants will inevitably perceive will create large barriers to creation of a successful market.

Chapter 3

Climate Change and Carbon Taxes

BY ROY E. CORDATO, PH.D.

I. Introduction

The United Nations summit, held in December 1997 in Kyoto, Japan, produced the Kyoto Protocol, a binding agreement committing developed countries to reduce their emissions of greenhouse gases which was signed by President Bill Clinton in November 1998. Were the Kyoto Protocol to be ratified by the United States Congress, the United States would be committed by the 2008–2012 timeframe to reduce its level of greenhouse gas emissions by seven percent from 1990 levels.

This is not a trivial reduction. Adding together the increased emissions since 1990, the emission increases that would have occurred in the "no-protocol" world, and the additional seven percent reductions called for in the protocol, the total required reduction in greenhouse gases is about 28 percent.[51] Achieving these levels would require large reductions in the nation's fuel use and prodigious efforts to extract more efficiency from the fuels we do consume. Even reducing the expected demand for fuel by 50 percent between now and 2010 would only gain us half the necessary reductions in greenhouse gas emissions.[52] Though a few analysts assert that such large reductions in fuel use and accelerated replacement of energy-using equipment can be done painlessly at the point of the consumer, or through permit-trading schemes (domestic or international), the majority of studies have found that such reductions would almost certainly have to be driven through steep new taxes on the use of fossil fuels, primarily coal and oil.[53] As discussed in the previous chapter, the problems with permit-trading systems are numerous and might well forestall their development, moving carbon taxation back to its formerly prominent position in the hierarchy of favored strategies by advocates of urgent action on climate change.

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[51] According to the US Department of Energy, estimated carbon dioxide emissions in 2010 without reduction efforts would total around 1,720 million tons. Seven percent below the US 1990 emission levels is about 1,237 million tons, a reduction from the "no-protocol" world of about 28 percent. Values based on Raymond Kopp, "Targets and Timetables: Getting out the Carbon" (Washington, D.C., Resources for the Future, Fall 1997), available at www.rff.org

[52] Kopp, Raymond, "How Tough Will it Be for the United States to Meet a Climate Target by 2010" (Washington, D.C., Resources for the Future, Fall 1997), available at www.rff.org

[53] For the purpose of this study (and indeed, for the sake of accuracy), the words "tax," or "taxes," will be used to characterize not only levies traditionally called "taxes," but also those levies economically equivalent to taxes, but called by other names, such as marketable permits, user-fees, etc. Where these taxes specifically target greenhouse gases, they will be called carbon taxes, since the universal unit of warming is based on the warming impact of carbon dioxide.

Greenhouse-gas reductions sufficient to forestall climate change will impose substantial economic and lifestyle impacts on most Americans. Most estimates suggest that in order for the United States to reduce carbon emissions to 1990 levels, a tax of at least $100-$200 per ton of CO_2 emissions would be needed.[54] The additional seven percent reductions called for by the Kyoto Protocol would, presumably, raise this cost proportionately. Such taxes would significantly increase the prices of heating oil, electricity, and gasoline.

Though it is well known that taxation discourages productive activity, it is argued that carbon taxes, being designed to remedy environmental problems, produce net social benefits by eliminating harms greater than those they inflict. This argument lacks merit: for reasons discussed below, deriving a carbon tax that is meaningfully linked to social and individual benefits either by reducing greenhouse gas concentrations or preventing climate change is not possible. In order for a carbon tax to be justified using a net-benefits rationale, it would have to be shown that the speculative future benefits from reducing the threat of global warming would outweigh the more certain present-day health and mortality effects of reduced economic growth. As chapter one of this study showed, such a justification is questionable.

II. A Tax That Will Make You Better Off?

A basic principle of economics is that if one wants less of something, one taxes it (if one wants more of something, one subsidizes it). Therefore, it is economically uncontroversial to argue that if the goal is strictly to reduce the amount of greenhouse gases in the atmosphere, a carbon tax that is set high enough will do the job.

