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JLY
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"Thank you for meeting last Friday's initial deadline. Please find attached a very rough (preliminary and incomplete) climate change economic analysis packet. I would appreciate your comments on this informal draft by COB Thursday, April 16. You will have another opportunity to comment on a subsequent draft. Our goal is to release the final version on Friday, April 24. Thank you again for your help."

Sincerely,

Peter Orszag
April 14, 1998

PRELIMINARY
& INCOMPLETE

CLIMATE CHANGE ECONOMIC ANALYSIS

DRAFT #1

April 13, 1998

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Tab A:

Testimony of Dr. Janet
Yellen before the House
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March 4, 1998

**TESTIMONY OF DR. JANET YELLEN
CHAIR, COUNCIL OF ECONOMIC ADVISERS
BEFORE THE HOUSE COMMERCE COMMITTEE
ON THE ECONOMICS OF THE KYOTO PROTOCOL
MARCH 4, 1998**

Thank you, Mr. Chairman. The President has said that we can work to avert the grave dangers of climate change, while at the same time maintaining the strength of our economy. I agree and am pleased to have this opportunity to appear before the Committee to elaborate on the Administration's views on these issues.

The international agreement that was reached in Kyoto this past December is a crucial step forward in addressing global climate change. But it is only one step in a journey. Since the international effort to reduce greenhouse gas emissions is still in some respects a work-in-progress, it is not yet possible to provide a full authoritative analysis of it. Many of the specifics in several crucial areas are not completely resolved in the diplomatic arena, forcing analysts to make a variety of assumptions about the ultimate form of the international regime. In my testimony today, I will attempt to identify key elements of the agreement and the Administration's policy, such as international emissions trading, meaningful developing country participation, inclusion of land-use activities that absorb carbon ("sinks") and six categories of gases, as well as domestic initiatives, that together can ensure that reductions in global greenhouse gas emissions are consistent with continued strong economic growth. I will explain the reasoning underlying our conclusion that, under these conditions, economic impacts are likely to be modest.

The Administration is strongly committed to ensuring that these key elements are reflected in our domestic and international climate change policies. We are firmly committed to

meaningful developing country participation, the use of sinks to offset emissions requirements, and emissions trading both domestically and internationally. And as you know, the President's FY 1999 budget includes a \$6.3 billion package of tax cuts and R&D investments over the next 5 years; this package makes good sense in terms of energy policy and will jumpstart our efforts. A final component of the President's climate change policy is his support for electricity restructuring in a manner that will offer approximately \$20 billion in cost savings to electricity consumers, while reducing greenhouse gas emissions.

I. Basic Economic Rationale of the Kyoto Treaty

To begin our analysis, it may be worth stepping back and examining the larger question of the basic rationale, from an economist's perspective, for the Kyoto Protocol.

The earth's surface appears to be warming from the accumulation of greenhouse gases from myriad sources worldwide. None of these emitters presently pays the cost to others of warming's adverse effects -- a classic externality in the language of economists. As a result of these distorted incentives, disruption of the Earth's climate is likely to proceed at an excessive pace and if left uncontrolled may pose substantial costs in terms of harm to commerce and the environment alike. The fundamental economic logic of the Kyoto Protocol is thus that without such an international agreement, individual nations will not have the proper incentives to address the threats from global climate change.

II. Costs of Climate Change

In evaluating efforts to mitigate global warming, the first step is to consider the costs

of inaction. These costs --and they are significant-- provide the primary motivation for actions to reduce greenhouse gas emissions.

The Intergovernmental Panel on Climate Change (IPCC) jointly established by the World Meteorological Organization and the United Nations Environment Programme, concluded in 1995 that "the balance of evidence suggests that there is a discernible human influence on global climate." Current concentrations of carbon dioxide, methane, nitrous oxide, and the other so-called greenhouse gases have reached levels well above those of preindustrial times. Of these, carbon dioxide (CO₂) is the most important: net cumulative CO₂ emissions resulting from the burning of fossil fuels and deforestation account for about two-thirds of potential warming from changes in greenhouse gas concentrations related to human activity.

Climatic Impact

If growth in global emissions continues unabated, the atmospheric concentration of CO₂ will likely double relative to its preindustrial level by midway through the next century and continue to rise thereafter. As a result of the increased concentration of CO₂, the IPCC estimates that global temperatures will increase by between 2 to 6 degrees Fahrenheit in the next 100 years, with a best guess of about 3.5 degrees Fahrenheit. While scientists believe that human activities are leading to a gradual warming of the *average* temperature of the earth, the change in temperature in a given region at a given time may differ substantially from this average. Indeed, models predict warming will be greater in high latitudes than in the tropics, and greater over land than ocean.

Potential consequences associated with this shift in climate include a rise in sea levels, greater frequency of severe weather events, shifts in agricultural growing conditions from

changing weather patterns, threats to human health from increased range and incidence of diseases, changes in availability of freshwater supplies, and damage to ecosystems and biodiversity.

Economic and Monetary Damages

The derivation of quantitative or monetary estimates of the damages from such a change in the climate is extremely difficult given the capacity of today's models. Estimates of the economic damages from climate change fall into the following broad areas: agriculture, sea-level rise, air conditioning and heating, water supply, human life and health, air pollution, and other costs (hurricanes, relocation costs, human amenity, construction, leisure activities, urban infrastructure, and ecological damages such as forest loss and species loss). Although the quantification of these effects is quite demanding, researchers have developed estimates that prompt substantial concern. The IPCC reports that a doubling of carbon dioxide levels would lead to approximately 10,000 estimated additional deaths per year for the current U.S. population from higher summer temperatures, even after netting out the effects of warmer winters and assuming acclimatization. Other researchers have predicted sea level increases of about 20 inches by 2100, with greater increases in subsequent years.

Despite the difficulties, respected researchers have developed estimates of the monetary damages expected from an average worldwide temperature increase. For example, William Cline, then of the Institute for International Economics, estimated that a temperature change of 4.5 degrees Fahrenheit would impose annual damages of about 1.1 percent of GDP per year on the U.S. economy. That amounts to \$89 billion in today's terms. (Cline's original estimate is quoted in 1990 dollars. The figure given above translates this number into 1997

terms by scaling it to current GDP.) William Nordhaus of Yale University has likewise computed estimates of the dollar loss attributable to a doubling of greenhouse gas concentrations. Although he uses methods that differ from Cline's in several respects, Nordhaus estimates that a slightly larger temperature change of 5.4 degrees Fahrenheit would impose losses equal to about 1 percent of GDP. A third independent estimate reported by Nordhaus is close to Cline's. It must be noted, however, that this similarity among aggregated estimates masks the true uncertainty associated with forecasts of the damages from given increases in global warming — the estimates are all fundamentally based on extrapolations from current and past experience, and may not fully incorporate effects that will unfortunately become apparent only with future experience.

One key difficulty in interpreting and monetizing these estimates of damages is uncertainty over the extent that they should be discounted because they occur in the distant future. Since the benefits of stemming future climate change accrue over not only decades but centuries, small changes in the discount rate can produce substantial changes in the results. But the precise discount rate that should be used to evaluate questions as important as the future climate of the planet remains a subject of intense debate. It is safe to say that there is, as yet, no professional consensus on the issue. Indeed there can be no technical answer to the ethical question how we should value the welfare of future generations.

A similar difficulty with such estimates is that they do not include potential nonlinearities in the relationships between greenhouse gas concentrations and temperature, between temperature and economic damages, or in the various other complicated relationships governing interactions between greenhouse gas emissions, the climate, and the economy. Current estimates

of damages do not, and cannot, accurately reflect the value of reducing the unknown risk of large-scale and potentially irreversible discrete events with potentially catastrophic consequences.

Two such possibilities serve as illustrations. Warming of Northern tundra may release huge amounts of methane from the permafrost, thereby leading to accelerated warming. We do not know at what point, if any, such potentially unstable activity would be triggered. Second, evidence from climate models suggests that some types of climate change may lead to changes in ocean currents, including weakening of the Gulf Stream that warms Western Europe. Scientific evidence suggests that abrupt seawater temperature shifts have occurred over periods as short as decades.

To what extent are we willing to take such chances with our planet? There is a strong argument for the Kyoto Protocol as a form of planet insurance. But what numerical weight should one assign to these catastrophic risks? In other words, what is the value of the insurance policy? Although it is difficult for an economist, or anyone, to know, reductions in the risk of such catastrophic outcomes must be considered in addition to the costs and benefits that can be reasonably quantified. Since human beings are typically averse to risk, such catastrophic risks are especially important in evaluating whether the benefits of a particular climate control policy justify the costs. One must have at least some sympathy with those who criticize economists on the grounds that the effects of climate change are extremely difficult to quantify in a single monetary number.

III. Addressing Global Climate Change in an Efficient Manner

The costs of unabated climate change may thus be difficult to quantify, but they are nonetheless real and provide the motivation for reducing greenhouse gas emissions. In taking action to reduce those emissions, economic analysis suggests that two elements are absolutely essential:

- The effort must be global, to address the global externality inherent in the nature of the problem.
- The effort must be flexible and market-based, to ensure that we achieve our objectives in the most efficient manner possible.

Need for Global Action

Climate change is a global problem requiring a global solution. As I mentioned earlier, no single country has an incentive to reduce emissions sufficiently to protect the global environment against climate change. Each has an economic incentive to “free ride” on the efforts of others. Even if the United States sharply reduced its emissions unilaterally without an international agreement limiting emissions abroad, greenhouse gas emissions from all other countries would continue to grow, and the risks posed by climate change would not be significantly reduced. It is important to emphasize that emissions of different gases anywhere in the world have very similar effects on global climate.

The threat of disruptive climate change has led to coordinated international efforts to reduce the risks of global warming by reducing emissions of greenhouse gases. A landmark international agreement to address global warming was the Framework Convention on Climate

Change signed during the Earth Summit in Rio de Janeiro in 1992. This convention established an objective of limiting greenhouse gas concentrations and called upon industrial countries to return their emissions to 1990 levels by 2000. Since then, it has become clear that the United States and many other participating countries will not meet this voluntary goal; quite the contrary, emission levels have continued to rise not fall among both developed and developing countries.

To address the lack of progress among many industrialized countries toward meeting the Rio objective, the United States and approximately 160 other nations agreed in negotiations held in Kyoto, Japan, last December, to reduce emissions of greenhouse gases. The Kyoto Protocol, which requires the advice and consent of the Senate, would place binding limits on each industrial country's combined emissions of the six principal categories of greenhouse gases: carbon dioxide (CO₂), nitrous oxide (N₂O), methane, sulfur hexafluoride, perfluorocarbons, and hydrofluorocarbons. These limits apply to the 38 so-called Annex I countries, which are the industrialized countries, defined to include Russia, Ukraine, and most Eastern European countries.

Under the Kyoto Protocol, each industrial country's baseline is its 1990 emissions of CO₂, methane, and N₂O and its choice of 1990 or 1995 levels of the other three categories of gases. The United States agreed to a target of 7 percent below this baseline by the period between 2008 and 2012. Given the changes in the definition of the baseline for the three long-lived chemical compounds (HFCs, PFCs and SF₆) from 1990 to 1995 combined with a change in the way sinks are accounted for in the baseline, the actual reduction required in the U.S. is no more than 2-3% more than the President originally proposed as the U.S. negotiating

position. The targets for the European Union and Japan are 8 percent and 6 percent below 1990 levels, respectively. Australia, New Zealand, Norway, Russia, and Ukraine all have limits somewhat less ambitious when phrased as cuts relative to their 1990 levels. In sum, over the period from 2008 to 2012, the industrial countries are expected to reduce their average emissions of greenhouse gases to about 5 percent below their 1990 levels.

The President has made clear that he will not submit the Kyoto Protocol to the Senate without meaningful participation from key developing countries (who are not included in Annex I).

There are several reasons why meaningful participation from developing countries is essential. First, developing countries are projected to contribute a majority of world emissions around 2030 under a continuation of business-as-usual. Without the participation of developing economies, efforts by the industrialized countries to limit emissions will therefore not provide adequate protection from climate change.

Second, developing country participation is crucial because it would permit relatively low-cost emissions reductions to be internationally recognized as a substitute for more expensive emissions reductions that might otherwise be achieved domestically by U.S. companies and those in other industrialized countries. Since greenhouse gas emissions have the same basic impact on the climate regardless of where they occur, emission reductions in developing countries have the same environmental benefit as reductions in the U.S. But these reductions are much less costly than reductions in the U.S. or in other developed nations, because of the very inefficient and carbon-intensive uses of energy in these countries today. It thus makes sense, from both an environmental and an economic perspective, to incorporate emissions reductions in

developing countries into the international system.

Third, principles of basic fairness suggest all countries should do their part, depending, in part, on their ability to contribute to the solution. Thus even poor countries should participate, although the lack of resources in such countries may limit the extent of their participation.

Some have expressed fears that the Kyoto Protocol might adversely affect the competitive position of American industry. Evaluating how the Kyoto Protocol could affect competitiveness of a few specific manufacturing industries -- especially those that are especially energy-intensive, such as aluminum and chemicals -- is complex. The answer depends, in part, on the impact of the agreement on energy prices, which we will shortly address. In general it is difficult to undergo a structural change in the economy without having the effect of expanding some sectors and contracting others. But to provide some perspective on this issue, consider the following facts. First, on average, energy constitutes only 2.2 percent of total costs to U.S. industry. Second, energy prices already vary significantly across countries. According to the *1997 Statistical Abstract*, for example, in 1996 premium gasoline cost \$1.28 per gallon in the United States -- but only 8 cents per gallon in Venezuela. Similarly, gas prices were \$3.71 per gallon in Switzerland and \$4.41 per gallon in France. Electricity prices also vary significantly: in the U.S. they were 5 cents per kilowatt hour in 1995, a fraction of prices in Switzerland of 13 cents per kilowatt hour. Yet U.S. industry is not moving en masse to Venezuela, nor is Swiss industry moving to the United States. Third, roughly two-thirds of all emissions are not in manufacturing at all, but in transportation and buildings, sectors which, by their very nature, are severely limited in their ability to relocate to other countries. We therefore believe we need

developing country participation because the problem is global and cost-effective solutions are essential, than to avoid adverse effects on competitiveness.

Flexibility and Market Mechanisms

A global solution is thus critical to the global problem of climate change. Globalizing the solution is not, however, enough by itself. We must also ensure that our efforts to reduce global greenhouse gas emissions reductions in the most efficient manner possible. The nature of the climate change problem suggests three basic methods to lower costs of achieving given levels of environmental protection. They can be characterized in terms of three categories of flexibility: (1) "when" flexibility; (2) "what" flexibility; and (3) "where" flexibility, which may be the most important of all. Such methods have long been championed by economists interested in increasing the efficiency of protection. Indeed, over 2,500 economists from academia, industry, and government alike urged such approaches in a letter they signed last year advocating action on climate change:

"Economic studies have found that there are many potential policies to reduce greenhouse gas emissions for which the total benefits outweigh the total costs...The most efficient approach to slowing climate change is through market-based policies."

1. "When flexibility" (timing)

First is "when flexibility" or timing. Since climate change is a long-term problem, the exact timing of emissions reductions is, within some range, not of primary importance. Thus the freedom to delay or accelerate reductions within an agreed upon time frame -- while ensuring credibility of emissions reductions -- lowers costs.

As a result of U.S. leadership, the Kyoto Protocol incorporates this principle of "when

flexibility” in four ways:

- First, the initial emissions reductions are less severe, and the period over which they occur ends much later than what had been proposed by many other countries. By adopting a gradual and credible path of reductions in the early years, we can greatly reduce costs such as those from prematurely scrapping coal-fired electricity plants, while attaining the same ultimate environmental goals.
- Second, under the Kyoto Protocol, the emissions target is not specified in terms of a specific year, but rather in terms of an average over a five-year period (2008-2012). Averaging over five years, instead of requiring countries to meet a specific target each year, can lower costs, especially given an uncertain future. The averaging can smooth out the effects of short-term events such as fluctuations in the business cycle and energy demand, or hard winters and hot summers that would increase energy use and emissions.
- Third, there is allowance for “banking” emission reductions within the 2008-2012 commitment period, for use in a subsequent commitment period [although the emission targets of the subsequent periods have not yet been specified].
- Fourth, CDM credits achieved between 2000 and 2008 may be banked until 2008 to 2012.

2. “What flexibility” (gases and sinks)

The second type of flexibility is “what flexibility”, along two dimensions. The first is the inclusion in the agreement of all six greenhouse gases. Emissions of different kinds of gases, not just carbon dioxide, contribute to the greenhouse effect. Since the IPCC has developed

conversion factors for all greenhouse gases by estimating their global warming potentials, reductions in emissions of one gas can be used to substitute for increases in emissions of another by an amount that has equivalent environmental effects. Again at U.S. urging, all six gases are included, while Japan and the EU had insisted until the end on covering only three. Thus the U.S. succeeded in having the Kyoto Protocol stipulate that countries with binding targets are to reduce their *total* greenhouse gas emissions by certain percentages, but does not require specific reductions for specific gases. Since a molecule of sulfur hexafluoride is 23,900 times more potent over 100 years than a molecule of CO₂, it may be cheaper to achieve the same environmental benefit by eliminating one molecular unit of SF₆ than nearly 24,000 units of CO₂.

Some initial analysis indicates that a strategy of reducing non-CO₂ greenhouse gas emissions by a greater percent than CO₂ emissions could lower prices by as much as 10 percent. Thus allowing countries flexibility in what gases they reduce -- essentially trading emissions reductions across gases -- can help lower significantly the costs of meeting their targets.

The second source of "what flexibility" is the treatment of sinks, i.e., land use activities that promote the removal of carbon from the atmosphere through the growth of plants. At the urging of the U.S. delegation, sinks can be used to offset emissions targets. Promoting such sinks through afforestation and reforestation may reduce atmospheric concentrations of CO₂ at much lower costs than reducing emissions of greenhouse gases.

3. "Where flexibility" (international)

The third type of flexibility, and perhaps the most important, is "where flexibility" (international). As I have already emphasized, emissions have the same environmental consequences regardless of where in the world they occur. Therefore, the least-cost approach to

controlling climate change is to reduce emissions wherever such reductions are cheapest. The Kyoto Protocol, because of U.S. insistence and persistence, includes three important cost-saving provisions of this nature.

- First, it provides the opportunity for countries that take on binding targets to trade rights to emit greenhouse gases with each other. This market in emissions permits could ensure that emissions reductions occur where they are least expensive within the industrial countries. In particular, U.S. companies could purchase emissions reductions in other participating countries when doing so would reduce their costs -- thus lowering costs without affecting the level of environmental protection. While currently only industrialized countries have emissions caps, this mechanism also offers an incentive for developing countries to take on emissions targets.
- Second, the agreement provides for Joint Implementation by Annex I countries. Thus if some countries do not develop programs to trade permits internationally, U.S. firms could nonetheless implement projects in those countries for which they could receive emissions reductions credits in the U.S.
- Third, the agreement allows industrial countries to invest in "clean development" projects in the developing world and use these projects' certified emissions reductions toward meeting their targets. Many such clean development projects may be quite cheap in terms of the cost per ton of emissions avoided, as has been illustrated by the Joint Implementation pilot program that is already in place in the U.S.

Details of how these provisions will operate will be discussed in future negotiations such as the one in Buenos Aires later this year. Nonetheless, effective international trading of

emission credits, Joint Implementation, and the Clean Development Mechanism can lead to substantial reductions in costs relative to alternative policies that do not exploit the power of market incentives. To illustrate briefly the ability of U.S. industry to perform beyond expectations when given appropriate economic incentives, consider further EPA's highly acclaimed sulfur dioxide (SO₂) program, which relies, among other things, on a system of tradeable permits to reduce emissions of SO₂ from electric utilities. The SO₂ program has been successful in several ways: a large number of utilities participate, SO₂ emissions and ambient concentrations have fallen and the costs of reducing emissions are considerably lower than originally forecast.

As has been frequently noted, the average cost of SO₂ emissions reductions has recently been significantly lower than was originally forecast, in part due to the role of incentives in fostering innovation. Emission permit prices, currently at approximately \$100 per ton of SO₂, are well below earlier estimates of around \$250 to \$400 per ton.

Trading programs may not always bring cost savings as large as those achieved by the SO₂ program; trading programs will not always be accompanied by the discovery of much cheaper control strategies. However, the SO₂ experience demonstrates clearly how programs like international permit trading, Joint Implementation, and the Clean Development Mechanism will lead firms to find cheaper ways of reducing emissions that can lead to unexpectedly low costs.

IV. Difficulties of Economic Analysis of the Kyoto Protocol

Now that we have a Protocol -- even if it is not yet fully complete nor ready for the President's submission to the Senate -- it is possible to examine it in somewhat more detail from

an economic perspective. But, once again the inherent limitations of any such estimates deserve emphasis. Such limitations should not be surprising to you: economists have a difficult enough time projecting the behavior of the economy over the next quarter or year, let alone over the next two decades. The scale of the forecasting exercise is therefore daunting, and any specific results should be treated with substantial caution.

The difficulties associated with economic analysis of climate change fall into three broad categories. First are the uncertainties that still remain over the terms of the ultimate treaty, necessitating assumptions on which the analysis is predicated. Second are the inherent limitations of available models to analyze even short-term costs and benefits. And finally is a topic discussed earlier: the impossibility of putting a single monetary number on the long-term benefits of climate change mitigation, although there will clearly be economic benefits of emission reductions.

Uncertainties in the International Effort to Combat Climate Change

The Kyoto Protocol was an historic accomplishment, delineating the broad terms of the international effort to address climate change. But although we know a lot more than we did before Kyoto about how that international system can work, and that informs our analysis, there is still much that we do not know.

First, some provisions raise complex implementation issues. At issue here is the treatment of so-called sinks -- activities that affect the rate at which carbon is removed from the atmosphere and "sequestered," e.g., by the planting of trees.

Second, the details of a number of items -- primarily concerning international trading, the Clean Development Mechanism, and developing countries -- are the subject of further

discussions including future negotiations in Buenos Aires next fall, because they had not been definitively settled by the end of the Kyoto talks.

Finally, and most importantly, we have not yet negotiated international agreements to limit emissions beyond the 2012 window. The emission cuts agreed upon at Kyoto are only a first step on a long journey. The first step that we propose to take over the next 15 years is critical. But the reason it is critical is *not* that, by itself, it will solve the climate change problem -- emissions during any given decade are small compared to the cumulative concentrations in the atmosphere. Rather, the first step is critical because we can not take the second and third steps until we have taken the first. At the same time, any analysis is complicated by the lack of knowledge over what the subsequent steps will be.

Inherent Limitations of Models

In addition to these uncertainties about the details of the international effort to address climate change, are the inherent limitations of the models used to evaluate that effort. Even within a given model, answers depend critically on the precise nature of the question asked. For example, the costs of emissions reductions depend critically on the extent of global participation and international trading that a treaty is assumed to feature. But in addition to the dependence of the results from a given model on the precise assumptions, different models can give different answers even when all the assumptions are specified to be the same -- a concrete illustration of the range of uncertainty to which we must assign the predictions of any one individual model.

One area in which the uncertainty is particularly large is the pace of technological progress --especially the diffusion of existing energy-efficient technologies, but also the development of new technologies -- and the extent to which the pace will accelerate in response

to government programs. Models and experts on climate change policy tend to have a wider range of disagreement on the scope for speeding the diffusion of existing energy-efficient technologies than on any other single issue.

Furthermore, each model has strengths and weaknesses; each has questions to which it is better or worse suited to answer. Some, for example, model the energy sector in detail. Some allow for the fact that a coal-fired power plant cannot costlessly be converted to one that runs on natural gas. Some show the effects of hypothetical tax cuts made possible by the new revenues earned through the auction of emissions permits. Some are capable of showing recessions and booms. Others include a long-term “carbon cycle” model that can keep track of the accumulation of greenhouse gas concentrations in the atmosphere and their climatological effects. Some break down the rest of the world into regions and so can model international trade. No one model does everything, and therefore we must not rely blindly on the results of any one model or set of models. Professional judgement and economic intuition, along with diplomatic assessments, are also crucial.

Benefits of Averting Climate Change

As discussed above, it is evident that the benefits of averting climate change are potentially immense. But we have chosen not to try to quantify them in monetary terms, in light of the difficulties we have enumerated. These include the uncertainty of these benefits, their timing and therefore the extreme sensitivity of the results to the chosen discount rate, and the dependence of benefits on emissions paths after the 2008 to 2012 budget period specified in Kyoto.

V. Assessing the Kyoto Protocol

In order to evaluate the likely net economic impact of the Kyoto Protocol, *excluding the benefits of mitigating climate change itself*, we have drawn upon a variety of tools to assess the various possible costs and non-climate benefits of the Administration's emissions reduction policy. To give away the punch line, our conclusion is as follows: the net costs of our policies to reduce emissions are likely to be small, assuming those reductions are undertaken in an efficient manner and we are successful in securing meaningful developing country participation as well as effective international trading, and the Clean Development Mechanism in future negotiations. That potential small net premium, even excluding the benefits of mitigating climate change, in effect, purchases a partial insurance policy against a serious environmental threat.

Because the results from any model must be treated with caution, the Administration has employed a broad set of economic tools to assess the Kyoto Protocol. We have drawn on the insights of a wide range of models of the energy sector and economy over the next 25 years, including but not limited to the results of the Stanford Energy Modeling Forum exercises, the IPCC's review of the economic and social dimensions of climate change, the work of the OECD on Economic Dimensions and Policy Responses to Global Warming, and the staff-level Interagency Analytical Team analysis produced last year. Other tools include simple relevant statistics, "meta-analyses" such as work by the World Resources Institute, models, and basic economic reasoning. Drawing on this broad array of analytical tools is crucial to an intelligent evaluation of the policy alternatives.

To our knowledge, no model -- whether used inside the government or not -- has yet been set up to analyze the implications of the Kyoto Protocol, since this agreement is only a few

months old and remains unfinished. In particular, no model is currently designed to assess Kyoto's treatment of sinks, or all six greenhouse gases. Some model-builders outside the government tend to take as long as several years to incorporate changes in policy parameters into their models.

Our thinking has been informed, however, by simulations conducted with the Second Generation Model of Battelle Laboratories, one of the leading models in the field. The SGM is one of the models best positioned to analyze the role of international trade in emission permits, which we consider to be a critical element of the Kyoto Treaty. However, the SGM does not cover all six gases included in the Kyoto Protocol or include a role for sinks. We have used the SGM model as one input into our overall assessment of the Kyoto treaty, but have attempted to supplement its results with additional analysis to account for such special features of the agreement as the inclusion of six gases, a possible trading arrangement that could include a subset of the Annex I countries and the Clean Development Mechanism. We will share with you today some preliminary results of this analysis. To the extent possible, we have compared results obtained with the SGM model with those of other modelling efforts.

Mindful of the limitations of any single model, we are eager to see features of the Kyoto Protocol assessed by other models to obtain a better feel for the range of possible effects. This work is just beginning and much of it will continue to go on outside the government. For example, the Energy Modeling Forum, based at Stanford University, is a long-running model comparison exercise involving many of the leading climate models. EMF is currently studying

how features of the Kyoto legal language can be translated into terms recognizable to economic modelers. We expect that the group will conduct a full scale analysis of the Kyoto Protocol. The Energy Modeling Forum believes that its members will need at least until mid-year to update their results.

VI. Assessing the Potential Costs of Emissions Reductions

I said in Congressional testimony last July that we can do this smart or we can do this dumb. I was referring to the point that the costs of cutting emissions can be much reduced if flexible, market-based mechanisms are used. Our economic analysis highlighted the importance of such flexible, market-based mechanisms -- which are therefore reflected, at the President's insistence, in the Kyoto Protocol and our ongoing diplomatic strategy.

Within the Kyoto Protocol, this means an insistence on international trading, Joint Implementation, the Clean Development Mechanism, and, ultimately, on meaningful developing country participation. Domestically, this means that we implement any emissions reductions through a market-based system of *tradeable* emissions permits, which ensures that we achieve reductions wherever they are least expensive. But this also means taking serious and responsible steps in the short run to prepare us to meet our obligations in the longer term.

The first such step is the inclusion in this year's budget of an aggressive, \$6.3 billion program of tax cuts and R&D investments -- \$1.3 billion more than the \$5 billion package the President promised in his October 22 speech on this issue. The goal is both to stimulate the development of new energy-saving and carbon-saving technologies and to encourage the dissemination of those that exist already. The proposed package contains \$3.6 billion over the

next 5 years in tax cuts for energy efficient purchases and renewable energy, including tax credits of \$3,000 to \$4,000 for consumers who purchase highly fuel efficient vehicles, a 15 percent credit (up to \$2,000) for purchases of rooftop solar equipment, a 20 percent credit (subject to a cap) for purchasing energy-efficient building equipment, a credit up to \$2,000 for purchasing energy-efficient new homes, an extension of the wind and biomass tax credit, and a 10 percent investment credit for the purchase of combined heat and power systems. The package also contains \$2.7 billion over the next 5 years in additional research and development investments -- covering the four major carbon-emitting sectors of the economy (buildings, industry, transportation, and electricity), plus carbon removal and sequestration, Federal facilities, and cross-cutting analyses and research. One example of the R&D effort is the Partnership for a New Generation of Vehicles (PNGV). PNGV is a government-industry effort to develop attractive, affordable cars that meet all applicable safety and environmental standards and get up to three times the fuel efficiency of today's cars. In FY99, the combined proposal for PNGV is \$277 million, up from \$227 million appropriated in FY98. Similar government-industry efforts are proposed to develop more efficient diesel engines for both light trucks and heavy trucks.

A second responsible step entails industry-by-industry consultations to prepare emission reduction plans in key industrial sectors. The Administration will work in partnership with industry to identify ways in which the Federal government might remove regulatory hurdles that discourage energy efficiency. In addition, DOE will spearhead a comprehensive effort to improve the energy efficiency of the Federal government's own operations and purchases.

The third step is the promotion of an environmentally-responsible electricity restructuring bill, which the President identified as part of his domestic climate change package

in his address to the National Geographic Society on October 22. An electricity sector freed from government regulation would be a more efficient energy sector. Costs to consumers would fall. In addition, stronger incentives for improved generation efficiency in conjunction with appropriate market based provisions could achieve modest reductions in emissions. A reasonable overall estimate of the contribution of federal electricity restructuring to the rest of the President's program to address climate change is that it would make further progress to the same emission reduction goals at a cost saving of roughly \$20 billion per year. These steps should be taken regardless of Kyoto, because they make sense in terms of energy efficiency. But they have the added benefit of preparing us for Kyoto.

Estimated Reduction in Costs from Annex I Trading

In the language of the treaty, "Annex I," is the set of countries that have agreed to take on binding limitations in emissions of greenhouse gases. Even without meaningful developing country participation -- which, again, the President has emphasized is essential before the treaty would be submitted for ratification -- costs could be reduced substantially by emission trading among the Annex I countries. To provide some indication of the possible efficiency improvements, Russia and Ukraine consume six times as much energy per dollar of output as does the United States. Such large international differences in energy efficiency suggest that adoption of existing U.S. technology would yield very large emissions reductions in these countries.

Estimates derived from the SGM model confirm that emissions trading among Annex I countries can reduce the cost to the United States of achieving its targets for 2008-2012 emissions by about half relative to a situation in which such trading was not available. This

concept of costs is meant to capture aggregate resource costs to the US economy, including the cost to domestic firms of purchasing emission permits from other countries where emission reductions may be cheaper than in the United States. Although these estimates reflect idealized international trading in efficient markets, the overall conclusion is clear. The dramatic reduction in costs potentially available from Annex I trading within the SGM model -- cutting the costs involved by half -- highlights why the President insisted that international trading be part of the Kyoto Protocol; and why its achievement by our negotiators in Kyoto was such an important accomplishment.

Estimated reduction in costs from umbrella trading

One possibility that emerged in Kyoto, which none of us foresaw, was the idea developed there by the U.S. delegation, that the United States might undertake trading with a subset of Annex I countries, dubbed the “umbrella”. Countries that have expressed interest in the umbrella include the United States, Australia, Canada, New Zealand and Russia, with strong indications of interest from some others. This subset of Annex I countries shares a common interest in promoting market-based mechanisms, most specifically, fully flexible rules for international trading of emissions permits.

It is too early to state the precise form the umbrella will take. But we can envision a number of potential benefits. The umbrella could, for example greatly reduce costs to the U.S. Results that we have derived from various SGM simulations of efficient international trading suggest that, relative to the situation in which there is no trading at all, the umbrella can reduce costs by an estimated 60-75 percent, depending on whether the former Warsaw Pact countries fall within the umbrella. The Kyoto Protocol classifies these countries outside of the EU bubble

for the first budget period 2008-2012.

Estimated reduction in costs from developing country participation

The next consideration is participation by developing countries. The President has said that he will not submit the treaty for ratification without meaningful participation by key developing countries. Such participation would further reduce the costs involved.

The substantial potential gains from meaningful developing country participation are highlighted by the significant benefits that will likely accrue from the limited role that the developing countries have already agreed to: the Clean Development Mechanism (CDM), modeled after the U.S. joint implementation concept. The CDM cannot realistically be expected to yield all the gains of binding targets for developing countries, but it might shave costs by roughly another 20 to 25 percent from the reduced costs that result from trading among Annex I countries.

Another possibility is that we persuade some of the key developing countries that are the largest emitters to commit to targets, and allow us to buy emission reductions from those paths. Simulations with the SGM model suggest that full participation by non Annex I countries could cut roughly 55 percent off the reduced costs that result from Annex I trading. The actual cost reduction would depend on the extent of developing country participation that is ultimately obtained, as well as the effectiveness of international trading arrangements. The more developing countries that take on modest binding targets and trade in international permit markets, the lower will be costs.

These cost-saving opportunities are fundamental tenets of the U.S. position. The promise of Kyoto cannot be achieved without effective emissions trading. Moreover, if we do

not get meaningful participation by key developing countries, we won't submit the treaty for ratification to the Senate. So, while our analysis may be predicated on some ambitious conditions concerning trading and developing country participation, it is exactly those conditions that form the foundation of the U.S. position in international negotiations including those at Buenos Aires.

