Assessing the Role of Voluntary Programs in Climate Change Policy

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ABSTRACT

Voluntary programs have become an increasingly popular instrument of climate change policy. Evaluating such programs is difficult because traditional analytic models treat poorly one of the programs' potentially most important aspects -- their ability to address the effects of imperfect information. This paper proposes an analytic approach for assessing voluntary programs, such as EPA's Energy Star, as one part of a portfolio of climate change policies. The approach uses agent-based models to represent program impacts on the flow of information among economic agents and robust decisionmaking methods to treat their role as part of a robust portfolio of near-term policies designed to address the deep uncertainty posed by the climate change problem. Implementing this framework should help suggest the role voluntary programs can play in private sector, national, and international response to climate change.

Introduction

Voluntary programs have become an increasingly popular instrument of climate change policy. In a voluntary program private sector firms, often in cooperation with the government, set goals for environmental performance that go beyond any legally binding regulations. Over the last decade, the United States Environmental Protection Agency has implemented several voluntary programs designed to reduce greenhouse gas emissions. These include Green Lights, launched in 1991, which encourages U.S. institutions to use energy-efficient lighting, and Energy Star, launched in 1992, which labels products whose manufacture meets energy efficiency standards. More recently, the Bush Administration announced voluntary agreements with more than a dozen industry associations on reducing greenhouse gas emissions. Independently of any government programs, many firms have also set targets for greenhouse gas reductions (Margolick 2001).

Voluntary agreements are seen, along with other new approaches such as educational and information programs, as a more flexible, less costly, and less confrontational supplement to legally binding command-and-control and market-based approaches (Dietz 2002). Government interest in such new approaches arises from many sources, ranging from the opportunity to take advantage of an increasing environmental consciousness on the part of many business leaders and consumers to a need to work more closely with a business community that may have grown more successful at blocking unwanted environmental regulations. Firms have seen such programs as an opportunity to display an environmentally friendly image to their consumers and as a means to prepare for potentially more stringent future regulations.

The increasing use of such programs increases the importance of assessing them as part of the response to the threat of climate change. Integrated assessment models have provided one of the key tools for assessing the efficacy of climate change policies. These models combine representations of the climate and economic systems and allow users to compare the potential impacts of alternative policy responses. Such models have been used extensively to examine the relative merits of mandatory programs such as carbon taxes or emissions trading programs for reducing greenhouse gas emissions. Integrated assessment is particularly important given the intertemporal, regional, and sectoral tradeoffs policies to address climate change must address.

Integrated assessment, however, cannot easily address the potential contribution of voluntary programs to climate change policies, because such models generally do not consider the effects of imperfect information ranging from firms' lack of knowledge about the performance of novel technologies to consumers' lack of knowledge about the environmental performance of competing firms. Such information gaps have become an increasingly important area of economics research (McMillan 2002). Given imperfect information, firms and other economic actors may not generate the optimally efficient level of environmental performance because these actors lack critical information. By providing incentives for generating and disseminating information, voluntary programs help the economy operate more efficiently (Howarth, forthcoming).

This paper describes an integrated assessment approach that can be used to evaluate the role of voluntary programs in an overall strategy for climate change. First, we use an agent-based model to represent the effects of imperfect information on the potential diffusion of emissions reducing technologies, including the roles that technology adoption decisions by economic agents and different types of government policies can play in ameliorating these effects. Agent-based models follow the decisions and aggregate consequences of individual economic actors over time, providing a convenient mathematical means for representing the effects of imperfect information and of policies to improve information. Second, because the representation of imperfect information effects is severely limited by both a shortage of good data and deep uncertainty about factors that will affect future technology diffusion, we employ a new approach to decision analysis, robust decision making (Metz 2001), that permits strong policy conclusions even in the face of such uncertainty. While our focus is on assessing the role of government voluntary programs, our general approach should also be of interest to industries trying to understand their own voluntary greenhouse gas emissions-reduction targets.

