Micromotives in global environmental policy

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Abstract
Protecting ourselves cost-effectively from global environmental threats like climate change requires a good understanding of the behavioral underpinnings that drive choice under risk and uncertainty, lead to the design of efficient and effective protocol for cooperative action across nations, and create incentives for different control strategies within nations. Researchers can use experimental economic methods to gain insight into these micromotives of climate policy by testing the robustness of theoretical predictions, and by recognizing new patterns of choice. This paper discusses how experiments can be used to sharpen the best guesses guiding policy by identifying how decision makers can try to get more environmental progress at less cost by accounting for the relevant determinants of behavior.

Do economists who run small experiments in the lab have anything to say about big environmental policy in the wilds? This question stuck in my mind throughout my 1997 turn as a senior economist for environmental policy at the Council of Economic Advisers (CEA) in the White House. After spending a decade using the lab to better understand the micromotives that underpin the theory of environmental economics, I had the opportunity to think about the efficiency and fairness of global environmental policy. By micromotives, I mean the desire to avoid risk, to smooth over or create conflicts, to cooperate, to control the destructive actions of others, and to evaluate one's actual demand for environmental protection. I wondered whether the lessons I learned in the lab about these motives would help me reason through the political economy of the volatile policy debates in Washington, D.C. on clean air, endangered species, toxic waste clean-up, biodiversity, risks to children, and climate change.

Let me first explain what experimental economists mean by "the lab." Economists run experiments in a lab just like a chemistry or physics laboratory, except we substitute test tubes and particle accelerators for experimental instructions and networked computers programmed to create interactive markets, strategic games, and individual choices. By last count, over 100 labs around the world are dedicated to the study of experimental economics. Experimentalists recruit both students and non-students to participate to these labs to test the boundaries of theory and to explore new phenomenon that can arise in human choices made within and outside of exchange institutions like competitive markets.

Joining the CEA, I believed the lessons taught by experimental economists could help guide global environmental policy by providing insight into how a proposed change in incentives or benefits might affect behavior, and consequently, the likely success of a policy. By supplying information on the behavioral link between incentives, values, and choice, experiments might affect, somewhat, how policy was formed and evaluated. I also knew that since the lab environment differs from the wilds by necessity, experimental data used to back stated positions of policy should be viewed as support for or against a specific case of a more general phenomenon or theory. Experimental evidence complements theoretical insight, field data, and simulation models to improve our understanding of the underlying assumptions and incentives that drive behavioral responses to policy.

I was also prepared for skeptics who would reject lab-based counsel with the complaint that environmental issues are too complex to be captured in an experiment. Relying on Smith [1982] and Plott [1987, 1989, 1994] as a foundation, I had two retorts ready. First, a general theory of environmental policy should work in a specific case. If not, its general validity is questionable, which means one should question its applicability to the more complicated world. One could shift the burden of proof back onto a proponent of a general theory of global policy by arguing that if it did not hold up in a specific case, it might not apply in other cases. For example, the theory that people will adopt costly technologies that promote long term energy efficiency without a change in the relative price of energy is not supported in lab experiments—normal people have a high discount rate that shrinks future net benefits.

Second, complexity is often argued to hamstring experimental methods because on cannot capture all the needed interactions and feedback loops in the lab. But one can counter that complexity is not an argument against experiments as an informationgenerating tool; it is an argument for thinking about policy in situations in which the complexity of the question gradually increases to allow one to isolate and control the factors that affect the validity of the theory. The insight from lab experiments comes from the using control and repetition to understand how additional complications can affect behavior.

If that reasoning did not work with proponents of economic-lite environmental policy, I was prepared to offer the technical olive leaf that "I am really not so different" by pointing out that natural scientists and experimental economists have a lot in common. While economics has traditionally devoted most of its effort to theory and empirical work based on field data, it commonly uses controlled experimentation today, just as do such natural sciences as biology and ecology. We run experiments just like the people on whom environmentalists often rely to make their cases for more environmental protection [Shogren and Nowell, 1991].

But none of this came to pass. Lab experiments rarely came up. Instead, I used the experimental literature as my collective backbone to help me sort through the daily grind of macro integrated modeling assessments and wishful thinking of technological optimists that dominates global environmental policy. I trusted the experimentalists' discipline to identify and explain the many critical micromotive questions at work within the nexus of institutions, endowments, and behavior. Based on their research, social scientists have improved our understanding, for instance, on how people misjudge risk and how institutions can either attenuate or accelerate these misjudgments; how markets for pollution can really cut costs, and how institutional friction limits the gains; how people reveal values for environmental protection, and how auction mechanisms can affect the demand for new technologies. Their insight from four decades of observing and evaluating choice and judgment sharpened my judgments about latent incentives and subsequent arguments about policy.

Given this foundation and the experience gained in the policy debates, I remain convinced that big questions do not always need big science. While aware of the perils of false parallelism, I now have greater appreciation for the lab work detailing how and why the interactions between institutions and behavior matter. The lessons from the lab matter, even if they are less direct than expected. In this paper, I explore how lab experiments affected my thinking about the behavioral underpinnings of global environmental policy. I believe that micromotives affect global environmental policy because our choices shape nature just as nature shapes our choices. Policies that artificially separate natural from behavioral phenomena often generate biased predictions and can ultimately be self-defeating. Evidence from the lab helps define the micromotives the underlie how people react to and protect themselves from risk, create and avoid conflict, search for opportunities to cooperate, codify rules of control, and value environmental resources—key areas that frame the political economic debate in environmental policy [Shogren 1993].