Accounting for Carbon Sinks

The preceding discussion has emphasized the importance of trading arrangements and the CDM. In reaching an overall economic assessment, it is also important to factor in the potential role of carbon sinks. Again, the U.S. delegation obtained a novel concept, that carbon absorbing activities called sinks could be used to offset emissions. The arrangements concerning carbon sinks in the Kyoto Protocol have received less attention than they merit. The Kyoto Protocol specifies that removals of CO₂ by sinks count toward meeting the target. The Kyoto Protocol counts the net emissions effects of three sink activities –afforestation, reforestation, and deforestation. Very preliminary estimates of the implications for the United States of the Kyoto provision on sinks indicate that carbon sinks could comprise a significant portion of the – total required emissions reductions. Moreover, decreasing the required emissions reduction by, for example, 10% would likely result in cost-savings greater than 10%.

Even this estimate of the effect of sinks is conservative in one respect: it is based on an assumption for sink activity in the U.S. over the 2008-2012 period, and no assumed benefits from sinks elsewhere in the world. Very preliminary estimates suggest that incorporating the gains from sinks *throughout the world* can substantially reduce the costs of meeting the Kyoto target, on top of the gains from trading among Annex I countries. (Furthermore, no model has yet

even tried to take into account that government policies can help increase the activities qualifying as allowable sinks, like some tree-planting.) Because the quantitative uncertainty is so large, we do not yet have an estimate with which we are comfortable. But we expect that complete modelling of the Kyoto provision pertaining to sinks will likely have favorable and potentially large effects on projected costs.

Accounting for the role of improvements in energy efficiency

Another issue in analyzing the Kyoto protocol concerns future improvements in energy efficiency due to innovation and diffusion of existing technology. The parameter that figures most prominently in analysis of energy efficiency is the rate of improvement in the so-called Autonomous Energy Efficiency Index (AEEI), that is the rate at which the total use of energy falls relative to GDP. A plausible assumption on the AEEI is an improvement of 1.0 percent per year. Reflecting a conservative interpretation of the 15-year impact of various climate change initiatives, this is only a small increase above the 0.9 percent number in the Energy Information Administration's Annual Energy Outlook. That assumption is not the most optimistic outcome that might occur. Some authorities in the field of energy policy forecast more rapid technological progress. Experts at five national laboratories managed by the Department of Energy, using an engineering approach rather than an economic paradigm, found that a third of the emissions reductions necessary to return to 1990 levels by 2010 could be achieved through the adoption of existing energy-efficient technologies at no net resource cost, or even some savings. The National Academy of Sciences reached qualitatively similar conclusions in a 1992 report.

The President's FY 1999 budget, as I have noted, includes a \$6.3 billion package of

tax cuts and R&D investments intended to spur the discovery and adoption of new technologies. If the Administration is successful in this effort, the rate of improvement in energy efficiency could rise and such improvements would lower the cost of meeting our Kyoto target. For example, published results based on SGM model simulations with different assumed rates of AEEI suggest that an increase in the AEEI of 25 percent could lead to declines in the permit price of approximately 40 percent.

Our justification for incorporating into our assessment a small assumed impact of Administration technology policies is somewhat analogous to the Administration's rationale for employing mainstream economic assumptions in our budget forecasts: in the presence of uncertainty, we are conservative in our estimates of the speed with which the economy will grow, tax receipts will rise, and the budget will improve. That way, any revisions or surprises that occur are likely to be in the pleasant direction. In this instance, we prudently and conservatively assume that there will be substantial delays between investments in new technology or the diffusion of existing technology, and the returns to such investments.

Moreover, at the recent automobile show in Detroit, General Motors announced that it has developed a hybrid-based vehicle that can achieve fuel efficiency of 80 miles per gallon, and that this car could be in commercial production within a few years. Ford also exhibited a prototype of a light-weight highly fuel efficient sedan that could be in commercial production by the middle of the next decade. These announcements followed an earlier breakthrough announced by DOE and its partners of a fuel cell that could run on gasoline and double current fuel economy while reducing conventional air pollution emissions by 90 percent. These technological advances have been made possible through the efforts of the Partnership for a New

Generation of Vehicles between the Administration and the U.S. auto companies and their suppliers.

Such progress may be replicated in other sectors. VCRs and TVs, while switched off, consume about \$1 billion worth of electricity annually. EPA has established a partnership with major manufacturers that has a goal of achieving up to a 70 percent reduction in energy use by VCRs and TVs while they are switched off, without sacrificing product quality, usefulness, or increasing costs. This partnership offers promise of substantial improvements in energy efficiency.

Non-Climate Benefits

A final factor that should be included in any comprehensive assessment of the economic implications of the Kyoto protocol are the benefits of the agreement. The literature has emphasized that any relative price shifts that prove necessary to reduce emissions should produce non-climate benefits in three areas: traffic congestion, highway accidents, and air pollution unrelated to climate change. These benefits are hard to quantify precisely but are potentially significant: our rough estimates suggest that these three benefits could offset approximately a quarter of the resource cost of the climate change policy.

Synthesis

A comprehensive evaluation of the economic impact of the Kyoto Protocol must integrate all of the factors described above: reliance on flexible market-based mechanisms domestically; international trading and Joint Implementation among Annex I countries; the Clean Development Mechanism; meaningful developing country participation; the potential cost-mitigating role of including six gases and carbon sinks; the benefits of electricity restructuring;

and emissions reductions achieved as a consequence of other proposed Administration climate change initiatives. Assuming that effective mechanisms for international trading, Joint Implementation and the Clean Development Mechanism are established, and assuming also that the U.S. achieves meaningful developing country participation, our overall assessment is that the economic cost to the United States in aggregate and to typical households of attaining the targets and timetables specified in the Kyoto Protocol, will be modest.

This conclusion that the impact will be modest is not entirely dependent upon, but is fully consistent with, formal model results. I have previously emphasized the limitations of relying on any single model in assessing the economic impact of the Kyoto Protocol, and continue to view any such results as just one input into an overall analysis. But it is worth emphasizing that model results reflecting the details of the Kyoto Protocol are consistent with our conclusion. For example, under the assumptions of either trading under the umbrella or within Annex I, the CDM and permit trading with developing countries, estimates derived using the SGM model, which adjust for the inclusion of six gases and assume little banking of credits beyond 2012, suggest that the resource costs of attaining the Kyoto targets for emission reductions might amount to \$7 to \$12 billion per year in 2008 to 2012. This implies that overall costs, excluding not only climate and non-climate benefits, but also such cost mitigating factors as sinks and payoffs from the President's electricity restructuring and climate change initiatives, would reach roughly one tenth of one percent of projected GDP in 2010.

A more tangible measure of costs is the estimated effects on energy prices. Excluding the impact of electricity restructuring and the ancillary benefits of mitigation and better forest management, the SGM-based estimate, corresponding to the gross resource cost estimate cited

above, is an emissions price in the range of \$14 to \$23 per ton of carbon equivalent. This translates into an increase in energy prices between 2008 and 2012 at the household level of between 3 and 5 percent, an increase in fuel oil prices of about 5 to 9 percent, natural gas prices of 3 to 5 percent, gasoline prices of 3 to 4 percent (or around 4 to 6 cents per gallon), and electricity prices of 3 to 4 percent. This increase in energy prices at the household level would raise the average household's energy bill in ten years by between \$70 and \$110 per year, although such predictions may not be observable because they would be small relative to typical energy price changes, and nearly fully offset by electricity price declines from Federal electricity restructuring. In particular, this increase in energy prices is small relative to the average of *year to year* real energy price changes experienced by U.S. consumers since 1960: such *annual* changes have averaged 3.8 percent. In addition, by 2008-2012, the anticipated 10 percent decline in electricity prices from the restructuring that is part of our climate change agenda is projected to lead to expenditure reductions of about \$90 per year for the average household.

As highlighted earlier, there are substantial but unavoidable uncertainties surrounding estimates like these. For example, the estimate just discussed is predicated, among other things, on the developing country participation that we are insisting upon as a condition for our ratifying the Kyoto Protocol, but which is not yet part of that Protocol, and on effective international trading. Moreover, other models will yield other answers and much work remains to be done by the modeling community to test the robustness of these results. Preliminary comparisons of the SGM model to the few other models that have attempted to evaluate the Kyoto accord, suggest that its predictions concerning the impact of the Kyoto Protocol on carbon permit prices are neither the most conservative nor the most optimistic of the models that have been developed.

The predictions of the SGM model are robust in the sense that virtually all energy models reveal the potency of effective, flexible, domestic and international trading mechanisms to reduce substantially the cost and energy price impact of meeting the Kyoto targets.

Of course, the most important factor that has been left out of the above assessment is the benefit of mitigating climate change itself. A full cost-benefit analysis would include mitigation in the benefits column. The only reason we have not done so, explained repeatedly above, is the difficulty in coming up with a number to capture the monetary benefits. But nobody should lose sight of our ultimate objective -- keeping our planet the hospitable home that we enjoy today.

Effects on employment and aggregate output

So far we have said nothing about job losses resulting from climate change policy. Although there may be job gains in some sectors and job losses in others, we do not anticipate any significant aggregate employment effect if we achieve the conditions we have discussed. The effects on energy prices described above will occur only 10 to 14 years in the future. Not only are these effects small relative to historical variations in energy prices, and offset by other policies like electricity restructuring, they would occur sufficiently far in the future to enable monetary policy to keep the economy operating at its potential. In energy-intensive sectors some employment reduction could occur, although given the very small predicted change in energy prices, impacts in most such sectors are apt to be minimal. Furthermore, a large number of jobs will be created in other sectors -- many of them high-tech jobs paying high wages. The President is firmly committed to assisting any workers who are adversely affected during the transition to a climate-friendly economy.

VII. Conclusion

In conclusion, the Kyoto Protocol and the President's general approach to climate change reflect the insight of economic analysis. The Kyoto Protocol includes key provisions on international trading and Clean Development projects. The President's approach relies on market incentives -- first, with a system of tax cuts and R&D investments, and then later with a market-based system of tradeable permits -- to ensure that our objectives are achieved as efficiently as possible.

Our overall conclusion is that the economic impact of the Protocol will be modest under the conditions we have identified. The purpose of this testimony has been to explain the reasoning underlying this conclusion, which draws insights from not only the forecasts of individual models, any one of which has its own strengths and limitations, but also a broad variety of additional analyses.

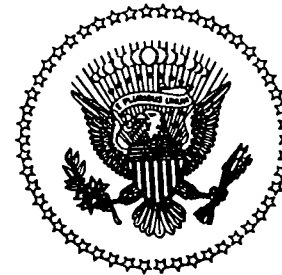
I look forward to continuing to work with members of this Committee, as well as other interested parties, in further analyzing the Kyoto Protocol and evaluating the net effects of reducing greenhouse gas emissions. It is my hope that economic analysis will continue to play a key role in designing policies in this area.

I welcome your questions.

Tab B:

*Economic Report of the
President, February 1997*

Economic Report of the President



**Transmitted to the Congress
February 1997**

**TOGETHER WITH
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The existing statutory and regulatory framework may make it difficult to resolve the complex issues, such as ensuring system reliability, that are sure to arise as competition in electricity evolves. Accordingly, the Administration is considering a variety of legislative proposals to modify existing regulatory frameworks. Such legislation could promote competition and efficiency in the electricity industry by permitting more flexible industry structures and clarifying the jurisdictional boundaries between State and Federal Governments.

The Telecommunications Act, the FERC's open access orders, and State and Federal actions to implement them illustrate how government policy can facilitate the development of responsive, competitive markets. The street goes both ways, however. Recent policy developments regarding pollution control, spectrum management, and land use show how government can use market forces to help achieve important social objectives. (Box 6-7 indicates how advances in telecommunications are making the government more accessible to the public.)

Concerns about environmental degradation and resource depletion have led to an intensified search for innovative, cost-effective solutions. One fairly new approach is emissions permit trading. Proposed at least as long ago as the 1971 *Economic Report of the President*, emissions trading is now often regarded as the preferred policy approach to a range of environmental problems. By giving polluters a financial incentive to reduce emissions in the least expensive possible way, emissions trading reduces the costs of environmental protection. Firms with high abatement costs can purchase permits from firms with low abatement costs, which thus find it profitable to reduce their emissions and sell their surplus permits. As a result, greater responsibility for reducing emissions is allocated to those firms that can do so at least expense.

Emissions Trading in Practice

Much of the enthusiasm for emissions trading is due to its success in attaining mandated reductions in sulfur dioxide (SO_2) emissions from electric utilities, at lower-than-expected costs. The Environmental Protection Agency (EPA) implemented emissions trading as part of its Acid Rain Program. That program, instituted under the 1990 Clean Air Act Amendments, called for major reductions of atmospheric SO_2 and nitrogen oxides (NO_x), the pollutants that cause acid rain. To hold SO_2 emissions to a targeted maximum total level, the EPA issued each polluter a number of permits based on fossil-fuel usage in the mid-1980s. (Box 6-8 discusses the relative merits of giving away emissions permits, auctioning them to the highest bidder, and charging emissions fees.) After the initial distribution, permit holders were allowed to buy or sell permits or use them to offset excess pollution in other parts of their own operations.

During the debate over the Clean Air Act in the 1980s, utilities warned that annual compliance costs could exceed \$4 billion by the year 2000, and SO_2 pollution allowances were predicted to trade at prices ranging from \$170 to almost \$1,000 per ton of emissions. By the end of 1995, however, the price of SO_2 permits was around \$80 per ton. Some preliminary analyses suggest that several factors—deregulation that reduced the cost of shipping Western low-sulfur coal by rail, improvements in fuel blending technology, and subsidies for the installation of equipment (called “scrubbers”) to filter out emissions from smokestacks—reduced demand for and thus the price of SO_2 permits. The flexibility provided by the emissions trading system, however, is credited with promoting competition in coal markets and encouraging innovation that led, at least in part, to these cost reductions. Whatever the linkage, as market-based methods reduce the costs of abatement, more stringent environmental standards become easier to justify.

The first phase of SO_2 emissions trading, affecting 110 plants, began January 1, 1995. Phase II of the Acid Rain Program is slated to begin in 2000, when an additional 700 fossil fuel-burning plants will be subject to emissions caps. Moreover, analysts expect that permit trading will play a greater role in other ways as the market expands. The EPA is examining ways to respond to increased competition following the FERC's Order No. 888, which according to the EPA's analysis will increase the market share of relatively high emission coal-fired plants. A trading system for NO_x is a strong contender.

Emissions Trading and Climate Change Policy

In July 1996 the Administration announced that the United States would support an international effort to set reasonable and attainable, binding emissions-reduction targets for greenhouse

Box 6-8—Trading Pollution Versus Giving Away Emissions: Trading Permits Versus Auctioning

When an emission permits under the EPA's Acid Rain Program were issued to utilities without charge. But handing out tradable emissions permits for free is not the only way to introduce markets into environmental protection. Other policy options include placing fees on emissions, and auctioning rather than giving away permits. By changing relative prices, and therefore incentives, all of these policies seek to improve upon traditional command-and-control methods that specify pollution limits for each plant and, in some cases, even the technologies to be used to achieve those limits. Market-based incentive policies tend to increase efficiency by imposing a marginal cost on firms not polluting through either paying more fees, purchasing more permits, or forgoing the opportunity to sell permits to someone else. Facing these costs gives firms the incentive to reduce pollution, most at plants where it costs the least to do so, and by developing and using less expensive abatement technologies.

Economically, the choice between fees and marketable permits is of secondary importance. It is crucial to set some absolute limit on the quantity of pollution introduced into the environment. Permits, together with stringent enforcement, can ensure that that limit is not exceeded. If the incremental social cost from adding pollution is known to be relatively constant, the theoretically better approach would be to set fees equal to that cost. The chief advantage of fees and auctioning rather than giving away permits is that they raise revenue that can be used for deficit reduction or to offset other more distortionary taxes.

Whether regulation gives away permits, auction them off, or imposes pollution fees, however, that forces firms to abate pollution or pay. One concern is that it raises the cost of supplying the goods and services those firms produce. These higher costs translate into higher product prices. Higher prices, however, lead consumers to take pollution costs into account when making their own purchasing decisions.

gases—the gases whose emission is believed to cause global warming. The possible effects of global warming include risks to coastal areas from rises in sea level; changes in rainfall and agricultural productivity; and increased incidence of diseases such as malaria, yellow fever, and cholera. Combustion of fossil fuels, primarily coal and oil, is the main source of elevated levels of carbon dioxide, the most prevalent of the greenhouse gases.

The United States has called for flexible and market-based approaches for reducing these emissions, one of which may be domestic and international greenhouse gas emissions trading systems. Extending trading internationally is especially intriguing. An international trading system would be able to take advantage of greenhouse gas reductions in those participating nations where the marginal cost of reducing emissions is relatively low.

Other Implementation Issues

Determining the initial distribution of emission permits can be contentious. The alternative to allocating permits through the market by auctioning them is to rely on a formula, which may be based on past and current pollution. Such formulas can be controversial because recipients of permits are given a scarce and valuable resource. Moreover, companies anticipating an allocation based on current practices have an incentive to delay actions to limit pollution or other environmentally harmful activities, in order to qualify for more permits. This incentive can be partially neutralized by linking reductions to some prior historical baseline. However, this approach can make the choice of allocation formula more difficult, since participants will realize that a distribution of permits based on historical practices penalizes those who were the first to undertake actions to improve the environment.

In cases where the incremental harm from emissions is relatively constant over time, the efficiency of emissions trading can be enhanced, at least in the short run, by allowing polluters to bank and borrow permits. Under such a system, polluters could defer their use of a permit, or borrow against future allowances, as their costs dictate. Where workable, this can allow the emissions trading market to allocate reductions over time in a more efficient manner. Timing flexibility can reduce compliance costs through better coordination of emissions reductions when replacing old facilities with less polluting technology. In the first year of the EPA's SO₂ trading program, emissions reductions were about 40 percent greater than the target level, as utilities "banked" allowances for future years.

A problem can arise when the damages from emissions are not distributed evenly over the geographic area in which firms can trade permits. If polluters with high abatement costs—the ones most likely to buy permits—are geographically concentrated, a "hot spot" area that is persistently in serious noncompliance may result. Hot spots are a potential problem with SO₂, but they may be more serious with regard to NO_x. Better market mechanisms for dealing with hot spots should be developed.

Despite these and other complications, interest in emissions trading remains strong, primarily because of the potential cost savings and efficiency gains. The EPA estimates that meeting possible SO₂,

NO_x, and mercury targets through an emissions trading program with banking would reduce abatement costs in 2005 by almost two-thirds compared with a traditional command-and-control approach. Researchers at the Stanford Energy Modelling Forum have predicted that international emissions trading for carbon dioxide could reduce costs as much as 50 percent below the minimum achievable using purely domestic programs—and as much as 80 percent if flexibility in the timing of emissions reductions is allowed. These cost savings do not conflict with considerations of intergenerational equity, because they take place within a program designed to ensure that concentrations of carbon dioxide never exceed critical target levels in any year.

SPECTRUM AUCTIONS

Auctions of rights to use publicly owned resources can allocate those resources efficiently, as well as generate revenues to help cover the costs of government programs. The chief example in 1996 was the FCC's auctions of rights to use parts of the radio spectrum for personal communications systems (PCS). By virtually all accounts, this was an enormously successful example of using market forces to complement the public sector.

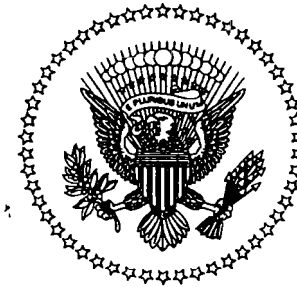
Auctions can be designed in numerous ways. Some feature one-time sealed bids, whereas others feature repeated open bids. Rights or permits to be auctioned can be offered together or one at a time. Winning bidders may pay the bid they offer or, to limit strategic incentives to underbid, they may pay the second-highest bid offered. The winner can be determined either as the last to make an offer higher than all preceding offers, or as the first to speak up as an auctioneer offers a succession of declining sales prices. Regardless of the method, the goals are the same: to get assets into the hands of those who will derive the greatest economic value from them, and to do so rapidly and efficiently. How best to design the auction depends on a variety of strategic considerations. A primary factor in the PCS auctions (Box 6–9) was to enable bidders to pursue collections of licenses and preserve their options when strategies needed revision. This added flexibility is likely to have increased firms' willingness to bid, allowing the government to capture some of the economic benefits created by making it easier for firms to place bids for one license based on their beliefs about whether they will win others.

Spectrum auctions have particular advantages over earlier methods of issuing spectrum licenses. Comparative hearings, in which the FCC attempted to distinguish among prospective licensees on noneconomic grounds, generated enormous delay and expensive litigation with little if any public benefit. Using lotteries to distribute licenses randomly to applicants eliminated the need for the

Tab C:

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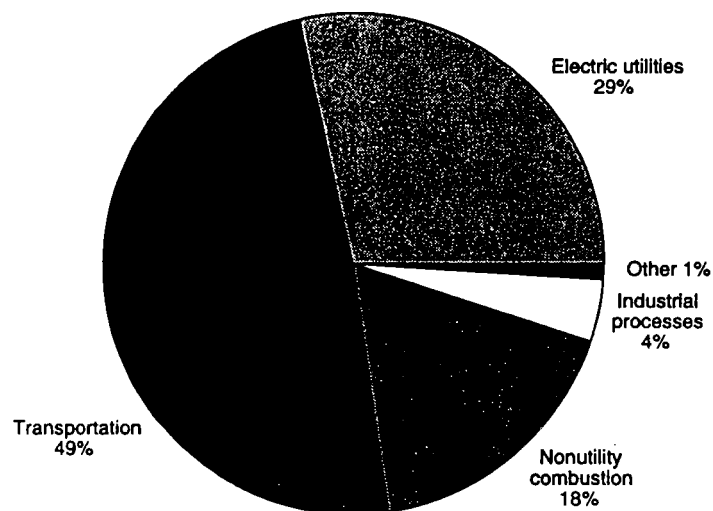
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Chart 5-3 Sources of Nitrogen Oxides Emissions in 1995
Vehicles are the principal source of nitrogen oxides emissions.



Note: Nonutility combustion includes residential and commercial heating.
Source: Environmental Protection Agency.

Thus, extending NO_x trading to nonutility sources could reduce costs. However, the scope of the program may be limited by the need to ensure accountability. For example, some smaller sources have considerably lower control costs than electric utilities, but their claimed emissions reductions may be more costly to monitor.

Including more sources from different sectors in the trading program may also have desirable distributional effects. Utilities are likely to pass the cost of compliance on to consumers in the form of higher electricity prices, and low-income households spend a higher share of their income on electricity bills than do households near the median income. Moreover, broader scope can decrease the average cost of pollution abatement, reducing the burden on all parties, including the poor.

Another challenge in designing a trading program for NO_x within the context of the regional ozone reduction strategy is to maintain broad geographic scope while ensuring that trading does not result in significant adverse environmental effects. The goal of this strategy is to improve air quality in nonattainment areas cost-effectively. In its simplest form, the problem of pollution transport can be thought of in terms of a single downwind nonattainment area that is affected by a number of upwind pollution sources located at varying distances from it along a line indicating wind direction. In this case, sources that are farther upwind will have less impact on the air quality of the area than sources that are closer, all other things being equal, and such differences may be as large as 10 to 1. It might then appear that emis-

sions trading could undercut the effectiveness of pollution controls if it resulted in shifting emission reductions farther upwind. Trading ratios that weight the reductions made at different sources according to their distance from the downwind nonattainment area might be considered to address this problem. In reality, however, there are a large number of nonattainment areas spread out over the region, and several different weather patterns and wind conditions characterize the ozone pollution episodes that the program is trying to remedy. Sources affect multiple nonattainment areas in a variety of directions from them, and it affects any single nonattainment area differently under different weather conditions. The polycentric nature of this problem complicates the identification of a unique and stable set of trading ratios that would work for all relevant cases. Thus, striking the proper balance between achieving the cost savings from larger geographic scope and limiting the potentially significant adverse environmental effects of trading is an ongoing challenge.

Like most air pollution control programs, NO_x trading programs would require an estimate of emissions from each regulated source in order to ensure compliance. The estimation method can have significant implications for cost-effectiveness, both directly, through the cost of performing the estimate, and indirectly. One indirect implication is that more costly requirements may limit the number of sources that could meet the estimation requirements and participate in trading, and thereby raise costs. On the other hand, a more reliable estimation method may offer regulators and sources greater confidence in the permits, and thereby increase the willingness of sources to buy them or offer them for sale. For example, the SO_2 program requires continuous emissions monitoring to provide precise information on emissions. Such monitoring is expensive and impractical for many smaller sources and thus may effectively exclude such sources from participating. But such precise monitoring may not always be necessary. Methods for estimating emissions that provide unbiased, although less precise, estimates of emissions may be accurate enough to ensure accountability.

CLIMATE CHANGE

Climate change is a global environmental externality: warming of the earth's surface results from the accumulation of greenhouse gases from myriad sources worldwide, none of which presently pay the cost to others of warming's ill effects. The Intergovernmental Panel on Climate Change, jointly established by the World Meteorological Organization and the United Nations Environment Programme, concluded in 1995 that "the balance of evidence suggests that there is a discernible human influence on global climate." Current concentrations of carbon dioxide (CO_2), methane, nitrous oxide (N_2O), and other so-called greenhouse gases have reached levels well above those of

preindustrial times. Of these, CO₂ is the most important: net cumulative CO₂ emissions resulting from the burning of fossil fuels and deforestation account for about two-thirds of potential warming from changes in greenhouse gas concentrations related to human activity. If growth in global emissions continues unabated, the atmospheric concentration of CO₂ will likely double, relative to its preindustrial level, midway through the next century.

The accumulation of greenhouse gases poses significant risks to the world's climate and to human well-being. Potential impacts include a rise in sea levels, greater frequency of severe weather events, shifts in agricultural growing conditions from changing weather patterns, threats to human health from increased range and incidence of diseases, changes in availability of freshwater supplies, and damage to ecosystems and biodiversity.

Climate change is a complex, long-term problem requiring global cooperation and a long-term solution. No single country has an incentive to reduce emissions sufficiently to protect the global environment against climate change. Even if the United States sharply reduced its emissions unilaterally, greenhouse gas emissions from all other countries would continue to grow, and the risks posed by climate change would not be significantly abated. Since many of these gases remain in the atmosphere for a century or more, the climatic effects of actions taken today will primarily benefit future generations. But delaying action to reduce greenhouse gas emissions until the disruptive effects of climate change become widespread will considerably reduce the options for remedial or preventive measures.

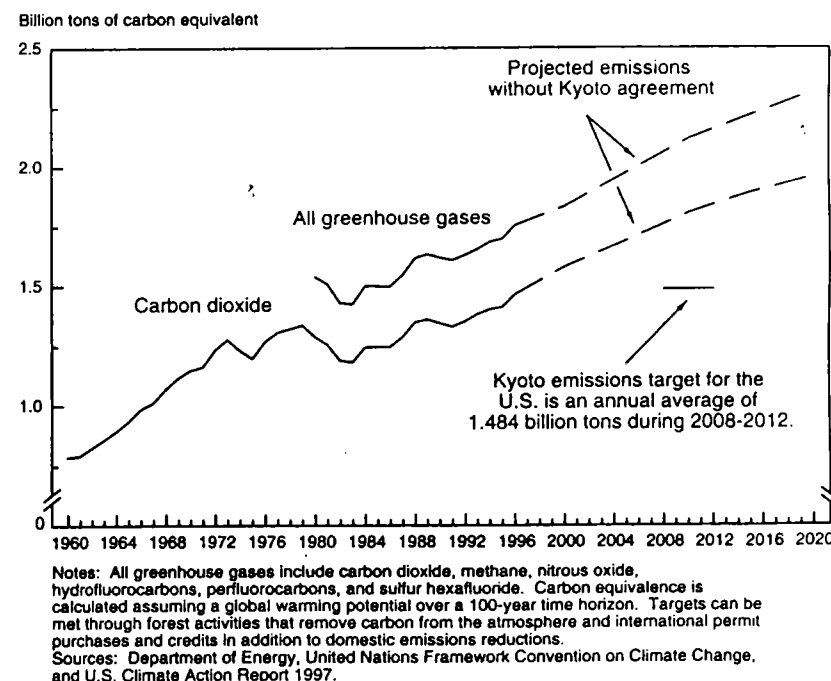
The Framework Convention on Climate Change

The threat of disruptive climate change has led to coordinated international efforts to reduce the risks of global warming by reducing emissions of greenhouse gases. The first international agreement to address global warming was the Framework Convention on Climate Change signed during the Earth Summit in Rio de Janeiro in 1992. This convention established a long-term objective of limiting greenhouse gas concentrations and encouraged the established industrial countries to return their emissions to 1990 levels by 2000. Since then it has become clear that the United States and many other participating countries will not meet this goal.

To address the lack of progress among many industrial countries toward meeting this first target, the United States and approximately 159 other nations, in negotiations held in Kyoto, Japan, last December, agreed to take substantial steps to stabilize atmospheric concentrations of greenhouse gases. The Kyoto agreement, which requires the advice and consent of the Senate, would place binding limits on industrial countries' emissions of the six principal categories of greenhouse gases: CO₂, methane, N₂O, sulfur hexafluoride, perfluorocarbons, and hydrofluorocarbons. Each industrial country's "1990

baseline" is actually based on its 1990 emissions of CO₂, methane, and N₂O and its choice of 1990 or 1995 levels of the other three categories of gases. The United States agreed to a target of 7 percent below 1990 levels over 2008-2012. To meet that target, net U.S. emissions of greenhouse gases—all emissions minus removals of CO₂ by certain forest activities such as planting trees—must average no more than 1,484 million metric tons of carbon equivalent per year during that period (Chart 5-4). The targets for the European Union and Japan are 8 percent and 6 percent below 1990 levels, respectively. Australia, New Zealand, Norway, Russia, and Ukraine all have less stringent limits. In sum, over the period from 2008 to 2012, the industrial countries are

Chart 5-4 U.S. Greenhouse Gas Emissions, Actual and Projected
The U.S. emissions target under the Kyoto agreement is about 25 percent below current projections in 2008-2012.



expected to reduce their average emissions of greenhouse gases to about 5 percent below their 1990 levels.

The Kyoto agreement provides opportunities for the industrial countries to trade rights to emit greenhouse gases with each other. They may also invest in "clean development" projects in the developing world and use these projects' certified emissions reductions toward meeting their targets. Both of these mechanisms allow for emissions reductions to occur where they are least expensive. Many of the details of these provisions will be worked out in subsequent negotiations.

Emissions Permit Trading for Greenhouse Gases

One component of the Administration's climate change proposal, announced last October by the President, is a domestic emissions permit trading program for greenhouse gases starting in 2008. As in the similar program for SO₂, permit trading would allow emissions targets to be met at a lower cost than under a traditional regulatory approach that sets fixed limits on individual firms' emissions.

As previously discussed, one consideration in designing an emissions permit trading program for greenhouse gases is how initially to distribute permits. The method of initial allocation would not generally affect the efficiency with which emissions reductions are achieved, but would have significant distributional implications. Another issue is where, in the marketing chain of products responsible for greenhouse gas emissions, permits would be required. One approach, called the permit-to-market approach, would impose the emissions limits at the point of first sale of the commodities responsible for greenhouse gases. In the case of SO₂ emissions, permits would be required for the sale of fossil fuels and specified in terms of the amount of SO₂ released in their combustion. The requirement would be imposed at the wellhead or the refinery (in the case of oil or natural gas), at the mine (in the case of coal), or at the port of entry (in the case of imported fossil fuels). Alternatively, a permit-to-emit approach would issue permits to consume these fuels or to sell products, such as automobiles, that do so. A hybrid of the two approaches may also be possible.

The design of an effective greenhouse gas permit system needs to take several other issues into account. First, a sufficient number of participants must be included in the domestic permit market to ensure that the market is competitive and efficient.

Second, the system should include a monitoring mechanism that assesses compliance in the most cost-effective manner possible. In the case of a permit-to-market system, since the amount of SO₂ emitted per barrel of oil or ton of coal consumed is relatively fixed, the task of measuring SO₂ emissions is straightforward. Moreover, for accounting purposes firms already collect information and keep records about their fuel transactions. Under the permit-to-emit approach, monitoring would likely involve a more complex combination of emissions calculation and measurement for all regulated greenhouse gas emitters.

Third, a permit system that would allow trades across all sectors of the economy would minimize total cost. If, for example, the incremental cost of reducing emissions is much lower in electric power generation than in transportation, one could reduce the cost of meeting the reduction target by allowing permit trading between the two sectors. The permit-to-market approach would generally allow trades across sectors. The permit-to-emit approach could also yield the same result, depending on how it is implemented.

Timing Flexibility in Meeting Emissions Reductions

Flexibility about *when* emissions reductions take place can further lower the cost of reducing greenhouse gas emissions. A system that allows participants to borrow emissions permits from the future or to save unused permits for future use would take advantage of differences in cost abatement opportunities across time.

Three features of the Kyoto agreement contribute to timing flexibility. First, the target for emissions reductions is based on a 5-year commitment period. For example, the target set for the United States of a 7-percent reduction in emissions below 1990 levels is specified as an annual average over 2008-2012. By averaging over 5 years instead of requiring the United States to meet the 7-percent target each year, the agreement provides flexibility in the timing of reductions that can lower costs, especially given an uncertain future. Averaging can smooth out the effects of short-term events such as fluctuations in the business cycle and energy demand. It can also lessen the impact of a year with a hard winter, when energy demand, and thus emissions, would increase. Further, if firms anticipate that a new technology will soon be available that lowers the cost of reducing emissions, they could emit more greenhouse gases in the early years of the period and less after the technology becomes available. Another advantage of this approach is that it may avoid forcing a costly rapid turnover of capital stock for electricity generation.

The Kyoto agreement allows countries to bank unused emissions rights from one commitment period for use in the next. Should investments in research and development yield some pleasant surprises in the form of cleaner and more efficient technologies, banking will encourage the early adoption of these technologies in order to save unused emissions permits for future periods when the costs of emissions abatement may be higher.

In addition to banking across commitment periods, countries may bank certified emissions reductions obtained through the "clean development mechanism" discussed below. Countries may use emissions reductions achieved through this mechanism over the 2000-2007 period to assist in complying with their targets in the first commitment period. This provides an incentive for firms in industrial countries to begin investing in energy-efficient technologies in developing countries before 2008.