Survey of Voluntary Programs

Voluntary environmental programs have become increasingly common in both the United States and Europe in the past fifteen years. Between 1988 and 1998, US government and industrial trade organizations had launched 42 voluntary initiatives including more than 7000 firms, local governments, and NGOs. More than 350 such agreements are in place in OECD countries (Mazurek 2002). US programs are primarily "public voluntary" programs, or open-ended public challenges which apply widely but expect no particular actor to join. In contrast, European voluntary programs typically constitute "voluntary agreements" between government and industry for meeting specific targets. Though many European agreements are non-binding, some do take the form of contracts and most are backed by a strong expectation of compliance as well as an implicit threat of regulation should the agreements fail (Harrison 2002).

Most US voluntary programs address climate change by reducing greenhouse emissions or pollution prevention by reducing toxic chemical releases. The Green Light program instituted in 1991 encourages the installation of energy-efficient lighting technologies in commercial and industrial buildings. The US EPA 33/50 program from 1991 to 1995 encouraged manufacturers to reduce emissions of 17 target chemicals by 50 percent. US voluntary programs rely on information subsidies, technical assistance, and public recognition to encourage participation (Mazurek 2002).

Of particular interest to climate change policy is the US government's Energy Star program, sponsored by the US EPA and DOE, which allows participating manufacturers to label their products with a well-recognized logo.[1] The program focuses on specific types of products. Following a June 1992 introduction focused on personal computers and monitors, the program has expanded to include 33 products ranging from fax machines to boilers to roofing products. In recent years the program has also expanded to include the firms which use, rather than produce, energy-efficient product (Cohen 2002). Energy Star labeled products must meet a variety of criteria, including cost effectiveness and significant energy-savings potential. Current Energy Star products exceed federal efficiency standards by 10 to 27 percent.

Evaluation of voluntary programs has not been straightforward. By one estimate, between 1991 and 1999 the Energy Star program reduced carbon dioxide emissions by 260 million metric tons and nitrogen dioxide emissions by 150,000 tons and saved more than $7 billion in energy bills (EESI 1999). Nonetheless, there are a variety of potential weaknesses in such estimates.

Voluntary programs have a variety of goals for which data is often not available. The Energy Star program seeks not only to reduce pollution, but also to expand the market for energy-efficient products and to encourage innovation and competition. An oft-unstated goal of such programs is to reduce the acrimony between business and environmental regulatory agencies (Mazurek 2002). Data is rarely available to assess progress toward such qualitative goals. Many voluntary programs have not required the gathering of data reporting that would allow assessment of quantitative goals, such as the amount of pollution reduced.

It is also not clear what baseline ought to be used in evaluating such programs. Many assessments, like that for Energy Star, report reductions relative to performance in a base year. Such estimates may inappropriately attribute to the voluntary program changes that would have otherwise occurred. One assessment of the 33/50 program, for example, found that while emissions of 17 toxic pollutants decreased by 50 percent between 1988 (the most recent prior year for which such data were available) and 1995, four fifths of these reductions may have occurred independently of the 33/50 program, because participating firms had a significant reduction rate for these emissions prior to the program, some reductions occurred before the program came into effect, and firms not participating in the program also made significant reductions (Harrison 2002). Some researchers also suggest that evaluations of such programs should be compared with the effects that might be expected from a regulations that might have otherwise been implemented.

Robust Decision Making Approach

In this study, rather than assess the value of a voluntary program against a particular set of program goals, we ask how and under what conditions voluntary programs can contribute to a portfolio of different policies designed to address the overall goals of climate change policy. The importance of this question derives from the particular challenges of the climate change policy problem.

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[1] Laitner and Sullivan (2001) report that more than 40% of the American public recognizes the Energy Star logo.

Compared to other environmental issues, climate change presents a particularly vexing decision-making challenge. In the 1992 Framework Convention on Climate Change, most nations agreed to a common though ambiguous long-term goal of stabilizing atmospheric concentrations of greenhouse gases at a safe level. Achieving this goal presents a difficult long-term, global challenge further confounded by unavoidable uncertainty about the extent of the threat and the effectiveness of alternative policies for addressing it. Current scientific evidence can be cited to support a range of views on the problem, from those holding the problem is a potential environmental catastrophe to those holding its effects will be hard to notice among the other changes of the 21st century. Nonetheless, it is clear that stabilizing atmosphere greenhouse gas concentrations at *any* level will eventually (that is, fifty to hundreds of years from now) require bringing society's net emissions to near-zero (Edmonds 2001).