On the other hand, it is another basic economic principle that taxation discourages productive activity. This effect becomes more pervasive when the activity or product being taxed (such as energy) is a basic input of other production processes. Any tax that would significantly increase the cost of energy production, under ordinary circumstances, would also have a significant negative effect on the production of everything else. Indeed, it is difficult to imagine any productive activity that does not involve the use of energy for heating, cooling, transportation, electricity, or some other element in the production chain.

But carbon taxes, and pollution taxes in general, are portrayed as an exception to the rule outlined above. Carbon tax supporters assert that carbon taxes will not only discourage the use of carbon-based fuels but will ultimately make us better off. That is, they will "generate net gains in overall social welfare."[55] Carbon tax advocates assert that: "*A properly set pollution tax generates net gains in overall social welfare from the environmental improvements it creates….justification for a carbon tax is that the benefits are worth the costs….*"[56] And, "*Unlike taxes that discourage economically beneficial activities….environmental charges [taxes] provide...economic gains*."[57]

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[54] WEFA Group and H. Zinger & Associates, "A Review of Economic Impacts of AOSIS-Type Proposals to Limit Carbon Dioxide Emissions" (Washington, D.C.: Global Climate Coalition, May 30, 1996), p. 3.

[55] Roger C. Dower and Mary Beth Zimmerman, *The Right Climate for Carbon Taxes: Creating Economic Incentives to Protect the Atmosphere* (Washington: D.C.: World Resources Institute, 1992), p. 13., and Robert Repetto, Roger Dower, Robin Jenkins, & Jacqueline Geoghegan, *Green Fees: How a Tax Shift Can Work For the Environment and the Economy* (Washington: D.C.: World Resources Institute, 1992), p. 9.

[56] Dower and Zimmerman, *The Right Climate for Carbon Taxes*, p. 13.

[57] Robert Repetto, et al., *Green Fees: How a Tax Shift Can Work For the Environment and the Economy*, p. 9.

In order to make this argument, pollution tax supporters invoke a "market failure" framework to argue that pollution taxes are exempt from the drawbacks of all other taxes. According to the market failure framework, when an otherwise productive and socially beneficial activity imposes costs on third parties, as is typically the case when there are problems of air and water pollution, markets operate inefficiently, or "fail" to allocate costs and benefits efficiently. Pollution costs of production in this framework are not borne by the consumers and producers of the product, but instead fall generally onto "society." In such cases, it is argued that the product in question is "underpriced" and "overproduced," because, if the producers were bearing all costs, including pollution costs, the price of the good or service would be higher and production/ consumption would be lower.

Elimination of the "overproduction" produces the net societal benefit in this framework, based on the assumption that if the extra quantity of the polluting product were not produced, additional resources would flow into the production of other things more highly valued by society. Ultimately, this viewpoint holds, the combination of this increased output of other, presumably nonpolluting products and the reduction in pollution would give rise to an overall increase in social well-being. In other words, architects of this framework assume that people will prefer the new allocation of resources along with the reduced pollution to the old allocation of resources, with the higher level of pollution.

Setting aside consideration of this speculative benefit, a fuel tax (like any other tax) would actually make some people worse off—those who would have to pay higher prices for the product—and others better off, those who would enjoy reduced levels of pollution. Even accepting the framework at face value reveals substantial, indeed insurmountable, methodological, conceptual, and implementation problems.

A. Global Warming, Social Costs, and Carbon Taxes

The economic case for carbon taxes is a direct application of the "market failure" pollution-tax theory.