International Trading in Greenhouse Gas Emissions

Building on the benefits of the domestic trading program just described, the Administration proposed in Kyoto an international trading program for greenhouse gas emissions permits. The Kyoto agreement established the right of countries assigned emissions targets to meet their commitments by trading among themselves. This establishment of the right to trade provides the foundation for a trad-

ing regime among industrial countries, but leaves the details to be agreed upon later. Since it is easier to reduce emissions in some countries than others, and given that greenhouse gas emissions have equivalent climate effects regardless of their location, allowing global trading would achieve climate change objectives at lower cost. Such a global approach would ideally allow trading among all sources of greenhouse gases in participating countries and could incorporate opportunities to *remove* greenhouse gases from the atmosphere, for example by issuing emissions credits (which could then be sold to other firms) for reforestation projects.

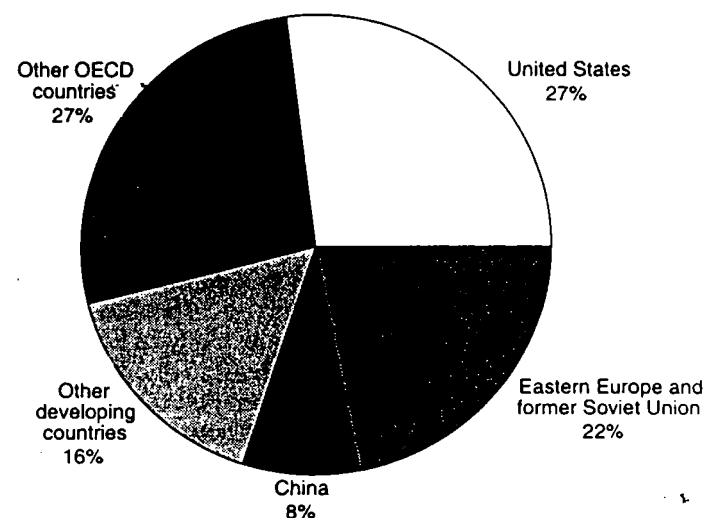
International trading could take place among firms that have been allocated permits through domestic trading programs. For countries that have no domestically tradable permits because they have opted for a command-and-control or a tax approach to controlling emissions, it may still be possible instead to arrange exchanges on a government-to-firm or government-to-government basis.

The setting of binding targets among all countries, together with international trade in permits, could in principle result in a global market price for permits for greenhouse gas emissions. For example, the permit price could be expressed in terms of dollars per ton of carbon equivalent emitted. Firms in all countries would reduce their emissions until the cost of further reductions exceeded this price, at which point they would buy additional permits. Large differences in both the patterns of energy use and the efficiency of energy technologies among countries imply that the cost savings from international permit trading would be large compared with a system without international trading. Put differently, even in comparison with a system with full domestic trading of emissions permits, international trading could substantially lower costs. Some models predict that the incremental cost of reducing CO₂ emissions may be as little as one-seventh of the cost of reductions from domestic trading alone. The gains from international trade in permits would be particularly large if developing countries were to participate.

The Importance of Developing-Country Participation

Negotiations leading up to the Kyoto agreement sought binding limits on greenhouse gas emissions among industrial nations. Developing countries have resisted committing themselves to binding limits on their emissions because of concern that to do so would severely constrain their economic growth, and because by far the greater part of accumulated greenhouse gases in the atmosphere is the result of past economic activity in the industrial countries (Chart 5-5). However, current forecasts project that greenhouse gas emissions from developing countries will surpass those from industrial countries around 2030, and even sooner if industrial countries are successful in limiting their emissions (Chart 5-6). Thus, eventual curbs on emissions from developing countries are essential in order to

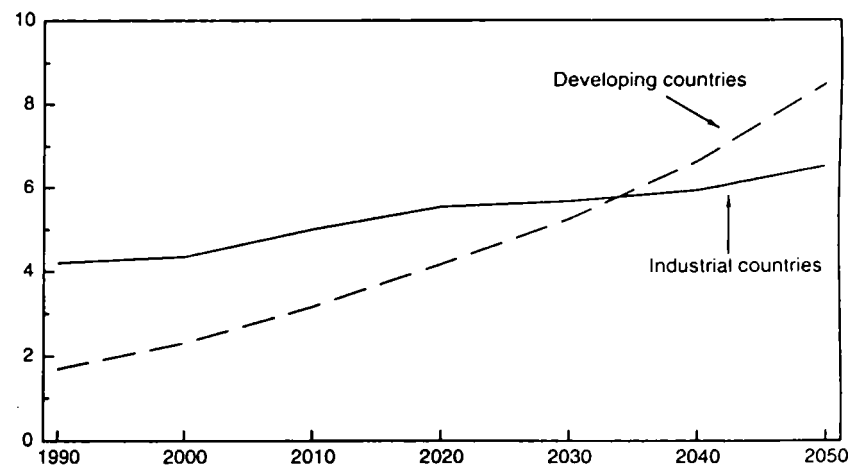
Chart 5-5 Cumulative World Emissions of Carbon Dioxide, 1950-95
Industrial countries are responsible for the vast majority of accumulated carbon dioxide in the atmosphere.



Note: Other OECD countries include the countries of the European Union, Australia, Canada, Iceland, Japan, New Zealand, Norway, Switzerland.
Source: Department of Energy.

Chart 5-6 Projected World Carbon Dioxide Emissions Without Kyoto Agreement
Around 2030, annual carbon dioxide emissions from developing countries are expected to surpass industrial countries' emissions.

Billion tons of carbon equivalent per year



Note: These projections are consistent with the Intergovernmental Panel on Climate Change IS92A global projection through 2100.
Source: Unpublished calculations by A. Manne, Stanford University and R. Richels, Electric Power Research Institute.

stabilize the amount of greenhouse gases in the atmosphere. Moreover, some of the least cost opportunities for reducing greenhouse gas emissions are in developing countries, because those countries now use energy relatively inefficiently. Moreover, those that are industrializing rapidly have greater scope to build their industry around cleaner and more efficient energy technologies and fuels than do mature economies whose capital stock is already in place.

Failure to involve developing countries in an international agreement limiting greenhouse gas emissions could lead to a more rapid rate of increase in emissions in those countries than would occur without any agreement at all. This "leakage" effect of emissions reductions could come about in any of several ways. As industrial countries reduce their use of fossil fuels in response to emissions controls, future world oil and coal prices are likely to be lower than they would be otherwise. This is likely to increase energy consumption in countries not bound to limit their emissions. U.S. industries are also concerned about their international competitiveness if some countries remain outside an international agreement, since factories in those countries will face lower costs for producing goods that take relatively large amounts of energy to manufacture. Some may be concerned that energy-intensive industries might choose to relocate to countries not subject to emissions constraints, although there is little evidence to suggest that this would pose a significant problem in most industries. For example, energy costs for manufacturing industries average just 2.2 percent of total costs.

Given the projected growth of developing countries' emissions, the Administration's position is to seek meaningful participation by key developing countries in the reduction of greenhouse gas emissions as a condition for the United States taking on binding emissions reductions. The President has indicated he will not submit the Kyoto agreement for Senate ratification until there is meaningful participation by key developing countries.

Joint Implementation and the Clean Development Mechanism

To encourage participation by developing countries in the climate change initiative even before they formally sign on for binding emissions limits, the President has proposed a program known as joint implementation. This program would provide incentives to developing countries to reduce their emissions of CO₂ and other greenhouse gases. The Kyoto agreement embraces the President's proposal in its designation of a "clean development mechanism" (CDM): U.S. companies that undertake projects that reduce greenhouse gas emissions in developing countries could count those reductions to meet their commitments. Institutionalizing key elements of joint implementation through this mechanism would encourage firms in the United States to transfer a larger volume of cleaner and more energy-efficient technology to developing countries, especially in the electric power

generating industry, while providing substantial cost savings to U.S. firms. It would also provide incentives to expand forests, which absorb CO₂. In addition to the CDM, the agreement allows industrial countries to undertake joint implementation projects with each other.

A key issue is how to ensure that credits are awarded for actual, additional emissions reductions, and not simply for projects that would have been carried out anyway. The Kyoto agreement requires that emissions reductions occurring through the CDM be certified to provide real, measurable, and long-term benefits related to the mitigation of climate change, and that the emissions reductions achieved are additional to any that would occur in the absence of these projects. Future negotiations will focus on developing the rules for certifying and enforcing projects undertaken through the CDM.

Promoting Clean and Efficient Energy Technology

The President's plan to reduce greenhouse gases commits new resources to energy research and programs to promote the wider use of cleaner and more energy-efficient technologies in the U.S. economy. The emissions permit trading system for greenhouse gases is also likely to encourage more private research and innovation, as companies seek to lower the cost of meeting environmental targets.

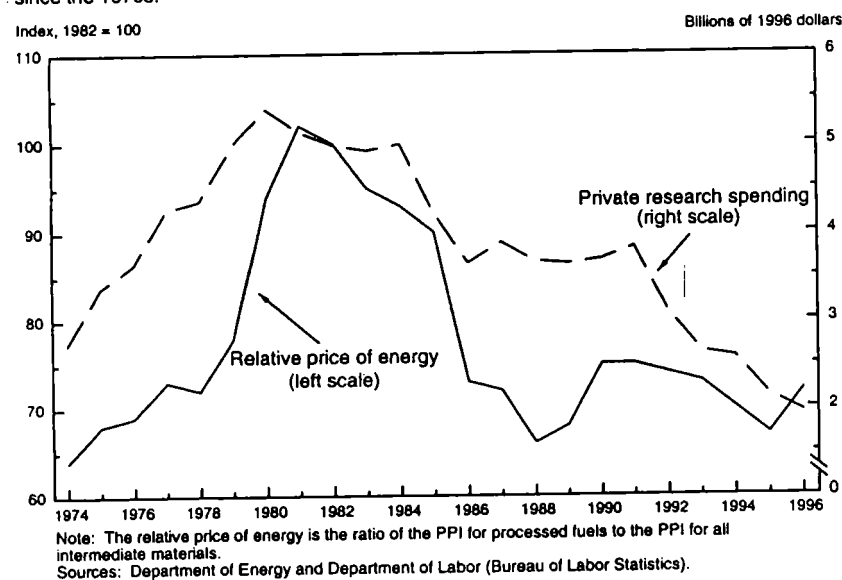
Government support for science and technology in general addresses an important market failure. Promising new technologies often fail to attract sufficient private sector interest if their technical risk is high and if they create economic and social benefits beyond what the investing firms can capture for themselves. Economic studies have shown that private firms, despite intellectual property protection, are able to appropriate only about half of the total economic benefits from their own research. This gap between social and private returns may be particularly large for research on cleaner and more efficient energy technology, when the environmental externalities associated with energy use have not been fully addressed by environmental and other regulatory policies.

The appropriability problem is not limited to basic research but frequently extends to precommercial research as well. Precommercial research is research that is close to yielding new products or processes, but still far enough away from commercialization that further development poses a substantial financial risk. New renewable energy industries (wind power, solar energy, and biomass energy, for example) may face particularly formidable constraints to commercialization. First-of-a-kind products often have high unit costs. High-volume production provides economies of scale, generates experience in manufacturing and operation, and opens new opportunities for incremental technological improvements—all of which may lead to lower costs.

The President's commitment to increase Federal support for new energy technology seeks to reverse a trend of declining national

investment in energy research (Chart 5-7). One reason investment in energy research has declined since the late 1970s is falling or stagnant energy prices, which reduced the economic incentive to develop new sources of energy and improve efficiency. In the 1990s it is primarily private sector energy research that has declined. Increasing government investment in energy research is likely to be complemented by more private research: public research on longer term, basic scientific studies can open up new, profitable opportunities for applied research and commercial development by the private sector. An increase in support for research that raises the rate of progress in developing cleaner and more efficient technologies would lower the costs of reducing greenhouse gas emissions.

Chart 5-7 Energy Prices and Private Energy Research
Energy prices and private investment in energy research have followed similar trends since the 1970s.



The President's proposal also includes programs and tax incentives to encourage the wider adoption of existing technologies that can decrease greenhouse gas emissions. Of particular importance are technologies that reduce consumption of fossil fuels. In addition to encouraging clean and renewable energy sources, these programs will provide economic incentives and other forms of assistance (such as better information) for improving energy efficiency in industry, transportation, and homes. The President's plan to use Federal procurement policy to reduce greenhouse gas emissions is another way to increase market penetration of these technologies.

Until an emissions cap and trading system are in place, however, the economic incentive to use these technologies may be low, because at present the price of energy does not reflect the environmental cost of

CO₂ emissions. This environmental externality results in a market failure to make the most efficient use of new technologies that lower emissions. Many of these technologies are expected to be more profitable once a CO₂ emissions cap is in place and the environmental costs associated with energy use are more fully reflected in energy prices.

There is also evidence that many households and businesses fail to invest in some home and building improvements that appear profitable even at today's energy prices. More efficient home refrigerators and air conditioners, fluorescent lighting, and "low-E" glass for windows, for example, are available on the market and, by some accounts, offer potentially large energy and cost savings. By spending money now on these more efficient technologies, proponents argue, many consumers could quickly recoup their investments in the form of lower energy bills. But if such investments are in consumers' own economic interest, why don't they invest in them on their own? Insufficient knowledge and information may be a key factor: consumers may not be aware of new technologies that could reduce CO₂ emissions and save them money on energy bills, or may not be convinced of the economic benefits that could be realized from adopting them. Lack of up-to-date information on recent technological developments may also lead people to overestimate technical risks—they may doubt whether a new technology is as reliable as current methods, particularly if the new technology is not yet widely used.

On the other hand, even if a new technology is beneficial for many users, it may not be so for everyone. People differ in their willingness and ability to make investments today in order to realize savings in the future, especially if the initial expense is relatively large. In addition, some consumers may value a product for attributes other than its energy efficiency—for example, its convenience, size, or design. And not all consumers may achieve all of the promised energy savings, depending on the climate of the region where they live. These considerations reflect the great diversity of needs and preferences among businesses and households and help explain why new technologies may diffuse slowly over time.

Better information about the potential cost savings from improving energy efficiency may increase the use of technologies that already meet the market test—that is, that meet consumer standards for quality and dependability and offer real economic benefits. The Federal Government is working with the private sector to promote wider use of such technologies. For example, through the Green Lights program, the EPA provides technical information to private companies on the economic and environmental benefits of switching to new, fluorescent lighting systems. Energy Star is another EPA program, in which innovative products that use significantly less energy than older generation products are allowed to bear a special, readily identifiable label. More rapid diffusion of new emissions-saving technologies would make an important contribution toward meeting the goals of the Kyoto agreement.

Tab D:

Economists' statement on
climate change, endorsed by
over 2500 economists
including eight Nobel
Laureates

ECONOMISTS' STATEMENT ON CLIMATE CHANGE

*Endorsed by Over 2500 Economists
including eight Nobel Laureates*

I. The review conducted by a distinguished international panel of scientists under the auspices of the Intergovernmental Panel on Climate Change has determined that "the balance of evidence suggests a discernible human influence on global climate." As economists, we believe that global climate change carries with it significant environmental, economic, social, and geopolitical risks, and that preventive steps are justified.

II. Economic studies have found that there are many potential policies to reduce greenhouse-gas emissions for which the total benefits outweigh the total costs. For the United States in particular, sound economic analysis shows that there are policy options that would slow climate change without harming American living standards, and these measures may in fact improve U.S. productivity in the longer run.

III. The most efficient approach to slowing climate change is through market-based policies. In order for the world to achieve its climatic objectives at minimum cost, a cooperative approach among nations is required—such as an international emissions trading agreement. The United States and other nations can most efficiently implement their climate policies through market mechanisms, such as carbon taxes or the auction of emissions permits. The revenues generated from such policies can effectively be used to reduce the deficit or to lower existing taxes.

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One Kearny Street • 4th Floor

San Francisco, CA 94108

Phone: (415) 781-1191

Fax: (415) 781-1198 _____

E-Mail: info@RProgress.org

January 3rd, 1997

Dear Colleague,

As you may know, representatives of the world's nations will convene in Kyoto in December, 1997 to negotiate an international agreement addressing the threat of global climate change due to greenhouse gas emissions. This presents a significant opportunity for the United States to exercise a leadership role in ensuring our long-term well-being. Conversely, a failure on the part of the U.S. government to put forward a well-reasoned position would be a major environmental, economic, and diplomatic setback.

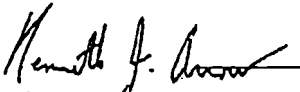
As the climate debate unfolds, it is imperative that public policy be guided by sound economics rather than misleading claims put forward by special interest groups. For this reason, we invite you to join us in endorsing the attached non-partisan consensus statement on the economics of climate change.

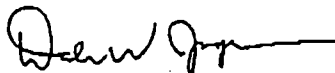
Once this statement has been signed by a large number of economists, it will be widely disseminated to leaders in the public and private sectors, and to the general media. This effort is being coordinated by Redefining Progress, a non-partisan, non-profit public policy organization.

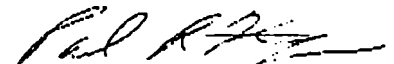
Attached please find an endorsement form for your consideration. This letter and endorsement form are being sent to the membership of the American Economic Association. Please feel free to circulate it to your colleagues in case they are not on the AEA mailing list.

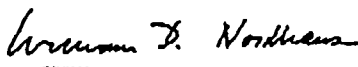
We thank you for your prompt attention to this critical issue.

Sincerely,


Kenneth J. Arrow


Dale W. Jorgenson


Paul R. Krugman


William D. Nordhaus


Robert M. Solow

**NOBEL LAUREATE SIGNATORIES
TO
ECONOMISTS' STATEMENT ON
CLIMATE CHANGE**

Kenneth Arrow (1972)
Stanford University

Gerard Debreu (1983)
University of California at Berkeley

John Harsanyi (1994)
University of California at Berkeley

Lawrence Klein (1980)
University of Pennsylvania

Wassily Leontief (1973)
New York University

Franco Modigliani (1985)
Massachusetts Institute of Technology (Emeritus)

Robert Solow (1987)
Massachusetts Institute of Technology

James Tobin (1981)
Yale University

ECONOMISTS' STATEMENT ON CLIMATE CHANGE

LIST OF ECONOMISTS WHO HAVE ENDORSED TO DATE

MARCH 24, 1997

NAME	AFFILIATION	NAME	AFFILIATION
A. W. Coats		Daniel G. Swanson	
Abbass Bozory		Danny A. Bring	
Abdul Qayum		David Ashmore	
Ahmad Afraslabi		David Buland	
Ajal Chopra		David Burress	
Alan R. Winger		David C. Campbell	
Almudena Arcelus		David C. Roberts	
Amos Khasigian		David Calvin Gogerty	
Andrea Dean		David D. Hanig	
Andrew Chritton		David I. Siskind	
Andrew Horowitz		David M. Eaves	
Andrew W. Weler		David R. Burnett	
Angela E. Chang		David Reiffen	
Ann A. Dean		David Sandler	
Ann M. Watkins		David Schenker	
Anonymous		Debojyoti Sarkar	
Anthony Apostolides		Deborah A. Senior	
Anthony Barkume		Deenie Neff	
Arthur C. Ashbrook, Jr.		Delle Nadler	
Arturo R. Torres Jr.		Desiderius Viktor	
Arun Kumar Ghosh		Dhez Woodworth	
Austin Curwood Hoggatt		David W. Riggs	
Barbara Weinstein		Donald E. Agthe	
Barbara Y. Peters		Donald J. O'Hara	
Benjamin Bridges		Donald W. O'Connell	
Bernard Gordon		Donald Wooten	
Bernard Kemp		Douglass B. Lee	
Brian C. Jack		Dr. Raynal Hammetton	
Bruce Fallick		Drue Barker	
Caren Grown		Dubravko Mihaljek	
Carlos Padilla		Edgar J. Gordon	
Carlos Uliberri		Edward K. Smith	
Carmine Gorga		Elias R. Ason	
Charles D. Coleman		Elliot A. Ponchick	
Charles Ronald Ross		Elmer F. Lotshaw	
Charles S. Maurice		Eloy Mestre	
Chetan Sanghavi		Eric Nauenburg	
Chris Beacham		Ernest C. Olson	
Christian Ergen-Zucchi		Eugene D. Straub	
Chyongchiou Lin		Evamaria Uribe	
Clara Chu		Evert Van Der Helde	
Clyde Tappwig		F. Brian Simmons, III	
Cornelia Strawser		Ferdinand P. Sioshansi	
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MARCH 24, 1997

NAME	AFFILIATION	NAME	AFFILIATION
Thesia I. Garner		Donald Rosenthal	American Management Systems
Thomas Foster		Tom Everding	American Medical Association
Thomas M. Stanback, Jr.		Alan G. Isaac	American University
Thomson Whittin		Bruce H. Lubich	American University
Tim Lefever		Donald Bowles	American University
Timothy D. Baker		Howard M. Wachtel	American University
Timothy E. Mc Clive		James H. Weaver	American University
Timothy E. Sullivan		Robin Hahnel	American University
Va Nee V. Van Vleck		Sue Headlee	American University
Valeo Schultz		Karen Hallows	American University, Averett College
Van Lam		Ralph E. Beals	Amherst College
Volker Wieland		Richard C. Hoyt	Analytics
W. C. Brainard		Samuel Cubins	Annual Reviews Inc.
W. N. Turpin		Elbert V. Bowden	Appalachian State University
Willem J. Jansen		James Cavallo	Argonne National Laboratory
William A. Masters		Lutz Hendricks	Arizona State University
William Crowell		Michael Lemmon	Arizona State University
William Dellal		Gary A. Latanich	Arkansas State University
William J. Weiskopf		Brian J. Cody	Arthur Andersen
William Kahley		Kevin J. O'Connor	Assistant Attorney General
William R. Belmont		Thomas White	Assumption College
William S. Stine		Christopher J. Monroe	AT&T
Yves Maroni		Douglas G. Hobbs	AT&T
Clark C. Abt	ABT Associates, Inc.	Jian Cao	AT&T
Gregory B Mills	ABT Associates, Inc.	Kumiko Powell	AT&T
Günar Hauff Platals	ABT Associates, Inc.	Gregory Napierkowski	AT&T Laboratories
Jacob Benus	ABT Associates, Inc.	Louis T. Brewer	AT&T, Ltd.
Larry L. Orr	ABT Associates, Inc.	Henry Thompson	Auburn University
Leland Deck	ABT Associates, Inc.	John P. Sophocleus	Auburn University
Marty Mäkinen	ABT Associates, Inc.	Robert F. Hebert	Auburn University
Robert Kornfeld	ABT Associates, Inc.	Jürgen Brauer	Augusta State University, School of Business
Ulrich F.W. Ernst	ABT Associates, Inc.	Hiro Fukao	Aurthur D. Little
Allen B. Ferguson	AFE, Inc.	Patrick J. Kennon	Aviation Economics
Amy K. Taylor	Agency for Health Care Policy and Research	Mark Tomass	Babson College
Chiou-nan Yeh	Alabama State University	Stephen Silver	BADM, The Citadel
Earl W. Adams	Allegheny College	Judith A. Smrha	Baker University
Kenneth G. Almsworth	Allegheny College	Barbara Sherman Rolleston	Baldwin-Wallace College
Stephen D. Casler	Allegheny College	Terence E. Byrne	Baltimore-Washington Financial Advisors
Pamela Mobilia	Alpine PCS	Leland S. Prussia	Bank of America Corporation
Michael Stavv	Alternative Energy and EV's	R. McFall Lamm, Jr.	Bankers Trust Co.
Paul Thompson	AMBAC Indemnity	Maxwell Rhee	Banque Nationale de Paris
Riad Tabbarah	Ambassador of Lebanon to the U.S.	Mary Lashley Barcella	Barcella Associates
Daniel Bell	American Academy of Arts & Science	Dimitri Papadimitriou	Bard College
M. Abdul Shibli	American Economic Association	Shannon Mudd	Barente Group
Paul Kahane	American Economic Association	Gopal Iyer	Baruch College
Jay G. Chambers	American Institutes for Research	Theodore Joyce	Baruch College

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LIST OF ECONOMISTS WHO HAVE ENDORSED TO DATE

MARCH 24, 1997

NAME	AFFILIATION	NAME	AFFILIATION
Ted Walther	Bates College	David Well	Boston University
Steve Shantle	Battelle	Debraj Ray	Boston University
Kathrine F. Wellman	Battelle Memorial Institute	Eli Berman	Boston University
Dave Anderson	Battelle-Northwest	Ingo Vogelsang	Boston University
David B. Belzer	Battelle-Northwest	Jonathan Eaton	Boston University
Joseph A. McKinney	Baylor University	Laurence J. Kotlikoff	Boston University
John Katharopoulos	BCBS of Michigan	Shane J. Hunt	Boston University
Emie Nadel	BCI	Thomas McGuire	Boston University
Wayne A. Morra	Beaver College	Wei Yu	Boston University
James Lacey	Bell Labs	William M. Capron	Boston University
Steven G. Lanning	Bell Labs - Lucent Technologies	Zvi Bodie	Boston University
Roger Story	Bellcore	Zvika Neeman	Boston University
Kristina Weir	Bellevue Community College	William F. Samuelson	Boston University, School of Management
Gary L. Hodglin	Belmont University	John Fitzgerald	Bowdoin College
Mary M. Thompson	Belmont University	Alan Day Haight	Bowling Green State University
Warren Palmer	Beloit College	Charles R. Chittle	Bowling Green State University
Marc Bendick, Jr.	Bendick & Egan Economic Consultants, Inc.	Harold I. Lunde	Bowling Green State University
Bertrand LaNoue, O.S.B.	Benedictine College	Kyoo Kim	Bowling Green State University
Janet M. Thomas	Bentley College	Mark Kasoff	Bowling Green State University
Lucy Ackert	Berry College	Paul F. Haas	Bowling Green State University
Bassem Abou-Zeld	Bethel College	Stephen Ziliak	Bowling Green State University
Phyllis Campbell	Bethel College	Felicia Yesari	BPBA-New York
Miles O. Bidwell	Bidwell Associates Inc.	Kalman Goldberg	Bradley University
Edward A. Manfield	Binary Traders	Kevin M. O'Brien	Bradley University
Charles W. Bischoff	Binghamton University	Anne P. Carter	Brandeis University
Clifford D. Clark	Binghamton University	Arthur Lewbel	Brandeis University
Dr. N.J. Wulwick	Binghamton University	Gary H. Jefferson	Brandeis University
Stanley H. Masters	Binghamton University	Rachel McCulloch	Brandeis University
L. Aubrey Drewry, Jr.	Birmingham-Southern College	Brian Kelly	Brian Kelly Inc.
M. Iqbal Akhtar	Blackburn College	Edward R. Fried	Brookings Institution
Bennett W. Golub	Blackcrouk Financial Management	Margaret M. Blair	Brookings Institution
Edward Bloom	Bloom Research	Nora Lustig	Brookings Institution
Woo-Bong Lee	Bloomsburg University	Robert Axtell	Brookings Institution
Ronald L. Friesen	Bluffton College	Robert E. Litan	Brookings Institution
Chong-en Bai	Boston College	Robert Solomon	Brookings Institution
Christopher Baum	Boston College	William Dickens	Brookings Institution
Donald J. White	Boston College	Leo J. Raskind	Brooklyn Law School
Frank M. Gollop	Boston College	Akio Yasuhara	Brown University
Harold Petersen	Boston College	Louise Putterman	Brown University
Joseph F. Quinn	Boston College	Mark B. Schupack	Brown University
Kathleen Lang	Boston College	Michael Spagat	Brown University
Marvin Kraus	Boston College	David R. Ross	Bryn Maur College
Paul Streeten	Boston College	Thomas Loo	Budget Comp.
Robert G. Murphy	Boston College	Joel D. Fischer	Burnham Securities Inc.
Andrew Weiss	Boston University	Hasan MacNeil	Butte College
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ECONOMISTS' STATEMENT ON CLIMATE CHANGE

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MARCH 24, 1997

NAME	AFFILIATION	NAME	AFFILIATION
Daniel M. Bernhofen	Clark University	Chaltram J. Talele	Columbia State College
John C. Brown	Clark University	Elliot Zupnik	Columbia University
Joseph Golec	Clark University	Giulio Pontecorvo	Columbia University
Rudy Yaksick	Clark University	Harold W. Watts	Columbia University
Wayne B. Gray	Clark University	Hugh Patrick	Columbia University
Fredric Menz	Clarkson University	James W. Kuhn	Columbia University
J.K. Mullen	Clarkson University	Jay Pil Choi	Columbia University
Holley Ulbrich	Clemson University	Maurice Wilkinson	Columbia University
Donald G. Freeman	Cleveland State University	Richard R. Nelson	Columbia University
John F. Burke Jr.	Cleveland State University	Roberto Perotti	Columbia University
Jon D. Harford	Cleveland State University	Roger F. Murray	Columbia University
Michael Bond	Cleveland State University	Ronald M. Schramm	Columbia University
Myong-Hun Chang	Cleveland State University	Stefan H. Robock	Columbia University
Vijay K. Mathur	Cleveland State University	Susan S. Wleier	Columbia University
Nancy C. Wilson	Climate Institute	Duncan K. Foley	Columbia University, Barnard College
Peter J. Francis	CNA Corporation	Perry Mehrling	Columbia University, Barnard College
H. A. Gemery	Colby College	Rajiv Sethi	Columbia University, Barnard College
Randy Nelson	Colby College	Andrew Haggard	Committee for Economic Development
Tom Tietenberg	Colby College	Ronald S. Boster	Committee for Economic Development
David M. Sturges	Colgate University	Van Doorn Ooms	Committee for Economic Development
Michael R. Haines	Colgate University	William J. Beeman	Committee for Economic Development
Oz Honkalehto	Colgate University	Robert Atallo	Comp. Resource Solutions
Robert W. Turner	Colgate University	Jeffrey G. Woods	Concord College
Wayne A. Grove	Colgate University	Dick Nanto	Congressional Research Service
Lawrence J. Frateschi	College of Du Page	William A. Cox	Congressional Research Service
Mary Goldschmid	College of Mount Saint Vincent	Spencer J. Pack	Connecticut College
Lee H. Endress	College of Security Studies, Asia-Pacific Center	Daniel W. Kennedy	Connecticut Labor Dept.
Marcia J. Frost	College of St. Benedict	Stuart Harshbarger	Coopers and Lybrand
James R. Ashley	College of St. Catherine	Ziad Ayash	Coopers & Lybrand
Miles B. Cahill	College of the Holy Cross	Habtu Braha	Coppin State College
David H. Feldman	College of William and Mary	Donald C. Cell	Cornell College
Eric R. Jensen	College of William and Mary	Gordon Urquhart	Cornell College
John S. Strong	College of William and Mary	Imran Farooqi	Cornell College
Robert B. Archibald	College of William and Mary	Bill Rosen	Cornell University
Carol A. Dahl	Colorado School of Mines	Duane Chapman	Cornell University
Graham Davis	Colorado School of Mines	Erik Thorbecke	Cornell University
Wade E. Martin	Colorado School of Mines	Gary S. Fields	Cornell University
Charles Revier	Colorado State University	John H. Bishop	Cornell University
John B. Loomis	Colorado State University	M. Gardner Clark	Cornell University
John R. McKean	Colorado State University	Robert C. Lind	Cornell University
Kenneth C. Nobe	Colorado State University	Robert Gibbons	Cornell University
Robert R. Keller	Colorado State University	Robert H. Frank	Cornell University
Stephen Weller	Colorado State University	Shankar Subramanian	Cornell University
Chris Mayer	Columbia Business School	Seymour Smidt	Cornell University, Johnson Graduate School
Kenneth N. Kuttner	Columbia Business School	Hirsch S. Ruchlin	Cornell University Medical College
Orba Traylor	Columbia College	Michael D. Topper	Cornerstone Research