Formally, climate change is best described as a challenge of decision-making under conditions of deep uncertainty; that is, a situation in which decisions made today will have future implications impossible to predict with any confidence.[2] Such challenges are difficult, ubiquitous and tractable. Explicitly or implicitly, government, business and individuals commonly address problems with deep uncertainty, often by using robust, adaptive strategies. A robust strategy is one that will work reasonably well, at least compared to the alternatives, across a wide range of plausible futures. Robust strategies are often adaptive, that is, they are designed to evolve over time in response to new information. The process of planning an outdoor event during a rainy season provides an example of robust planning. If the weather for the date of the event were known with certainty, then one would either rent a room safe from the rain or enjoy the sunshine without spending the money needed for a tent. Given uncertainty about the weather, however, reserving a tent beforehand and deciding whether to use on the day of the event is a reasonable, robust adaptive-decision strategy, even if a second-best solution for either a sunny or a rainy day.

Climate change, given its long-term, contentious, and deeply uncertain nature, seems a natural candidate for a robust, adaptive-decision approach (Lempert 2000). Nonetheless, most analytic assessments have treated climate change policy as a problem of finding an optimum policy under conditions of well-characterized uncertainty. In recent years, however, the increasing capabilities of computers has spawned a new generation of quantitative tools that allow decision-makers to systematically evaluate the effectiveness of alternative decisions under conditions of missing data and fundamentally unpredictable futures. Rather than seeking optimum policies, these methods seek robust policy strategies, that is, ones which perform reasonably well compared to the alternatives across a wide range of scenarios. Such robust decision making methods are increasingly applied in both public policies and business strategies.

Considering climate change policy as a robust adaptive strategy has several implications for voluntary programs. First, such programs should be considered as part of a portfolio of different policy options needed to hedge against the deep uncertainty of the climate change problem. Second, the performance of a policy portfolio depends critically on the interaction among its components. Thus, voluntary programs for climate change cannot be viewed in isolation, but rather in conjunction with the other policies in the portfolio. Third, voluntary programs should address more than a single climate policy goal. In particular, such programs seem appropriate to address both near-term emissions reductions

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[2] See Lempert, Popper, and Bankes (forthcoming) for a review of decisionmaking under conditions of deep uncertainty.

goals as well as helping to generate an array of technology options that might facilitate meeting more aggressive future emissions reductions goals. We now turn to how integrated assessment modelling can provide a framework for assessing the role of voluntary programs.

Evaluating the Role of Voluntary Programs

In previous work (Robalino and Lempert, 2000), we developed an integrated assessment model for climate change policies that is well suited for evaluating voluntary programs. This work used an agent-based model of technology diffusion to assess the role of technology subsidies in a robust strategy for mitigating greenhouse gas emissions. The model focuses on the effects of imperfect information on policy and the adoption of new technologies.

Agent-based models are seeing increasing use in the social sciences (Epstein 1996; Batten 2000). Compared to more traditional representative agent models (such as those in the differential equations used in traditional economic simulations), agent-based models can better represent the effects of imperfect information and bounded rationality. Agent-based models also excel at describing the behavior of heterogeneous populations with different information, preferences, and capabilities.