A Briefing on Climate Change

Imagine an invisible quilt covering the earth. Its warmth allows us to grow food, build shelter, and clothe ourselves. But we may face a problem. Scientists warn that our daily actions could adversely affect the global climate: developing land, raising livestock, and burning fossil fuels are disrupting the planet's climate—and the consequences are global and potentially devastating. They warn of increased flooding, spreading tropical diseases, shifting gulf streams, and reduced agriculture productivity [Schelling 1992; IPCC 1996].

Their argument is based on two observed trends. First, the Earth has warmed 0.5 degree Celsius, or one degree Fahrenheit, over the past 100 years. Second, atmospheric concentrations of greenhouse gases (GHG) have increased by about 30 percent over the last 200 years. Concentrations of greenhouse gases depend on the long-term profile of emissions – changes in any one year emissions have a trivial effect on overall concentration levels. Significant reductions in emissions made today would not substantially affect concentrations for decades or longer. A connection between these two trends of higher temperatures and GHG concentrations has been suggested, and the United Nations' Intergovernmental Panel on Climate Change [IPCC 1996b] concluded with the now well-worn quote: "the balance of evidence suggests that there is a discernible human influence on global climate." As a result, many now scientists advocate a worldwide reduction in greenhouse gas emissions from fossil fuel use.

Climate change is a global environmental risk because cumulative GHG concentrations are a global public bad—a ton of GHG released in Centennial, Wyoming has the same effect on the climate as a ton released in Umeå, Sweden. In addition, risks are determined by the GHG concentrations that accumulate over the decades rather than the annual level of emissions. Climate protection requires global participation in long-run emission reductions. Attempts to form an international climate change agreement crested in Kyoto, Japan in 1997 when over 150 nations met at the Third Conference of the Parties to the United Nations Framework Convention on Climate Change [Schelling 1997].

The Kyoto protocol was important because 55 nations drafted a "binding" protocol that committed the signatories to hit differentiated, sub-1990-level targets for GHG emissions within the next decade. Developed nations essentially agreed to make major changes in energy use, technology, and consumption patterns. To reduce the potential costs of meeting these targets, the protocol also included the option that nations could use flexible economic incentive schemes. Nations could use tradable emission markets and bilateral agreements that would allow developed nations to buy "greenhouse gas permits" from developing nations. Each nation would issue these permits to private actors in an amount equal to some national limit on greenhouse gas emissions, like the target in the Kyoto Protocol. The permits can be freely bought and sold, and their price creates incentives for emissions abatement similar to a tax on GHG emissions. Developed nations with their relatively large cost to reduce emissions domestically given their current capital stocks would buy permits that represent emission reductions in developing nations. These permits reflect the GHG savings generated from a new project relative to an estimated baseline of business as usual [CEA 1998]. Details of how emissions trading would actually work were not specified in the Kyoto protocol, and have yet to be defined.

The Kyoto protocol and the more recent Conference of Parties [COP6] at The Hague in November 2000 have failed to deliver several of the big players. The protocol did not include such developing nations as China and India, which are predicted to be the major GHG emitters by the middle of this century. Although nations at Kyoto clearly recognized that the source of climate change is widespread (fossil fuels) and that responsibility to reduce risk should be widely shared, the incentives do not work in that direction. But the paradox of international agreements is that a self-enforcing agreement is easiest to make when the stakes are small or, at the other extreme, when no other option exists. Nations have a common interest in responding to the risk of climate change, yet many are reluctant to reduce greenhouse gases voluntarily, and no global police force exists to enforce an agreement. An agreement must be voluntary and self-enforcing —sovereign nations must have no incentive to deviate unilaterally [Barrett 1994].

Widespread responsibility increases the difficulty of creating a stable agreement because nations have an incentive to take a free ride on the actions of other nations. The difficulty is compounded by national differences in income, vulnerability to climate change, and capacities to respond and adapt to risk [Mendelsohn and Neumann 1999; Kane and Shogren, 2000]. These national differences also impact the projected estimates of the benefits and costs of Kyoto climate based on macro-integrated assessment models vary. Some researchers suggest the developed nations like the US could meet its target at negligible or modest cost; others, however, call Kyoto an economic disarmament; and still others fall in between [Shogren 1999]. The range of estimates depends on several key factors—the inclusion of developing nations like China and India, the ability to use cost-effective economic incentives to reduce costs, and the diffusion of new energy-efficient technologies. The costs of climate protection will ultimately depend on how quickly and broadly a nation revamps its fossil-fuel driven capital stock toward energy sources like nuclear, and solar, which emit fewer GHGs.