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C. K. Woo	Energy and Environmental Economics, Inc.	Daniel A. Mizak	Frostburg State University
Bruce Stram	Enron Corporation	William J. Serow	FSU, Center for the Study of Population
Kenneth Ackes	Env. Damage Valuation & Cost-Benefit News	Young J. Park	Fu Associates, Ltd.
Paul Holden	ERI	Raul Moreno	Fundacion Nacional Para El Desarrollo
Robert Neal Peterson	ERS	Kim M. Gardey	Gardey Investment Management
Dennis Erickson	Erskine College	Anthony Negbenebor	Gardner Webb University
Kenneth P. Selden	Essential Economics, Inc.	Frances Hammond	General Motors Corporation
Richard Castellana	Fairleigh Dickinson University	Carrie A. Meyer	George Mason University
Steven A. Seelig	FDIC	Chris G. Rodrigo	George Mason University
Kevin Lansing	Federal Reserve Bank of Cleveland	Steven C. Michael	George Mason University
Joseph Halmowitz	Federal Reserve Bank of Kansas City	Anita M. Benivigni	George Washington University
Edward Lotterman	Federal Reserve Bank of Minneapolis	David C. Riber	George Washington University
Richard M. Todd	Federal Reserve Bank of Minneapolis	Elinor H. Solomon	George Washington University
Patricia Pollard	Federal Reserve Bank of St. Louis	Eric Kodjo Ralph	George Washington University
Alexander David	Federal Reserve Board	Julian Silk	George Washington University
Charles Slegman	Federal Reserve Board	Mary Ann Bally	George Washington University
Chunsheng Zhou	Federal Reserve Board	Stephen C. Smith	George Washington University
Dale W. Henderson	Federal Reserve Board	Vincy Fon	George Washington University
Dean F. Amiel	Federal Reserve Board	Warren Greenberg	Georgetown University
Guy V.G. Stevens	Federal Reserve Board	Charles K. Ebinger	Georgetown University
Laura S. Rubin	Federal Reserve Board	Dale Murphey	Georgetown University
Murat F. Iyigun	Federal Reserve Board	Daniel Kahn	Georgetown University
Randall Mariger	Federal Reserve Board	George J. Viksnins	Georgetown University
Steve Rhoades	Federal Reserve Board	Ibrahim M. Owelss	Georgetown University
Gerald D. Lomen	Federal Reserve Board of New York	James Tybout	Georgetown University
George Budzelka	Federal Reserve Board of New York, Rtd.	Jens Ludwig	Georgetown University
Richard E. Ludwick, Jr.	Federal Trade Commission	John Cuddington	Georgetown University
Ohannes Hagopian	Felician College	Mitch Kaneda	Georgetown University
Abdollah Ferdowsi	Ferris State University	Robert E. Moore	Georgia College & State University
Daniel Teferra	Ferris State University	Usha Nair	Georgia Institute of Technology
Herbert E. Nell	Financial and Economic Strategies	David L. Sjoquist	Georgia State University
Gabriel Torres	Fitch Investor Services	Jorge Martinez-Vazquez	Georgia State University
Benjamin Chinitz	Florida Atlantic University	Julie Hotchkiss	Georgia State University
Alison Butler	Florida International University	Ronald G. Cummings	Georgia State University
Maria Willumsen	Florida International University	Rubin Saposnik	Georgia State University
Charles-E. Rockwood	Florida State University	Peter G. Sassone	Georgia Tech
James Cobbe	Florida State University.	Richard J. Cebula	Georgia Tech
Michael Slotkin	Florida Tech	Brendan Cushing-Daniels	Gettysburg College
Peter M. Ewen	Forcasts Department, APS	Katsuyuki Niino	Gettysburg College
Dominick Salvatore	Fordham University	Ralph Chances	Gettysburg College
Jacqueline G. Coolidge	Foreign Investment Advisory Service	Janamitra Devan	Global Strategies Group
Betty F. Slade	Formerly Harvard Inst. for Intl. Development	Randal G. Gunden	Goshen College
Glenn G. Stevenson	Formerly Oak Ridge National Laboratory	Katherine Henneberger	Goucher College
Ronald C. Riddker	Formerly of The World Bank	Mark Montgomery	Grinnell College
Richard W. Stewart	Frontier Cooperative Herbs	Claude Gruen	Gruen Gruen & Associates
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NAME	AFFILIATION	NAME	AFFILIATION
Lawrence Y. Fu	Illinois College	Stephen A. Vostl	International Food Policy Research Institute
J. Lon Carlson	Illinois State University	Nazrul Islam	International Inst. for Advanced Studies
L. Dean Hiebert	Illinois State University	Adolfo Barajas	International Monetary Fund
Michael A. Nelson	Illinois State University	Adrienne Cheasty	International Monetary Fund
Michael C. Seeborg	Illinois Wesleyan University	Alphecca Muttardy	International Monetary Fund
Thomas E. McGlannis	Indiana State Government	Caroline Van Ryckeghem	International Monetary Fund
Craig W. Holden	Indiana University	David T. Coe	International Monetary Fund
David Waterman	Indiana University	Dev Kumar Kar	International Monetary Fund
Eckhard Janeba	Indiana University	Elaine Buckberg	International Monetary Fund
Fwu-Rang Chang	Indiana University	Rosendo Hernandez-Casta	International Monetary Fund
Herbert Kiesling	Indiana University	Geert J. Almekinders	International Monetary Fund
Janardhanan A. Alse	Indiana University	George Iden	International Monetary Fund
Joyce Man	Indiana University	Gian Maria Milesi-Ferretti	International Monetary Fund
Lloyd Orr	Indiana University	Gregory C. Dahl	International Monetary Fund
Marianne V. Felton	Indiana University	Gustavo Canonero	International Monetary Fund
Martin C. Spechler	Indiana University	James E. Blalock	International Monetary Fund
Phillip T. Powell	Indiana University	Jeromijn Zetzelmeier	International Monetary Fund
Phillip Saunders	Indiana University	John E. Leimone	International Monetary Fund
Roy Gardner	Indiana University	Kevin L. Ross	International Monetary Fund
Scott Smart	Indiana University	Lorenzo L. Perez	International Monetary Fund
Clarence C. Morrison	Indiana University, Bloomington	Malcom D. Knight	International Monetary Fund
Ashton I. Veramallay	Indiana University East	Mark R. Stone	International Monetary Fund
Shyam I. Bhatia	Indiana University Northwest	Michael G. Papaloannou	International Monetary Fund
Arthur Martel	Indiana University of Pennsylvania	Michael F. Eldy	International Monetary Fund
Robert J. Stonebraker	Indiana University of Pennsylvania	Nicholas Tsaveas	International Monetary Fund
Roger W. Schmenner	Indiana University School of Business	Patricia A. Reynolds	International Monetary Fund
Lawrence J. Haber	Indiana-Purdue at Fort Wayne	Peter B. Clark	International Monetary Fund
Thomas L. Guthrie	Indiana-Purdue at Fort Wayne	Rakia Moalla-Felini	International Monetary Fund
Robert Weiss	Industrial Electrotechnology Laboratory	Richard Stillson	International Monetary Fund
Roy B. Helfgott	Industrial Relations Counselors Inc.	Sunil Sharma	International Monetary Fund
Charles Marston	Infinity Inc.	Thomas Rumbaugh	International Monetary Fund
Thomas P. Rothrock	Info Tech Inc.	Toshiro Nishizawa	International Monetary Fund
Bruce McKinlay	Information Systems Group	Vikram Haksar	International Monetary Fund
Jon Christianson	Inst. for Health Services Research	Wayne E. Lewis	International Monetary Fund
Geoffrey Carliner	Institute for International Economics	William L. Hemphill	International Monetary Fund
Robert J. Muscal	Institute for Policy Reform	Zeljko Bogetic	International Monetary Fund
Richard Webb	Instituto Cuanto	Jonathan Levin	International Monetary Fund, Ltd.
Charles Richter	Inter-American Development Bank	Robert F. Lundy	Interstate Commerce Commission, Ltd.
Michael A. Gomez	Inter-American Development Bank	Roger Williams	INVEST
Michael Gavin	Inter-American Development Bank	David Hennessy	Iowa State University
Orlando A. Reos	Inter-American Development Bank	J. Peter Mattila	Iowa State University
Alan McInnes	Internal Revenue Service	John A. Miranowski	Iowa State University
Joseph M. Grows	Internal Revenue Service	Peter Orazem	Iowa State University
Peter C. Balash	Internal Revenue Service	Stanley R. Johnson	Iowa State University
Agnes R. Quisumbing	International Food Policy Research Institute	William Merrill	Iowa State University
Dean Jolliffe	International Food Policy Research Institute	Cynthia Halcemun	Iowa Wesleyan College

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NAME	AFFILIATION	NAME	AFFILIATION
Theodore Palivos	Louisiana State University	John P. Hoehn	Michigan State University
Howard Baetser, Jr.	Loyola College	Kenneth D. Boyer	Michigan State University
James Kenow	Loyola Marymount University	Mordechai Kreinin	Michigan State University
Bruce Vanderporten	Loyola University, Chicago	Norman P. Obst	Michigan State University
George Kaufman	Loyola University, Chicago	Paul L. Menchik	Michigan State University
Marc Douglas Hayford	Loyola University, Chicago	Paul Segerstrom	Michigan State University
Robert Carow	Loyola University, Chicago	Richard T. Baillie	Michigan State University
Dan C. Messerschmidt	Lynchburg College	Robert J. La Londe	Michigan State University
D. Sykes Willford	M.D. Bankers Trust	Scott M. Swinton	Michigan State University
Marshall Pomer	Macroeconomic Institute	Stephen A. Woodbury	Michigan State University
Emily Sun	Manhattan College	W. Paul Strassmann	Michigan State University
John F. Tomer	Manhattan College	Paul A. Nelson	Michigan Technological University
Bruce Carpenter	Mansfield University	Atanu Saha	Micronomics Inc.
Joan E. Gadsby	Market Media International Corporation	Bichaka Fayissa	Middle Tennessee State University
James Tober	Marlboro College	Reuben Kyle	Middle Tennessee State University
David E. Clark	Marquette University	John Craven	Middlebury College
David L. Marshall	Marshall & Associates	Yoshi Fukasawa	Midwestern State University
Harlan M. Smith, II	Marshall University	Alec R. Levenson	Milken Institute
Mark A. Thompson	Marshall University	Kurt R. Schaefer	Miller Freeman Inc.
Amy M. Dlduch	Mary Baldwin College	Ross Miller	Miller Risk Advisors
Amala	Marygrove College	Marion Ross	Mills College
Calvin Timmerman	Maryland Public Service Commission	Patrick A. Taylor	Millsaps College
Steven Payson	Marymont University	Kevin Richardson	Minute Maid Company
Lyle Nelson	Mathematica Policy Research	Paul W. Grimes	Mississippi State University
Merrile Sing	Mathematica Policy Research	Robert O. Weagley	Missouri University
Walter Corson	Mathematica Policy Research	Alberto Blisin	MIT
Karen Akerhjelms	Mathtech Inc.	Carl Kayser	MIT
Ramsey Nguon Lay	McDonnell Douglas Aerospace West	Donald Lessard	MIT
David Wyss	McGraw Hill	E. Cary Brown	MIT
Anthony Pennington-Cross	McGraw-Hill	Eli Shapiro	MIT
Susan M. Lund	McKinsey & Company	Evsey D. Domar	MIT
B. David Collier	Medical College of Wisconsin	Franklin M. Fisher	MIT
Charles H. Andrews	Mercer University	George W. Rathjens	MIT
C.W. Blowens	Metro-Dade County Planning Department	Jorn Steffen Pischke	MIT
David J. O'Hara	Metropolitan State University	M. A. Adelman	MIT
O. Homer Erekson	Miami University	* Paul Krugman	MIT
Raymond Gorman	Miami University	Paul Smoke	MIT
Robert L. Conn	Miami University	*, ** Robert Solow	MIT
William K. Hutchinson	Miami University	Robin Wells	MIT
William R. Hart	Miami University	Scott Stern	MIT
Peter Eckstein	Michigan AFL-CIO	Susan Athey	MIT
H. William Rockwell, Jr.	Michigan Dept. of Natural Resources	Tim Riddiough	MIT
Corinne M. Krupp	Michigan State University	William C. Wheaton	MIT
Daniel R. Taltelm	Michigan State University	Alan M. Strout	MIT, Rtd.
Harry J. Holzer	Michigan State University	B. Wernertelt	MIT, Sloan School of Management
James L. Dorn	Michigan State University	Erik Brynjolfsson	MIT, Sloan School of Management

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MARCH 24, 1997

NAME	AFFILIATION	NAME	AFFILIATION
Lori Leachman	Northern Arizona University	Mario J. Miranda	Ohio State University
Richard J. Dowen	Northern Illinois University	Nancy Ettlinger	Ohio State University
Tedd Knoop	Northern Illinois University	Nelson C. Mark	Ohio State University
Virginia Wilcox-Gok	Northern Illinois University	Peter Howitt	Ohio State University
Young C. Kim	Northern Illinois University	Richard A. Tybout	Ohio State University
Gary E. Clayton	Northern Kentucky University	Robert J. Caswell	Ohio State University
Martin G. Ciesbrecht	Northern Kentucky University	Stephen G. Cecchetti	Ohio State University
Tom Cate	Northern Kentucky University	Chulho Jung	Ohio University
Hillar D. Neumann, Jr.	Northern State University, South Dakota	Kurt A. Schwabe	Ohio University
R. Stephen Elliott	Northwestern State University	James V. Koch	Old Dominion University
Alan M. Taylor	Northwestern University	Paul R. Koch	Olivet Nazarene University
Boaz Moselle	Northwestern University	Vartkes L. Broussalian	OMB, Washington, Rtd.
Burton A. Weisbrod	Northwestern University	Rohit Sah	Oppenheimer Funds, Inc.
Deborah Lucas	Northwestern University	Carol Horton Tremblay	Oregon State University
Mark A. Satterthwaite	Northwestern University	Emery N. Castle	Oregon State University
Michael Wallerstein	Northwestern University	Joe Kerkvliet	Oregon State University
Todd Pulvino	Northwestern University	Laura S. Connolly	Oregon State University
Donald P. Jacobs	Northwestern University, J.C. Kellogg School	Ronald A. Oliveira	Oregon State University
St. Beth Anne Tercek	Notre Dame College	Bronwyn H. Hall	Oxford University, UK
Liang-rong Shiao	NSU	Jacques J. Polak	P. Jacobson Foundation
John Tepper Marlin	NYC Comptroller's Office	Richard Ottinger	Pace Law School
Eileen R. Kaufman	NYC Dept of Design & Construction	Michael Szenberg	Pace University
Larry M. Blair	Oak Ridge Associated Universities	Bruce McWilliams	Pacific Institute
C. J. Austermiller	Oakland Community College	Marlen Miller	Pacific Lutheran University
Kevin J. Murphy	Oakland University	Norris A. Peterson	Pacific Lutheran University
A. T. Aburachis	Oannon University	Rachel Nugent	Pacific Lutheran University
David L. Cleeton	Oberlin College	John A. Jaksch	Pacific Northwest National Laboratory
Hirschel Kasper	Oberlin College	Joseph M. Roop	Pacific Northwest National Laboratory
James Whitney	Occidental College	Michael J. Scott	Pacific Northwest National Laboratory
Michael K. Tamada	Occidental College	H. Joe Story	Pacific University
Robert L. Moore	Occidental College	Phillip J. Ruder	Pacific University
Edward H. Clarke	Office of Management & Budget	Loren A. Lee	Palomar College
Joseph R. Mason	Office of the Comptroller of the Currency	Teresa L. C. Laughlin	Palomar College
Robert DeYoung	Office of the Comptroller of the Currency	Craig Paxton	Paxton Analysts
William O. Shropshire	Oglethorpe University	Brandt Witte	Peace Corps
Frederick Church	Ohio Legislature Budget Office	Daniel A. Underwood	Peninsula College
Alan Randall	Ohio State University	Collin Polsky	Penn. State Univ., Earth System Science Center
Amy Jocelyn Glass	Ohio State University	Mark D. Agee	Pennsylvania State University
Belton M. Fleisher	Ohio State University	Ali Abdelrezaq	Pennsylvania State University
Brent Sohngen	Ohio State University	Ann Fisher	Pennsylvania State University
Elián Khalil	Ohio State University	Barry N.	Pennsylvania State University
Eric Fisher	Ohio State University	Chidem Kudas	Pennsylvania State University
Hassan Y. Aly	Ohio State University	Donald J. Epp	Pennsylvania State University
Herbert Parnes	Ohio State University	Gary Bolton	Pennsylvania State University
Jay L. Zagorsky	Ohio State University	Jacob DeRooy	Pennsylvania State University
Jingang Zhao	Ohio State University	James D. Rodgers	Pennsylvania State University

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Bernard Rose	Rocky Mountain College	Patricia Dillon	Scripps College
Kenna Taylor	Rollins University	Jere W. Clark	SCSC
Ron Balman	Roosevelt University	M. Louise Curley	Scudder, Stevens & Clark
Dale Bremner	Rose - Hulman Institute of Technology	Allen S. Bellas	Seattle University
Stephen Smith	Rose State College	Vinay Datar	Seattle University
Manijeh Sabl	Russell Sage College	William L. Weber	SEMO State University
A. Myrick Freeman III	Rutgers University	Jerry Jenkins	Sequoia Institute
Bruce Mizrach	Rutgers University	Henry C. F. Arnold	Seton Hall University
Carlos Selgile	Rutgers University	Tony Loviscek	Seton Hall University
Edmund M. Tavenier	Rutgers University	Alan G. Myers	SEWS
Horace J. De Podwin	Rutgers University	Michael J. Chapman	Shearman & Sterling
Leslie E. Small	Rutgers University	Thomas H. Sheenan, Jr.	Sheenan International
Marlene Kim	Rutgers University	Danell A. Pavsek	Shenandoah University
Michael A. Crew	Rutgers University	Signe L. Sherman	Sherman Holdings
Michael K. Taussig	Rutgers University	Kirk E. Vandezande	Simon Fraser University
Richard W. Johnson	Rutgers University	Sharon Fang	Skadden, Arps, Slate, Meaher & Flom
Robert H. Patrick	Rutgers University	Deborah Haas-Wilson	Smith College
Marjorie W. Munson	Rutgers University, Douglass College	Roger T. Kaufman	Smith College
William H. Wrean	Sacajawea & Company	L. Scott Muller	Social Security Administration
Lucjan Orlowski	Sacred Heart University	Michael V. Leonesio	Social Security Administration
Alannah Orrison	Saddleback College	Carlos A. Benito	Sonoma State University
Kenneth G. Woodward	Saddleback College	Stephen D. Lewis	Sonoma State University
Hong Y. Park	Saginaw Valley State University	Robert G. McGilivray	Sound Economics
Charles Henning	SAIC	Thomas Mitchell	South Illinois University
Gilbert Becker	Saint Anselm College	Elizabeth Granitz	Southampton College
Reza Ramazani	Saint Michael's College	Christopher R. Mann	Southeast Michigan Council of Govts.
Thampy Mammen	Saint Norbert College	Kenneth Chinn	Southeastern Oklahoma State University
Dorothy Ryan Siden	Salem State College	Scott Bellamy	Southern Arkansas University
Chee Y. Thum	Salomon Brothers Inc.	Paul Shder	Southern California College
Adam Gifford, Sr.	San Diego State University	David Lui	Southern California Edison
Douglas B. Stewart	San Diego State University	Donald Elliott	Southern Illinois University
James Gerber	San Diego State University	Jim Musumeci	Southern Illinois University
S. Crossbay-Shechtman	San Diego State University	Julius Horvath	Southern Illinois University
Diuchi O. Nnachi	San Francisco Juvenile Court	Paul Trescott	Southern Illinois University
Betty J. Blecha	San Francisco State University	S. Grosskopf	Southern Illinois University
Joanna Moss	San Francisco State University	Stanford L. Levin	Southern Illinois University
R. Newby Schweitzer	San Francisco State University	R.W. Hafer	Southern Indiana University
Yea-Mow Chen	San Francisco State University	J. Carter Murphy	Southern Methodist University
Douglas F. Greer	San Jose State University	Thomas Osang	Southern Missouri University
Thomas Drennen	Sandia National Laboratories	Thomas Dalton	Southern University at New Orleans
Helen Popper	Santa Clara University	C. E. Chang	Southwest Missouri State University
Michael Kevane	Santa Clara University	E. Dale Wasson	Southwest Missouri State University
R. D. Norton	Sarkisian	Anne R. Hornsby	Spelman College
Edward Alban	Savannah State University	Bernice de Gaines Scott	Spelman College
John Watters	SBC Communications	Kenneth N. Hamilton	Spring Hill College
Frank D. Weiss	School of Advanced International Studies	Brian K. Stalhr	Sprint

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NAME	AFFILIATION	NAME	AFFILIATION
Stephen Golub	Swarthmore College	Ronald H. Miller	The Hudson Group
Roger C. Dower	Sycom Enterprises	Thomas E. O'Hare	The Interlich Group
A. Dale Tussing	Syracuse University	Cina Livermore	The Levin Group
Bernard Jump	Syracuse University	David C. Stapleton	The Lewin Group
Donald H. Dutkowsky	Syracuse University	Linz Audain	The Mandate Corporation
Michael Wasylenko	Syracuse University	William G Rhoads	The Nature Conservancy
David I. Goldeberg	Systematic Forecasting, Inc.	Martin Duffy	The Perseus Group
Faith Breen	Systems Resource Management	Hiroshi Kawamura	The United Nations
Dana Stevens	Takashi Corporation	Larry Willmore	The United Nations
Cindy Houser	TAMU	Fernando Losada	The Weston Group
William L. Beaty	Tarleton College	Peter C. Moll	The World Bank
Thomas D. Legg	TD Legg Financial Economics	A. Mead Over, Jr.	The World Bank
Robert E. Lucore	Teamsters Union	Andrew Steer	The World Bank
Michael J. Ileo	Technical Associates, Inc.	Carter Brandon	The World Bank
Charles P. Hall	Temple University	Charles C. Griffin	The World Bank
Charlotte Phelps	Temple University	David Dollar	The World Bank
J. Jay Choi	Temple University	Delbert Fitchett	The World Bank
Thomas E. Getzen	Temple University	Estelle James	The World Bank
Seisel Jonakin	Tennessee Tech. University	Gianni Zanini	The World Bank
Whewon Cho	Tennessee Tech. University	Gunnar S. Eskeland	The World Bank
Louise L. Jones	Texas A & M University	Herman Cesar	The World Bank
Wade L. Griffin	Texas A&M University	Hideo Akabayashi	The World Bank
Amy P. Thurow	Texas A&M University	Humayun Tal	The World Bank
C. Richard Shumway	Texas A&M University	Indermit Singh	The World Bank
Farshid Vahid	Texas A&M University	J. Michael Finger	The World Bank
James H. Ullmer	Texas A&M University	Jacques Van der Gaag	The World Bank
Javier Gimeno	Texas A&M University	John Kellenberg	The World Bank
John R. Moroney	Texas A&M University	John Williamson	The World Bank
Julian E. Gaspar	Texas A&M University	Keith E. Hansen	The World Bank
Manzoor E. Chowdhury	Texas A&M University	Loerene Yap	The World Bank
Neh-Sun Kwark	Texas A&M University	Manuela Ferro	The World Bank
Rajiv Sarin	Texas A&M University	Maria Freire	The World Bank
Ronald C. Griffin	Texas A&M University	Mark W. Leiserson	The World Bank
Thomas D. Jeitschko	Texas A&M University	Martha De Melo	The World Bank
Frank Giesber	Texas Lutheran University	Martin Ravallion	The World Bank
Richard E. Quandt	The Andrew W. Mellon Foundation	Maurice Schiff	The World Bank
Kenneth T. Wise	The Brattle Group	Moshe Syrquin	The World Bank
Paul R. Carpenter	The Brattle Group	Nobuhiko Fuwa	The World Bank
Peter Fox-Penner	The Brattle Group	Pedro Belli	The World Bank
Peter Fox-Penner	The Brattle Group	Robert Armstrong	The World Bank
C.R. Guralnik	The Business Group, Inc.	Robert Hunt	The World Bank
Donald E. Campbell	The College of William & Mary	Saji Thomas	The World Bank
A. Doris Capistrano	The Ford Foundation	Stefan G. Koeberle	The World Bank
Bernard Wasow	The Ford Foundation	Timothy King	The World Bank
Henry E. Cole	The Future Group International	Yi Chen	The World Bank
Gerald Kraft	The CSK Group, Ltd.	Yin-kann Wen	The World Bank

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ECONOMISTS' STATEMENT ON CLIMATE CHANGE

LIST OF ECONOMISTS WHO HAVE ENDORSED TO DATE

MARCH 24, 1997

NAME	AFFILIATION	NAME	AFFILIATION
Robert M. Williams	UCLA	Mark Zupan	University of Arizona
Stuart O. Schweitzer	UCLA	Richard Newcomb	University of Arizona
Tom K. Lieser	UCLA	Roger W. Fox	University of Arizona
Trudy Ann Cameron	UCLA	Ronald J. Vogel	University of Arizona
Wei-Yin Hu	UCLA	Willard T. Carleton	University of Arizona
Werner Z. Hirsch	UCLA	Gary Ferrier	University of Arkansas
Brad Cornell	UCLA, Anderson School of Business	William P. Curington	University of Arkansas
Bhagwan Chowdhry	UCLA, Anderson School of Management	Michael Sher	University of Auckland
David R. Bell	UCLA, Anderson School of Management	David W. Stevens	University of Baltimore
M. J. Brennan	UCLA, Anderson School of Management	Esa Bennathan	University of Bristol, UK
Marvin Lieberman	UCLA, Anderson School of Management	Aaron S. Edlin	University of California, Berkeley
Jose' De La Torre	UCLA, Anderson School of Mgmt.	Anne M. Libby	University of California, Berkeley
Richard H. Sander	UCLA, School of Law	Anthony Fisher	University of California, Berkeley
Georgios Karras	UIC	Ben F. Vaughan, IV	University of California, Berkeley
Bill Lord	UMBC	Clair Brown	University of California, Berkeley
Nathaniel Wollman	University of New Mexico	Clark Kerr	University of California, Berkeley
Ella K. Hensley	Union College	David Romer	University of California, Berkeley
J. Douglas Klein	Union College	Frank E. Triakl	University of California, Berkeley
Therese McCarthy	Union College	Garland L. Brinkley	University of California, Berkeley
Todd A. Burgman	Union College	Gary Charness	University of California, Berkeley
Dr. Faruk G. Sabel	United Nations	** Gerard Debreu	University of California, Berkeley
Gary W. Grizzle	United Parcel Service	Glen A. Woroch	University of California, Berkeley
Herbert Traxler	United States PHS	Gordon Rausser	University of California, Berkeley
John Mark Lindrall	Univ. of Phoenix, Southern CA campus	Gregory Grossman	University of California, Berkeley
Stanley Long	Univ. of Pittsburgh, Penn. State Univ.	Hal R. Varian	University of California, Berkeley
James J. Heckman	University of Chicago	Jeffrey S. Petersen	University of California, Berkeley
Richard Bryant	University of Missouri-Rolla	Jerome Siebert	University of California, Berkeley
Gautam Vora	University of New Mexico	John M. Letiche	University of California, Berkeley
Richard W. Stratton	University of Akron	Larry S Karp	University of California, Berkeley
Harris Schlesinger	University of Alabama	Lee S. Friedman	University of California, Berkeley
Nancy S. Barrett	University of Alabama	Mark Rubinstein	University of California, Berkeley
Walter S. Misiolok	University of Alabama	Maurice Obstfeld	University of California, Berkeley
Robert A. McLean	University of Alabama, Birmingham	Miguel Cantillo	University of California, Berkeley
Seung-Dong Lee	University of Alabama, Birmingham	Oliver E. Williamson	University of California, Berkeley
John F. Schnell	University of Alabama, Huntsville	Peter Berck	University of California, Berkeley
William S. Brown	University of Alaska - SE	Richard B. Norgaard	University of California, Berkeley
Todd R. Smith	University of Alberta, Canada	Robert M. Anderson	University of California, Berkeley
Alberta H. Chamey	University of Arizona	Sylvia Lane	University of California, Berkeley
David A. King	University of Arizona	Theodore E. Keeler	University of California, Berkeley
Edward E. Zajac	University of Arizona	David J. Teece	University of California, Berkeley, Haas School
Eric Monke	University of Arizona	** John C. Harsanyi	University of California, Berkeley, Haas School
Gordon Tullock	University of Arizona	Pablo T. Spiller	University of California, Berkeley, Haas School
James C. Cox	University of Arizona	Stephen Penman	University of California, Berkeley, Haas School
John L. Wilson	University of Arizona	Richard H. Holton	University of California, Berkeley, Haas School
Leslie S. Stratton	University of Arizona	Richard Meese	University of California, Berkeley, Haas School
Lester D. Taylor	University of Arizona	Daniel Rubinfeld	University of California, Berkeley Law School

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NAME	AFFILIATION	NAME	AFFILIATION
Francis Tannian	University of Delaware	John B. Braden	University of Illinois
Lawrence P. Donnelley	University of Delaware	Robert Resek	University of Illinois
Pamela C. Brown	University of Delaware	Robert W. Gillespie	University of Illinois
Pamela J. Smith	University of Delaware	Thomas S. Ulen	University of Illinois
Donald Pemberton	University of Detroit, Mercy	Walter W. McMahon	University of Illinois
Maurice Tsai	University of Evansville	George Rosen	University of Illinois, Chicago
David Denelow	University of Florida	Houston H. Stokes	University of Illinois, Chicago
Elias Dinopoulos	University of Florida	Richard F. Kosobud	University of Illinois, Chicago
Eugene Brigham	University of Florida	William F. Maloney	University of Illinois, Urbana
Ira Horowitz	University of Florida	William F. Malowey	University of Illinois, Urbana
Jay R. Ritter	University of Florida	David J. Balan	University of Illinois, Urbana-Champaign
John F. Scoggins	University of Florida	Koji Taira	University of Indiana
Max R. Langham	University of Florida	Benjamin Wilner	University of Iowa
Richard E. Suttor	University of Florida	Calvin D. Siebert	University of Iowa
Sanford V. Berg	University of Florida	Gerald Nordquist	University of Iowa
Tracy R. Lewis	University of Florida	Joel Horowitz	University of Iowa
Andy Keeler	University of Georgia	John M. Brooks	University of Iowa
P. Mather Lindsay	University of Georgia	S. Y. Wu	University of Iowa
Steve Turner	University of Georgia	Thomas F. Pogue	University of Iowa
W. J. Florkowski	University of Georgia, Griffin	De-Min Wu	University of Kansas
Paul Callaghan	University of Guam	Joseph Sidllan	University of Kansas
Bharat Kolluri	University of Hartford	Neal Becker	University of Kansas
Demetrios Giannaros	University of Hartford	Donald J. Mullineaux	University of Kentucky
Farhad Rassekh	University of Hartford	James Stoker	University of Kentucky
Rao Singamsetti	University of Hartford	Yoonbai Kim	University of Kentucky
Chung H. Lee	University of Hawaii	Gonyung Park	University of La Verne
David McClain	University of Hawaii	John Vahaly	University of Louisville
James Moncur	University of Hawaii	Anthony Lanyi	University of Maryland
Louis A. Rose	University of Hawaii	Arvind Panagariya	University of Maryland
Richard E. Peterson	University of Hawaii	Christopher K. Clague	University of Maryland
Sumner La Croix	University of Hawaii	Douglas Meade	University of Maryland
David L. Hammes	University of Hawaii, Hilo	Erik Lichtenberg	University of Maryland
Denise Eby Konan	University of Hawaii, Manoa	John H. Cumberland	University of Maryland
A. Reza Hoshmand	University of Hawaii, West Oahu	John W. Dorsey	University of Maryland
A. Marvasti	University of Houston	Karla Hoff	University of Maryland
D. Andrew Austin	University of Houston	Lee E. Preston	University of Maryland
Janet Kohlhaase	University of Houston	Maureen Cropper	University of Maryland
Steven G. Craig	University of Houston	Paul A. Weinstein	University of Maryland
Roger H. Coupal	University of Idaho	Peter Cramton	University of Maryland
Stephen Devadoss	University of Idaho	R. Betancourt	University of Maryland
Anil K. Bera	University of Illinois	Robert Costanza	University of Maryland
Donald W. Paden	University of Illinois	Suzi C. Kerr	University of Maryland
Eliezer B. Ayal	University of Illinois	Theodore C. Karliotis	University of Maryland
George G. Pennacchi	University of Illinois	Phillip Weltzman	University of Maryland (JNW College)
Gerrit Knaap	University of Illinois	Branch Ben	University of Massachusetts
Hans J. Brems	University of Illinois	Donald W. Katzner	University of Massachusetts

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NAME	AFFILIATION	NAME	AFFILIATION
Barry M. Popkin	University of North Carolina, Chapel Hill	John Kagel	University of Pittsburgh
David J. Ravenscraft	University of North Carolina, Chapel Hill	Josephine E. Olson	University of Pittsburgh
Michael Luger	University of North Carolina, Chapel Hill	Kevin Sontheimer	University of Pittsburgh
Robert Gallman	University of North Carolina, Chapel Hill	Michael H. Spiro	University of Pittsburgh
Teresa L. Kauf	University of North Carolina, Chapel Hill	Steve Husted	University of Pittsburgh
Richard A. Zuber	University of North Carolina, Charlotte	Steven F. Rushen	University of Pittsburgh
Andrew C. Brod	University of North Carolina, Greensboro	Evaldo A. Cabarrouty	University of Puerto Rico
Donald R. Escarraz	University of North Dakota	Kate Stirling	University of Puget Sound
Fikret Ceyhan	University of North Dakota	Lorenzo Garbo	University of Redlands
Michael Nieswiadomy	University of North Texas	John P. Burkett	University of Rhode Island
Michael A. McPherson	University of North Texas	S. Chon Rhee	University of Rhode Island
Steven G. Thorpe	University of Northern Iowa	Stephen Swallow	University of Rhode Island
Charles K. Wilber	University of Notre Dame	Jonathan Wight	University of Richmond
Jeffrey H. Bergstrand	University of Notre Dame	Peter W. Schuhmann	University of Richmond
Ralph Chami	University of Notre Dame	Robert Dolan	University of Richmond
Richard G. Sheehan	University of Notre Dame	Florian Zettelmeyer	University of Rochester
Robert E. Florence	University of Notre Dame	James A. Kahn	University of Rochester
James C. Hartigan	University of Oklahoma	Jeffrey S. Banks	University of Rochester
Zhen Zhu	University of Oklahoma	Lionel W. McKenzie	University of Rochester
Shuanglin Lin	University of Omaha	Per Krusell	University of Rochester
Bruce A. Blomgen	University of Oregon	Eric Hanushek	University of Rochester, Wallis Institute
James P. Ziliak	University of Oregon	Yhi-Min Ho	University of Saint Thomas
Paul B. Simpson	University of Oregon	Rosalie Liccardo Pacula	University of San Diego
Raymond Mikesell	University of Oregon	Man-Lui Lau	University of San Francisco
Robert E. Smith	University of Oregon	Mike Lehmann	University of San Francisco
Stephen Haynes	University of Oregon	Ed Scahill	University of Scranton
Alan Heston	University of Pennsylvania	John H. McDermott	University of South Carolina
Andrew Postlewaite	University of Pennsylvania	Oliver G. Wood, Jr.	University of South Carolina
Arthur I. Bloomfield	University of Pennsylvania	Randolph C. Martin	University of South Carolina
Herbert S. Levine	University of Pennsylvania	Samuel L. Baker	University of South Carolina
** Lawrence R. Klein	University of Pennsylvania	William S. Rawson	University of South Carolina
Morris Hamburg	University of Pennsylvania	William T. Moore	University of South Carolina
Patricia M. Danzon	University of Pennsylvania	Dennis A. Johnson	University of South Dakota
Paul E. Fischer	University of Pennsylvania	Eila Hanni	University of South Florida
Petra E. Todd	University of Pennsylvania	John C. Briggs	University of South Florida
Daniel Levinthal	University of Pennsylvania, Wharton School	John W. Rowe, Jr.	University of South Florida
David Cummins	University of Pennsylvania, Wharton School	K. Gyimah-Boadi	University of South Florida
Elizabeth E. Bailey	University of Pennsylvania, Wharton School	R. Mark Wilson	University of South Florida
Franklin Allen	University of Pennsylvania, Wharton School	Thomas N. Chirikos	University of South Florida
Richard C. Marston	University of Pennsylvania, Wharton School	Catherine S. Elliott	University of South Florida, New College
William G. Whitney	University of Pennsylvania, Wharton School	Frederick R. Strobel	University of South Florida, New College
Alvin E. Roth	University of Pittsburgh	Semoon Chang	University of Southern Alabama
Daniel Berkowitz	University of Pittsburgh	Baizhu Chen	University of Southern California
Edward Sussna	University of Pittsburgh	Jeff Chapman	University of Southern California
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Jerome C. Wells	University of Pittsburgh	Kevin Chang	University of Southern California