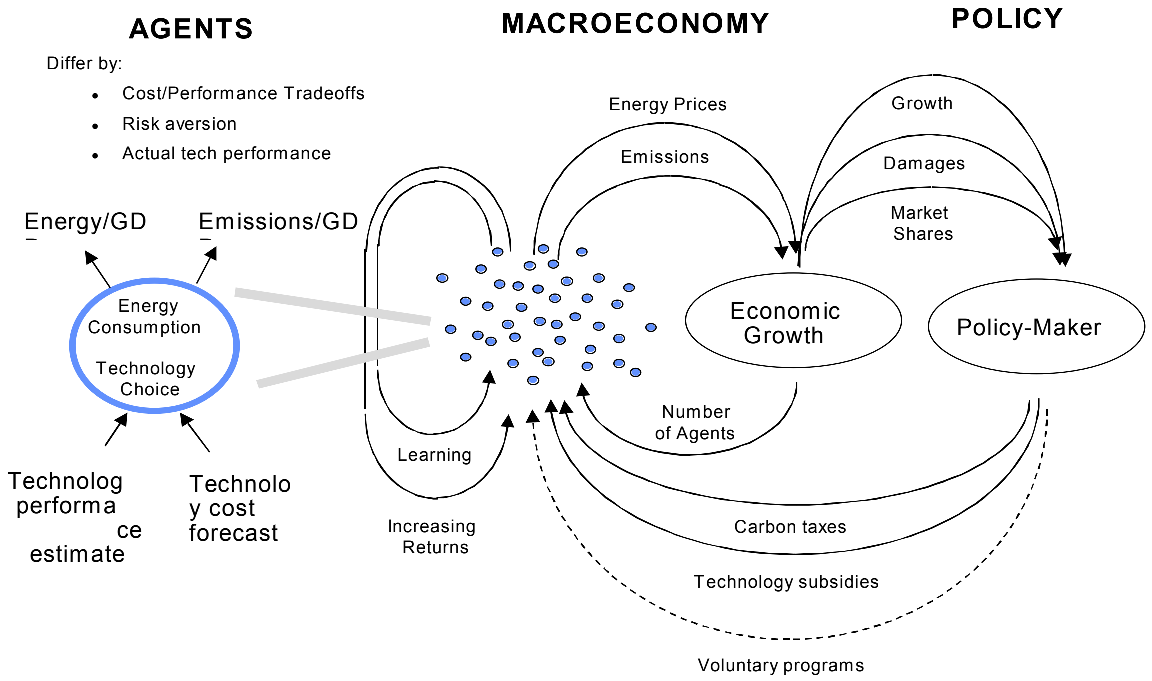
To date, their use for policy-analysis has been limited. Agent-based models can have strongly non-linear dependence on the structural and parametric assumptions in the models. Since it often difficult to have reliable values for all the parameters and rules necessary to specify the behavior of such models, it is difficult to exploit the reliable information the models do contain using standard tools of policy analysis. This difficulty is exacerbated in the study of voluntary programs, where the lack of comprehensive data is particularly pronounced. Robust decision making methods can be crucial for drawing strong policy conclusions in areas of incomplete data, for agent-based models in general (Lempert 2002), and the study of voluntary programs in particular.

Existing Model

Our agent-based model of technology diffusion focuses on the social and economic factors that influence economic actors in choosing whether to adopt new emissions-reducing technologies. We link this agent model to a simple macro model of economic growth. The agent-based representation is particularly useful because it represents key factors influencing technology diffusion, and thus, policy choices, such as the heterogeneity of technology preferences and the flows of imperfect information influencing decisions. It facilitates the evaluation of near-term policies addressing emission reduction and future technology options.

Each agent in our model (Figure 1) represents a producer of a composite good, aggregated for total GDP, with energy use as one key input. In each time period the agents choose among several energy-generation technologies and then, given their chosen technology, choose how much energy to consume. (That is, agents choose a production function and where to operate on that production function.) We assume that agents pick a technology to maximize their utility, which depends on each agent's expectations about the cost and performance of each technology.

Figure 1. Agent-Based Model of Technology Diffusion Used to Compare Alternative Climate Change Abatement Strategies



Source: Robalino and Lempert, 2000

We assume that our agents choose among these technologies in order to maximize an intertemporal expected utility. The agents have imperfect information, so they estimate utility on the basis of their expectations about technology performance and costs. We define $\langle U_{i,g,j}(\tau,\mathrm{T}_i^{life})|t\rangle$ as the agent i in region g's estimate at time t of the risk-adjusted pay-off it would gain by using energy conversion technology j from some time τ>t through the end of the technology's lifetime, $\mathrm{T}_\mathrm{i}^{\mathrm{life}}$. We write this risk-adjusted pay off using the Cobb-Douglas functional form

$$\langle U_{i,g,j}(\tau,\mathrm{T}_i^{life})|t\rangle = \langle Performance_{i,g,j}{}^{\alpha_i}|t\rangle\langle Cost_{i,g,j}(\tau,\mathrm{T}_i^{life})^{\alpha_i-1}|t\rangle - \lambda_i\left(Var_{Performance}+Var_{Cost}\right) \qquad (1)$$

