

Global Warming Policy: Some Economic Implications

by

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Executive Summary

Many analysts believe that human-caused emissions of greenhouse gases — principally carbon dioxide (CO₂) from the consumption of fossil fuels such as petroleum products, natural gas and coal — are contributing to an increase in global temperatures.

The link between greenhouse gas emissions and global temperature increases is uncertain, and some scientists believe the net effect of any global warming could be beneficial. Still, the United States has signed — but not ratified — an accord drawn up at Kyoto, Japan, in late 1997 that would obligate the U.S. to reduce its CO₂ emissions to 7 percent below 1990 levels between 2008 and 2012. The accord also assigns various targets to other industrialized nations. It will become a binding treaty only if countries accounting for 55 percent or more of 1990 CO₂ emissions ratify it. Thus far no industrialized nation has done so.

What difference will the treaty make? The treaty would not actually reduce global CO₂ emissions. Instead, it would merely slow their growth:

- The U.S. Department of Energy has projected that from 1990 to 2010 emissions of CO₂ from the consumption of fossil fuels will rise by 45 percent worldwide.
- If the Kyoto accord were implemented, the net effect would be to slow the worldwide growth of CO₂ emissions to 30 percent.

Despite the fact that the impact on global CO₂ emissions would be modest, the effects on the U.S. economy would be large:

- This study estimates that compliance with the Kyoto accord would require the U.S. to reduce its energy consumption by about 25 percent below the amount that would otherwise occur.
- To appreciate what this would mean, consider that about one-fourth of total U.S. energy consumption in 1996 was for transportation.
- One way (but not the most efficient way) of reducing energy use in the United States by one-fourth would be to stop nearly all highway, rail, sea and air traffic permanently.

Economists often use cost-benefit analysis to determine whether government action should be taken and, if so, what action will produce the best results at the least cost. This study compares the worldwide benefits of U.S. reduction of CO₂ emissions with the worldwide costs. The benefits can be ex-

pressed as the economic value of avoiding the environmental damage that might arise from global warming. Fewer hurricanes mean less property damage; avoiding tidal flooding increases the value of coastal property; less crop destruction translates into lower food prices; fewer diseases mean lower health care costs. This study estimates these benefits based on the average finding of studies that conclude the benefits are positive.

The costs can be expressed in terms of economic opportunities lost as a result of using less fossil fuel. In general, economic well-being is maximized at the level of abatement where the last barrel of oil not consumed creates benefits equal to the costs of not consuming it. For abatement beyond that point, the additional cost outweighs the additional benefit. This study finds:

- The economic benefits of lower energy use justify U.S. reduction in CO₂ emissions of only about 14 percent of that required by the treaty.
- Thus the Kyoto treaty would require seven times more CO₂ reduction by the United States than is justified by a comparison of costs and benefits.
- Similar results also apply to other developed countries.

Regardless of its impact on the world as a whole, CO₂ emissions reduction would be costly for the United States. In general, the cost of reducing CO₂ emissions can be measured in terms of fewer goods and services purchased at lower energy levels. It might be possible to reduce these costs through international transactions. For example, the United States could purchase the right to emit additional units of CO₂ from other countries. Alternatively, the U.S. could obtain the right to emit more by helping other countries reduce their emissions. This study finds:

- Without any offsets or credits, U.S. GDP would be 3.6 percent to 5.1 percent lower in 2010, representing a loss of \$330 billion to \$467 billion or about \$1,100 to \$1,600 per capita.
- Using offsets and credits, compliance would cost the U.S. from 3 percent to 4.3 percent of GDP, representing a loss of between \$921 and \$1,320 for every man, woman and child in the country.

If reducing CO₂ emissions is similar to purchasing insurance against the possible consequences of global warming, these figures suggest that U.S. compliance with the Kyoto accord represents costly and excessive insurance.