As Harvard economist Robert Stavins and environmental consultant Bradley Whitehead claim, "*The higher prices would internalize the anticipated costs of climate change. This would reduce direct demand for fossil fuels [and] lead to a more appropriate mix of resources.*"[58] Presumably, if the future social costs of global warming could be quantified, then a tax could be devised that would require the producers and consumers of greenhouse-gas-generating fossil fuels to consider (internalize) these costs in their production and consumption decisions. This internalization would lead to a reduction in the use of these fuels and, consequently, a reduction in the future social costs of global warming. In addition, in the face of higher prices for oil and coal, use of non-greenhouse-gas-emitting methods of generating power (such as hydroelectric and solar power) would increase.[59] As noted by carbon-tax advocates Roger Dower and Mary

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[58] Robert Stavins and Bradley Whitehead, *The Greening of American Taxes: Pollution Charges and Environmental Protection* (Washington, D.C.: The Progressive Policy Institute, 1992), p. 18. In advocating carbon and other pollution taxes, Repetto, et al. (*Green Fees*, pp. 7–10) present this economic model in a very explicit manner, using graphical analysis found in most economic textbooks. However, they fail to mention two necessary, but wholly unrealistic, assumptions that are part of the textbook analysis. First, the particular inefficiency under consideration must be the only inefficiency in the entire economy and, second, the marginal utility of money must be constant and the same for everyone, i.e., all people in the economy would receive the same amount of satisfaction from an additional dollar added to their income. When these assumptions are absent, as is always the case in the real world, the proposed tax has none of the efficiency properties ascribed to it by its proponents. Typically, carbon-tax advocates do not mention these assumptions of the economic model when invoking it to justify their proposals. For an extensive theoretical discussion and explanation of these issues, see Roy E. Cordato, *Welfare Economics and Externalities in an Open Ended Universe*, (Boston: Kluwer Academic Publishers, 1992), pp. 1–10.

[59] Theoretically, this list should also include nuclear power, but the same interest groups that oppose the use of coal and oil also oppose the use of nuclear energy in the United States. Therefore, for political reasons, a carbon tax would probably not lead to an increase in the use of carbon free nuclear energy.

Beth Zimmerman "*[b]y increasing the price of fossil fuels to reflect their contribution to the risks of climate change, carbon taxes create an economic incentive for each source of CO_2 to seek out reduction alternatives.*"[60] According to carbon-tax proponents, the net effect of these changes would be an overall improvement in social welfare as compared to the allocation of resources without the carbon tax.

Though advocates of carbon taxes do cite some specifics in making their case, they acknowledge that the case for a particular level of tax necessarily lacks specifics. Dower and Zimmerman, for example, seem to endorse estimates suggesting that the social cost of future global warming caused by a doubling of CO_2 in the atmosphere will be between $60 billion and $117 billion annually, at a minimum. This estimate is approximately 1-2 percent of the United States's Gross Domestic Product.[61]

Currently, global warming theorists typically argue that, if left unchecked, the amount of atmospheric CO_2 will double by the year 2025, "although the resulting increase of temperatures would occur "decades later."[62] Presumably, then, these predicted economic losses, even if accurate, would not begin to occur, at least in full force, until sometime late in the 21st century. Nevertheless, these are the future global-warming related costs that the tax would allegedly allow the economy to avoid.

In addition, carbon tax proponents argue that the economy would benefit from inherently unspecifiable improvements in energy efficiency and investments in new low-emission technologies. Dower and Zimmerman, for example, suggest that, "*Investments in energy-efficient lighting, motors, and other appliances, for instance, can often generate savings in electricity demand at half the cost of developing new power plants.*"[63] The impetus for making such investments would come from an attempt to reduce energy costs given the higher post-tax price of oil and coal.[64] Furthermore, carbon tax advocates claim that the reduction in the use of fossil fuels would, as an additional benefit, lead to the reduction of other emissions besides CO_2, such as sulfur dioxide and nitrogen oxide and will reduce the incidence of oil spills and other problems associated with transporting fossil fuels. Finally, there are alleged to be national security benefits associated with reductions in the use of imported oil. The direct benefits from reducing the risks of global warming plus these associated indirect benefits would, presumably, outweigh the losses to the economy associated with the tax.