Both the Clinton and Bush administrations recognize that the potential restrictions from Kyoto could affect everyone, and the scope of the potential response – a break from fossil fuels is impressive. The unknown magnitude and distribution of such impacts has and continues to provide fodder for testy negotiations about who should take action and when, and who should bear the costs. As a consequence, the Bush Administration has recently pulled back from the Kyoto protocol, citing a recommitment to "common sense and sound economics" [Hubbard 2001]. The new administration wants to revisit Kyoto by stressing greater market incentives for technological innovation, greater global participation, and more measured policy changes. The retreat from Kyoto also recognizes the political reality that the US Senate in 1997 voted 95-0 for the non-binding Byrd-Hagel resolution that the body would not ratify a climate treaty that did not include the developing nations like China [Shogren and Toman 2000].

This reconsideration by the US about who and how climate protection should proceed beyond 2001 leaves an opening to use information gleaned from the lab to inform the policy debate. Although generalizing beyond the lab is dangerous, experiments that improve our understanding of the micromotives at work in climate change policy can help policymakers to guess the likely reactions to alternative protection options. Consider first how people react to risk from environmental threats.

Environmental Risk

Questions of risk underlie the climate policy debate, and any policy prescription will not eliminate these risks completely—they will only create a new distribution or "environmental lottery" of gains and losses. Climate change poses many threats to society, some minor and some major. Climate modelers often presume that the effects of climate change will come about as temperature or precipitation slowly and steadily increase. But other researchers, policymakers, and politicians warn that a presumption of gradual change ignores the real risk—the risk of catastrophe and surprise. They raise the specter of the sudden rupture, such as structural changes in ocean currents as the Gulf Stream, the melting of the western Antarctic ice sheet, an unraveling of the web of life as some keystone species die off, or environmental refugees fleeing starvation. But these risks are not as clear-cut as the rhetoric suggests. Some point to El Niño—a disruption of the ocean-atmosphere system in the tropical Pacific—as an example of the damages one might expect with climate change [Eizenstat, 1998]. But according to the Federal Emergency Management Agency (FEMA), the El Niño winter of 1997-1998 was no costlier than the previous two winters in the US—$289 million in 1997-1998 as compared to $294 million in 1996-1997 and $280 million in 1995-1996 [Shogren, 1999].

Whether founded on science or political scare tactics, fears of catastrophe and our limits on reaction time ultimately frame the debate over climate protection. Tell normal people that the stream of warm air that keeps much of North America and northern Europe habitable may shift, and many become frightened to take climate risks seriously, even if the probability of this shift is low or unknown. This is because, relative to our standard *homo economicus* benchmark—expected utility maximization—people are spooked easily when confronted with risk, especially the risk of the these catastrophic, low-probability events that surround climate change.

When the outcome is potentially very bad, experience tells us little about low-probability risks. Many experimental studies of risk perception reveal that people overreact to risk, and commonly overestimate the chance that they will suffer from a risk with low odds and high damage, for example, a nuclear power accident [Viscusi 1992]. People who have low odds of confronting a catastrophe often seek information to help them judge the likelihood that a bad event will actually occur. If the source of that outside information stresses severity without giving some notion of the odds, people tend to bias their risk perceptions upward. Even policymakers are not immune to this tendency [Viscusi and Hamilton 1999]. Thoughtful people dealing with risk have tendency to be conservative. They follow the old saying "plan for the worst, hope for the best" rather than balancing the costs and benefits of alternative options.

In fact, laboratory experiments reveal that behavioral anomalies abound when people confront risk similar to climate change. Classic examples include (1) inconsistent preferences when choosing between gambles [Allais 1953], (2) extra aversion to risks that have ambiguous probabilities [Ellsberg 1961], and (3) an systematic discrepancy between choosing and valuing alternative gambles, i.e., the so-called preference reversal phenomenon [Lichtenstein and Slovic 1971]. These anomalies are relevant to establishing rational policy on climate risk because they threaten the validity of the cost-benefit estimates economists use to evaluate alternate protection strategies. Tversky and Kahneman [1986], Dawes [1988], Thaler [1992], and Camerer [1995] write about risky choices and associated anomalies.

First, expected utility theory is the cornerstone of modern decision making under risk, and consequently the cost-benefit analysis of climate protection. The theory presumes that people are fairly sophisticated such that they can evaluate both old an new gambles consistently. Allais [1953], however, revealed people routinely violate this presumption of rationality. In particular, people seem to not follow the so-called *independence axiom* used to construct expected-utility theory. According to the independence axiom, a person's choices should not be unduly affected by unrelated information. Formally, if a person prefers lottery *A* to lottery *B*, that person prefers the combination $aA + (1 - a)Z$ to $aB + (1 - a)Z$ for all $a > 0$ and *Z*. Intuitively, the independence axiom says that a person's choice between two gambles depends only on the states of nature in which those gambles yield different results.

Allais provided the first counterexample to expected utility theory with the following two pairs of choices:

(A) A 100 percent chance of $1 million

versus

(B) A 10 percent chance of $5 million,
A 89 percent chance of $1 million, and
A 1 percent chance if zero dollars.

and

(C) A 10 percent chance of $5 million, and
A 90 percent chance if zero dollars

versus

(D) A 11 percent chance of $1 million, and
A 89 percent chance if zero dollars.