The first term, $\langle Performance_{i,g,j}|\mathrm{t}\rangle$, is the agent i's expectation at time t of the performance it will get from the technology j, which it forms on the basis of its own past experience with the technology and from the experience of other agents that have used it. This term depends on the rate at which the agents sample the experience of others in order to learn about the performance of new technologies, represented here by the fraction of the agent population sampled by each agent each time period. The second term, $\langle Cost_{i,g,j}(\tau,\mathrm{T}_i^{life})|\mathrm{t}\rangle$, is the expected cost of using the technology over its lifetime, which depends on projections of future use and estimates of the potential for cost reductions from learning-by-doing. The projections and estimates are derived from observations of past trends in usage and cost of the technology. This term depends on potential for cost reductions due to increasing returns to scale. The third term represents the agent's risk aversion taken as a function of the variance of the estimates of technology performance and future costs.

Worldwide emissions of carbon dioxide are given by

$$E(t) = \sum_{g} \sum_{i=1}^{Ng(t)} \mathrm{s(t)}\; n_{g,i,j(i)}(t)\; \mathrm{m}_{j(i)}\,, \tag{2}$$

where $s_g(t) = GDP_g(t) / N_g$ is the number of agents in each region, each producing s (t) units of economic output. The CO_2 emissions intensity $m_{j(i)}$ (carbon emitted per unit energy consumed) is determined by agent i's choice of technology j. The energy intensity $n_{g,i,j(i)}(t)$, the energy agent i requires to produce one unit of GDP with technology j, represents the agent's choice of energy consumption and is determined by the cost of energy (inclusive of all taxes and subsidies), the elasticity of substitution, and improvements in energy efficiency. Global emissions of carbon dioxide in our model are determined by the energy intensities, $n_{g,i,j(i)}(t)$, for each agent. Each agent chooses to consume the amount of energy that will minimize its cost for producing one unit of output, so that its energy intensity depends on both its choice of energy technology and the (exogenous) state of conservation technology used in region g. Assuming that agents have a CES production function, we write

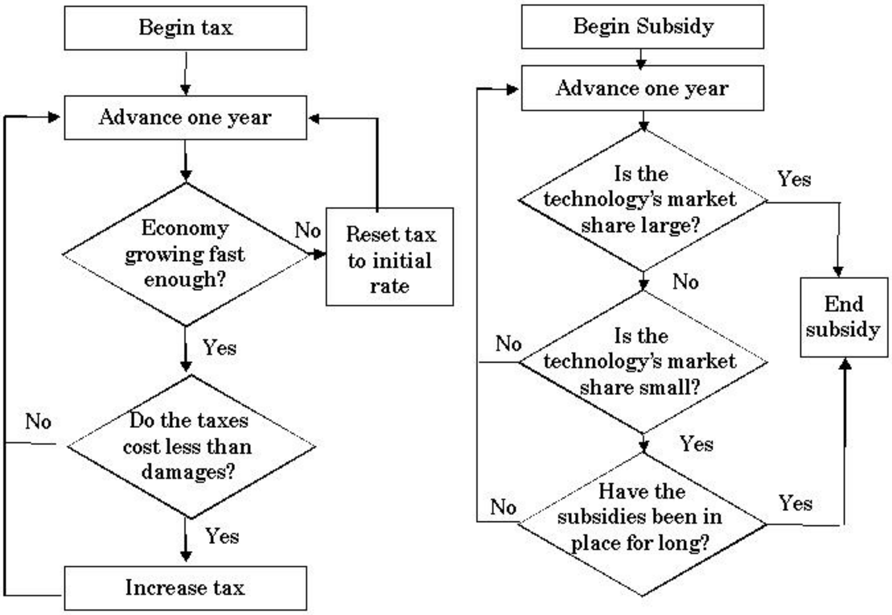
$$n_{g,i,j(i)}(t) = \frac{a_{g,i}(t)}{\left\{\left[1 - \overline{\mathrm{S}}\left(\mathrm{T}_{\mathrm{i}}^{\mathrm{adopt}}\right)\right]\mathrm{C}_{\mathrm{j}}\left(\mathrm{T}_{\mathrm{i}}^{\mathrm{adopt}}\right) + \mathrm{Tax}(t)\mathrm{m}_{j}\right\}^{\varepsilon}} \tag{3}$$