A tangential benefit of carbon taxes, usually cited as a reason for adopting carbon taxes rather than other methods of CO_2 abatement, relates to how the revenues from the tax are used. Many advocates of carbon taxes suggest that revenues from the tax could be used to reform the income tax system, reducing the tax burden on labor, investment, and capital formation. Dower and Zimmerman argue that "Carbon tax revenues can be used to shift the economic burden of our current tax to encourage investments in capital and labor."[65] Then, borrowing themes from supply-side economists, they point out that: "When the income from investment in new capital is taxed...less capital will be used to produce goods and services and...productivity

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[60] Dower and Zimmerman, *The Right Climate for Carbon Taxes*, p. 13.

[61] Dower and Zimmerman, *The Right Climate for Carbon Taxes*,. p. 10, quoting study by William Cline, *Global Warming: The Economic Stakes* (Washington, D.C.: The Institute for International Economics, 1992). For a more modest cost projection—0.5 percent GDP loss—see William D. Nordhaus, "Economic Approaches to Greenhouse Warming," in Dornbusch and Poterba, *Global Warming: Economic Policy Responses* (Cambrige, Massachusetts: MIT Press), 1991.

[62] William R. Cline, Comment on Schelling, "Economic Responses to Global Warming: Prospects for Cooperative Approaches" in Dornbusch and Poterba, *Global Warming: Economic Policy Responses*, p. 222.

[63] Dower and Zimmerman, *The Right Climate for Carbon Taxes*, p. 4.

[64] Ibid., p. 6.

[65] Ibid., p. 8.

will fall. The same is true of taxes on labor income....Because of this phenomenon, for every dollar raised in tax revenues, more than a dollar's worth of private production is lost."[66]

This is not an argument for carbon taxes per se. Rather, this potential tax-shifting option would be an advantage of carbon taxes when compared to other methods of CO_2 abatement, such as direct regulation or tradable permits, according to carbon tax proponents. But the advantages of tax reforms that reduce the income tax bias against investment activities and work effort could be achieved as an end in itself, rather than a means to a different end. Indeed, the benefits of such tax reforms are actually mitigated by combining them with a carbon tax. The advocates of carbon taxes are citing the advantages of reducing the tax burden on capital and labor and ascribing those advantages to the carbon tax. However, the positive impact of this type of tax reform would be even greater in the absence of an accompanying carbon tax. Any tax reform to accompany a carbon tax might offset some of the economic losses resulting from the carbon tax; but the benefits from higher productivity would count as a benefit of the tax reform itself, not of the carbon tax.

Though the economic theory that has undergirded proposals for a carbon tax is itself problematic, even more problematic are several fundamental implementation issues that, in essence, make it impossible to translate the theory into practice using anything but arbitrary tax calculations.

B. The Insurmountable Information Problem

Before one can begin to argue for a carbon tax using economic analysis, one must demonstrate that the buildup of greenhouse gases will indeed generate harmful effects on future generations, and one must be able to calculate the dollar costs of those long-term effects with some degree of accuracy. This requirement implies that two very broad scientific questions must be answered. First is whether or not an increase in greenhouse gases will indeed cause warming, and second is whether this warming, if it does occur, will be harmful, in what ways, and to what extent. The answer to these questions is beyond the scope of this chapter. However, even a brief literature review shows substantial uncertainty with regard to both of these questions.[67]

Indeed, almost no one proclaims that global warming and the extreme harms often attributed to it will occur with certainty. Even those who are the least skeptical and most strident in their support of the tax tend to hedge their bets. For example, pro-tax advocates from the World Resources Institute conclude that: "*Man-made emissions of carbon dioxide...**may** warm Earth's atmosphere*" and that "*risks are **potentially** large and diverse*"[68] (emphasis added). Such language also implies that warming may not occur and that, since the more definitive word "probably" was not used, risks are also "potentially" small or even zero. On the other side of the issue, representing a much greater degree of uncertainty are scientists such as Fred Singer of the Science and Environmental Policy Project and Virginia state climatologist Patrick Michaels,[69] who predict little or no warming, and even, possibly, a potential benefit from global warming.[70] *Science* magazine summarized the state of the science in May 1997 by noting that "*many climate experts caution that it is not at all clear yet that human activities have begun to warm the planet—or how bad greenhouse warming will be when it arrives*."[71]

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[66] Ibid.