Allais first asked people to compare and choose their preferred lottery, either A or B. Next Allais had each person choose his or her preferred lottery, either C or D. If the independence axiom holds, a person who selected A—the safer bet, he should then pick D (or, if his first choice was B, his second choice should be C). To be consistent, a person who prefers a certain $1 million (A) to a 10 percent chance to win $5 million (B), should also prefer the 11 percent chance of $1 million (D) to the 10 percent chance of $5 million (C). But among his subjects, Allais observed most chose A and C. People like certainty but they are willing to give up one percentage point to go for $5 million prize. One percentage point appears to be a cheap price for a chance at $4 million extra dollars. Many other studies have since replicated Allais findings.

The problem the Allais paradox raises for climate policy is that cost-benefit analysis based on expected utility theory might be context-dependent rather than the unbiased measure researchers presume. This means an estimate of net benefits could depend more on how the question of climate protection was asked, or "framed" rather than the question itself. This suggests that one can create any degree of support for or antagonism against a particular climate protection depending on the gambles considered. Inconsistent estimates of net benefits based on expected utility theory suggests that either the behavioral model must be expanded to include likely explanations of the Allais paradox or one must qualify any estimate as incomplete from a behavioral perspective.

Second, Ellsberg [1961] raised a second challenge to expected utility theory. He demonstrated that people will irrationally avoid a risk when it has ambiguous probabilities. Ellsberg obtain his results by asking people to choose between two probability distributions in a lottery, one of which was known and the other was ambiguous. People usually chose the known distribution even though the ambiguous distribution had a higher expected utility**.** The Ellsberg paradox suggests most people will usually avoid the ambiguous risk.

Consider the following example. Two urns contain a large number of red and black balls. Urn A is known to contain 50 red balls and 50 black balls. Urn B contains red and black balls in unknown proportions. Suppose a person wins $100 if we draw the color ball of her choice from of the urns. Which urn do most people select to draw from?

Most people prefer Urn A with known odds to Urn B with ambiguous odds, even though they do not care whether they go for a red ball or a black ball in Urn B. This indifference suggests that their subjective odds are 50:50 in the ambiguous Urn B, the same as the objective odds in Urn B. This violates expected utility theory in that the decision weights assigned to different states of the world should be independent of the origin of the uncertainty. People will pay a premium to avoid participating in such ambiguous lotteries.

Irrational aversion to ambiguity is especially relevant for climate change risk, which is as vague as risk gets. Researchers do not have any reasonable estimates of the odds that potential catastrophes will come to pass. The most researchers usually say is that the odds that severe events will come to pass are "uncertain" [Barron 1995]. The basic urge to avoid such ambiguous climate risk puts pressure on policymakers to do something now, which can be costly because strategies that are more cost-effective may take longer to implement. Fear of ambiguous risk, however, makes these cost-effective plans politically hard to implement because some people will pay more to reduce the ambiguity now.

Third, climate change policy uses information on people's preferences for reduced risks to life and limb, also called the "value of statistical life" [Shogren et al. 1994]. A rational person makes consistent choices—the lottery he prefers is the lottery he values the most. But evidence from the lab suggests that people are not so consistent in their preferences for risk reduction. People reverse their preferences when their ranking of two lotteries differs from the selling prices they assign to the lotteries. Many researchers have documented the phenomenon; these studies include tests of real gamblers in Las Vegas and retests by skeptical economists [Grether and Plott 1979].

To induce preference reversals, researchers commonly present people with some variation of the following pair of bets and asks them to choose one bet out of the pair:

P-bet: p chance of $X , and
1-p chance of $x

$-bet: q chance of $Y, and
1-q chance of $y

where X > x, Y > y, p > q, and Y > X. They then ask each person to value each bet by stating the maximum (minimum) he or she was willing to pay (accept) to buy (sell) the bet. A specific gamble is:

P-bet: 35/36 chances to win $4 and 1/36 chance to lose $1
(expected value $3.86)

$-bet: 11/36 chances to win $16 and 25/36 chances to lose $1.50
(expected value $3.85)

According to expected utility theory, people will choose the bet with the greatest stated value. But many people violated this prediction by choosing the P-bet and assigning a greater value to the $-bet.

One explanation of preference reversals is that people do not think about odds and consequences simultaneously as expected utility requires. Rather people often seem to separate the two elements and make their decision based on the most attractive element—either certain odds or a big prize [Machina 1987; Slovic and Lichtenstein 1968; March and Shapira 1987]. People seem to use this heuristic to simplify their choices. They separate probability and consequences, and then focus their attention on one element first and then the other. When a player fails to frame the choice problem comprehensively as expected utility presumes, his or her view on the relative importance of probability and consequences will affect the decision [Edwards 1953].

People who believe consequences eclipse probabilities focus on avoiding the severity of the bad state while neglecting or discounting the odds it will come to pass. In other choices, people focus on the odds first and then the outcomes, again leading to choices different from the rationality predicted by expected utility theory. Such behavior forces economists to appreciated that their presumption that people make rational choices could bias climate change policy. If people generally make choices that deviate from predicted rational actions, the cost-benefit estimates based on these models are suspect, as are the choices based on these estimates of net impacts.