where ε is the elasticity of substitution, and $a_{g,i}(t)$ is an energy-efficiency coefficient for agent i proportional to the Autonomous Energy Efficient Improvement Index (AEEI) used in other climate change studies. The terms in brackets represent the cost in constant 1997 dollars (inclusive of all taxes and subsidies) of producing one unit of energy with technology j adopted in the year T_i^{adopt}.

The agents begin with imperfect information about the current performance of new technologies, but can improve their information based on their own experience, if any, with the technology and by querying others who have used it. The agents are also uncertain about the future costs of new technologies, and whether these costs will decrease with increasing returns to scale. Agents estimate future costs based on observations of the past rates of adoption and cost reductions. Thus, the diffusion rate can depend reflexively on itself, because each user generates new information that can influence the adoption decisions of other potential users.

We have used this model to consider two types of policies, a carbon tax that raises the cost of operating any technology in proportion to its emissions and a technology subsidy that selectively lowers the cost of non-emitting technologies. As shown in Figure 2, each type of strategy is adaptive in that it can evolve over time in response to new information. This evolution of both strategies is consistent with both the theoretical literature and qualitative understanding of the political conditions under which the policies would operate. These policies change the incentives on the agents and may influence their technology adoption decisions and thus the paths of emissions, economic growth, and technology costs.

Figure 2. Adaptive Decision Strategy for Adjusting Carbon Taxes (Left Column) and Technology Incentives (Right Column) Over Time



Source: Lempert and Schlesinger 2002

Adding Voluntary Programs

We can modify this agent-based model to include voluntary programs as well. Voluntary programs are often intended as information dissemination programs. They can provide consumers with information that causes them to purchase more environmentally beneficial products and help firms better understand new energy efficient technologies.

A recent survey (Cohen 2002) found firms joined the Energy Star program primarily as a means of expanding their potential markets in part by improving their image with potential customers (Table 1). Firms also joined the program to help communicate corporate goals throughout the organization, that is, promote the design of energy-efficient products within the firm. These results are consistent with the author's own surveys which suggest firm investments are largely driven by a desire to respond to external market opportunities and to advance the firm's strategic goals (Lempert et. al. 2002).

These results suggest that voluntary programs such as Energy Star may help energy-efficient firms by increasing information about them. Consumers who value a product's environmental qualities may not otherwise have a means for learning about them. A government-labeling program may provide sufficient information to consumers so that they can express a preference for more energy-efficient products, and thereby enable market forces to encourage firms to meet that preference. Such a dynamic would explain the results of the survey of firms in the Energy Star program and is consistent with the observation that government actions can facilitate the flow of information and thus help create well-functioning markets (McMillan 2002).

The existing agent-based model has no representation of the consumer market for environmentally benign technologies. Nonetheless, with two changes it can represent the impact of voluntary programs. First, the models could depict the ability of agents to choose an energy-efficiency technology which improves their energy-efficiency coefficient in Eq (3). Such investments will require upfront cost but yield subsequent savings in the cost of operating whatever energy technology the agent has adopted. Second, the policy-maker will have the option of implementing a voluntary program designed to acknowledge those agents which choose such investments in energy-efficiency. We assume such a program has the effect of allowing any consumer preference for more energy efficient production to express itself. Given such a voluntary program, agents that choose energy efficient technologies will receive a boost in their performance factor in Eq. (1), representing increased consumer demand for these firms. We assume that there are no significant monetary costs (at least as compared to carbon taxes and technology subsidies policies) to the government for such programs, instead inquiring under what circumstances they make any substantial difference.

Table 1. Results of Survey (Cohen 2002) Inquiring Why Firms Participate in EPA's Energy Star Program.