[67] Kenneth Green, A Plain English Guide to the Science of Climate Change, Reason Public Policy Institute, Policy Study No. 237, December, 1997.

[68] Dower and Zimmerman, *The Right Climate for Carbon Taxes*, p. 3.

[69] See Patrick Michaels, *Sound And Fury* (Washington, D.C.: The Cato Institute, 1992).

[70] Fred Singer, "Trick of Treaty: An Energy Tax in Disguise," The Washington Times, July 1, 1997, p. A15.

[71] Richard Kerr, "Greenhouse Forecasting Still Cloudy," *Science*, Vol. 276, May 16, 1997, p. 1041.

Beyond the question of the inherent uncertainty of potential physical harms stemming from climate change, other uncertainties stand in the way of setting a meaningful carbon tax, beginning from its first premise: that benefits of a carbon tax must equal or exceed the costs being imposed on society per (additional) unit of greenhouse gas being eliminated.

As every economics student learns, only opportunity costs are relevant to economic analysis. Opportunity cost is the satisfaction that is foregone when making one choice rather than another; that is, it is satisfaction that is not realized. These opportunity costs are subjective, and therefore unmeasurable and speculative, even from the perspective of the individual making the choices. If a person faces a choice between going to the movies and going bowling, that person speculates about the satisfaction that would be received from each of the activities and then chooses the one that, according to those expectations, would be the most satisfying. If the trip to the movies is chosen, that individual never knows for sure whether the bowling would have been less satisfying, hence the speculative nature of opportunity costs.

The nature of opportunity costs has profound implications for setting the "proper" carbon tax because opportunity costs are subjective, unmeasurable, and unobservable by outside analysts. Consequently, the entire concept of social cost, as the sum of the opportunity costs experienced by the individuals that make up society, cannot be "operationalized" to determine any objectively based "appropriate" pollution tax.[72]

When considering the carbon tax and the costs of global warming, these calculation problems become even more profound, since the opportunity costs of global warming, should they arise, are to be experienced by future generations. The analyst would need to know the choices that will face individuals in future generations as a result of global-warming problems and how these individuals will value the opportunities that are foregone as a result of the choices that are actually made.

For example, imagine, in the year 2050, people living in an area that has become more susceptible to flooding because of global warming. In order to determine the opportunity costs of global warming to this group, the analyst, in 1997, would need to know how these individuals in the year 2050 would value the alternatives that they must forgo in order to deal with the additional risk of flooding. Imagine that people must pay more for flood insurance. The analyst-policy maker, *in 1997*, would need to know how these individuals, *in 2050*, would value the goods and services that would have been produced if they did not have to purchase the additional insurance. Furthermore, additional resources would go into the insurance industry: How will they use and invest those resources, and how will "society" value the results of this reallocation compared to a non-global warming scenario? Again, this information must be obtained in order to assess the opportunity costs of future global warming. Also, additional resources will flow into sand-bagging river banks or other activities such as reinforcing or building new dams for flood prevention. The true measurement of the opportunity costs of additional flooding caused by global warming would have to specify the value that people place, in terms of foregone satisfaction, on the output that would have been produced if these other activities were not pursued. To know this, the policy analyst operating in 1997 would have to know the subjective evaluations that future individuals would make regarding production that never occurs as a result of allocating resources to other uses.