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NAME	AFFILIATION	NAME	AFFILIATION
Norman R. Cloutier	University of Wisconsin, Parkside	Bruce Petersen	Washington University
Richard H. Keehu	University of Wisconsin, Parkside	Marcus Berliant	Washington University
Ahdol Sooti	University of Wisconsin, Platteville	Wilhelm Neufeld	Washington University
Lawrence Welser	University of Wisconsin, Stevens Point	Dennis L. Lambert	Washington University, School of Medicine
Thomas D. Crocker	University of Wyoming	R. W. La Hote	Washtenaw Community College
Mark D. Soskin	University of Central Florida	Kenneth G. McColn	Waterford International
John D. Bitzan	Upper Great Plains Transportation Institute	Yong U. Glasure	Wayland Baptist University
Gerhard N. Rostvold	Urbanomics Research Associates	Doris Gelde-Stevenson	Weber State University
Christine Williams	USG	John Mukum Mbaku	Weber State University
Amit Batabyal	Utah State University	Sarah Tinkler	Weber State University
Carl Lundgren	Valmarpro Forecasting	James Burtie	WEFA Group
Andrea Maneschi	Vanderbilt University	Jeffrey F. Werling	WEFA Group
C. Elton Hinshaw	Vanderbilt University	Virendra Singh	WEFA Group
Fred M. Westfield	Vanderbilt University	Marshall Goldman	Wellesley College
Gian S. Sahota	Vanderbilt University	Gary Yohe	Wesleyan University
Malcolm Getz	Vanderbilt University	John P. Bonin	Wesleyan University
Rudolph C. Blitz	Vanderbilt University	Joyce Jacobsen	Wesleyan University
Stephen Buckles	Vanderbilt University	Lori Bollinger	Wesleyan University
Geoffrey A. Jehle	Vassar College	Mamie W. Mueller	Wesleyan University
Phyllis W. Isley	Vermont Law School	Clifford B. Hawley	West Virginia University
N. Laopodis	Villa Julie College	Douglas W. Mitchell	West Virginia University
Kishor Thanawala	Villanova University	Jerald J. Fletcher	West Virginia University
Wen Mao	Villanova University	Kem O. Kymn	West Virginia University
Amy H. Dalton	Virginia Commonwealth University	Peter V. Schaeffer	West Virginia University
Eleanor C. Snellings	Virginia Commonwealth University	Stratford M. Douglas	West Virginia University
John H. Bowman	Virginia Commonwealth University	Walter C. Labys	West Virginia University
Thomas J. Meeks	Virginia State University	Susan K. Kask	Western Carolina University
Allan Mandelstamm	Virginia Tech	James A. Yunker	Western Illinois University
Catherine Eckel	Virginia Tech	Vaman Rao	Western Illinois University
Djavad Salehi-Isfahani	Virginia Tech	Annette N. Brown	Western Michigan University
George W. Norton	Virginia Tech	Bassam E. Harik	Western Michigan University
Glen H. Mitchell	Virginia Tech	Donald L. Alexander	Western Michigan University
Mark Stegeman	Virginia Tech	Emily P. Hoffman	Western Michigan University
Nicholas Tideman	Virginia Tech	Ustee Bandyopadhyay	Western Michigan University
Vijay Singal	Virginia Tech	Werner Sichel	Western Michigan University
Vernon O. Roningen	VORSIM	Dennis R. Murphy	Western Washington University
Christopher J. O'Leary	W. E. Upjohn Institute	John R. Wagner	Westfield State College
Jonathan Peters	Wagner College	Maria K. Wrotniak	Westminster College
Donald W. Walls	Walls & Associates	Gordon Well	Wheaton College
Lisa Daniels	Washington College	James Halteman	Wheaton College
Art Goldsmith	Washington & Lee University	John A. Walgreen	Wheaton College
Bruce Herrick	Washington & Lee University	James F. Shepherd	Whitman College
John C. Winfrey	Washington & Lee University	Samuel Webb	Wichita State University
Ernst W. Stromsdorfer	Washington State University	Charles Waldauer	Widener University
Gareth P. Green	Washington State University	Beth A. Wilson	Willamette University
Robert Rosenman	Washington State University	Don Negri	Willamette University

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NAME	AFFILIATION	NAME	AFFILIATION
Peter B. Rosendorff	University of Southern California	Gail Blattenberger	University of Utah
Peter Gordon	University of Southern California	Kenneth P. Jameson	University of Utah
Richard H. Day	University of Southern California	Lance Gorton	University of Utah
Timothy N. Cason	University of Southern California	Mark Glick	University of Utah
Howard F. Chang	University of Southern California Law School	R. Thayne Robson	University of Utah
Lewis R. Gale, IV	University of Southwest Louisiana	Thomas N. Maloney	University of Utah
Charles M. Gray	University of St. Thomas	Abbas Alnasrawi	University of Vermont
Demos P. Hadjiyanis	University of St. Thomas	Alfred L. Thimmon	University of Vermont
Marsha Blumenthal	University of St. Thomas	Michael Sesnowitz	University of Vermont
Paul R. Casperson	University of St. Thomas	Charles A. Holt	University of Virginia
Amy Farmer	University of Tennessee	Jane Irlig	University of Virginia
Charles B. Garrison	University of Tennessee	John Elder	University of Virginia
Jean Cauger	University of Tennessee	John K. Whitaker	University of Virginia
John W. Mayo	University of Tennessee	Mark R. Eaker	University of Virginia
Jonathan D. Rubin	University of Tennessee	Michael G. Rukstad	University of Virginia
Matthew N. Murray	University of Tennessee	John Treble	University of Wales
Peter M. Bearse	University of Tennessee	Dan Jacoby	University of Washington
Sidney L. Carroll	University of Tennessee	Gardner Brown	University of Washington
Thomas R. Sadler	University of Tennessee	Haldeh Salehi-Esfahani	University of Washington
E. Bruce Hutchinson	University of Tennessee, Chattanooga	J. Lawarree	University of Washington
William J. Crowder	University of Texas	Kathryn Dewenter	University of Washington
Brian M. Trinke	University of Texas, Austin	Robert Varadi	University of Washington
Charles C. Holt	University of Texas, Austin	William Beyers	University of Washington
Chrys Dougherty	University of Texas, Austin	Abbas A. Taheri	University of Wisconsin Center, Fox Valley
David Kendrick	University of Texas, Austin	Darwin Wassink	University of Wisconsin, Eau Claire
David Scoones	University of Texas, Austin	Maria DaCosta	University of Wisconsin, Eau Claire
Don Fullerton	University of Texas, Austin	Wayne Carroll	University of Wisconsin, Eau Claire
Dwight Steward	University of Texas, Austin	Sayed Payesteh	University of Wisconsin, Fond du Lac
Geoffrey T. Andron	University of Texas, Austin	Thomas S. Nesslein	University of Wisconsin, Green Bay
Paul W. Wilson	University of Texas, Austin	Glenn Knowles	University of Wisconsin, La Crosse
Ray Marshall	University of Texas, Austin	Donald A. Nichols	University of Wisconsin, Madison
Stephen L. McDonald	University of Texas, Austin	James Andreoni	University of Wisconsin, Madison
Tracy Hofer	University of Texas, Austin	James D. Schilling	University of Wisconsin, Madison
Charles Lackey, Jr.	University of Texas, Brownsville	Kenneth D. West	University of Wisconsin, Madison
Wim P.M. Vijverberg	University of Texas, Dallas	Patricia Hallinan	University of Wisconsin, Madison
Jose A. Pagan	University of Texas, Pan American	Arik Levinson	University of Wisconsin, Madison
John Merrifield	University of Texas, San Antonio	James D. Shilling	University of Wisconsin, Madison
David E. Keefe	University of the Pacific	Martin David	University of Wisconsin, Madison
Michael Ballot	University of the Pacific	Ragnar Oygard	University of Wisconsin, Madison
Walter C. Wagner	University of the Pacific	W. A. Brock	University of Wisconsin, Madison
Johannes Overbeek	University of the Virgin Islands	David J. Bernstein	University of Wisconsin, Milwaukee
Alan H. Gleason	University of Toledo	Markos J. Mamalakis	University of Wisconsin, Milwaukee
C. R. Winegarden	University of Toledo	Sol Shalit	University of Wisconsin, Milwaukee
John Murray	University of Toledo	M. Kevin McGee	University of Wisconsin, Oshkosh
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NAME	AFFILIATION	NAME	AFFILIATION
Herbert Glwtes	University of Massachusetts	G. Edward Schuh	University of Minnesota
Irving Gershenberg	University of Massachusetts	Grant Haner	University of Minnesota
James K. Kindall	University of Massachusetts	Jared Creason	University of Minnesota
James T. Campen	University of Massachusetts	Jay S. Coggins	University of Minnesota
Nancy Folbre	University of Massachusetts	Jerrold M. Peterson	University of Minnesota
Norman D. Altken	University of Massachusetts	John A. Nyman	University of Minnesota
Paul M. Brown	University of Massachusetts	Leonid Hurwicz	University of Minnesota
Andres Torres	University of Massachusetts, Boston	Mahmood A. Zaidi	University of Minnesota
David Terkla	University of Massachusetts, Boston	Margaret Peteraf	University of Minnesota
Joann Stewart	University of Massachusetts, Boston	Pareena Lawrence	University of Minnesota
David M. Kemme	University of Memphis	Phillip M. Raup	University of Minnesota
K. K. Fung	University of Memphis	Robert T. Kudrle	University of Minnesota
Anphonse G. Holtmann	University of Miami	Roger Feldman	University of Minnesota
Bryan W. Roberts	University of Miami	Timothy J. Kehoe	University of Minnesota
David C. Mauer	University of Miami	Vernon W. Ruttan	University of Minnesota
David Letson	University of Miami	Arne Kildergaard	University of Mississippi
Kerry Anne McGeary	University of Miami	Norman K. Womer	University of Mississippi
Alan V. Deardorff	University of Michigan	Chyi-Ing Lin	University of Missouri
Albert Park	University of Michigan	Donald J. Schilling	University of Missouri
Christine PapaJohn	University of Michigan	Floyd K. Hamston	University of Missouri
Edward Gramlich	University of Michigan	Nicholas Kalaitzandonakes	University of Missouri
F. Thomas Juster	University of Michigan	Robert J. Bevin	University of Missouri
Frank Thompson	University of Michigan	Shawn Ni	University of Missouri
J. Kmenta	University of Michigan	W. Whitney Hicks	University of Missouri
James N. Morgan	University of Michigan	Phillip B. Thompson	University of Missouri, Rolla
Jeffrey K. Mackle-Mason	University of Michigan	Douglas Dalenberg	University of Montana
Jonathan A. Parker	University of Michigan	John Duffield	University of Montana
Merritt B. Fox	University of Michigan	Michael Kupillik	University of Montana
Michael R. Moore	University of Michigan	Craig R. MacPhee	University of Nebraska
Michael Wellman	University of Michigan	E. Wesley F. Peterson	University of Nebraska
Paul N. Courant	University of Michigan	Gordon Karels	University of Nebraska
Richard A. Hirth	University of Michigan	Lilyan E. Fulginiti	University of Nebraska
Robert Stern	University of Michigan	Roger F. Riefler	University of Nebraska
Steven T. Vass	University of Michigan	Richard K. Perrin	University of Nebraska, Lincoln
Terry L. Roe	University of Michigan	Ronald M. Cronovich	University of Nevada
Warren C. Whalley	University of Michigan	Ricardo Gazel	University of Nevada, Las Vegas
Wolfgang F. Stolper	University of Michigan	Bwayne Wrightsman	University of New Hampshire
Yan Chen	University of Michigan	W. David Bradford	University of New Hampshire
David Weinstein	University of Michigan Business School	Edward A. Downe	University of New Haven
Sugato Bhattacharyya	University of Michigan Business School	Robert Rainish	University of New Haven
Mark J. Perry	University of Michigan, Flint	Christine Sauer	University of New Mexico
N. N. Reddy	University of Michigan, Flint	Geoffrey J. Bannister	University of New Mexico
Bryan Dowd	University of Minnesota	K. Gawande	University of New Mexico
C. Ford Runge	University of Minnesota	Max D. Bennett	University of New Mexico
Edward Coen	University of Minnesota	Arja Turunen-Red	University of New Orleans
Edward Foster	University of Minnesota	Alfred J. Field Jr.	University of North Carolina, Chapel Hill

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NAME	AFFILIATION	NAME	AFFILIATION
Peter S. Menell	University of California, Berkeley, Law School	Michael M. Hutchison	University of California, Santa Cruz
Robert D. Cooler	University of California, Berkeley, Law School	Richard B. Howarth	University of California, Santa Cruz
Robert D. Cooler	University of California, Berkeley Law School	Catherine Y. Co	University of Central Florida
David F. Layton	University of California, Davis	Andres Rodriguez	University of Chicago
John E. Roemer	University of California, Davis	David Hummels	University of Chicago
Klaus Nehrling	University of California, Davis	Gale D. Johnson	University of Chicago
Lovell S. Jarvis	University of California, Davis	James D. Fearon	University of Chicago
Peter H. Lindert	University of California, Davis	Lars Peter Hansen	University of Chicago
Robert Smiley	University of California, Davis	Mary Jean Bowman	University of Chicago
Thomas Mayer	University of California, Davis	Milton Harris	University of Chicago
Barrie R. Nault	University of California, Irvine	Stefan Krieger	University of Chicago
David Brownstone	University of California, Irvine	Thomas Sargent	University of Chicago
Dennis J. Algrner	University of California, Irvine	Uzma Qureshi	University of Chicago
Kenneth A. Small	University of California, Irvine	Claire Friedland	University of Chicago, George J. Stigler Center
Michelle R. Garfinkel	University of California, Irvine	Cass D. Sunstein	University of Chicago, Law School
Peter Navarro	University of California, Irvine	Austan Goolsbee	University of Chicago, School of Business
Aziz Khan	University of California, Riverside	Lars A. Stole	University of Chicago, School of Business
Jang-Ting Guo	University of California, Riverside	Timur Kuran	University of Chicago, School of Business
Keith C. Knapp	University of California, Riverside	Dennis Hanseman	University of Cincinnati
Keith Griffin	University of California, Riverside	Wolfgang Mayer	University of Cincinnati
R. Robert Russell	University of California, Riverside	Naci Mocan	University of Colorado
Steven Helfand	University of California, Riverside	Bernard Udis	University of Colorado, Boulder
Victor D. Lippit	University of California, Riverside	Charles De Bartolome	University of Colorado, Boulder
Takeo Hoshi	University of California, San Diego	Charles W. Howe	University of Colorado, Boulder
Alex Kane	University of California, San Diego	Keith E. Maskus	University of Colorado, Boulder
Allan Timmermann	University of California, San Diego	Kenneth R. Beauchemin	University of Colorado, Boulder
Christopher Woodruff	University of California, San Diego	Mark Cronshaw	University of Colorado, Boulder
Joel Watson	University of California, San Diego	Paul Stutsman	University of Colorado, Boulder
John Conlisk	University of California, San Diego	Robert K. Davis	University of Colorado, Boulder
Joseph Grunwald	University of California, San Diego	Robert McNowen	University of Colorado, Boulder
Lawrence B. Krause	University of California, San Diego	Russell R. Wermers	University of Colorado, Boulder
Michael Willoughby	University of California, San Diego	Daphne Greenwood	University of Colorado, Colorado Springs
Richard T. Carson	University of California, San Diego	Michael J. Mueller	University of Colorado, Colorado Springs
Richard W. Ruppert	University of California, San Diego	Arthur W. Wright	University of Connecticut
Elliot Marseille	University of California, San Francisco	C. P. Hallwood	University of Connecticut
Harold S. Luft	University of California, San Francisco	Lanse Minkler	University of Connecticut
Charles D. Kolstad	University of California, Santa Barbara	Peter Barth	University of Connecticut
Doug Steigerwald	University of California, Santa Barbara	Susan Randolph	University of Connecticut
Lloyd J. Mercer	University of California, Santa Barbara	Walter Dolde	University of Connecticut
Robert T. Deacon	University of California, Santa Barbara	John Rapp	University of Dayton
Stephen J. DeCanio	University of California, Santa Barbara	George R. Parsons	University of Delaware
William S. Comanor	University of California, Santa Barbara	Kenneth A. Lewis	University of Delaware
Alan Richards	University of California, Santa Cruz	Laurence Seidman	University of Delaware
Daniel Friedman	University of California, Santa Cruz	Russell F. Settle	University of Delaware
Lori Kletzer	University of California, Santa Cruz	Stacie E. Beck	University of Delaware
Menzie D. Chinn	University of California, Santa Cruz	David E. Black	University of Delaware

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ECONOMISTS' STATEMENT ON CLIMATE CHANGE

LIST OF ECONOMISTS WHO HAVE ENDORSED TO DATE

MARCH 24, 1997

NAME	AFFILIATION	NAME	AFFILIATION
Edward K. Hawkins	The World Bank, Rtd.	Marshall Reinsdorf	U. S. Bureau of Labor Statistics
Enrique Lerda	The World Bank, Rtd.	Adam A. Sokoloski	U. S. Bureau of Land Management
George C. Maniatis	The World Bank, Rtd.	Marc Rubin	U. S. Bureau of the Census
Phillip J. Glaessner	The World Bank, Rtd.	Anthony C. Homan	U. S. Consumer Product Safety Commission
Ralph H. Hofmeister	The World Bank, Rtd.	Elliot Levy	U. S. Department of Commerce
Theodore Lang	Thomas Lane & Associates	H. Kemble Stokes, Jr.	U. S. Department of Commerce
Michael H. Thomson	Thomson Econometrics	John E. Jelacic	U. S. Department of Commerce
James W. Thomson	Thomson Investing	Inja K. Palk	U. S. Department of Energy
Richard Skolnik	Tiffin University	Robert Copaken	U. S. Department of Energy
Nayyer Hussain	Tougaloo College	Joseph M. Burns	U. S. Department of Justice
B. Michael Gilbar	Town of Hanover, New Hampshire	Robert Blicksilver	U. S. Department of Labor
Chang Min Kong	Towson State University	C. Anne Pence	U. S. Department of State
George C. Georgiou	Towson State University	Jon H. Goldstein	U. S. Department of the Interior
William Ingram	Tradewinds Realty	Stewart E. Butler	U. S. Department of Transportation
Bruce Vermeulen	Training & Development Corp.	Deborah Shields	U. S. Dept. of Agriculture
Andrew J. Gold	Trinity College	Robbin Shoemaker	U. S. Dept of Agriculture
Ward S. Curran	Trinity College	James M. MacDonald	U. S. Dept of Agriculture, Economic Research
William Breit	Trinity University	Kenneth Hanson	U. S. Dept of Agriculture, Economic Research
David Gillette	Truman State University	David Schimmelpfennig	U. S. Dept of Agriculture EPS
Jane Sung	Truman State University	Tanya Roberts	U. S. Dept of Agriculture, EPS
Seymour Patterson	Truman State University	Ken Borghese	U. S. Dept of Commerce
Werner Sublette	Truman State University	Christian Ehemann	U. S. Dept. of Commerce, Bureau of Economic
Carsten Kowalczyk	Tufts University	Paul D. Gayer	U. S. Dept of Health and Human Services Rtd.
David M. Garman	Tufts University	Monroe Burk	U. S. Foreign Service
Gilbert Metcalf	Tufts University	Michael E. C. Ely	U. S. Foreign Service, Rtd.
Jonathan Harris	Tufts University	William B. Shear	U. S. General Accounting Office
Joseph A. DiMasi	Tufts University	William McNaught	U. S. General Accounting Office
Neva Goodwin	Tufts University	Charles Collier	U. S. Government
Thomas A. Downes	Tufts University	Edgar A. Peden	U. S. Government
Dahlia Remler	Tulane University	Thomas F. Jennings	U. S. International Trade Commission
David Hotchkiss	Tulane University	Oscar A. Echevarria	U. S. Investment Group
David Malueg	Tulane University	John Helnberg	U. S. Labor Department
Eamon M. Kelly	Tulane University	Adrian Kendry	U. S. Naval Academy
Irving H. LaValle	Tulane University	Brian J. Richter	U. S. Nuclear Regulatory Commission
Jonathan B. Pritchett	Tulane University	Donald Rousslang	U. S. Treasury Department
William H. Oakland	Tulane University	James M. Russell	U. S. Treasury Department
John H.Y. Edwards	Tulane University, The World Bank	William B. Trautman	U. S. Treasury Department
Campat Ramesh	U.N. Development Program	Lawrence D. Krohn	UBS Securities
David A. Heesen	U.S.A.I.D.	Donald Shoup	UCLA
Donald A. Sillers	U.S.A.I.D.	Hilary Sigman	UCLA
James L. Mudge	U.S.A.I.D.	Jack Hirschleifer	UCLA
Jerre A. Manarolla	U.S.A.I.D.	John G. Riley	UCLA
Michael Crosswell	U.S.A.I.D.	John J. McCall	UCLA
Liliana E. Pezzin	U. S. Agency for Health Care Policy & Research	Mohan Penubarti	UCLA
Arden K. Sansom	U. S. Army Corps of Engineers	Paul M. Ong	UCLA
Frank D. Campbell	U. S. Army Trade Analysis	Rebecca Menes	UCLA

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Theodore S. Woodruff	St. Ambrose University	Charles E. McLure, Jr.	Stanford University, Hoover Institute
Mark Partridge	St. Cloud State University	Gerald M. Meier	Stanford University, School of Business
Patricia Hughes	St. Cloud State University	Thomas Hellman	Stanford University, School of Business
Micheal St. John	St. John & Associates	Andrea Shepard	Stanford University, School of Business
Daniel Finn	St. John's University	Jeremy Bulow	Stanford University, School of Business
Sara Gordon	St. John's University	Patricia Bowles	State Education
Ralph A. Terregrossa	St. Johns University	Gregory Vitale	State of Iowa
Linda R. Rudolph	St. Lawrence University	Khosrow Khojasteh	State of Iowa
Robert A. Blewett	St. Lawrence University	Bernard Brown	State of New Jersey
Sarah A. Stevens	St. Lawrence University	Richard Fryman	State University of West Georgia
Kathleen N. Gillespie	St. Louis University, School of Public Health	Siegfried G. Karsten	State University of West Georgia
Andrea T. Williams	St. Mary's College of California	William C. Schandel	State University of West Georgia
Joan Underhill Hannon	St. Mary's College of California	James E. Mallett	Stetson University
Theodore Tsukahara, Jr.	St. Mary's College of California	Ranjini Thaver	Stetson University
Gary Scott	St. Mary's University	Richard H. Wood, Jr.	Stetson University
Roy E. Robbins	St. Mary's University	Richard M. O'Connor	Stockholm School of Economics
Herbert Kessel	St. Michael's College	Hossein S. Kazemi	Stonehill College
David Emery	St. Olaf College	Raymond A. Pepin	Stonehill College
David W. Schodt	St. Olaf College	Jeffrey H. Rohlfis	Strategic Policy Research
Paul Wojcik	St. Olaf College	Karen Nelson	Streamline Training & Documentation
Rebecca Judge	St. Olaf College	Shahruz Mohtadi	Suffolk University
Xum Z. Pomponio	St. Olaf College	Jonathan Sunshine	Sunshine and Associates
John J. Donohue	Stanford Law School	Betty C. Daniel	SUNY, Albany
William F. Baxter	Stanford Law School	Jim H. Wyckoff	SUNY, Albany
A. Michael Spence	Stanford University	Kajal Lahiri	SUNY, Albany
Anne O. Krueger	Stanford University	Terrence Kinal	SUNY, Albany
Auner Greif	Stanford University	John S. Nader	SUNY at Delhi
B. Douglas Bernheim	Stanford University	Edward C. Kokkelenberg	SUNY, Binghamton
Bert G. Hickman	Stanford University	Manas Chatterji	SUNY, Binghamton
Bruce F. Johnston	Stanford University	Robert L. Basmann	SUNY, Binghamton
Ciaran S. Phibbs	Stanford University	Richard M. Romano	SUNY, Broome
Ezra Solomon	Stanford University	Frederick G. Floss	SUNY, Buffalo
Henry M. Levin	Stanford University	Murray Brown	SUNY, Buffalo
Hung-po Chao	Stanford University	Thomas Romans	SUNY, Buffalo
John Earle	Stanford University	David Ring	SUNY, College at Oneonta
Karine Nyborg	Stanford University	Edward I. Beck	SUNY, College at Oneonta
*** Kenneth J. Arrow	Stanford University	Aimar K. Parai	SUNY, Fredonia
Lawrence J. Lau	Stanford University	William H. Foeller	SUNY, Fredonia
Martin Carnoy	Stanford University	David A. Martin	SUNY, Geneseo
Mordecai Kurz	Stanford University	Roman A. Ohrenstein	SUNY, Nassau College
Myra H. Strober	Stanford University	Peter Vukasin	SUNY, New Paltz
Rosamond Naylor	Stanford University	Wade L. Thomas	SUNY, Oneonta
Scott Rozelle	Stanford University	William P. O'Dea	SUNY, Oneonta
Victor R. Fuchs	Stanford University	Michael A. Stoller	SUNY, Plattsburgh
Jeffrey Williams	Stanford University, Food Research Institute	Warren L. Fisher	Susquehanna University
Pan A. Yotopoulos	Stanford University, Food Research Institute	Larry E. Westphal	Swarthmore College

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NAME	AFFILIATION	NAME	AFFILIATION
James F. Kasting	Pennsylvania State University	Antonio L. Rosado	Puerto Rico Economist Association
Jeffrey K. Lazo	Pennsylvania State University	Dan Kovenock	Purdue University
Lawrence L. Blacchi	Pennsylvania State University	George R. Averitt	Purdue University
Norman R. Swanson	Pennsylvania State University	Gerald E. Shively	Purdue University
Phillip A. Klein	Pennsylvania State University	Hedayeh Samavati	Purdue University
Thomas A. Gresik	Pennsylvania State University	James C. Moore	Purdue University
Tim Considine	Pennsylvania State University	Janet S. Netz	Purdue University
William J. Wheeler	Pennsylvania State University	John M. Connor	Purdue University
Elizabeth T. Hill	Pennsylvania State University, Mont Alto	Larry De Boer	Purdue University
M.M. Shahjahan	PEPCO	Patrick McCarthy	Purdue University
Morton Zeman	Perimeter Adult Learning & Services	Paul L. Farris	Purdue University
Peter L. Bernstein	Peter L. Bernstein, Inc.	George R. Hall	Putnam, Hayes & Barlett, Inc.
Yoon Kim	Phoenix, Inc.	Trish Kelly	Quinnipiac College
James Lehman	Pitzer College	Rex J. Bates	R. J. Bates
Sallaja Raparla	Point Systems Solutions, Inc.	Robert L. Randall	RainForest ReGeneration
Hans Lofgren	Policy Research Institute	Dana Goldman	RAND
Jane Venohr	Policy Studies, Inc.	Julia Lowell	RAND Corp.
Eleanor Brown	Pomona College	Shella Nataraj Kirby	RAND Corp.
Frank C. Wykoff	Pomona College	William Dow	RAND Corp.
James D. Likens	Pomona College	C. Barry Flitzner	Randolph Macon College
Michael Kuehlwein	Pomona College	Antoinette J. Criss	Randolph-Macon Woman's College
Stephen V. Marks	Pomona College	Eugenio Diaz-Bonilla	RDP Consulting Group
Giles H. Burgess Jr.	Portland State University	Richard B. Parker	Red Oak Research
Harold G. Vatter	Portland State University	Carl M. Stevens	Reed College
Helen Youngelson-Neal	Portland State University	Heidi Brown	Reed Consulting Group
John F. Walker	Portland State University	Benjamin H. Stevens	Regional Science Research Corp.
Myron B. Katz	Portland State University	H. Michael Coiner	Regis College
Thomas P. Potlowsky	Portland State University	Mary J. Oates	Regis College
Robert Kirchner	Potomac Electric Power Company	Robert L. Lessne	Rehabilitation Services, Inc.
Peter Merrill	Price Waterhouse	Donald F. Vitaliano	Rensselaer Polytechnic Institute
Burton Malkiel	Princeton University	Gary Zarkin	Research Triangle Institute
Elizabeth C. Bogen	Princeton University	Katherine B. Heller	Research Triangle Institute
Gregory Chow	Princeton University	Shella A. Martin	Research Triangle Institute
Maria Hanrahty	Princeton University	Mervin Feldman	Resource Decisions
Timothy Van Zandt	Princeton University	Dallas Burtaw	Resources for the Future
Albert O. Hirschman	Princeton University, Inst. for Adv. Studies	Alema-Karim	Rhode Island College
John P. Lewis	Princeton University, Woodrow Wilson School	Dagobert L. Brito	Rice University
Kenneth Rogoff	Princeton University, Woodrow Wilson School	Gordon W. Smith	Rice University
Mark Watson	Princeton University, Woodrow Wilson School	Kel-Mu Yi	Rice University
Michael Rothschild	Princeton University, Woodrow Wilson School	Melaku Lakew	Richard Stockton College of New Jersey
R. Thomas Burge	Proctor & Gamble Pharmaceuticals	Kirk D. Gifford	Ricks College
Curt Mueller	Project Hope	Henry J. Frank	Rider University
David Zalewski	Providence College	Paul J. Schoofs	Ripon College
Mary Jane Lenon	Providence College	Clare W. Zempel	Robert W. Baird & Co. Incorporated
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NAME	AFFILIATION	NAME	AFFILIATION
Ernst R. Berndt	MIT, Sloan School of Management	Carol L. Osler	New York Federal
** Franco Modigliani	MIT, Sloan School of Management	William J. Lawrence	New York Institute of Technology
Dale W. Larson	Mitsubishi Research Institute	Sonya Komreich	New York State Dept. of Labor, Ind.
Michael H. Lee	Montana Public Service Commission	Janusz A. Ordover	New York University
Phillip LeBel	Montclair State University	Adam Przeworski	New York University
William Gissay	Morehouse College	Amy Ellen Schwartz	New York University
Michael Rollins	Mount Holyoke College	Dick Netzer	New York University
Frank Zarnowski	Mount St. Mary's College	Edward Wolff	New York University
Arthur J. Raymond	Muhlenberg College	Holger C. Wolf	New York University
George Helfmann	Muhlenberg College	Jacob A. Toby	New York University
Rohini P. Sinha	Muhlenberg College	Jess Benhabib	New York University
Martin Milkman	Murray State University	Joshua Ronen	New York University
Seid Y. Hassan	Murray State University	Lawrence White	New York University
Brian Thomas	MWD	Lewis A. Kornhauser	New York University
Brian Crumb	NACT	Paul Wachtel	New York University
C. Stuart Callison	Nathan Associates, Inc.	Rita Maldonado-Bear	New York University
Gary L. French	Nathan Associates, Inc.	Roy Radner	New York University
John Varley	Nathan Associates, Inc.	W. Van Der Klaauw	New York University
Abraham J. Fallick	National Association of Business Economists	Walter W. Haines	New York University
Brian J. Ostrom	National Center for State Courts	** Wassily Leontief	New York University
Gerald C. Berg	National Defense University	William J. Baumol	New York University
Robert W. Beckstead	National Defense University	Robert A. Kavesh	New York University, Stern School
Alan J. Daskin	National Economic Research Associates Inc.	Thomas A. Pugel	New York University, Stern School
David Tabak	National Economic Research Associates Inc.	Mark J. Lawless	NFPA International
Leonardo Giacchino	National Economic Research Associates Inc.	Thomas A. Foulkes	NHTI
Li-Lan Cheng	National Economic Research Associates Inc.	Stanton A. Warren	Niagara University
Marc Kramer Mayer	National Economic Research Associates Inc.	Yuzo Kumasaka	NLI Research Institute
Robert Petersen	National Economic Research Associates Inc.	Blair T. Bower	NOAA Consultant
Stephen E. Usher	National Economic Research Associates Inc.	Carol A. Jones	NOAA Damage Assessment Center
Carolyn Dewa	National Opinion Research Center	Gregory N. Price	North Carolina A&T University
Ted R. Miller	National Public Services Research Institute	Lawrence B. Morse	North Carolina A&T University
Chris Wise-Mahr	National Science Foundation	Ryuichi Sakano	North Carolina A&T University
Robert Schmidt	National University	Darren L. Frechette	North Carolina State University
Bill Gates	Naval Postgraduate School	Duncan M. Holthausen	North Carolina State University
David Whipple	Naval Postgraduate School	Fanis Tsoulouhas	North Carolina State University
Joseph DaBoll-Lavoie	Nazareth College	Michael B. McElroy	North Carolina State University
Edward A. Schroeder, IV	Nazareth College of Nazareth	Samim Cilem	North Carolina State University
Joyce Gleason	Nebraska Wesleyan University	J. Carl Poindexter	North Carolina State University
Richard McGahey	Neece, Cator & McGahey	Allen Vander Muelen	North Central College
Richard L. Kaluzny	New Jersey Division of Taxation	Thomas M. Love	North Central College
David T. Geithman	New Jersey Institute of Technology	Lynn Schneider	North Georgia College & State University
Elliot Orton	New Mexico State University	Watson Collins	Northeast Utilities
Robert Heilbroner	New School for Social Research	Barbara M. Fraumeni	Northeastern University
Willi Semmler	New School for Social Research	Gustav Schachter	Northeastern University
Alex L. Yufa	New York City Economic Dev. Corp.	John Adams	Northeastern University
Sidney Friend, Jr.	New York City Police Department	Kamran M. Dadkhah	Northeastern University