Preference reversals should matter to those setting climate change policy. If researchers who want to estimate the benefits of climate protection ask people what they are willing to pay to decrease the risk of climate change, and people state values for this risk reduction that are inconsistent with their underlying preferences, researchers obtain no useful information with which to judge the benefits of alternate climate policies. If values are context specific such that they change with the policy, we cannot compare two climate policies using risk-benefit analysis because it would be like comparing apples and oranges. Economists cannot rely on standard risk-benefit analysis to guide policy if people's values always depend on the context [Irwin et al. 1993].

These three anomalies are powerful reminders that people sometimes behave in ways rational choice theory does not predict. While one might conclude that rational climate protection policy might just be a pipedream, we have to remember that the concept of *rationality* in economics is a social construct not an individual phenomenon [Smith 1991]. Markets create rationality in the population by putting a cost on irrational behavior [Arrow 1987; Becker 1962; Gode and Sunder 1993]. Evidence from the lab shows that behavioral anomalies often fade away when people make similar choices within active exchange institutions that punish inconsistent behavior through arbitrage. People in markets have a reason to be rational because rationality pays; people outside markets can afford to be irrational because others do not exploit their choices [Baik et al. 1999; Camerer 1987; Chu and Chu 1990; Cox and Grether 1996; Evans 1997; Shogren 1997; Van Huyck et al. 1994].

In evaluating climate risks, people confront choices affected by market arbitrage, and other choices that are not. An interesting question that researchers can address in the lab is whether the rationality induced by arbitrage in a market spills over to choices in a nonmarket setting? If so, rational choice theory is a reasonable guide for climate policy. Cherry, Crocker, and Shogren [2000] design a laboratory experiment and showed that rationality spillovers exist—the rationality induced in a market can transfer to decisions outside the market. These spillovers remained robust even when people faced hypothetical and environmental choices. In addition, people did not change their preference ordering; rather they revised their stated values downward for low-probability, high-severity lotteries. The observation that preferences remain stable and stated values drop with market experience suggests that rational choice theory is not undercut by erratic first principles. Rational people start by trying to sell high and buy low.

In sum, these findings from lab experiments about rational choice under risk within alternative institutional arrangements helped me to prepare for the debate over climate protection. First, expected utility theory might be too thin to explain many aspects of behavior under risk. For instance, people seem to simplify their decisions by separating the probability of risk from the outcomes, which goes against the presumption that people can deal with both odds and outcomes simultaneously. Economists can inform people that politicians and policymakers who stress severity over the odds of climate catastrophe generally endorse costly immediate protection measures. Second, expected utility does better within a market context. And if one views preserving the existing climate as a hedge against uncertainty (that is, planet insurance), markets serves two roles for understanding risky choices—the more well-known role of providing the flexibility to hit a target at fewer costs, and the less appreciated role of modifying overreactions to low-probability risks. Third, since dealing with risks from climate threats requires choices in both inside and outside markets, rationality spillovers suggest that the presumption of rationality in nonmarket questions might still be a reasonable guide for policy decisions.

Finally, understanding the degree of alarmist reaction to ambiguous probabilities of catastrophe remains an important area for future research. Researchers will need to continue to explore and redefine the boundaries of rationality under unclear odds. Their insights into whether market and nonmarket choices affect each other, how they do so, and when can help us to develop sound models to guide climate policy. The results of future laboratory experiments will further refine our thinking about when we should presume that rationality works in helping us to manage risk and when we should presume that it does not.

Environmental Cooperation

Good climate policy is only as effective as the coverage and stability of an international agreement that unites nations with common purposes. While the nations that negotiated the Kyoto protocol made progress in many areas (for example, emission targets and emission trading), they failed in one key task, persuading developing nations to sign on. Developing nations have many pressing needs now other than climate protection, such as supplying potable water and stable food supplies, and they have fewer financial and technical resources to mitigate and adapt to climate change. They have little incentive to sign an agreement they see as imposing unacceptable costs on them. A Chinese delegate captured the sentiment underlying the opposition: "What they (developed nations) are doing is luxury emissions, what we are doing is survival emissions."

Developing nations are unwilling to negotiate if they think they will end up committed to a bad deal. Rather their motivation to engage in negotiations could be affect by protocol that allows them to invent ideas that will improve everyone’s well-being, such as the promise of side-payments through financial or low-cost technical assistance [Susskind, Levy, and Thomas-Larmer 2000]. Until nations jointly define such protocols, the establishment of an international climate policy remains shaky and emissions will continue to flow at what many see as unacceptable levels.

When delay is costly, understanding the behavioral foundations of effective bargaining protocol seems worthwhile. The bargaining literature, both the theoretical and experimental, is enormous—maybe the most explored area in experimental economics [Roth 1995]. Many researchers have documented the inner workings of the collaborative process by exploring how people make decisions and reach compromises [Raiffa 1995]. Decision makers can and have employed information gleaned from experiments to select an appropriate and cost effective collaborative process to resolve a particular environmental management dispute. Raiffa [1982], for instance, gives many examples of informal in-class bargaining experiments designed as teaching tools.