The subjective nature of opportunity costs is one of several "calculation" obstacles that one faces in constructing a social welfare-enhancing carbon tax. Determining the costs of global warming would be a

72 It should be noted that in textbook, strictly theoretical explanations of pollution taxes, this problem is avoided by assumption. The textbook model assumes that the world conforms to what is called a perfectly competitive general equilibrium. This is a highly idealized and unrealistic state of the world in which, if all the conditions are met, it happens to be the case that the prices that people pay for things are also an accurate measure of opportunity costs. But the real world is never in general equilibrium. Outside of the laboratory conditions specified in the textbook model, the assumption of measurable opportunity costs cannot be sustained. Furthermore, it would be illogical for supporters of the carbon tax to assume that the world is in general equilibrium since such a world is, by definition, a world without externality problems.

necessary, albeit impossible, first step. Architects of a carbon tax would also have to show that abating those costs (the benefits of the tax) are worth the costs of abatement (the losses due to the tax). This simple-sounding project involves the use of information that only omniscience could provide, since the problem involves intergenerational comparisons of costs and benefits. Yet opportunity costs and benefits all relate to subjective evaluations made by specific individuals at a particular time and under particular circumstances. Thus, adding and subtracting costs and benefits across aggregated future individuals to come up with a measurement of "net social benefit" is highly problematic.

The task is further complicated when one acknowledges that reductions in present output imply reductions in future output. As one analyst has warned, "*Losses in real output from current [carbon] taxes are irreversible*."[73] This assertion means that, before any intergenerational cost-benefit analysis could be undertaken (assuming such an analysis could be made meaningful), it must be determined whether or not future generations will, on net, benefit from the carbon tax, even if the global warming costs are in fact reduced.

The cumulative effect of the tax implies a reduction in output for both current and future generations. The higher tax today will mean less investment and saving to fund future production activities. It would also mean that fewer resources in the present will be available for current research and development and for the funding of new entrepreneurial insights. All of this would reduce future growth over what it otherwise would be and, therefore, could make future generations materially worse off.

Thus, even if the global warming hypothesis is accurate and currently imposed carbon taxes would reduce or even eliminate the impacts of future global warming, global warming advocates must show that future generations would value those impact reductions over the lost output that would result from the cumulative effect of the tax. In other words, it is quite possible that future generations might be more than happy to deal with expected global warming problems if these problems are coupled with an overall higher standard of living.

The ramifications of this circumstance, though, go well beyond losses in economic growth. Macroeconomic analysis of the impact of the tax gives us numbers. But these numbers have human consequences which, when recognized, highlight in graphic terms the impossibility of calculating the efficient tax.

In recent years, a number of studies in the field of risk analysis examined the impact of changes in economic variables, such as an individual's employment status or the level of personal income, and the mortality rate. These studies show a significant link between these economic variables and the death rate or one's expected life span.[74] Combining the insights of these studies and the results of analyses examining the economic losses that are likely to occur if a carbon tax is imposed sheds light on the human costs of a carbon tax and the conceptual difficulty of accurately calculating such a tax to offset costs with benefits in the way proposed by carbon tax proponents.

Carbon-tax advocates must ultimately invoke what Nobel laureate economist F.A. Hayek has referred to as "the pretence of knowledge."[75] They "pretend," in abstract economic models, to have knowledge that cannot be obtained. One must have knowledge of:

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73 Dornbusch and Poterba, *Global Warming: Economic Policy Responses.*

74 Aaron Wildavsky, "Richer is Safer," *The Public Interest*, vol. 60, pp. 23–29; William Kip Viscusi, "Mortality Effects of Regulatory Costs and Policy Evaluation Criteria," *Rand Journal of Economics*, vol. 25, 1994, pp. 94–109; Ralph L. Keeney, "Estimating Fatalities Induced by the Economic Cost of Regulations," Journal of Risk and Uncertainty, Vol. 14, 1997, pp 5–23.

75 F.A. Hayek. "The Pretence of Knowledge," Nobel Memorial Lecture, delivered in Stockholm, December 11, 1974, reprinted in *The Essence of Hayek* (Stanford, Cal.: Stanford University Press, 1984), pp. 266–277.

- The variety of goods and services that would be produced into the indefinite future, both in the presence of the tax (fewer goods and services but reduced risk from global warming-related problems) and in the absence of the tax (more goods and services but greater risk from global warming) by people who are both not yet born and, as noted, never will be born; and
- How people living in these present and future worlds would value the alternative production possibilities.