Motivation	Most Important	Important	Least Important
Improve Image to Customers	78%	16%	6%
Improve Market Share	65%	16%	19%
Promote the Design of Additional Energy Efficient-Products	64%	23%	13%
Improve Product distribution	56%	17%	27%
Shape Industry efficiency standards	47%	32%	21%
Increase government contracts	39%	23%	38%
Enhance image to investors	32%	16%	52%
Quality and characteristics of other participants	31%	31%	38%
Improve relationship with EPA	30%	32%	38%
Aid in employee morals	12%	17%	71%

Note: Shaded Regions Are Those To Be Represented in the Agent-Based Model Described Here.

Experimental Design

In previous work we have used this model to compare the performance of alternative portfolios of greenhouse gas mitigation strategies. In particular, we have compared the performance of a "Limit Only" strategy that uses only carbon taxes (or emissions trading) to a "Combined" strategy using both carbon taxes and technology subsidies. Using the robust decision making methods, we compared the performance of these two strategies across a very wide range of plausible futures. These futures span roughly an order of magnitude of future "basecase" emissions scenarios, of potential future costs of climate mitigation strategies, and of impacts due to climate change, but all are consistent with existing data on emissions, technology costs, and climate impacts.

We identified five key uncertainties that drive the choice between the “Limits Only” and “Combined" strategies. These include the rate of cost reductions due to increasing returns to scale for the non-emitting technologies, the rate at which agents learn from one another about the performance of new technologies, the agents’ risk aversion, the heterogeneity of the agents’ price-performance preferences for new technologies, and the potential damages due to climate change. We then viewed a series of interactive computer visualizations, using different combinations of these key uncertainties as independent variables, each comparing the performance of the "Limits-Only" and "Combined" strategies.

A clear pattern emerged. The "Limits-Only" strategy is preferable in a world where the agents' technology preferences are homogeneous, imperfect information effects are small, and the damages due to climate change emerge slowly. When these conditions do not hold, the "Combined" tax and subsidy strategy is more attractive. In other words, near-term creation of technology options becomes particularly important relative to the near-term emissions reductions when there are significant social benefits to early adoption of new emissions-reducing technologies not captured by the earlier adopters themselves.

We can assess the role of voluntary programs in a portfolio of near-term climate change policies by adding a voluntary program option. Decision-makers can decide whether to implement such a program independently or in conjunction with a either the "Limits Only" or and "Combined" strategies. We can consider a variety of alternative introduction times for these later policies. In particular, the “Limits Only” policy can be introduced today or delayed until there are unambiguous observations of climate trends or of climate impacts that suggest such a policy is necessary. Technology subsidies and voluntary programs may also be implemented today. Because the voluntary program entails few costs to the government, we will neglect any adaptive of voluntary programs over time analogous to those shown in Figure 2.

We hypothesize that three uncertainties, in addition to those most important to the choice between “Limits Only” and “Combined” strategies, may be important in affecting the importance of the voluntary programs. These are the cost to an agent of implementing the efficiency improvements, the economic benefits gained by an agent from these improvements, and the consumer response to the labeling program. The initial hypothesis is that voluntary programs would be most useful in a middle range of values for the economic benefit of the energy efficiency improvements. If the benefits are too small the voluntary programs will not suffice for significant adoption. If the benefits are sufficiently large, the voluntary programs will be superfluous. In addition, we hypothesize that the voluntary programs may be a useful complement to carbon taxes or technology subsidies but will not be useful on their own as a policy to address climate change. We will test these hypotheses using the agent-based model and robust decision making methods described here.

Summary

The need to assess the role of voluntary programs with integrated assessment models grows in importance as policymakers increasingly consider them as a component of their response to climate change. It is difficult to represent the impacts of voluntary programs in current integrated assessment models because such models poorly treat one of the potentially most important impacts of voluntary programs -- their ability to address the effects of imperfect information. This paper proposes an analytic approach for assessing the role of voluntary programs as one part of a portfolio of climate change policies. It focuses on programs such as Energy Star that may enable the expression of any market preferences for more environmentally friendly products or processes. The approach uses agent-based models to represent their impacts on the flow of information among economic agents and robust decision-making methods to treat their role as part of a robust portfolio of near-term policies designed to address the deep uncertainty posed by the climate change problem. Implementing this framework should help define the role voluntary programs can play in private sector, national, and international response to climate change.

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