One approach to understanding questions of bargaining under alternative institutional protocols is to consider the experimental work on Coasean bargaining. Based on the seminal article by Coase [1960], this line of bargaining research explores how cooperative institutions can be used to resolve environmental disputes in an efficient and rational manner. Researchers design experiments to test the robustness of the so-called Coase theorem. The theorem states that if a regulator could implement an efficient tax on pollution—a *green tax* such that a polluter must account for the social damages it causes with its production, then the costs of collecting information must be extremely small. Costs must be low because figuring out an efficient green tax would require information on the costs and benefits of pollution. But if these costs are really that low, Coase argued that the disputing parties could solve the problem themselves. They should be able to bargain to an efficient outcome, provided the government either gives one party the right to pollute or the other the right to clean air. If costs are low, the two parties would bargain to the same level of pollution—the only difference is in which party pays the other one for some of his rights. Clearly, this is not the *polluter pays principle*—the theorem says it does not matter *who* has the rights, it just matters that *someone* have the rights. The regulator's role switches from optimal tax assessor to one who assigns and enforce property rights, and may even help design or facilitate the bargaining protocol.

Coasean bargaining can provide some insight into the relative efficiency of alternative forms of bargaining protocol. Some might be more effective than others in removing barriers to negotiations; for example, power imbalances and asymmetric information. Efficiency and rationality can be used to measure the performance of alternative protocol in improving decision making concerning the environment and natural resources. By using a structured evaluative method allows, one can measure the performance of collaborative decision-making processes with some consistency, and create the foundation for making meaningful policy judgments. Early researchers found that the Coase theorem could be an efficient tool, and it held up reasonably well to large bargaining groups and uncertain payoff streams. Efficiency fell, however, as economic friction in the form of imperfect contract enforcement and delay costs [Hoffman and Spitzer 1982; Hoffman and Spitzer 1985; Shogren 1992].

The climate negotiations at Kyoto were more subtle and complex and had more levels and nuances than could be mimicked in the lab. Even so, experimental tests of environmental cooperation can help us to identify what elements of weak bargaining protocols reduce efficiency. Experimenters have considered the case in which a profitable opportunity not taken now is lost, a reasonable assumption in climate change in which a delayed agreement affects the stream of benefits to all nations. Delay costs accrue from the opportunity costs of delayed profits or delayed climate protection. Concern over this lost efficiency has prompted experts to recommend using more structured protocol in negotiations [Crowfoot and Wondelleck, 1990]. Some claim that a structured bargaining protocol might substitute for experience when people are negotiating over a shrinking pie.

In an experiment, Shogren [1998] considered how delay costs affected Coasean bargaining, examining how different specifications of discrete and continuous delay costs affect bargaining efficiency and the distribution of wealth. The results suggest that Coasean bargaining remained relatively robust to discrete and increasing marginal delay costs, but efficiency dropped with constant or decreasing marginal delay costs. Bargainers seemed to consider probability and consequences separately rather than in combination, as expected utility theory would predict. But they become more efficient as they gained experience. Additional research seems useful on how blending more intense experience and more detailed negotiation protocol into a bargaining institution might recapture efficiency gains lost.

Although experience helps bargainers, it may not help them enough in one-time events. Can new protocols help bargainers address the expected outcomes better than experience? Spencer and Shogren [2000] considered whether structured protocols could mitigate the losses in efficiency suffered by inexperienced bargainers. They examined the performance of two communication protocols commonly discussed in the theoretical bargaining literature: *alternating offers* in writing, and *cheap talk*—the costless, non-binding messages sent prior to actual bargaining used to coordinate expectations. In game theory, the term cheap talk reflects the notion of brainstorming without any commitments before bargainers make any binding agreements or sign any contracts.

Spencer and Shogren's results suggest that the communication mode matters in bargaining. When successful, cheap talk dramatically increased efficiency, but alternating offers do not. To test the view that an alternating offers is a reasonable approximation of free form bargaining, Spencer and Shogren also compared verbal and written offers. One might think that verbal exchanges should increase efficiency because of the ease in communication, but one could argue equally that written forms should increase efficiency for exactly the same reason—ease of communication. Controlling information exchange might increase efficiency because limiting bargainers' communication options increases the opportunity costs of time spent sending frivolous messages. Spencer and Shogren found that informal communication outperforms formal communication [Bolton and Chatterjee 1996].

Work on climate policy might well benefit from lab experiments that explore the pros and cons of bargaining protocol. Obviously experience negotiators like those at Kyoto know the ins and outs of diplomacy better than experimental economists, but that does not necessarily mean that both cannot learn something from each other. Researchers can capture the essential elements of different case studies in such experiments. They can then design institutions that reflect the basic types of collaborative decision-making protocol—choosing between majority and consensus decision making, selecting the number of stakeholders in a bargain relative to the number of interested parties, asking for an explicit commitment to resolve the environmental problem in question, impartial facilitators or mediators who help the group identify when they agree to disagree and when they are close to finding consensus, and asking for the voluntary participation of stakeholders who otherwise would not participate; evaluate the performance of the alternative institutions based efficiency and rationality; and design a new, refined institution that can improve on the process that works the best for each case study. This strategy can help people better understand the behavioral underpinnings of the collaborative protocol, by comparing relative effectiveness of the processes with the odds of achieving success for current and proposed decision-making models.