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NAME	AFFILIATION	NAME	AFFILIATION
Shawky El Toukhy	ITA of New Jersey	John P. Brown	KPMG Economic Consulting Services
Ella Kacapyr	Ithaca College	Richard A. Boykin	KPMG Economic Consulting Services
M. Raquibuz Zaman	Ithaca College	Steven D. Felgran	KPMG Economic Consulting Services
Marc Bilodeau	IUPUI	Stephen E. Baldwin	KRA Corporation
Jannette M. Barth	J.M. Barth & Associates, Inc.	Jon Haveman	Krannert School of Management
Andrew Kohen	James Madison University	David H. Robinson	La Salle University
Joanne M. Doyle	James Madison University	Dr. Mark J. Ratkus	La Salle University
Ehsan Ahmed	James Madison University	James C. Haefner	Labelon Corporation
J. Barkley Rosser, Jr.	James Madison University	Dwayne S. Breger	Lafayette College
William C. Wood	James Madison University	Howard Bodenhorn	Lafayette College
Kevin Stokes	Jefferson Community College	James DeVault	Lafayette University
Ronald Swanstrom	Jefferson High School	Jeffrey O. Sundberg	Lake Forest College
Edward J. Jorgenson	Jet Propulsion Laboratory	Richard F. Dye	Lake Forest College
Lawrence R. Clma	John Carroll University	Robert A. Baade	Lake Forest College
Thomas A. Sears	John F. Kennedy University	William Maskoff	Lake Forest College
Carl F. Christ	Johns Hopkins University	Rolando A. Santos	Lakeland College
Christopher D. Carroll	Johns Hopkins University	Judith Markland	Landmark Strategies
Cristino R. Arroyo	Johns Hopkins University	Thomas W. Langford	Langford & Associates
David G. Fernandez	Johns Hopkins University	Christopher J. Pleatsikas	Law & Economics Consulting Group
Isaiah Frank	Johns Hopkins University	Steven Stoft	LBNL
Louis J. Maccini	Johns Hopkins University	Hui-Liang Tsai	Lebanon Valley College
W. Max Corden	Johns Hopkins University	J. Richard Aronson	Lehigh University
Douglas W. Copeland	Johnson County Community College	Thomas Hydlak	Lehigh University
Nan L. Wilson	Johnson County Community College	Todd A. Watkins	Lehigh University
Zohreh M. Niknia	Johnson County Community College	Eban Goodstein	Lewis & Clark College
Milton Russell	Joint Institute for Energy and Environment	James H. Grant	Lewis & Clark College
Joseph A. Swanson	Joseph Swanson & Co.	Shaomin Huang	Lewis Clark State College
Kenneth A. Reinert	Kalamazoo College	Hal Sider	Lexecon Inc.
Amir Tavakkol	Kansas State University	Jeffery T. Collins	Lincoln Memorial University
Andrew Barkley	Kansas State University	Vishwanath Tirupattur	Lincoln National
Patrick Gormely	Kansas State University	Randy R. Grant	Linfield College
Richard L. D. Morse	Kansas State University	Stephen M. Lewarne	LMCL Corp
Robert B. Borges	Kansas State University	Douglas A. Wion	Lock Haven University
Roger Trenary	Kansas State University	Michael Edesess	Lockwood Financial Group
Steve Hamilton	Kansas State University	Gang Feng	Lockwood Trade Journal Co. Inc.
Pierre Carasso	Kayne Anderson	John T. Evans	Long Island University
Carol M. Condon	Kean College of New Jersey	P. M. Rao	Long Island University
Youn-Suk Kim	Kean College of New Jersey	Ranbir Varma	Long Island University
Alexander S. Kelso, Jr.	Kelso International	Brian R. Horrigan	Loomis, Sayles & Co.
Penelope B. Prime	Kennesaw State University	Steven Booth	Los Alamos National Laboratory
Richard J. Kent	Kent State University	Verne W. Loose	Los Alamos National Laboratory
Arthur D. Chesler	Kentucky Wesleyan College	Robby C. Winters	Los Angeles City College
Kottayam V. Natarajan	King Co. Dept. of Natural Resources	Nancy L. Sidener	Louisiana Council for Economic Education
Hamid Hosseini	King's College	Steven J. Prince	Louisiana Scholars' College
Zachary Roitnik	Kluwer Publishers	John M. Church	Louisiana State University Law Center
Wan Ho Cho	Korean Consulate	Marc C. Chopin	Louisiana Tech

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MARCH 24, 1997

NAME	AFFILIATION	NAME	AFFILIATION
Peter C. Mayer	Guam Power Authority	David T. Ellwood	Harvard University, Kennedy School of Govt.
Louis D. Johnston	Gustavus Adolphus College	Edward A. Parson	Harvard University, Kennedy School of Govt.
Herbert W. Fraser	H. W. Fraser Associates	F. M. Scherer	Harvard University, Kennedy School of Govt.
Ahmad Faruqui	Hagler Bailly	Jose Antonio Gomez-Ibanez	Harvard University, Kennedy School of Govt.
Harold A. Cohen	Hal Cohen, Inc.	Mun S. Ho	Harvard University, Kennedy School of Govt.
Robert E. Dansby	Halcyon Inc.	P. Timothy Bushnell	Harvard University, Kennedy School of Govt.
John Haldi	Haldi Associates, Inc.	Richard F. Garbaccio	Harvard University, Kennedy School of Govt.
Elizabeth J. Jensen	Hamilton College	Robert Stavins	Harvard University, Kennedy School of Govt.
Hilke Kayser	Hamilton College	William Spitz	Harvard University, Kennedy School of Govt.
Burke Burright	Hamon Systems Center	Robert H. Mnoulin	Harvard University, Law School
Robert Charles Graham	Hanover College	W. Kip Viscusi	Harvard University, Law School
Samuel S. Chun	Harvard Business School	Abram Bergson	Harvard University, Littauer Center
Thomas K. McCraw	Harvard Business School	Rashi Fein	Harvard University, Medical School
Randall Bluffstone	Harvard Inst. for International Development	David Hemenway	Harvard University, School of Public Health
Bruce R. Bolnick	Harvard Inst. for International Development	Maurine A. Haver	Haver Analytics
Clifford Zinnes	Harvard Inst. for International Development	Shelley M. Mark	Hawaii, Dept of Bus. Econ. Dev't & Tourism
Clive S. Gray	Harvard Inst. for International Development	Vincent A. Fulmer	Hawthorn College
David C. Cole	Harvard Inst. for International Development	Hilda Kahne	Heller School, Brandeis University
Glenn P. Jenkins	Harvard Inst. for International Development	David E. Ervin	Henry A. Wallace Institute
Jeffrey D. Sachs	Harvard Inst. for International Development	Michael MacCully	High Point University
Jeffrey Vincent	Harvard Inst. for International Development	Michael McCully	High Point University
John Luke Gallup	Harvard Inst. for International Development	Stephen L. Zabor	Hiram College
Amartya Sen	Harvard University	Ugur Aker	Hiram College
Andrew Metrick	Harvard University	James E. Metzger	Histecon Associates Inc.
Brian Hall	Harvard University	Takatoshi Ito	Hitoiubashi University, International
Cheol Soo Park	Harvard University	Matthew K. Loke	HMSA
Claudia Goldin	Harvard University	Jacob Welissman	Hofstra University
* Dale Jorgenson	Harvard University	Walter E. Hoadley	Hoover Institution
David Laibson	Harvard University	Robin Klay	Hope College
Dwight H. Perkins	Harvard University	Linda Marie Dynan	Hospital Research and Education Trust
James K. Hammitt	Harvard University	Chuck Nwaka	Howard University
Jerry R. Green	Harvard University	Cleveland A. Chandler	Howard University
John R. Meyer	Harvard University	Sung Kwack	Howard University
John Y. Campbell	Harvard University	C. Elisabeth Pittman	HPA, Inc.
Lawrence Katz	Harvard University	L. Douglas Lee	HSBC Washington Analysis
Lester E. Gordon	Harvard University	Mark Shroder	HUD (for identification only)
Martin L. Weitzman	Harvard University	David T. Hulett	Hulett & Associates
Michael Whinston	Harvard University	Daniel M. Ihara	Humboldt State University
Nathan Keyfitz	Harvard University	Saeed Mortazavi	Humboldt State University
Oliver Hart	Harvard University	Steven Hackett	Humboldt State University
Raymond Vernon	Harvard University	Tim Yeager	Humboldt State University
Robert Dorfman	Harvard University	Tatsuji Hayakawa	IADB
Roswell G. Townsend	Harvard University	Michael C. Barth	ICF Kaiser
Steven Shavell	Harvard University	Robert Tokle	Idaho State University
Tilman Slembeck	Harvard University	Rob F. Vos	IDB
Christopher Jencks	Harvard University, Kennedy School of Govt.	Mylene Kherallah	IFPRI

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NAME	AFFILIATION	NAME	AFFILIATION
Anne Bunton	Cotter College	Gordon S. Bergsten	Dickinson College
Alice Tepper Marlin	Council on Economic Priorities	Leo Brand	Director, Standard & Poor's
Lenore H. Burckel	Cowers TM	Cono Casella	Dowd College
Naomi Chesler	CPE	William M. Boal	Drake University
Joseph M. Phillips	Creighton University	Andrew Verzilli	Drexel University
Roberto Riley	Critical Decisions Group	Bijou Y. Lester	Drexel University
P. Hartland-Thunberg	CSIS	Shawkat Hammoudeh	Drexel University
Albert I. A. Bookbinder	CUNY	Vibhas Madan	Drexel University
Ashok Vora	CUNY	Carol Mansfield	Duke University
Hugo M. Kaufmann	CUNY	E. Roy Weintraub	Duke University
Irving Stone	CUNY	Ed Tower	Duke University
Joseph Berechman	CUNY	Mark Y. An	Duke University
Ki-Ho Kim	CUNY	Martin Bronfenbrenner	Duke University
Lawrence Jay Kaplan	CUNY	Philip J. Cook	Duke University
Robert Kaestner	CUNY, Baruch College	Pietro Peretto	Duke University
Yehuda L. Klein	CUNY, Brooklyn College	Wesley A. Magat	Duke University
V. Petratos	CUNY, C. S. L.	Richard Henning	E. Elgar Publishers
Howard Chernick	CUNY, Hunter College	C. A. Christofides	East Stroudsburg University
Harvey Gram	CUNY, Queens College	P. Neelakantan	East Stroudsburg University
Peter Ellbott	CUNY, Queens College	Seewoonundun Bunjun	East Stroudsburg University
Zadia H. Feliciano	CUNY, Queens College	Pern S. Mann	Eastern Connecticut State University
Peter Chow	CUNY, The City College	Harold D. Nordin	Eastern Illinois University
Paul G. Althaus	CUNY, York College	James E. Payne	Eastern Kentucky University
Dennis E. Logue	Dartmouth College	Thomas G. Watkins	Eastern Kentucky University
John A. Menge	Dartmouth College	Richard A. Yoder	Eastern Mennonite University
M. O. Clement	Dartmouth College	Adrian J. Lott	Eastern Michigan University
Michael M. Knetter	Dartmouth College	Michael G. Vogt	Eastern Michigan University
Sang-Seung Yi	Dartmouth College	Thomas W. Benson	Eastern Washington University
Sheri L. Aggarwal	Dartmouth College	Hugh Richards	ECON
C. Louise Nelson	Davidson College	Frederic B. Jennings, Jr.	Econometrics
David W. Martin	Davidson College	Richard A. Baum	Economic Analysis
George Szejner	DC Superior Court	Kenneth R. Button	Economic Consulting Services Inc.
Gary D. Lemon	De Pauw University	Geoffrey H. Moore	Economic Cycle Research Institute
Peter Meenan	Deloitte & Touche LLP	Jared Bernstein	Economic Policy Institute
Richard Sciacca	Deloitte & Touche LLP	Kenneth R. Dunmore	Economic & Policy Studies
Calvin A. Hoerneman	Delta College	John A. Laitner	Economic Research Associates
Craig Walker	Delta State University	Paul F. White	Economic Research Services, Inc.
Pete Morton	Denver University	Steve Holland	Economics Institute
Adolph E. Mark	DePaul University	An-Sik Min	Edinboro University of Pennsylvania
Animesh Ghoshal	DePaul University	Rudi W. Schadt	Edwin L. Cox School of Business, SMU
Bala Batavia	DePaul University	Robert J. Eggert	Eggert Economic Enterprises
Michael Marschoun	DePaul University	Ell Ginzberg	Eisenhower Center, Columbia University
Woods Bowman	DePaul University	E. Somanathan	Emory University
Eric R. Nelson	Development Alternatives, Inc.	Jeffrey A. Rosenweig	Emory University
Martha O. Blaxall	Development Alternatives, Inc.	Richard F. Muth	Emory University
Greig Harvey	DHS Associates	Robert Catlett	Emporia State University

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ECONOMISTS' STATEMENT ON CLIMATE CHANGE

LIST OF ECONOMISTS WHO HAVE ENDORSED TO DATE

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NAME	AFFILIATION	NAME	AFFILIATION
Robert Wassmer	Cal State Sacramento	Lester B. Lave	Carnegie Mellon University
James M. Payne	Calhoun Community College	Mark S. Kamlet	Carnegie Mellon University
Tsong-Yue Lai	California State University	Russell Sheldon	Carnegie Mellon University
Malcom Dole, Jr.	California Air Resources Board	Shyam Sunder	Carnegie Mellon University
Seymour Goldstone	California Energy Commission	Amresh Hanchate	Case Western Reserve University
Lionel J. Lerner	California Energy Commission, Rtd.	Bo Carlsson	Case Western Reserve University
Charles R. Plott	California Institute of Technology	Robert E. Schill	Castleton State College
Lance E. Davis	California Institute of Technology	Robert K. Arnold	CCSCE
Phillip Fanchon	California Polytechnic State University	Robert Deuson	Center for Disease Control
James Ahern	California Polytechnic University	Stephen T. Parente	Center for Health Affairs
Franklin Y. Ho	California State Polytechnic University	Zbigniew Bochniarz	Center for Nations in Transition, Univ. of
A. R. Gutowsky	California State University	Carol Moore	Center for Naval Analysis
Anil K. Puri	California State University	Jan Ondrich	Center for Policy Research, Syracuse University
Daniel R. Blake	California State University	Sidney Weintraub	Center for Strategic and Intl. Studies
Don R. Leet	California State University	James Reschovsky	Center for Studying Health System Change
Eduardo M. Ochoa	California State University	Paul B. Ginsburg	Center for Studying Health System Change
Eric J. Solberg	California State University	Brian Peterson	Central College
Madhu S. Mohanty	California State University	Richard Clendenning	Central College
Michael Perelman	California State University	N. Wayne Jordan	Central Florida Community College
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Tom C. Geurts	California State University	Baird Allen Brock	Central Missouri State University
Donald J. Oswald	California State University, Bakersfield	Bruce K. Johnson	Centre College
Robert G. James	California State University, Chico	David A. Anderson	Centre College
Suleman A. Moosa	California State University, Chico	Robert E. Martin	Centre College
Scott Houser	California State University, Fresno	Michael J. Walsh	Centre Financial Products Ltd.
Paul D. Staudohar	California State University, Hayward	Raymond Sfeir	Chapman University
Robert S. Ozaki	California State University, Hayward	Deloris R. Wright	Charles River Associates
Marion S. Beaumont	California State University, Long Beach	Philip K. Vealecer Sr.	Charles River Associates
Michael J. Farrell	California State University, Long Beach	Robert J. Lamer	Charles River Associates
John A. Tomaske	California State University, Los Angeles	Gladys A. Dejesus	Chowan College
H. Dieter Renning	California State University, Stanislaus	Koenraad M. Driessens	Christensen Associates
Mary Fair Berglund	California Transportation Commission	Laurence D. Kirsch	Christensen Associates
Young J. Park	California University of Pennsylvania	Laurits R. Christensen	Christensen Associates
Julie Elston	Caltech	Samuel Cutting	Christensen Associates
John P. Tiemstra	Calvin College	Philip Schoech	Christiansen Associates
Scott V. Parris	Cambridge University Press	Rita C. Sweeney	Christiansen Associates
Pierre Canac	Cameron School of Business	Kookshin Ahn	Chung-Ang University, Seoul
John M. Courington	Cameron University	Jarl R. Hellemalm-Ashfield	Church of God
Yu-Mong Hsiao	Campbell University	Frederick Schroeder	Cigna Financial Advisors, Inc.
Andrew C. Givens	Cardinal Energy Service, Inc.	Alfred Eisenpreis	City Innovation
Dickson K. Smith	Cardinal Strich College	Alfred Keisenpress	City Innovation
George H. Lamson	Carleton College	Gordon Alexander	City of Austin, Texas
Stephen H. Strand	Carleton College	Greg Hill	City of Seattle
Allan H. Meltzer	Carnegie Mellon University	Paul A. Zak	Claremont Graduate School
Chris L. Telmer	Carnegie Mellon University	Mark Haggerty	Clarion University
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NAME	AFFILIATION	NAME	AFFILIATION
Lorraine M. Connell		Richard B. Goode	
M. G. Zephlin		Richard Gomez	
M. S. Noorzooy		Richard Hooley	
Marianne Ferber		Richard J. Claycombe	
Mark D. Henson		Richard L. Ruth	
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Martine Duchatelet		Richard Young	
Mary McNally		Rick Mines	
Maud Naroll		Robert A. Rennie	
Michael Adler		Robert C. Young	
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Patricia Godoy-Kain		Rose Jochowitz	
Patrick Karand		Rudolph W. Hardy	
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Piljoo Yum		Souleyman Gueye	
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Rafael Montalvo		Stephen Altheim	
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NAME	AFFILIATION	NAME	AFFILIATION
Frank Lerman		John Hayes	
Frank W. Gery		John J. Hisnanick	
Fred Morser		John J. Soladay	
Gary Anders		John M. Hackett	
Gary Watts		John Maher	
George A. Jouganlos		John McFarland	
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Gordon Irlam		Jon Manger	
Gordon K. Douglass		Jonathan Willner	
Gregory L. Rosston		Joseph E. Bowring	
Gretchen McClain		Joseph F. Shaw	
H. Lynn Miller		Joseph Froomkin	
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Henry B. McFarland		Joseph V. Cartwright	
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Jack Beebe		Karl E. Sagner	
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James Duprey		Keith Waehrer	
James E. Clark		Ken Beler	
James E. Glassman		Kenan Ogelman	
James L. Hamilton		Kent R. Nilsson	
James Trask		Kent Sims	
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MARCH 24, 1997

NAME	AFFILIATION	NAME	AFFILIATION
James S. Hanson	Willamette University		
Elizabeth Brainerd	Williams College		
Matthew Hyle	Winona State University		
David Peterson	Wisconsin Department of Revenue		
Marcus Boggs	Wishview Press		
E. B. Cendel	Woodbury University		
Michael J. Radzicki	Worcester Polytechnic Institute		
Paul Faeth	World Resources Institute		
Robert Repetto	World Resources Institute		
Norman S. Anon	Wright State University		
Rishi Kumar	Wright State University		
Thomas Traynor	Wright State University		
Steven C. Agee	XAE Corporation		
Robert O. Zimmerman	Xavier University		
Henry Hansmann	Yale Law School		
Katherine O'Regan	Yale School of Management		
Paul W. MacAvoy	Yale School of Management		
Barry Nalebuff	Yale University		
Dirk Berlemann	Yale University		
** James Tobin	Yale University		
Jody Sindelar	Yale University		
Joel Waldfoegel	Yale University		
L. G. Reynolds	Yale University		
Lynne Bennett	Yale University		
M. J. Peck	Yale University		
Robert Evenson	Yale University		
T. Paul Schultz	Yale University		
* William Nordhaus	Yale University		
Gustav Ranis	Yale University, Economic Growth Center		

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Tab E:

**A Short Primer on
Externalities and Public
Goods**

A Short Primer on Externalities and Public Goods

Overview on externalities

A negative externality is a cost that one person or company imposes on another. For example, if your home furnace emits soot that soils your neighbors' laundry, you have imposed an externality on your neighbor. A key element of the externality is that the person imposing the cost does not bear the full (social) cost of the activity. In the case of the dirty furnace, the homeowner bears the costs of fuel and furnace maintenance, but escapes the cost of dealing with the soiled laundry. It is worth noting that externalities need not be bad; a positive externality confers a benefit on someone who did not have to pay for it. For example, if your yard's graceful trees and colorful flowers offer your neighbors a fine view, you have conferred on them a positive externality: they would be willing to pay something for the view, but it is not feasible (it would cost too much) to charge them for it. Left to itself, the free market will produce too little of a positive externality (like a pleasing landscape) and too much of a negative externality (like pollution).

The economists' term for this is **market failure** -- indicating the existence of external costs or benefits for which it is not feasible to compensate or charge those who bear the costs or enjoy the benefits. Economists have long recognized the role of externalities: Marshall (1898) introduced the concept of externalities, and Pigou (1920) incorporated the concept into welfare economics, introducing the distinction between private and social cost. Pigou also devised one of the classic responses to a negative externality. For example, assume that homeowners will emit too much soot if they do not have to bear all the costs of what they do. Pigou's solution was to levy a charge equal to the difference between marginal social cost and marginal private cost (see figure 1)-- thus forcing the homeowner to "internalize" the full social costs of her actions.

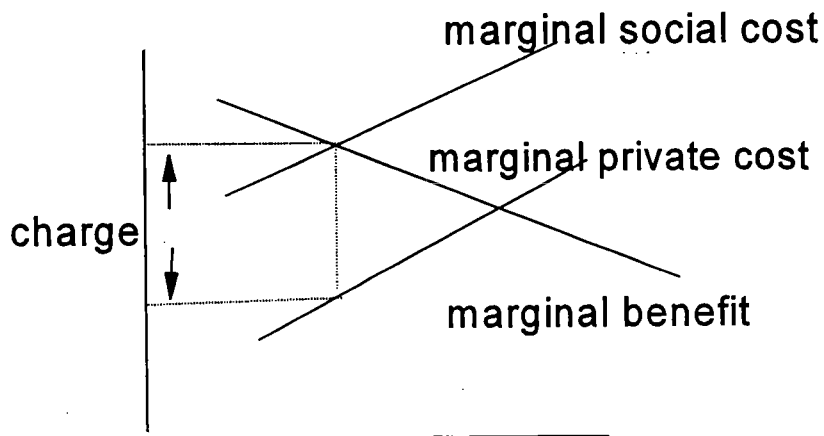


Figure 1: Pigouvian charge

Overview on public goods

A public good is one that must be provided in the same amount to all affected consumers. National defense is a public good: the amount of national defense I receive in no way diminishes the amount you receive. We may value it differently, but we all get the same amount. Moreover, there is no way for me to deny you the same amount that I get. A free market will provide too little of a public good, because there is no incentive for any individual to reveal the true value to him or her of the public good. The usual solution is for governments to provide public goods, although that leaves the problem of deciding on a common level.

A pure public good has both of the properties referred to above: nonrivalry and nonexcludability (Samuelson 1954, 1955).¹ Nonrivalry means that additional consumers do not have to compete with each other to use the good and therefore drive up its cost: the marginal cost of an additional individual using the good is zero. Nonexcludability means that the marginal cost of exclusion -- of stopping an individual from enjoying the good -- is prohibitive. Public goods thus permit **free riding**. Lighthouses, for example, are public goods: when lighthouse services are provided to one person, others may enjoy the same services without cost.

International public goods

The atmosphere is an international public good, in that atmospheric concentrations are the result of combined actions by all countries. That means that if one country's greenhouse gas reductions thwart global warming, all countries benefit.

Since different countries will be affected differently by climate change, the benefits of avoiding greenhouse warming will also differ from country to country. Further, some actions will simultaneously affect local atmospheric conditions (providing local public goods) and greenhouse concentrations. For example, actions that reduce urban driving improve local air quality and at the same time reduce greenhouse gas emissions.²

Property rights

Adam Smith's insight on the invisible hand of the marketplace (1776) remains the basis of welfare economics. Stated in modern form, it says that if each producer and consumer maximizes his own private net benefits, then markets that allow trading among all producers and all consumers will result in a socially optimal allocation of resources. Here, socially optimal means Pareto optimal, in that resources cannot be reallocated so as to make one person better off without at the same time making someone else worse off.

Environmental problems most often occur when well-defined property rights do not exist (Coase 1960). This may occur because the rights have not been comprehensively assigned (a person may hold title to a piece of land, but no one holds title to the air that circulates over it); because the rights are not exclusive; because the rights are not transferable

(a farmer who could not transfer his land would lack some incentive to preserve its fertility); or because the rights are not secure, thus encouraging the owner to exploit the resource while it is still under his control (Hanley, Shogren, and White 1997).

The absence of property rights for many environmental resources forms the justification for most government intervention in the environment.

Assigning property rights to the atmosphere is particularly difficult, however, since this would require the agreement of many sovereign states. Tradable greenhouse emission permits, discussed below, can be thought of as an attempt to resolve the problem by explicitly assigning property rights to greenhouse emissions.

Establishing property rights for emissions is not the same thing as considering the climate system itself as a public good. The Framework Convention on Climate Change refers to the climate system (not the atmosphere) as a "common concern of humankind." Atmospheric concentrations are the net result of emissions plus the contributions and effects of other factors such as the oceans, forests, and agricultural activity. Establishing property rights over emissions does not provide guidance for the consideration of these other influencing factors. Thus, establishing property rights for the atmosphere is only one of the mechanisms necessary to regulate climate change.

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Notes

1. For counter examples to the received wisdom, see Coase (1960). After Samuelson seminal articles in 1954 and 1955, Kneese (1962, 1964) extended the treatment of externalities with a series of articles in which he showed that an effluent charge would efficiently allocate the costs of clean up. See Baumol and Oates (1988) for a proof.

2. Although there may also be trade-offs: reductions in gases that contribute most to local pollution may sometimes be achieved at the expense of increased emissions of greenhouse gases.

Tab F:

Opportunities for Low-Cost Reductions Abroad

Opportunities for Low-Cost Reductions Abroad

The Framework Convention on Climate Change (FCCC) says that “policies and measures to deal with climate change should be cost effective.” Because greenhouse gas (ghg) emissions anywhere in the world have the same effect on the atmosphere, reducing a unit of emissions is equally valuable wherever it occurs.

Countries vary by two orders of magnitude in emissions of greenhouse gases per unit of gdp. At the low end are the poorest countries of sub-Saharan Africa: Rwanda, Burundi, Mali, Chad, and so on. These are pre-industrial economies that still rely on animal and human power supplemented by wood and crop wastes, rather than commercial fuels. The OECD countries lie in the middle of this range. Within the OECD, countries with low population density, an abundance of fossil fuels, a cold climate, or large average dwelling size use more energy per unit of gdp. Thus, Canada, Australia, and the US top the OECD list. China has the most carbon-intensive economy. Other countries with high greenhouse emissions per unit of gdp include India, Indonesia, Egypt, Mexico, Venezuela, Hungary, and South Africa. All these countries are all in the middle stages of industrialization, and most have large coal or oil reserves.

Many of these less developed countries (LDCs) and economies in transition (EITs) offer low-cost opportunities for reducing carbon emissions, for two reasons:

- *Energy Efficiency.* Many LDCs and EITs are less energy efficient than OECD countries.

Non-annex I countries use two and a half times as much energy per unit of gdp as Annex I countries. This manifests in all sectors of the economy, and in many individual end-uses of energy. Many investments in energy efficiency would quickly pay for themselves, yielding negative-cost reductions.

- ▶ Chinese coal-fired boilers are only 2/3 as efficient as US boilers. A recent World Bank study concluded that China could reduce its carbon emissions by 15 percent from its projected 2020 levels through zero- and negative-cost energy efficiency improvements. About 70 percent of these improvements would come as a result of market-oriented restructuring, with the remainder from particular technical projects.
- ▶ Russian cities spend large parts of their budgets on heat and heat subsidies; the city of Cheliabinsk, for example, spends more money on heat and heat subsidies than on health care.

- *High rates of growth and investment.* Because of their high growth rates, developing countries have an advantage over the OECD in their ability to meet their reduction targets by installing new, carbon-efficient plants rather than by retrofitting existing plants.

Non-annex 1 countries accounted for only 18 percent of world gdp in 1994 -- and only \$790 in gdp per head, as against \$12,200 for Annex 1. At the same time non-annex gdp

was growing at 5 percent annually (1990 to 1994), as against 1.2 percent for Annex 1. This has important implications for growth and investment.

When a power company in an OECD country considers building a new plant, it weighs the total cost of building a new natural gas plant against only the variable cost continuing to operate its existing coal plants. Unless coal prices jump, or the existing plant is in poor repair, only a large rise in coal prices will justify scrapping the old coal plant. When a power company in an LDC considers building a new plant, however, it weighs the total cost of building a new natural gas plants against the total cost of building a new coal plant. Here, only a small rise in coal prices could justify the decision to build a gas plant.

Joint implementation and trading

Joint implementation and international trading of carbon emission rights can help reduce emissions cost-effectively. Joint implementation could include switching from high-carbon to low-carbon fuels, investments in renewable energy projects, and the protection and expansion of forests as carbon sinks. The underlying idea is simple. If country A can reduce carbon emissions more cheaply than country B, B can buy greenhouse gas reductions from A by, for example, investing in tree-planting in A, or investing in new low-carbon energy sources in A.

Joint Implementation can serve other useful purposes besides reducing the cost of meeting greenhouse commitments: the opening of overseas markets, wider dissemination of advanced technologies, and improvements in local air quality.

Evidence for cost-effectiveness of trading and JI

Every economic study has found that trading and JI would lower costs worldwide. Barrett (1992), for example, stabilizing emissions country-by-country could cost the EU 50 times as much as stabilizing emissions for the EU as a whole. OECD's GREEN model shows that the costs of abatement vary among regions of the globe by a factor of 20 (Burnieux et al., 1992). GREEN also indicates that even with each region reaching its stabilization target at least cost, allowing trade between regions would lower worldwide compliance costs by another factor of two. The Battelle Laboratory's Second Generation Model (SGM) shows similar results, as do virtually all other economy-energy-carbon models now used to inform the debate.

Examples of successful JI projects

The FCCC continues to consider including JI as a way for signatories to meet their obligations. In the meantime, the US government and the World Bank, among others, have embarked on projects with JI characteristics.

World Bank. The Global Environment Facility (GEF) of the World Bank funds projects to demonstrate the effectiveness of interfuel substitution and technology innovation in reducing greenhouse emissions.

In Poland, the Coal to Gas Conversion (CTG) Project encourages coal-to-gas conversions in medium-sized boilers where concessional financing is necessary to meet acceptable rates of return. The GEF will divide the \$50 million cost with local sources.

In Mexico, the GEF encourages the replacement of incandescent lamps with fluorescent lamps in the cities of Guadalajara and Monterrey. This is forecast to reduce carbon emissions by 118,000 tons annually, sulfur oxides by 3000 tons annually, and nitrogen oxides by 208 tons annually.

The World Bank has also proposed a Carbon Investment Fund (CIF) to act as a market intermediary. The fund, on behalf of its investors, would undertake JI-type projects and sell the resulting carbon offsets to make a profit. Such a fund could improve on the efficiency of today's bilateral JI pilot projects by reducing transaction and search costs, providing efficient administration, and pooling risk.

United States. Since its foundation in 1993, the US Initiative on Joint Implementation (USIJI) has accepted 28 project proposals in 12 countries, helping US firms tap the potential outside the OECD for low-cost carbon reductions. These projects cover fuel switching, renewables, afforestation, and reforestation.

In the Czech Republic, The Bynov Heating Plant project in the city of Decin will switch the Bynov District Heating Plant from brown coal to natural gas, and at the same time improve the efficiency of the distribution system. In this project, the US Center for Clean Air Policy is collaborating with three US electric utilities and the City of Decin. Of the total capital investment of \$1.5 million, local officials will finance 60 percent, with US utilities expected to make significant contributions. The Washington-based environmental group World Resources Institute (WRI) will be responsible for monitoring and analysis. The project aims to offset 12,800 tons of CO₂ per year. In addition the project aims to substantially improve local air quality in a city whose peak SO₂ level is 10 times higher than the health standards set by the World Health Organization (WHO), by removing 96 tons of SO₂, and 3 tons of particulates.

The Biomass Cogeneration Project in India aims to demonstrate the feasibility of firing boilers at rural sugar mills with bagasse (sugar cane waste) during the 8-month crushing season, and with another renewable fuel during the four-month off-season. The project includes replacing existing boilers and installing cogeneration equipment, including high-pressure multi-fuel boilers, high-efficiency condensing extraction turbines, and advanced pollution control equipment.

In Costa Rica, the Klinki Forestry Project arranges with farmers to plant Klinki trees, specifically developed for their carbon-fixing ability. Farmers in Costa Rica plant trees to offset emissions of schools, individual homes, and small businesses in the United States, who contract with the project sponsors. Participating farmers, who sign a 40-year contract, receive tree seedlings, technical assistance, and a cash payment. The trees yield a high-grade industrial wood, suitable for utility poles and plywood, both of which continue to store carbon. The government of Costa Rica guarantees the reductions for 20 years, and will verify the extraction and storage of carbon. Project sponsors estimate that this method sequesters 16 tons of carbon per acre planted,

at a cost of only \$5 per ton to sequester carbon this way.

In Malaysia, the Massachusetts-based New England Electric Power has joined with Rakyat Berjaya SDN, a Malaysian forest products company to improve forest management techniques on 1400 hectares forest land. Three forestry research institutes are monitoring the results. Project sponsors estimate that it will sequester 300,000 to 600,000 tons of carbon.

In the first JI-like project, the US independent power producer Alternative Energy Systems (AES) joined forces with local groups in Guatemala to plant forests there, offsetting carbon emissions from power projects AES was constructing elsewhere. AES teamed with CARE to identify local partners in Guatemala; World Resources Institute (WRI) monitored the results.

In Paraguay, AES joined forces with the Nature Conservancy to preserve tropical forests, and to demonstrate that a JI project could also benefit biodiversity.

A project in Costa Rica has replaced fossil-fuel burning power sources with a 20 MW wind farm which is expected to reduce carbon emissions by 72,000 tons over 15 years.

A project in Russia planted 506 hectares of trees and is expected to reduce carbon concentrations by 35,000 tons over 60 years.

Other projects, in various stages of implementation, include:

A large forest management project in progress in Bolivia combines forest regeneration and protection with the promotion of sustainable forest-product enterprises to reduce atmospheric carbon by an estimated 14.5 million tons over 30 years.

Also in Bolivia, the Rural Solar Electrification Project will finance and install photovoltaic collectors, with auxiliary equipment, in 400 homes in the Oruro and Chuquisaca Departments, which are not serviced by the national grid. The project is intended to test the feasibility of photovoltaic electricity generation in a dispersed rural setting. If successful, this would lead to a larger project, of which the major US partner is GPU International (the independent power producer subsidiary of a large East-coast utility).

In Sri Lanka, the Solar Electric Light Company (SELCO) of Washington DC will help finance the distribution and installation of solar photovoltaic collectors in 812,000 homes, to provide power for lighting, radio, and television. This will reduce carbon emissions by displacing kerosene lamps for lighting, and diesel generators that now power other small appliances.

A project in Russia will improve heating efficiency in Zelenograd by installing new heat exchangers, pumps, and control equipment. This project can reduce carbon emissions by 440,000 tons over 30 years.

Other countries. Several EU members have embarked on JI projects.

- ▶ In 1996, the Netherlands set aside US \$51 million for JI projects in 6 countries: Bhutan, Czech Republic, Ecuador, Hungary, and Uganda.
- ▶ Norway funds a coal-to-gas conversion project in Poland, through the World Bank and the GEF. Norway has another JI project with Mexico.
- ▶ Australia is planning two JI projects in the south Pacific region, focusing on energy efficiency and renewables.
- ▶ Germany has 7 JI projects, in the Czech Republic, Indonesia, Jordan, Latvia, Portugal, and the Russian Federation. These focus on fuel switching, energy efficiency, and renewables.