In other words, analysts must have knowledge of both actual and potential, present and future resource scarcities, entrepreneurial insights and technological developments, and individual tastes and preferences. A host of "estimates" regarding the optimal carbon tax may be generated. However, unless they have incorporated the information discussed, they cannot specify the net effect of a carbon tax on social welfare.

Advocates of carbon taxes, to some degree, recognize these problems. For example, World Resources Institute's Roger Dower and Mary Beth Zimmerman state that: "*the ideal tax rate is...notoriously difficult to find, especially for benefits that may be many generations in the future or for situations in which the science or relative risks are not completely understood. This number cannot be calculated until...the environmental and economic impacts or injuries associated with the warming are assessed, and until a dollar value is placed on the estimated damages...researchers simply don't know enough yet to perform the initial calculations*."[76]

While not acknowledging the full scope of the problem as discussed above, these authors admit that they do not have enough information to perform even initial calculations. While admitting the problems involved, the WRI analysts nonetheless cite specific numbers: the study assigns a value of $27 billion to these costs. Dower and Zimmerman conclude that the "lack of formal data" should "not stop the development of programs to reduce risk."[77] However, they fail to show how such programs can realistically be implemented when formal data about the risks do not exist.

C. Compounding the Harm

With the uncertainties surrounding the science of global warming, a real danger is that a carbon tax, if implemented, could ultimately amount to a very costly mistake. As MIT economist James Poterba warns, "it is important to avoid substantial...losses today in pursuit of uncertain future benefits."[78]

A carbon tax in the face of no global warming problem would amount to a net loss for the population at large. However, it could generate benefits for government and certain industries. According to Poterba's study, "carbon taxes have the potential to generate substantial revenues...[for the U.S.] a $100/ton [1988 dollars] carbon tax would raise revenues of more than 3 percent of GNP."[79] In other words, the (minimal) $100 tax referred to, would establish government control over the allocation of an additional 3 percent of the nation's output. As Dower and Zimmerman point out, "*the large revenue streams generated by a carbon tax can have economic effects much larger than those triggered by changes in relative prices.*"[80]

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76 Dower and Zimmerman, *The Right Climate for Carbon Taxes*, p. 10.

77 Ibid., p. 10–11.

78 Dornbusch and Poterba, *Global Warming: Economic Policy Responses*, p. 94.

79 Ibid., p. 75–77.

80 Dower and Zimmerman, *The Right Climate for Carbon Taxes*, p. 15.

While the WRI authors see these new revenues as a benefit, others should be concerned about the economic and personal implications of such a large transfer of wealth to the public sector.

The direct transfer of wealth would be allocated to agencies and employees within the government and to special interests in the private sector. This transfer would probably include industries producing or otherwise advancing non-carbon-based forms of energy such as solar, wind, and hydroelectric power, as well as to low-carbon fossil fuels such as natural gas. But the cost to the private sector goes beyond the direct revenue transfers, to include dead-weight economic losses, implying that the overall level of economic well-being will be reduced. These losses are in addition to reductions in GDP caused by the higher cost of energy. These dead-weight losses result from the transfer of revenues from the more-efficient private markets to the less-efficient public sector. This transfer will reduce the efficiency with which resources are used and therefore will reduce economic productivity. While revenues in the private sector are allocated based on consumer wants and actual resource scarcities, government-sector revenue allocation is influenced by political considerations. As WRI's Dower and Zimmerman acknowledge, "*how tax revenues are allocated...is a political call*."[81]