One useful set of experiments is to determine whether a protocol that breaks complex climate negotiations into more manageable parts could increase efficiency [Sebenius 1995]. The research can help identify how separate or combined elements of climate policy might increase or decrease the efficiency of bargaining with delay costs.

Environmental Control

In establishing good environmental policy, policy makers address both the stringency of targets for, say CO_2 emissions, and what flexibility to permit participants in meeting these goals. Different policy tools to control behavior can inflate or attenuate the costs of hitting any given target. Inflexible policies would be more costly than flexible policies that achieve the same reductions in climate risk. Well-designed policies can achieve targets at the least possible cost and thereby make stringent targets affordable. Economists have long argued for cost-effective policy tools that create market-like incentives for organizations to reduce emissions [Crocker 1966].

The Clinton Administration pushed for a broad-based domestic and international emission trading system in the Kyoto protocol based on the success of the acid rain emission-trading program. The Acid rain program set the standard for tradable emission permits. The program achieved twice the level of emission reductions of sulfur dioxide fear to cause acid rain at half the projected costs, saving nearly $1 billion in costs by one estimate. Briefly consider some specifics about the program. The Clean Air Act amendments of 1990 aimed to reduce sulfur dioxide emissions by ten million tons from 1980 levels. The Environmental Protection Agency assigned emissions limits and allocated allowances to over one hundred electric utility plants based on their share of heat input for a baseline time period [Stavins 1998]. These plants could now emit sulfur dioxide only if they had enough allowances to cover their emissions. The trading program promotes cost-effectiveness by allowing plants to trade allowances: plants with high abatement costs could purchase allowances from plants with low abatement costs. Both plants gain from the exchange, so society captures extra benefits at no extra cost. The government also ran an annual auction of allowances, in which plants could buy or sell extra allowances, which we discuss in more detail below.

Ideally, emissions trading would work the same way for climate change. International and domestic trading systems could be used to reduce the cost of reducing GHG emissions—perhaps halving the costs of meeting an emissions target. The Kyoto protocol allowed for trading among the nations to help them fulfill their commitments cost-effectively. Each nation can issue greenhouse-gas-emission permits to firms in the private sector that equal the target set in the protocol. The firms can then freely buy and sell the permits among themselves; the protocol does not specify whether firms can trade freely across national borders. By establishing a cost for emissions, the trading price forces firms to reduce their greenhouse-gas-emissions if they can do so at less cost. This would stimulate fossil-fuel users to improve their energy efficiency to use less GHG-intensive fuels, and to consume fewer goods and services that rely on GHG-intensive fuels in their production. Finally, international GHG emissions trading makes sense because GHGs are what are called a *uniformly mixed pollutant*, which means that a ton of GHG can be treated the same irrespective of who and where the ton was emitted.

We need to work through the details of the trading system is designed before we can evaluate alternative policies. Although trading could make reducing emissions less costly for developed countries and provide benefits to less-developed nations selling these emissions rights as they are eventually defined will determine the transaction costs that may limit the scope of such trading. Transaction costs include the time, effort, and other resources firms must expend to search out, negotiate, consummate, and obtain governmental approvals for these trades. The promoters of emissions trading have yet to define and test the institutional, administrative, and financial arrangements needed to make trades, the guidelines for establishing criteria for eligibility and certification, and methods of verifying and monitoring emission reductions.

Curiously, the biggest supporters of GHG-emission trading in the US have been environmental interest groups—not economists. Many US environmental groups prefer trading to taxes because with trading the governments can fix the quantity of GHG flowing into the atmosphere. Using a fixed quantity of permits, the governments can shift risk from the environment to the economy in the form of price uncertainty. Many economists, however, question whether an international GHG trading system would even be feasible. They argue that the market for permits is likely to be thin because most nations have shown little interest in the system, and the costs of monitoring and enforcing the system are likely to be high.

Experimental economists can play a role by examining and comparing the efficiency of proposed trading systems. Researchers can use the lab to address many of the questions that persist about emissions trading: Will it work? How well? How flexible is it? How can we monitor and enforce trading rules? What liability rule covers a nation selling permits it does not own? How do other flexibility mechanisms, such as the clean development mechanism, affect the efficiency of trading? If a proposed trading scheme seems worth pursuing in around the globe, researchers can first turn to the lab to determine the details [Bjornstad, Elliot, and Hale 1999]. They can also use lab experiments to explore the efficacy of other control mechanisms like GHG taxes [Plott 1983], and the voluntary provision of public goods [Coursey and Smith 1984; Ledyard 1995].

For example, Cason's lab work on the trading of emissions that form acid deposition revealed a flaw in the original design of the permit auction run by the Environmental Protection Agency [Cason 1995; Cason and Plott 1996]. The lab results showed that changing how permits allocated would improve the efficiency of the auction. Originally, buyers and sellers submitted bids and offers for emission permits, and the EPA set the market price discriminatively off the demand curve by first matching the seller with the lowest offer to the buyer with the highest bid. It then continued by matching the second lowest offer to the second highest bid, and so on, until it reached the equilibrium quantity. Rational sellers should see through this auction quickly, and begin capturing rents by understating their true offers so they would be matched with a high bidder. The lab results confirmed this intuition: sellers undercut each other to get into the high end of the market. The end result was an inefficient auction. The lessons learned in the lab can prove profitable, but regulators should learn these lessons before they put a regulatory tool in place, and before they waste resources because of inefficient design.