In addition, at least 7 other countries have included Joint Implementation in their national action plans: Canada, Costa Rica, Japan, Denmark, Finland, Iceland, and Sweden. The group of potential host countries continues to grow. Projects have been launched or proposed in 17 countries. Thirty-two projects have received approval from both host and sponsor governments. On the US list alone, Bolivia, all 7 countries of Central America, Chile, Pakistan, and South Africa have all signed statements of their intent to cooperate with the United States.

Tab G:

“Cap and Trade” Emissions
Trading Programs: A
Mechanism to Achieve
Emission Reductions Cost
Effectively

“Cap and Trade” Emissions Trading Programs: A Mechanism to Achieve Emission Reductions Cost Effectively

The United States has successfully used a “cap-and-trade” emissions trading program as a tool to reduce the sulfur dioxide emissions which cause acid rain. This program has met the environmental goal while substantially lowering compliance costs, compared to other approaches. This paper explains the use of emissions trading by providing an introduction, a summary of how the Acid Rain Program works, an explanation of why the U.S. supports an international greenhouse gas emissions trading system for greenhouse gases, and some preliminary thoughts about how a domestic greenhouse gas emissions trading system would help the U.S. to meet the commitments envisioned by the Kyoto Protocol.

Introduction to Emissions Trading

- “Cap-and-trade” emissions trading programs have proved to be a successful and flexible approach to reducing pollution and lowering the cost of achieving emission reductions
- “Cap-and-trade” programs establish a legally binding limit on total emissions -- a legally-binding target -- providing the basis of environmental accountability.
- The target amount is divided into “allowances” and distributed (by an allocation system or by auction) to specific sources. These “allowances” can then be bought or sold. In the case of the U.S. acid rain program, the target was divided into one-ton “allowances” and allocated to electric utilities.
- Regulated sources are able to buy or sell allowances as needed to tailor their compliance strategies to reflect their own least cost approaches and adjust to changes in technology or market conditions. A source facing low compliance costs can “over-control” and sell extra allowances. A source facing high control costs can buy allowances.
- An effective system of tradeable permits achieves the environmental objective at the lowest possible cost. The crucial point is that tradeable permits allow firms to undertake reductions in the most efficient means possible. If one firm is able to reduce emissions at low cost, while another firm finds it difficult to reduce emissions, the first firm will be able to sell permits to the second firm -- reducing the overall cost of achieving the environmental objective.

Summary of the U.S. Experience with the Acid Rain Program

The Clean Air Act of 1990 established a “cap-and-trade” system for reducing the sulfur dioxide emissions responsible for acid rain. The first phase of emission reductions began in 1995 when 263 Phase I units were required to reduce their emissions by approximately 30 percent, on average, from 1980 levels of emissions. The second phase of the program begins in the year 2,000 and will require an average reduction of almost 50 percent from 1980 levels for

almost all electric utility units. During the first three years of Phase I, the utilities have reduced their emissions well beyond required limits. These “extra” reductions are being made now and “banked” in anticipation of the more stringent requirements taking effect in 2000, since the “banked” allowances can be used to reduce the cost of compliance with Phase II. As a result of allowance trading and banking, full compliance costs are now expected to be less than half of what the government estimated the program would cost in 1990.

The major steps needed to implement the Acid Rain Program are discussed in more detail in the next section, and highlighted below:

- Congress set the national cap (emission limit);
- Congress authorized EPA to allocate allowances (authorizations to emit SO₂) to each utility unit (boiler or turbine) according to legislative formulas;
- EPA developed draft regulations, incorporated public comment, and published final regulations
- Utilities determine their own compliance strategy, measure and report emissions, and conduct allowance trades;
- EPA collects, verifies, and publishes emissions data, records official allowance trades, and conducts annual compliance;
- Congress required automatic penalties for excess emissions

Acid Rain Program Implementations Steps

1. *Congress set the national cap (emission limit).* The Clean Air Act specifies that the goal of the Acid Rain Program is to reduce national emissions of SO₂ by 10 million tons.—For the electric utility industry (which accounted for 2/3 of the national SO₂ emissions in 1980), a reduction of 8.5 million tons (or almost 50 percent) will be required to reach the annual cap of 8.95 million tons by 2010. Phase I of the Program requires only the 263 largest and highest emitting boilers to reduce their emissions approximately 30 percent during the years 1995-1999, while Phase II of the Program (which begins in 2000) will require participation from approximately 2,000 units across the country.

2. *Congress authorized EPA to assign emission limits (allocate allowances) to each utility unit according to legislative formulas.* Within the 8.95 million ton cap, Congress authorized EPA to allocate “allowances” (one allowance is the authorization to emit one ton of SO₂) to the 2,000 affected utility units. If the allowances had been grandfathered using emission baselines, then a 50 percent emission reduction would have been required at every unit. Instead, EPA used a fuel utilization baseline and set a performance standard emission rate to assign allowances. In other words, higher emitting units in the base year were assigned steeper emission reductions (their

“assigned number of allowances” were much lower than 50 percent of their base year emissions), while some of the lower emitting units in the base year were assigned enough allowances to fully cover their base year emissions (plus room for growth in many cases). After using these basic formulas to allocate allowances to each of the 2,000 utility units, EPA made a further adjustment to ensure that the national total would result in no more than 8.95 million tons of annual emissions.

EPA was authorized to withhold 2.8 percent of each unit’s allowances to create a pool of allowances for auction for the benefit of new units, which were not assigned allowances. After soliciting bids from the private sector, EPA selected the Chicago Board of Trade to actually conduct this annual auction. The revenue raised from these auctions is returned (proportionately) to the utility companies. It is important to note that these are not extra allowances, but are set aside from within the national limit. The auction served the important function of providing an early price signal to the market. After the first year, the allowance market has emerged with private brokers facilitating almost all allowance trades, and now only a small fraction of traded allowances are purchased through the EPA auction held by CBOT. EPA still holds the auctions each year and publishes the results because Congress required them under the legislation.

3. *Utilities determine their own compliance strategy, measure and report emissions, and conduct trades.* Some utilities installed “scrubbers,” post-combustion technology installed in the stack to capture and essentially eliminate sulfur from the emissions into the atmosphere. Under the Acid Rain Program, scrubbers have become more efficient at removing sulfur and also more cost-effective. Other utilities have switched to lower sulfur fuels, for example by switching to lower sulfur coal or from coal to natural gas, or by blending coals to produce a lower average sulfur fuel. Low sulfur coal turned out to be less expensive than predicted at the beginning of the program, largely because transportation costs dropped under deregulation of the railroads. Nevertheless, the innovation in compliance strategies and the lower cost can be attributed to the flexibility utilities are accorded in choosing their own (lowest cost) emission reduction strategies.

Utilities are also required to install and maintain continuous emission monitors (CEMs), or alternative emission measurement equipment at each source. One of the most important features of the monitoring system established under the Acid Rain Program is the automated data collection and reporting -- computer systems were installed along with the measurement equipment to capture hourly emissions data and to provide reports in an EPA-specified standard format. Utilities are responsible for conducting quality assurance testing on the monitors, according to daily, quarterly, and annual testing procedures, and to report both the quality assurance data and the emissions data to EPA quarterly.

Of course, this means that each power company itself has computerized access to its own emission reports, and thus can decide if and when to trade allowances - either to sell “extra” allowances the particular unit won’t need, or to buy allowances if the unit will exceed its starting allowance budget. Many of these “trades” are internal to one company which owns more than one unit (since EPA started tracking allowance trades in 1994, over 50 million allowances have been traded from one private account to another). Some utilities go to other companies to buy or

sell allowances. More than 15 million allowances have been traded to date from one corporate entity to another. Among these private trades, 68 percent are between utilities and brokers, while only 10 percent are traded directly from one utility company to another (and many of these utility-utility trades may also involve private brokers who facilitate the direct transaction without taking title to the allowances). EPA tracks only official allowance trades which utilities (and brokers) want recorded officially (i.e. so that the utility can have the allowances for compliance with its emission reduction requirements); brokers and utilities are free to trade allowances outside the official EPA tracking system. However, the change in ownership of a traded allowance must be recorded in EPA's tracking system before it can be used by a source to cover emissions for compliance purposes.

4. *EPA collects, verifies, and publishes emissions data, records official allowance trades, and conducts annual compliance.* EPA spends most of its resources tracking, verifying, and publishing emissions data. EPA designed the standard electronic format for the quarterly emission reports, and processes approximately 1,700 files every three months. EPA uses its standard mainframe program to automatically check for certain data errors, and to provide feedback reports back to each utility to improve the quality of their reports. EPA then publishes quarterly summary reports, and carefully verified annual emission reports within a few months of receiving the data. These reports are the basis of the emissions data used to deduct the proper number of allowances from each utility account at the end of each year. EPA also has resources devoted to assisting the utilities with their monitoring hardware and software questions, and has implemented a program of field audits in cooperation with EPA Regional and State employees who visit the utilities and check the monitors directly.

Utilities and/or brokers carry out an allowance trade by filling out a simple one page form which identifies the buyer, the seller, and the allowances to be transferred. EPA does not collect the price for these official transactions -- the "public" price data is made available through the private sector, where the private sector brokers publish price information but keep the identity of the buyers and sellers confidential. EPA checks the allowance transfer form for proper authorization, and processes the trade by entering the data into a computer system which completes the transfer of allowances from one account to another, usually within 24 hours of receiving the form. EPA is planning on developing an electronic method for utilities to enter their requests.

About 100 people in Federal and State nationwide implement this program. EPA employs about 50 people in Headquarters to administer the SO₂ allowance program and to develop and administer programs to address NO_x and greenhouse gases : 25 to assist with monitoring or emissions data verification; 10 to manage the permitting, allowance trading, and annual compliance process; and the remainder to work on program evaluation, environmental assessment, and development of new programs focusing on NO_x and greenhouse gas emissions. The other 50 people work in our EPA Regional offices or the State Agencies, working more directly with sources, particularly in providing assistance with meeting the monitoring requirements and conducting field audits.

5. *Congress required automatic penalties for excess emissions.* A utility must hold enough allowances to cover its emissions at the end of each year; if a utility's emissions were to exceed its annual allowances, then the Clean Air Act specifies that the utility must both provide an "offset" by authorizing EPA to automatically deduct the excess emissions from the utilities' next annual allocation and also by requiring the utility to automatically pay a financial penalty of \$2,000 (adjusted for inflation) per ton of excess emissions. The \$2,000/ton of excess emissions was intended to be approximately three times the expected cost of compliance with the program. With the current price of allowances at \$100, and the inflation-adjusted penalty set currently at \$2,500/ton, the penalty is currently about 25 times the cost of compliance. During the first two years of the program, 100 percent of the affected utilities are in compliance with their emission reduction requirements.

Acid Rain Program Results

When the Clean Air Act legislation was developed in 1990, a typical "command and control ("policies and measures") program, which would have required each electric utility boiler to install standard pollution control technology, was estimated to cost about \$5 billion annually. To achieve the same level of emissions reductions using a "cap-and-trade" emissions trading program (which would allow electric utilities to choose the most cost effective approach for each boiler) was estimated in 1990 to cost about \$4 billion annually. Once the program actually became effective, pollution control costs dropped dramatically, and with trading, the U.S. Government Accounting Office has since estimated that the SO₂ program is costing about \$2 billion annually.

This dramatic drop in the nationwide cost of compliance is also reflected in the allowance price. In 1990, estimates of the likely permit price ranged from \$200 up to over \$1,000 (the higher end of the range was produced by industry analysts, who may not have been fully disinterested, and did not reflect all the institutional details of the final SO₂ program). The attached chart tracks the price of allowances, and shows that the current price of allowances is approximately \$115.

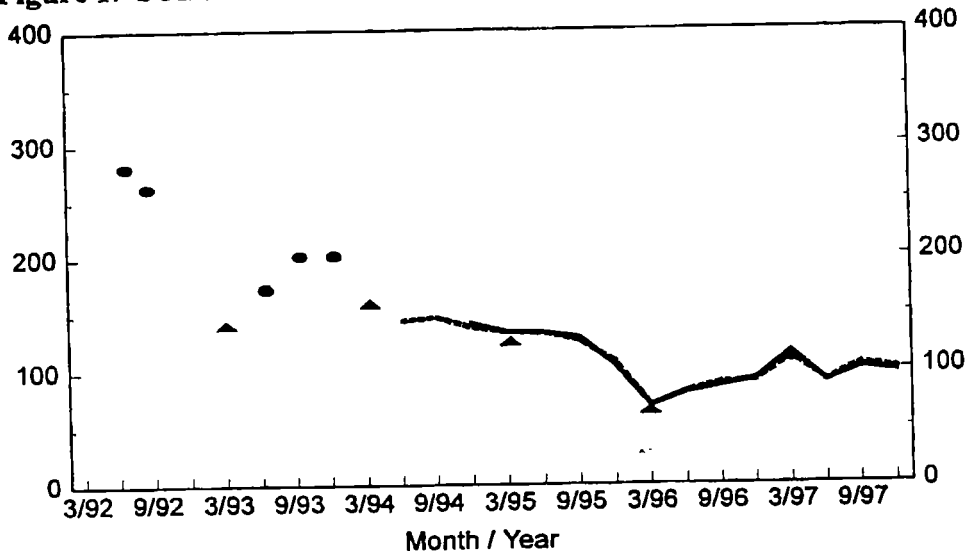
The U.S. has already experienced significant emission reductions under the first phase of the control program: by 1995, the U.S. experienced a 30 percent drop in national SO₂ emissions from 1980. The attached chart shows that Phase I utilities have reduced their emissions 30 percent beyond the required limits (note the significant 3 million ton drop from 1994 to 1995 -- a 40 percent reduction attributed to the first year of the SO₂ trading program).

In addition to the significant reduction in emissions, the U.S. has experienced dramatic drops in acidic deposition in some of the most sensitive regions of the country. EPA will continue to study the environmental impacts of the program.

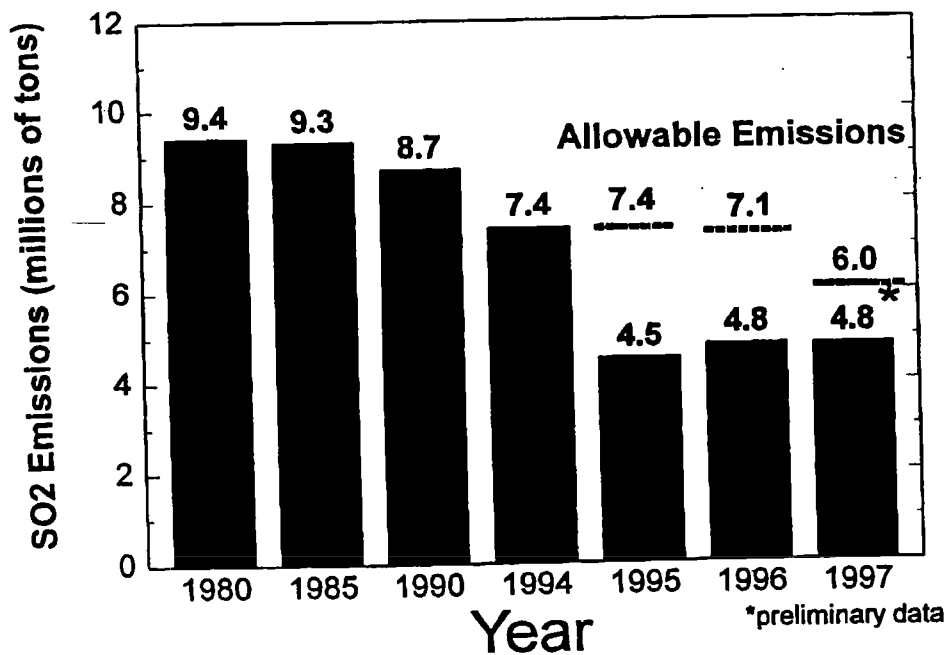
Conclusion

The U.S. government believes that the dramatic emission reductions and cost savings

realized by the emissions trading system under the Acid Rain Program can be applied to other appropriate environmental problems. Creation of an international greenhouse gas emissions trading system must be founded upon accurate, verifiable emissions measurement and reporting. Such an international emissions trading system can be designed to provide the certainty and flexibility needed to encourage the private sector to take economically efficient actions to reduce their greenhouse gas emissions. In particular, international emission trading will stimulate innovative and lower cost approaches to reducing greenhouse gas emissions, including the development of new technologies. New technologies and other low cost approaches to reduce greenhouse gas emissions will enable countries to achieve even greater emission reduction in the future.

Figure 1. SO2 Allowance Prices in US\$

Emissions 263 Phase I Units



Tab H:

Non-Climate Benefits of the
Kyoto Agreement (to be
revised)

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Non-Climate Benefits of US participation in the Kyoto Agreement

I. Ancillary Emissions Reductions

The Kyoto agreement will lead to ancillary reductions in emissions that contribute to local air pollution, e.g., NO_x, and VOCs. NO_x, for example, is a combustion by-product that contributes to ground-level ozone and fine particulate formation. Thus to the extent that carbon emissions are reduced through reductions in fuel use, NO_x emissions will also fall. In addition, NO_x emissions per unit energy are also greater from coal, a carbon-intensive fuel, so that substitution of natural gas for coal, as well as reductions in fuel use, will also result in reductions in NO_x.

We here treat the ancillary reductions in emissions of these gases as reducing the costs of meeting the new national ambient air quality standards (NAAQS). EPA estimated the costs of meeting the new NAAQS in 2010 to be \$9.6 billion per year for ozone, and \$37 billion per year for particulate matter. (These cost estimates may not be additive.)

A key question in estimating cost savings is whether carbon emissions reductions would avoid NAAQS related control measures. NAAQS related control costs would be avoided only if carbon-reduction strategies also reduced emissions that contribute to ozone and PM, *and* these ancillary emissions reductions were included in State Implementation Plans (SIPs) in a way that avoided the adoption of specific new control measures. SIPs that "demonstrate attainment" with the new NAAQS by specific dates that vary with air quality will be due in 2003 for ozone and 2005 for particulate matter. To date EPA has accepted in SIPs only those emission reductions that result from legally enforceable State actions. Thus EPA acceptance of emissions reductions from lower vehicle use resulting from higher fuel prices would be precedent setting, although it is apparently within the Agency's discretion. Since most of the control measures associated with attainment of the NAAQS entail sunk costs, cost savings may be reduced if controls to reduce carbon emissions occurred after, say, 2005, as may well be the case.

This note addresses ancillary reductions resulting from both reductions in fuel use and fuel switching based on the (incomplete) existing literature. It concludes that these ancillary benefits would range into the billions of dollars per year, given a carbon price of about \$100/ton. Assuming fuel price increases, reduced vehicle use might reduce Nox and VOC emission control costs by \$.15 billion in the short run to \$.5 billion in the long run.

I. Utilities and Point Sources.

This analysis relies on information from EPA that supercedes information from EIA. EIA had provided us with an estimate of Nox emissions reductions from electric utilities as a result of a \$100/ton carbon tax. EIA estimate is 1.6 million tons of Nox emissions per year nation-wide

from both fuel use and fuel switching. This estimate is an overstatement because it uses a baseline that neglects both the recent PM/ozone standards and EPA's recently proposed OTAG SIP call to reduce Nox. We believe that this overstatement is substantial because the estimated Nox reduction is approximately the reduction of 1.6 million summertime tons of Nox expected as a result of EPA's recently proposed OTAG Nox SIP call.

EPA supplied data on February 4 about two sets of air emissions reductions by pollutant (Nox, PM2.5, PM10, VOC and SO2), by sector and by State. The reductions are both from a baseline of partial attainment with the old NAAQS; EPA promulgated new NAAQS in July 1997.¹ The first set of reductions is for partial attainment of the new NAAQS, (it is unclear whether this is the new PM standard or the new ozone standard). The second set of reductions is for a \$40/ton price of "CO2" (I presume but have not confirmed that this is a price of carbon not carbon dioxide). The appropriate baseline depends in part on the timing of the NAAQS implementation relative to the likely timing of a carbon cap and trade system. We believe that the Administration's policy is to support a carbon cap and trade program to be implemented in 2008. Therefore an appropriate baseline is partial attainment of the new NAAQS, given the preceding discussion about SIP deadlines.

EPA has not supplied data on emissions reductions attributable to a carbon price given a baseline of partial attainment with the new NAAQS. To approximate such an estimate we assumed that the reductions from the \$40/ton case from a baseline of partial attainment of the old NAAQS, less the reductions from the partial attainment of the new NAAQS given the same baseline, gives the reductions that would result from the \$40/ton case given a baseline of partial

Non-Climate Benefits of US participation in the Kyoto Agreement

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from both fuel use and fuel switching. This estimate is an overstatement because it uses a baseline that neglects both the recent PM/ozone standards and EPA's recently proposed OTAG SIP call to reduce Nox. We believe that this overstatement is substantial because the estimated Nox reduction is approximately the reduction of 1.6 million summertime tons of Nox expected as a result of EPA's recently proposed OTAG Nox SIP call.

EPA supplied data on February 4 about two sets of air emissions reductions by pollutant (Nox, PM2.5, PM10, VOC and SO2), by sector and by State. The reductions are both from a baseline of partial attainment with the old NAAQS; EPA promulgated new NAAQS in July 1997.¹ The first set of reductions is for partial attainment of the new NAAQS, (it is unclear whether this is the new PM standard or the new ozone standard). The second set of reductions is for a \$40/ton price of "CO2" (I presume but have not confirmed that this is a price of carbon not carbon dioxide). The appropriate baseline depends in part on the timing of the NAAQS implementation relative to the likely timing of a carbon cap and trade system. We believe that the Administration's policy is to support a carbon cap and trade program to be implemented in 2008. Therefore an appropriate baseline is partial attainment of the new NAAQS, given the preceding discussion about SIP deadlines.

EPA has not supplied data on emissions reductions attributable to a carbon price given a baseline of partial attainment with the new NAAQS. To approximate such an estimate we assumed that the reductions from the \$40/ton case from a baseline of partial attainment of the old NAAQS, less the reductions from the partial attainment of the new NAAQS given the same baseline, gives the reductions that would result from the \$40/ton case given a baseline of partial attainment of the new NAAQS.

For each type of emissions (Nox VOCs etc.,) we calculated the imputed reduction from the \$40/ton policy given the baseline of partial attainment of the new NAAQS, under the additivity assumption. (When this approach yielded negative numbers we assumed a zero.) We then summed across all pollutants, sectors and States. For SO2, which we treated separately because of its lower abatement costs, the sum was .57 million tons, while for NOX+VOCs+PM2.5 it was .7 million tons.

For SO2, EPA had estimated an average cost/ton of \$580 for the reductions achieved under a prospective 60 percent utility SO2 cap and trade program (in addition to the Phase II Title IV program). A marginal cost may be more appropriate, but no estimate is available. Applying this average cost per ton to the estimated SO2 emissions reductions gives cost savings of \$.3 billion per year.

¹ The baseline is partial attainment as opposed to full attainment of the old NAAQS because Los Angeles and some other cities have trouble meeting the old NAAQS.

For the other pollutants, EPA estimated average costs/ton of \$1300 for the OTAG Nox cap, and \$1500 for industrial boilers covered under the OTAG Nox cap. Both estimates are average costs, not marginal costs which were significantly higher. Therefore we use \$2000/ton for nationwide estimates, as opposed to those limited to the OTAG region. Given this value per ton we calculate cost savings of \$1.4 billion for the \$40/ton case.

Aggregate cost savings are \$1.7 billion/year from point sources.

Annual Ancillary Utilities Emission Reductions: Tons and Cost Avoided
Table 1

Carbon Permit Prices	SO ₂ Cost Savings (billions)	Nox, VOCs and PM2.5 Cost Savings (billions)	Total Savings (billions)
\$40/ton	\$0.3	\$1.4	\$1.7

To put these estimated cost savings in perspective, the EPA's Regulatory Impact Assessment for the NAAQS uses \$3,200/ton of NOx as an estimate of average control cost for specified measures in this full attainment scenario (see p. 9-15). The EPA also used a figure of \$10,000/ton that for the incremental cost of the emissions reductions needed to reach full attainment of the new NAAQS, from a baseline of partial attainment.

Thus a \$40/ton carbon price might yield cost savings of \$1.7 billion per year.

II. Vehicles

NOx and VOC emission reductions from motor vehicles may come from more fuel efficient engines, reduced use, or changes in fleet composition. EPA estimates that 2010 Clean Air Act baseline NOx emissions from mobile sources (including motor vehicles and nonroad emissions sources) in ozone nonattainment areas will be 970 million tons; motor vehicle emissions nation-wide will be 7637 million tons.

Annual Ancillary Emission Reductions: Tons and Cost Avoided
Mobile Sources
Table 2

Area	Thousand tons/year					Cost Avoided per year (billions)	
	NOx	VOCs	Total Emissions	Emissions Reduced		Short Run	Long Run
				SR	LR		
Nation-wide ²	7,637	5,834	13,400	270	940	\$.3 ³ to \$.8	\$.9 to \$2.8
Nonattainment areas ⁴	1,433	841	2,300	50	160	\$.15 ⁵	\$.5

Note: Short run (SR) and long run (LR) emissions reductions reflect different price elasticities of demand; the long-run presumes vehicle fleet turn-over.

One recent study suggests that fuel price increases lead to reductions in carbon that are much larger than reductions in other emissions.⁶ Several estimates for four metropolitan areas in California indicate that fuel taxes of \$0.50 per gallon lead to Nox emissions reductions about 40 percent as large as carbon emission reductions. Reductions in VOCs are slightly larger, but for simplicity we ignore this difference. Given these relationships, we can posit a fuel price increase necessary to achieve a carbon emissions reduction, and then scale the Nox and VOC emissions reductions accordingly.

Our point of departure is the price hike needed to meet the Kyoto agreement. If the Kyoto agreement led to a domestic cap and trade system for carbon it might raise gasoline prices by \$100/ ton of carbon, or \$0.26 / gallon of refined petroleum products in the absence of

²Reflects Clean Air Act Baseline, and so does not exclude emission reductions to meet the NAAQS. Sum of nonroad and motor vehicle emissions.

³ At \$1000/ton and \$3,000/ton.

⁴Reflects Partial Attainment Scenario baseline. Sum of mobile and non-road emissions.

⁵These reductions are valued at \$3,200/ ton because they are exclusively in nonattainment areas.

⁶See *Transportation Pricing Strategies for California: An Assessment of Congestion, Emissions, Energy and Equity Impacts*, California Environmental Protection Agency, November 1996

international permit trading. This is approximately a 20 percent price increase. Given a demand elasticity (short-run estimates are around .25, long run estimates as high as .9) consumption should fall by 5 percent in the short run and 18 percent in the long-run. Using the scaling factor of .4 from the California study, Nox and VOC emissions reductions would be 2 percent in the short run and 7 percent in the long run. Applying these percentages to the baseline emissions reported in Table 2 above, the reductions in the short run are 270 and 50 thousand tons per year nationally and in nonattainment areas respectively. Reductions in the long-run are 940 and 160 thousand tons per year nationally and in nonattainment areas respectively. Reductions for smaller fuel price increases are available by assuming that these benefits are proportional to the fuel price increase.

For simplicity we do not distinguish between the control costs avoided for VOCs and Nox. VOC emissions in EPA's NAAQS RIA were assumed to be controllable at an average marginal cost of \$10,000/ton, but identified measures had an average incremental cost of \$4000/ton, i.e., above the comparable figure of \$3,200 for NOx. We ignore this difference and value both VOCs and Nox at \$3200/ton in nonattainment areas and \$1000 to \$3000 in attainment areas. This range of values is likely to be conservative for nonattainment areas; the extent of conservatism for nation-wide reductions is not clear. Thus the cost avoided from mobile source emissions reductions may be about a half billion dollars per year, given a carbon price of \$100/ton.

Congestion Related Benefits From Fuel Price Increases

The Kyoto agreement will reduce emissions from carbon by about 27 percent ($100/137=.73$). To the extent that these emissions reductions are achieved through fuel price increases, there will be a reduction in the use of motor vehicles, and there may be resulting increases in traffic congestion.

One recent study suggests that fuel price increases would lead to significant reductions in traffic delays.⁷ Several estimates for four metropolitan areas in California indicate that fuel taxes of \$0.50 per gallon in 1991 would have led to reductions in delay of about 7 percent.

A recent report funded by the Department of Transportation put the costs of congestion, relative to free-flowing traffic, at nearly \$60 billion in 1994, up from less than \$40 billion in 1986.⁸ These costs reflect both the dollar value of delays to motorists, and the additional fuel consumption from congestion, although only about a tenth of the total estimated costs are fuel-related.

Thus a \$100/ton carbon tax would lead to a \$0.25/gal fuel tax, and reductions in congestion related delays of about 3.5 percent in the four California cities. If extrapolated nationwide, reductions in congestion related delays, including the fuel savings, would be worth about \$2 billion per year.

These estimates exclude the reductions in inconvenience that travelers would experience as a result of being able to begin trips closer to their preferred travel time. Such reduced inconvenience may be as valuable as the reductions in delay.

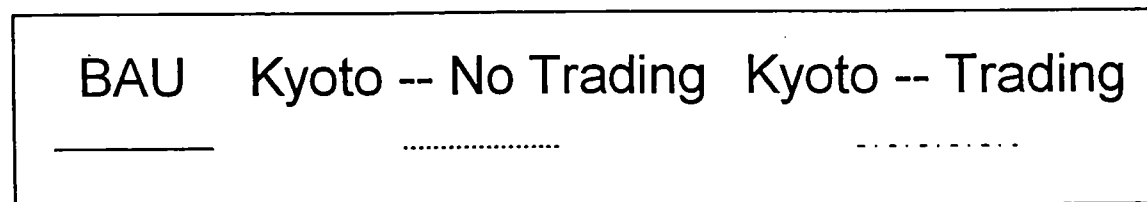
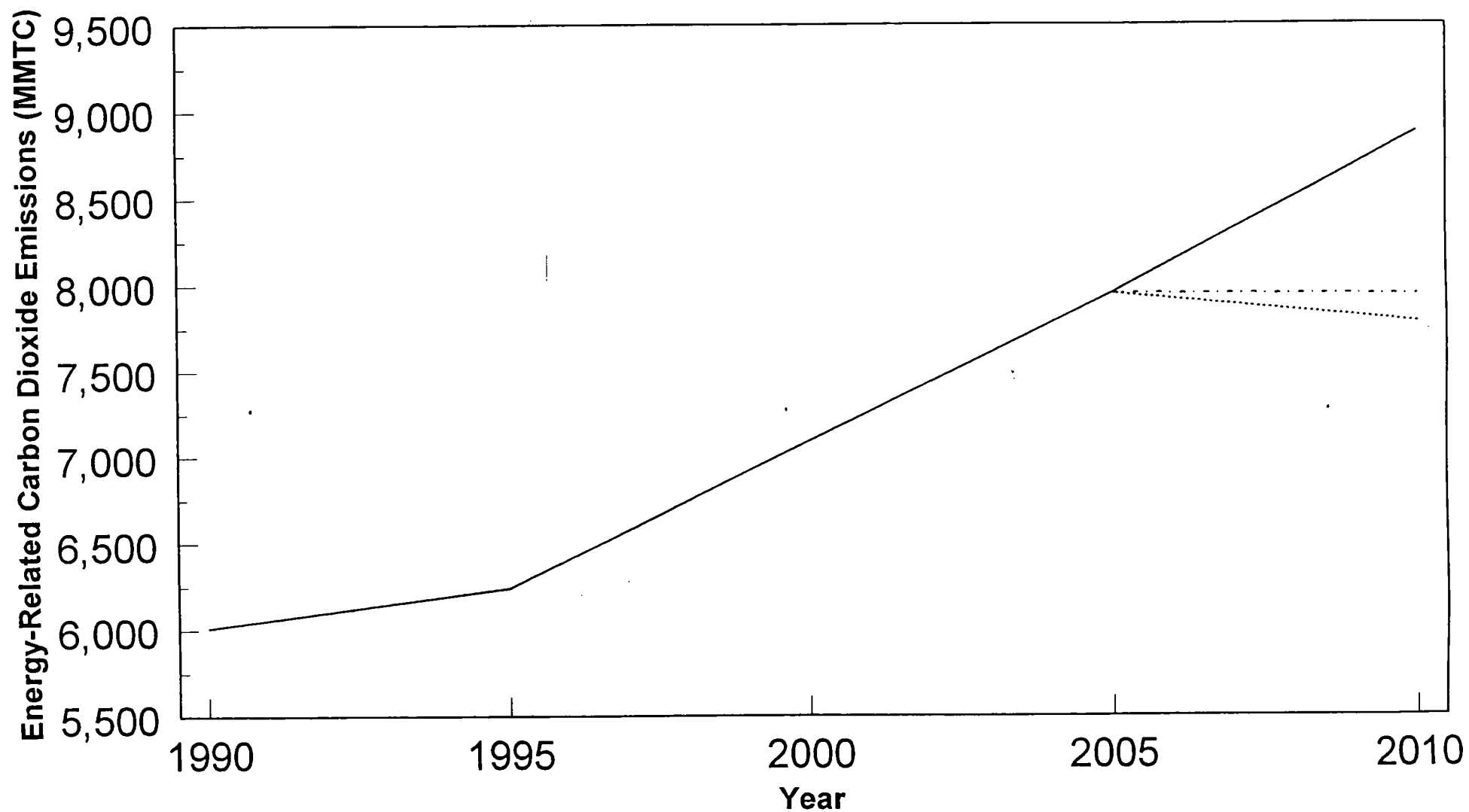
⁷See *Transportation Pricing Strategies for California: An Assessment of Congestion, Emissions, Energy and Equity Impacts*, California Environmental Protection Agency, November 1996

⁸ *Urban Roadway Congestion --1982 to 1994* Texas Transportation Institute, Texas Department of Transportation, and the Federal Highway Administration, August 1997

Tab I:

Background Charts

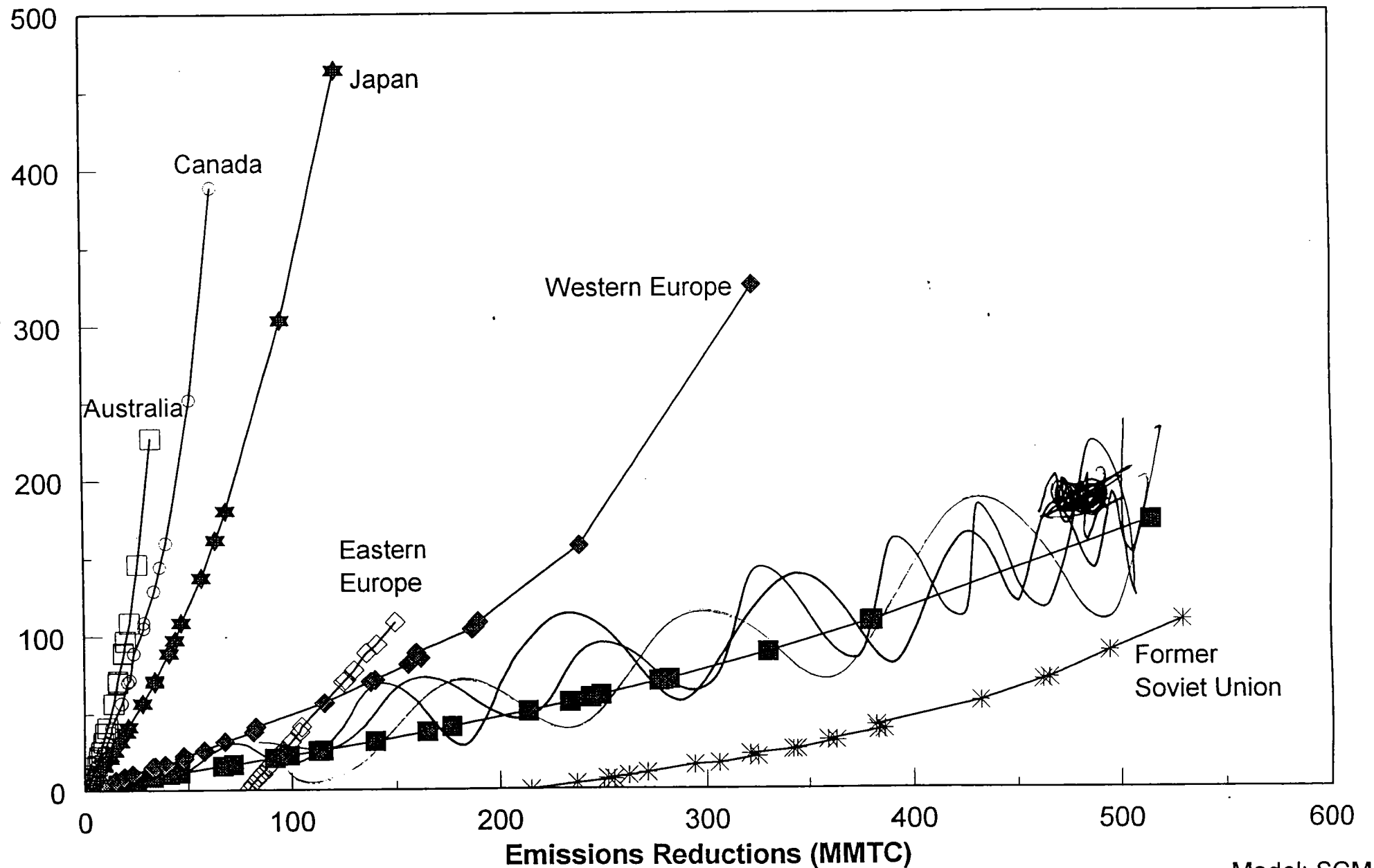
Trend in Global Energy-Related CO₂ Emissions



Sources: EIA IEO97 and AEO98

2010 Annex I Marginal Abatement Cost Curves for Energy-Related CO₂

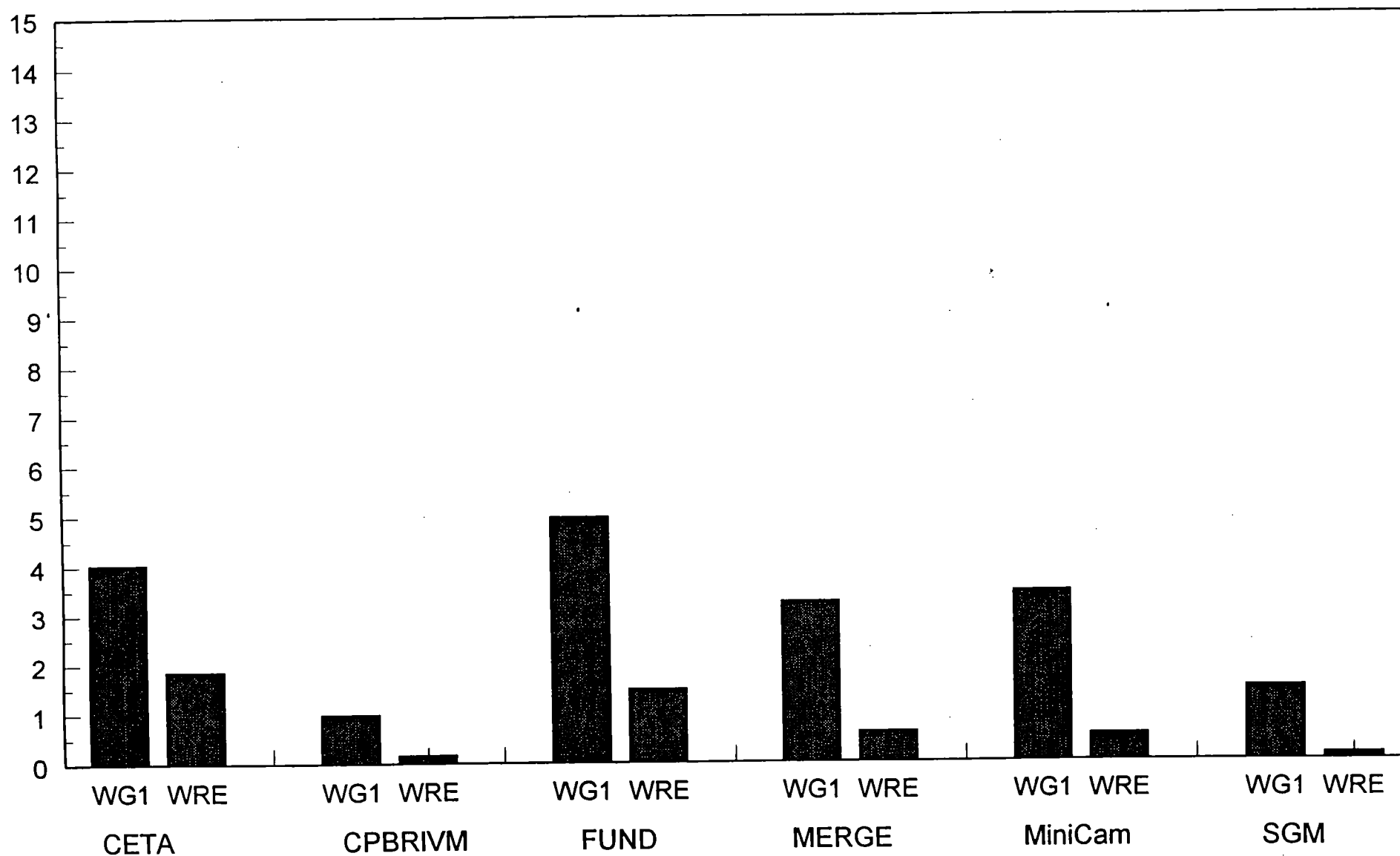
Permit Price (\$/ton)



Model: SGM

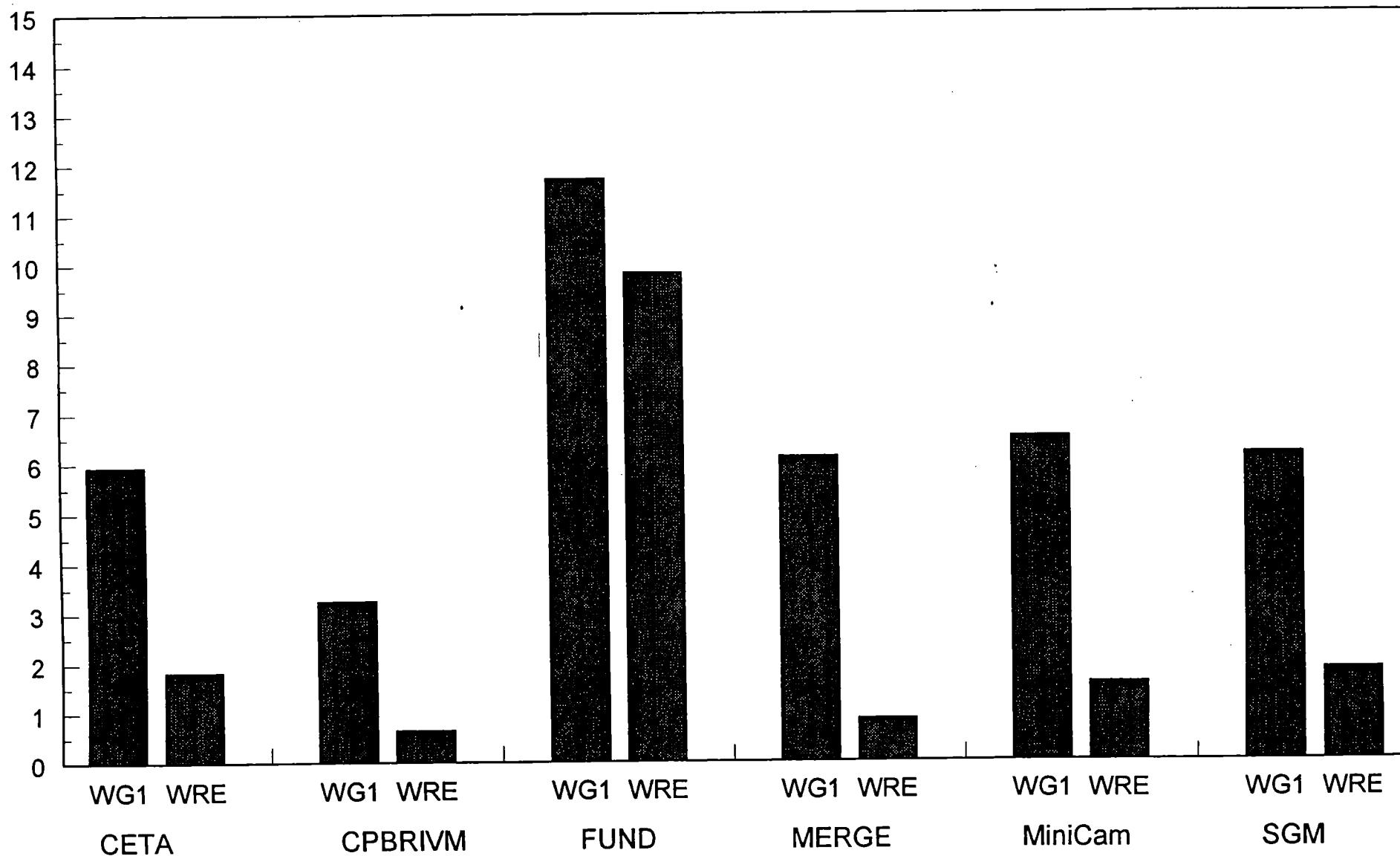
Cost to OECD, of Stabilizing CO2 Concentrations at 550ppmv, with International Trading

trillions of 1990 U.S. dollars



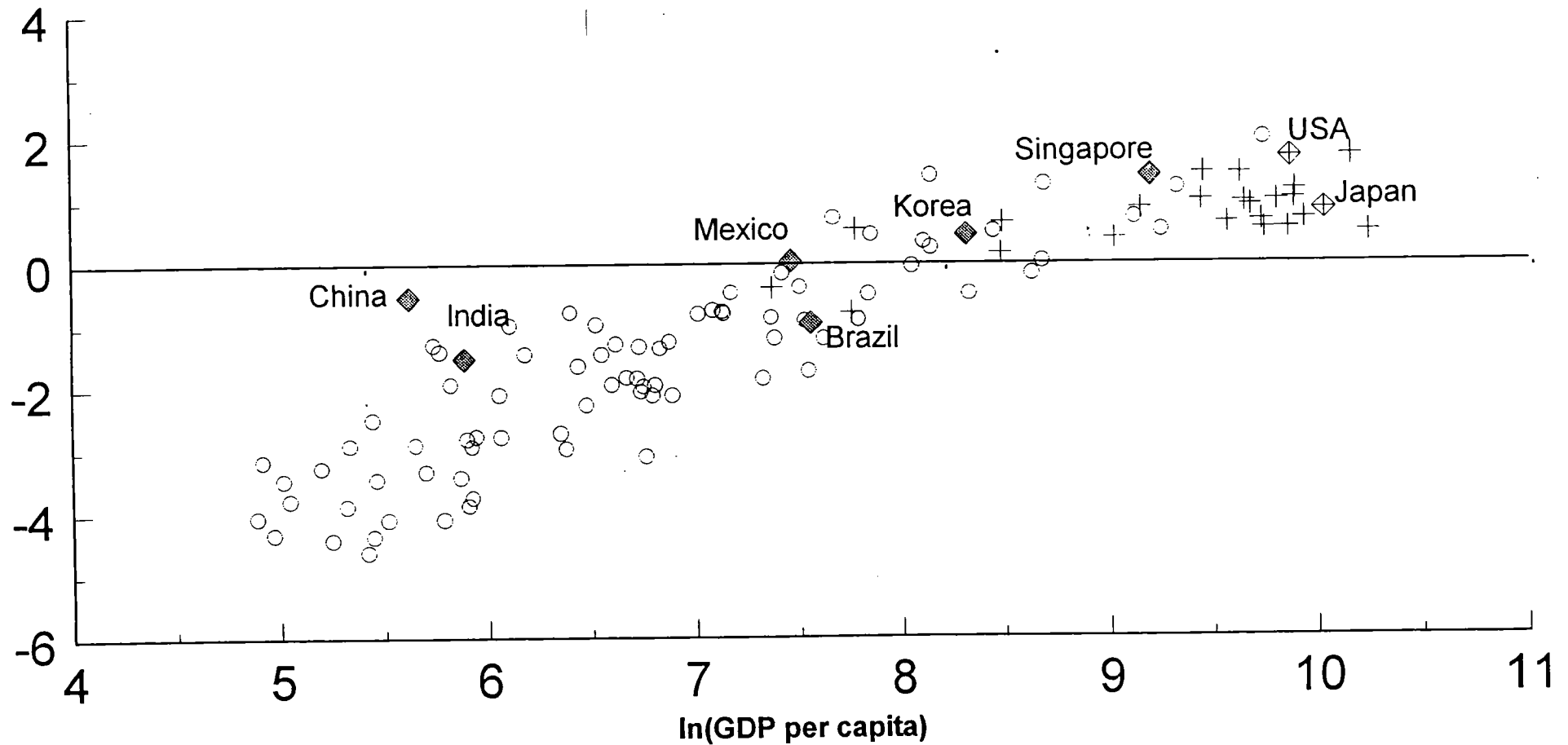
Cost to OECD, of Stabilizing CO2 Concentrations at 550ppmv, without International Trading

trillions of 1990 U.S. dollars



Country Carbon Emissions vs. GDP, 1988-1992 Average

ln(emissions per capita)



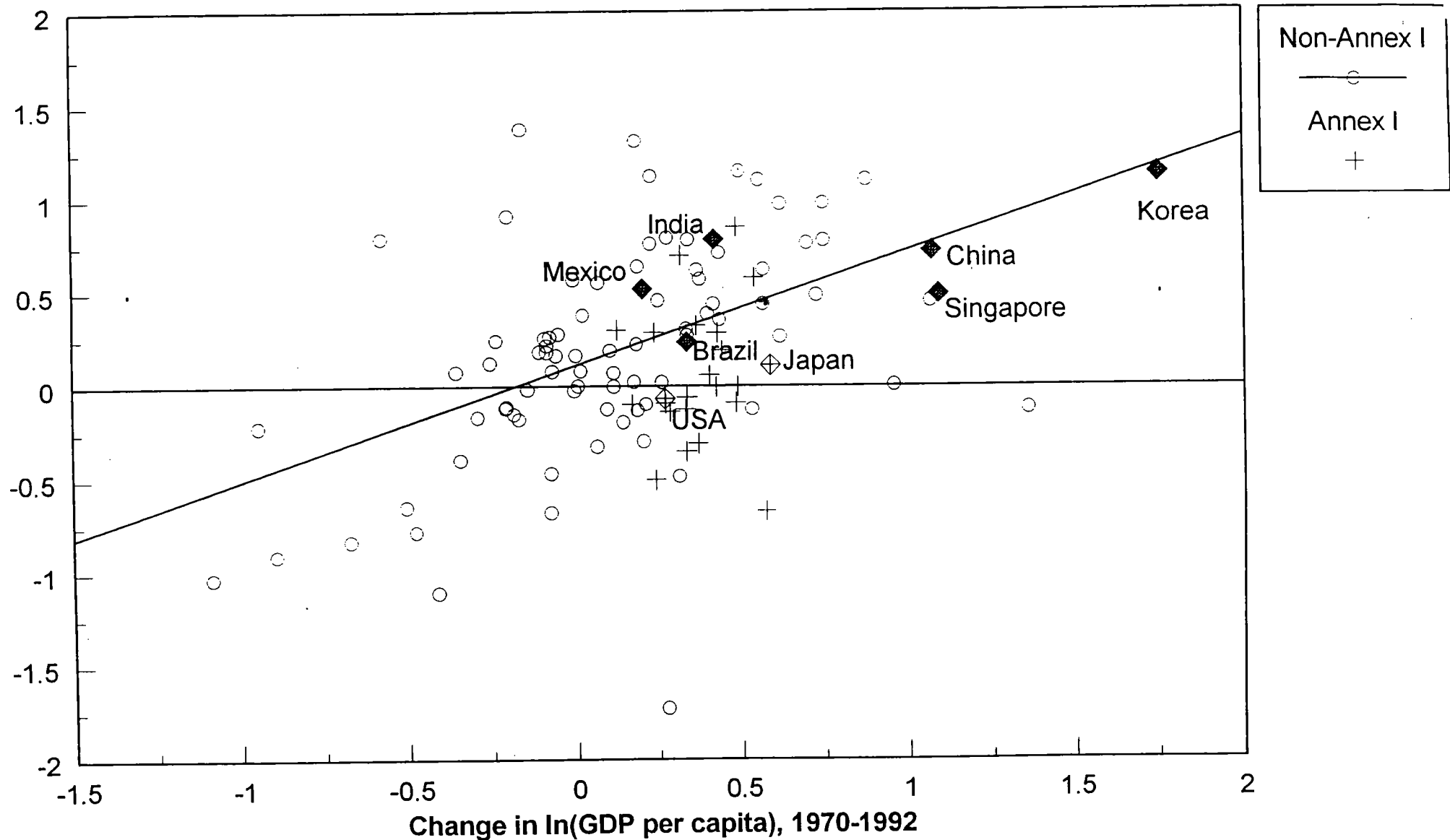
Non-Annex I Annex I

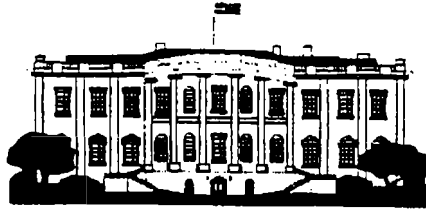
○

+

Change in Country Carbon Emissions vs. GDP, 1970-1992

Change in $\ln(\text{emissions per capita})$, 1970-1992





THE WHITE HOUSE
OFFICE OF CABINET AFFAIRS

cc: JY
JAF
AM
RL
JA
MJ

Date: 10/3

To: Climate Change Contact

From: Kris Balderston

Facsimile: _____

Telephone: _____

Subject: October 6th Conference

Pages: _____ (Including this cover sheet)

Comments: Please forward this to the appropriate people.

OLD EXECUTIVE OFFICE BUILDING ♦ ROOM 160 ♦ WASHINGTON, DC 20502

TELEPHONE (202) 456-2572 ♦ FACSIMILE (202) 456-6704

THE WHITE HOUSE :

Office of the Press Secretary

FOR IMMEDIATE RELEASE

October 2, 1997

PRESIDENT CLINTON TO PARTICIPATE IN WHITE HOUSE CONFERENCE ON CLIMATE CHANGE

Washington, D.C. -- President Clinton will participate in the White House Conference on Climate Change: The Challenge of Global Warming at Georgetown University on Monday, October 6, 1997. The conference will include discussions on the scientific, technological, international and economic aspects of climate change. Participants will include scientists, economists, corporate executives, environmental, civic and labor leaders, small business owners, members of Congress and representatives of state and local governments.

The conference agenda consists of remarks by the President, Vice President and First Lady; panel discussions led by President Clinton and Vice President Gore and featuring Secretary of Energy Federico Pena, Secretary of State Madeleine Albright and Deputy Secretary of Treasury Lawrence Summers; and lunchtime & breakout sessions hosted by cabinet members and senior Administration officials. The conference is part of the Administration's ongoing effort to educate the American people about climate change and is designed to help inform the development of U.S. policy on this important issue. It will be broadcast live via satellite to more than thirty locations across the country. A detailed agenda and list of satellite cities is attached.

WHAT: President Clinton to attend White House Conference on Climate Change.

WHERE: Gaston Hall, Healy Building, Georgetown University, Washington, D.C.

WHEN: Monday, October 6, 1997
Conference: 10:00 a.m.-4:30 p.m.
(President's remarks and participation: 10:00 a.m.-12:30 p.m.)

COVERAGE: OPEN PRESS (Breakout sessions will be CLOSED PRESS)

Press entrance: Will be directed on site.

Pre-set: 6:00-7:00 a.m.

Final access: 8:15-9:30 a.m.

NOTE: Media do not need to request credentials to cover this conference. Reporters must present valid photo identification and press accreditation on site at the designated entrance to gain access to the event. For additional information contact the White House Climate Change Task Force at 202/343-1060. To arrange an interview with any of the conference panelists or participants contact the White House press office at 202/456-7150.

**White House Conference on Climate Change:
The Challenge of Global Warming
October 6, 1997**

Agenda and Panels

Vice President Gore: *Welcome attendees*

President Clinton: *Opening Remarks*

Panel I: The Science of Global Warming and Climate Change

Presentation: **John Holdren**, Professor, Department of Earth and Planetary Sciences and the John F. Kennedy School of Government, Harvard University. Head of President's Committee of Advisors on Science and Technology (PCAST).

Panelists: **Robert Watson**, Incoming Chair of the Intergovernmental Panel on Climate Change (IPCC); Director for Environment, World Bank.
Tom Karl, Senior Scientist, NOAA, National Climatic Data Center.
Diana Liverman, Chair, National Academy of Sciences Committee on Human Dimensions of Global Change; Director, Latin American Studies Program, University of Arizona.
Don Wilhite, Director, National Drought Mitigation Center, University of Nebraska.

Vice President Gore: *Remarks*

Panel II: The Role of Technology in Reducing Greenhouse Gas Emissions

Presentation: **Federico Peña**, Secretary of Energy.

Panelists: **Tom Casten**, President & CEO, Trigen Energy Corporation.
Michael Bonsignore, President and CEO, Honeywell Corporation.
Mason Willrich, CEO, EnergyWorks.
Kurt Yeager, President, Electric Power Research Institute.
Larry Papay, Bechtel Corporation

Lunch: **Breakout Discussions with the Cabinet**

First Lady Hillary Rodham Clinton: *Remarks*

Panel III: The Kyoto Conference and U.S. National Interests

Presentation: Madeleine Albright, Secretary of State.

Panelists: James D. Wolfensohn, President, World Bank.

Richard Schmalensee, Professor of Economics and Management, Massachusetts Institute of Technology; Director of MIT Center for Energy and Environmental Policy Research; member of Council of Economic Advisers, 1989-91.

Daniel Yergin, President, Cambridge Energy Research Associates; author of "The Prize: The Epic Quest for Oil, Money and Power," winner of the Pulitzer Prize.

E. Linn Draper, Chairman, President, and Chief Executive Officer, American Electric Power.

Fred Krupp, Executive Director, Environmental Defense Fund.

Mae Jemison, President, Jemison Group, Inc. and Jemison Institute for Advancing Technology in Developing Countries at Dartmouth University. Former NASA astronaut.

Jessica Tuchman Mathews, President, Carnegie Endowment for International Peace.

Panel IV: Climate Change Policy and the U.S. Economy

Presentation: Larry Summers, Deputy Secretary of the Treasury.

Panelists: Robert Repetto, Vice President and Senior Economist, World Resources Institute. Co-author, "The Costs of Climate Protection: A Guide for the Perplexed."

William Nordhaus, Whitney Griswold Professor of Economics, Yale University. Author of "Efficient Use of Energy Resources," "Managing the Global Commons."

Robert Stavins, Professor of Public Policy and Chair of Environment and Natural Resources Program, the John F. Kennedy School of Government, Harvard University.

John Sweeney, President, AFL-CIO.

Richard Sandor, Chairman & Chief Executive, Centre Financial Products Limited; Vice-Chair of Chicago Board of Trade.

**The White House Conference on Climate Change:
The Challenge of Global Warming**

**Regional Conferences
October 6, 1997**

Tuscaloosa, AL	University of Alabama
Tucson, AZ	University of Arizona
Little Rock, AR	University of Arkansas
Los Angeles, CA	UCLA
San Francisco, CA	Golden Gate State University
Boulder, CO	University of Colorado
Middleton, CT	Wesleyan University
Dade County, FL	Dade County Commission Chamber
Atlanta, GA	Emory University
Des Moines, IA	Des Moines Area Community College
Chicago, IL	University of Illinois - Chicago
Kansas City, KS	EPA Regional Office
New Orleans, LA	Tulane University
Medford, MA	Tufts University
Woods Hole, MA	Woods Hole Oceanographic Institution
Ann Arbor, MI	University of Michigan
Reno, NV	Truckee Meadows Community College
Raleigh, NC	North Carolina State University
Durham, NH	University of New Hampshire
Piscataway, NJ	Rutgers University
Albany, NY	Cornell University Cooperative Extension
New York City, NY	Columbia University
Cleveland, OH	Great Lakes Science Center
Portland, OR	Portland V.A. Hospital
Albuquerque, NM	University of New Mexico
Pittsburgh, PA	Carnegie Mellon University
San Juan, Puerto Rico	Metropolitan University
Knoxville, TN	University of Tennessee
College Station, TX	Texas A&M University
Salt Lake City, UT	University of Utah
Seattle, WA	NOAA Offices
Williamsburg, VA	College of William and Mary

THE WHITE HOUSE
WASHINGTONcc: JY
JAF
AM
RL

September 30, 1997

MEMORANDUM FOR CLIMATE CHANGE CONTACTS

FROM: KRIS BALDERSTON/b

SUBJECT: OCTOBER 6 CONFERENCE ON CLIMATE CHANGE

Attached is a **DRAFT** agenda for October 6. There will be a Climate Change conference call tomorrow at 11:30 am. The code is 9108. The following agencies should have a representative on the call: State, Treasury, DOD, Interior, USDA, Commerce, DOL, HHS, HUD, DOT, Energy, EPA, UN, USTR, FEMA, NASA and USIA.

DRAFT AGENDA

10:05-10:20

President Clinton: Opening Remarks: Importance of Global Warming and Climate Change for the American People

10:20-11:15

Panel I: The Science of Global Warming and Climate Change

Presentation: **John Holdren**, Teresa and John Heinz Professor of Environmental Policy, Harvard University

Panelists: **Robert Watson**, Director for Environment, World Bank
Tom Karl, Senior Scientist, NOAA, National Climatic Data Center
Diana Liverman, University of Arizona
Don Wilhite, Director, National Drought Mitigation Center, University of Nebraska

11:30-11:45

Vice President Gore: Where We've Come From; Where We're Going

11:45-12:45

Panel II: The Role of Technology in Reducing Greenhouse Gas Emissions

Presentation: **Federico Peña**, Secretary of Energy
Panelists: **Maxine Savitz**, General Manager, AlliedSignal Aerospace Company's Ceramic Components Unit
Tom Casten, President and CEO, Trigen Energy Corporation
Michael Bonsignore, President and CEO, Honeywell Corporation
Mason Willrich, CEO, EnergyWorks
Kurt Yaeger, President, Electric Power Research Institute a non-profit collaborative research enterprise of the electric power industries.

1:00-2:00

Lunch: Breakout Discussions with Cabinet Members

2:15-2:30

Remarks by First Lady Hillary Rodham Clinton

2:30-3:30

Panel III: Kyoto Conference and U.S. National Interests

Presentation: **Madeleine Albright**, Secretary of State
Panelists: **Jessica Tuchman Mathews**, President, Carnegie Endowment for International Peace
E. Linn Draper, Chairman, President, and CEO, American Electric Power
Richard Schmalensee, Massachusetts Institute of Technology, Director of MIT Center for Energy and Environmental Policy Research
Fred Krupp, Executive Director, Environmental Defense
Daniel Yergin, President, Cambridge Energy Research Associates
Mae Jemison, President, Jemison Group, Inc. and Jemison Institute of Advancing Technology in Developing Countries

3:30-4:30

Panel IV: Climate Change Policy and the U.S. Economy ;

Presentation: **Larry Summers**, Deputy Secretary of the Treasury
Panelists: **Robert Repetto**, Vice President, World Resources Institute
William Nordhaus, Whitney Griswold Professor of
Economics Yale University
Richard Sandor, Chairman and Chief Executive, Centurion
Financial Products Limited
Richard Trumka, AFL-CIO

10/6/97

**LISA D.
BRANCH**
09/16/97 09:27:01 AM



Record Type: Record

To: William J. Antholis/OPD/EOP

CC:

Subject: WH Climate Change Conference

Jeff Frankel asked me to check with you about whether or not it is appropriate for him to attend this conference. Please respond soon. Also, is there a schedule for this event? Do you know its location?

Thanks.

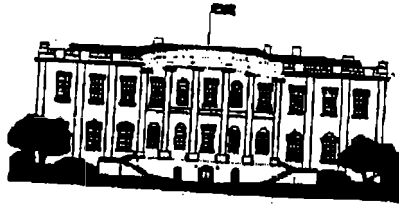
CABINET SITE BRIEFING**LOCATION**

The conference will be held in Gaston Hall on the 3rd floor of Healy building on Georgetown University Campus. Cabinet members will be met at the University's main gate at 37 and O Sts. NW and escorted to their holding room in the Healy building. Cabinet members will hold in Philodemic Room (Room 208) on the 2nd floor of the Healy building. Cabinet members should arrive in time to be in their holding rooms by 9:45 AM. At which time they will be escorted to their seats in Gaston Hall.

Cabinet members cars will proceed south on 37th St. to Prospect St. Turn right on Prospect St. and turn right again into University lot #9. Parking is free.

Cabinet member arriving for the lunch session only should proceed directly to the Leavey Center accessed via Reservoir Road (Entrance #1) at 38th St. NW, and follow directions to the Leavey Center entrance behind the Pasquerilla Building.

Cabinet members arriving for the afternoon panel sessions only should arrive at 37th and "O" Sts. NW and proceed into Gaston or to the Cabinet Holding Room in the Philodemic Room.



THE WHITE HOUSE
OFFICE OF CABINET AFFAIRS

Date: _____

To: Climate Change Contacts

From: Krist Baldwin

Facsimile: _____

Telephone: _____

Subject: Climate Change Conference

Pages: 2 (Including this cover sheet)

Comments:

The following is a cabinet site
briefing for October 6th

OLD EXECUTIVE OFFICE BUILDING ♦ ROOM 160 ♦ WASHINGTON, DC 20502

TELEPHONE (202) 456-2572 ♦ FACSIMILE (202) 456-6704

Mon, 10/6/97

William J. Antholis

09/17/97 07:35:44 AM

Record Type: Record

To: Lisa D. Branch/CEA/EOP

cc:

Subject: Re: WH Climate Change Conference 

lisa -- the final list has not yet been determined; we hope to do so by the end of the week. - bill

**LISA D.
BRANCH**
09/16/97 09:27:01 AM



Record Type: Record

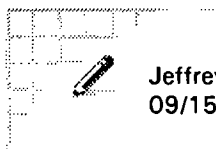
To: William J. Antholis/OPD/EOP

cc:

Subject: WH Climate Change Conference

Jeff Frankel asked me to check with you about whether or not it is appropriate for him to attend this conference. Please respond soon. Also, is there a schedule for this event? Do you know its location?

Thanks.



Jeffrey A. Frankel
09/15/97 08:07:28 PM

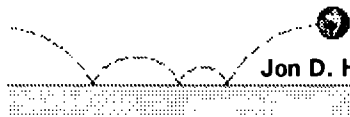
Record Type: Record

To: Jon D. Haveman/CEA/EOP
cc: Lisa D. Branch/CEA/EOP
bcc:
Subject: Re: FYI

I'd like to attend the Oct. 6 meeting, except that that is the day of the WH conference on climate change; I assume I will probably be attending that conference. (Lisa: maybe you should check with Bill Antholis to make sure that it is appropriate that I attend the conference, or most of it.) As to Sept. 23: Lisa, why don't you note it on my calendar; but we will wait to see whether (1) Jeff Lang issues an appeal for Deputies, or (2) conflicts develop for that time slot.

JF

Jon D. Haveman



Jon D. Haveman

09/15/97 07:57:04 PM

Record Type: Record

To: Jeffrey A. Frankel/CEA/EOP
cc:
Subject: FYI

Jeff,

At the TPRG meeting, it was decided that the next meeting should have a principle present, I assume that means you. They would like to have the meeting on October 6 at 4pm. I think that the major topic of the meeting will be the president's trip to south america.

There will also be a meeting to approve the Super 301 release on 9/23 at 10am. It wasn't clear whether or not they wanted somebody higher than me to attend.

Also, there was discussion about the Poland and automobiles issue. That is, there is now a considerable gap between the barriers to automotive imports from the EU (none) and the barrier to Chrysler's products (I don't think Chrysler has any production facilities in the EU, they for sure don't in Poland (both GM and Ford are already in Poland). We're going to try and convince Poland to lower the barrier to 10% on automobiles w/ > 2.0liter engines. 10% is the EU common external tariff. The choice of engine size is intended to allow in Chrysler, but not the Asians.

Nobody other than Commerce had much to say. I really don't like the approach, but didn't dissent other than to point out the likelihood that Asians would shift their emphasis to big cars and send