This transfer of revenues from the private to the public sector, then, would reduce overall output in the economy and enhance the scope and resources of the government. Carbon-tax advocates already argue that revenues from the tax should be used to expand existing government-spending programs and to start several new programs theoretically designed to help those who might be harmed by the tax. For low-income and poor people, some tax proponents have suggested that carbon-tax revenues be used to expand the Earned Income Tax Credit and increase food stamp benefits, the Supplemental Security Income Program, the Low Income Weatherization Assistance Program, and the Low Income Energy Assistance Program.[82] Furthermore, new programs are envisioned to compensate coal-producing states for their losses. For example, some carbon-tax proponents suggest that federal block-grant programs be established for states, based on the amount of losses that they will suffer from the tax. Revenues from the carbon tax would be used to establish new spending programs to create enterprise zones, job training and relocation programs, and early retirement programs.[83] In spite of some discussions calling for coupling new carbon taxes with decreases in other forms of taxation, a carbon tax would most likely result in increases in public spending on new and existing programs.

A carbon tax also introduces top-down planning of energy markets. Thus, a significant consequence of the tax is to reduce private consumption and investment choices. Since energy usage is part of almost every choice we make, from where we live and work to how and where we travel, the increase in the prices of heating, cooling, electricity, and gasoline caused by the tax would translate into significant constraints on many lifestyle decisions.[84]

For some tax advocates, this result of the tax is part of its purpose. In arguing for the tax, some have viewed a reduction in lifestyle choices as an ethically positive aspect of carbon taxes, in the same way that the freedom-restricting aspects of an alcohol tax might be viewed as a "moral good" by prohibitionists. Some prominent advocates of carbon taxes are concerned about post-World War II prosperity that spawned a baby boom generation overly focused on buying "*cars, houses, boats, and closets and garages full of high-tech gadgetry*."[85] Such consumption is seen as directly conflicting with a new ecological ethic that would lead to

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81 Ibid., p. 1.

82 Ibid., p. 26.

83 Ibid., p. 28.

84 WEFA, Inc. Global Warming: *The Economic Cost of Early Action*, Eddystone, PA., WEFA, Inc.

85 Francesca Lyman, *The Green House Trap* (Washington, D.C.: World Resources Institute, 1990).

a society with new "technology that [is] largely small scale, inexpensive, accessible, compatible with human needs, and ecologically responsible."[86]

In this sense, carbon taxes should not only be viewed as economic or environmental policy, but as an attempt to legislate new lifestyles and changes in traditional American ethical principles that emphasized personal responsibility and the right to pursue one's own happiness. Thus, part of the case against carbon taxes is that they conflict with the fundamental ethical principles that guide decisionmaking in a free society.

III. Conclusion

Carbon taxes, a climate change strategy that waits in the wings pending the probable failure to successfully implement permit-trading programs, cannot be justified on the basis of economic theory or as a way of unambiguously enhancing societal well-being. Indeed, many of the issues raised here have been recognized by carbon-tax advocates. For example, one study that tries to assess the social costs of global warming generated by automobiles candidly states that "*it is not possible to accurately estimate the actual costs of the current buildup of greenhouse gases.*"[87]

Calculation of the "correct tax"—a tax that would actually lead to an increase in social welfare and not just reduce greenhouse gas concentrations—would require information that is not only difficult to obtain but in large part conceptually impossible to specify.[88] Variables that would need to be specified, but can't, include virtually every economically relevant measure of the social costs of global warming:

- The costs forgone by the prevention of unspecifiable climate changes;
- The value systems of present and future generations;
- The extent to which carbon taxes introduce new health risks reduce prosperity; and
- The risks of allowing central planning of energy production.

This fundamental information problem plagues every variable that must be considered in constructing the tax. Ultimately, while a host of cost-benefit analyses may be undertaken and hypothetical numbers may be presented, any carbon tax purporting to be an application of the economic theory presented above will necessarily be arbitrary.

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86 Ibid., p. 151.

87 James MacKenzie, Roger Dower, and Donald Chen, *The Going Rate: What it Really Costs to Drive* (Washington, D.C.: World Resources Institute, 1992), p. 14.

88 The textbook assumptions mentioned in footnote 8 are what allow these problems to be ignored outside of a real world public policy setting, i.e., in the "laboratory."

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