Using the lab to test new regulations first is no different than engineers testing out a system on the computer before putting into practice. Testing the details on policy before implementation is especially important for climate change—a problem that dwarfs acid deposition in scope and impact.

Researchers can design a test GHG-emission-trading system and evaluate it in laboratory markets that include the institutional factors that will influence the effectiveness of GHG trading. They can design experiments to examine how flexibility in trading, imperfect information, multi-gas trading, links between domestic and international trading, and other factors affect the potential efficiency of trading. Experimental work could prove useful to policymakers trying to understand what elements of emission trading can reduce the costs of climate change policy.

Experimentalists should begin by designing and parameterizing a market that reflects the costs and productivity of the countries or regions expected to participate in an international emissions-trading initiative. They can then use these parameters to design an Internet market experiment that links traders from around the globe. These international traders would then test the efficiency of various proposed trading proposals (e.g., buyer versus seller liability) given potential impediments to efficient, cost-minimizing market outcomes, and the likely size of the market.

Given potential impediments within markets, researchers can use the lab to explore how an emissions-trading system might draw in new buyers and sellers, or how trades might be self-enforcing under different penalty schemes. They can seek alternate exchange institutions that would increase nations' ability to buy and sell low-cost reductions in GHG emissions from around the world. Researchers can examine what conditions are necessary to create a domestic or an international emission trading system and what conditions are need to evaluate such systems [Godby et al. 1997].

Unlike the acid deposition trading program, a program for international trading environment cannot be realistically expected to include a central enforcement agency to ensure that emissions created by countries will be within the levels allowed by the permit they hold. Without enforcement, it is unclear how international trade could occur and how the emissions targets agreed to in Kyoto could be met. One possible solution is to make buyers of permits liable for the excess emissions of the sellers of those permits. A country that purchases permits and commits funds to limiting its emissions to the level for which it has permits has demonstrated its willingness to meet the emission targets. But a country selling permits in the absence of an enforcement agency cheat by selling permits and producing emissions that exceed its remaining permits.

This could cause global trading to unravel because those spending money to meet their agreed-upon emission obligations would recognize that total emissions were not declining, at least not as much as they intended when they purchased permits. Such firms might be willing to buy permits only at very low prices or stop trading or abandon their efforts to control emissions altogether. Making buyers liable for sellers' emissions might avoid this problem by holding them responsible for any excess emissions released by the seller after the sale. Although the idea of holding buyers liable for ensuring that emissions decline is not novel to emission trading, it remains to be shown that a market based on such obligations will actually result in trades, and what the consequences are of imposing these costs on a market. We can use the lab to test how buyer liability affects market trading and how liability influences trade volume, prices, and market efficiency [Muller and Mestelman 1994].

The few experiments that specifically concern GHG-emission trading [Bohm and Carlén, 1999] and the many that concern general market design show that we should be wary of seemingly innocuous design choices that reduce the efficacy of any exchange institution. The evidence from market experiments suggests that efficiency suffers from the market friction created by the checks and balances that policymakers find irresistible. Researchers can develop experiments to help policymakers understand how different trading rules might affect trading behavior and cost-effectiveness.

Concluding comments

Global environmental risks such as climate change have motivated many people to reconsider society's relationship with nature. They note the complex union between economic and ecological systems and see that traditional markets and regulatory policies often mishandle this alliance by sending misleading signals or by polarizing public debate [Vitousek et al. 1997]. They ask environmental policymakers to concentrate on building new institutions that can accommodate the uncertain future in a way that maintains human and environmental health. It is unclear, however, how these new institutions will work, what incentives they will create, how these incentives will affect human behavior, and how policymakers and laypersons will evaluate performance.

Before people establish and attempt to enforce global environmental policies in societies, they probably should test their new rules of organization in the lab. Researchers can use experiments to flesh out the big ideas of resource efficiency and equity of wealth that often emerge in debates over global environmental policy. If the changes promoted in the name of global environmental policy are worth pursuing in detail, researchers can use the lab to assess the likelihood of success. They can strip down the big questions and address them systematically, as experimental economists have now done for the last three decades. Researchers can use the lab to test how new institutions affect choice to help policymakers understand the potential implications before they implement structure change on a grand scale.

We need additional research in the lab to address the micromotives at work in climate protection. Researchers should continue to explore how people make choices faced with the ambiguous odds of climate catastrophe and surprise. We would benefit from more work on markets for trading emissions to help use design effective and efficient institutions. We can construct scenarios that will help us understand how building institutions might succeed or fail to work given different levels and distributions of wealth. We can consider the incentives for technological progress that would be created by different climate policies over the long term, and the cost of inducing innovation in climate protection in lost opportunities to pursue other deserving goals. Finally, we should make sure that the economists who run these climate-policy experiments communicate effectively with those making policy as climate negotiations continue. Helping find the means to reduce climate risk cost-effectively through a better understanding of human motivation—that remains the ongoing objective of applying experimental economics to global environmental policy.

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