Introduction¹

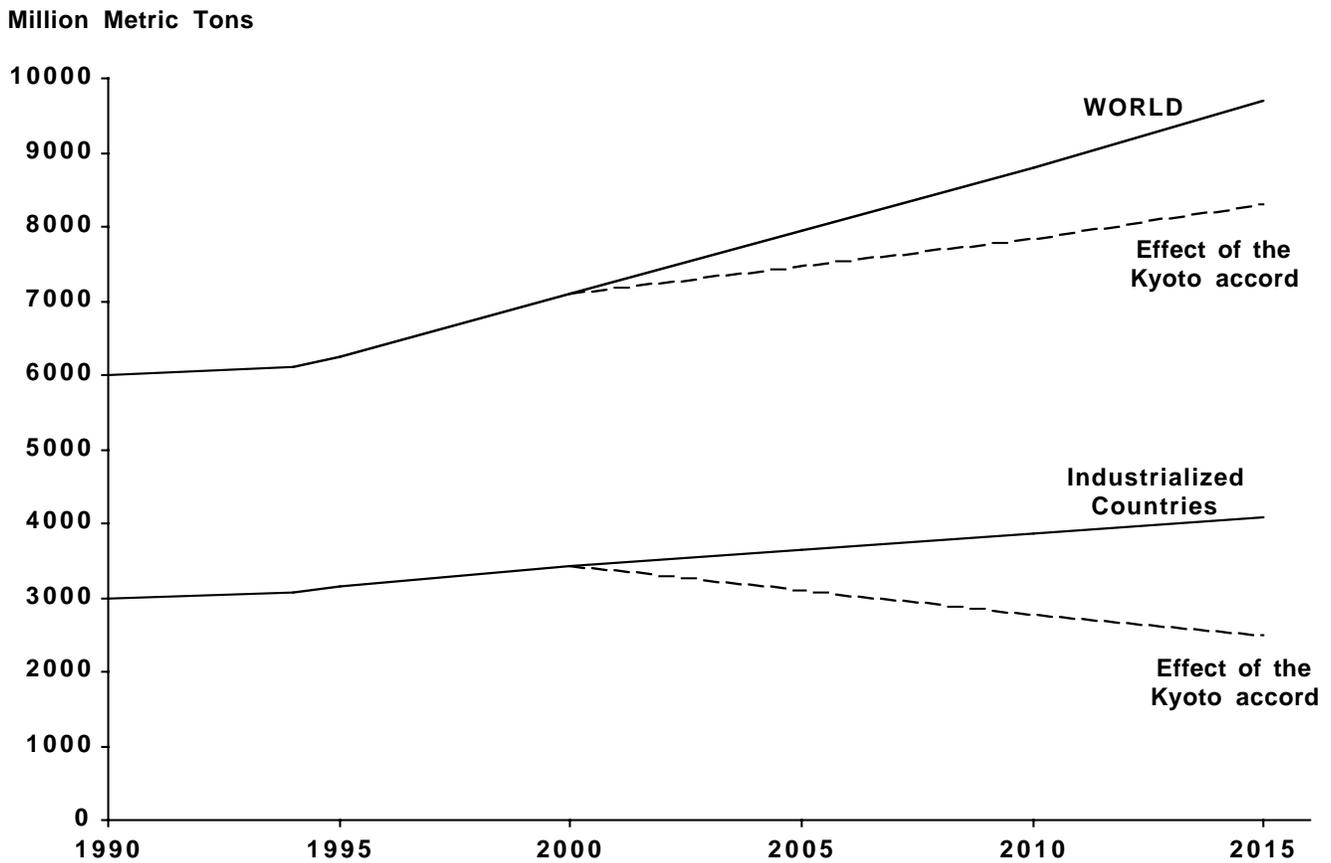
Although many analysts believe that greenhouse gases resulting from human activity are contributing to global warming, the linkage is highly uncertain. Human-caused emissions are only about 3 to 5 percent of the total annual emissions of greenhouse gases in the world. The greenhouse gas most frequently emitted through human action is carbon dioxide (CO₂) from fossil fuels (petroleum products, natural gas and coal).² Thus, the conservation of fossil fuels figures prominently in strategies to reduce CO₂ emissions.

Increased concerns about the extent and potential consequences of global warming led to a United Nations conference on global warming at Kyoto, Japan, in late 1997. Prior to the conference, President Clinton had proposed that the United States and other industrialized countries set a target for reducing each country's CO₂ emissions to 1990 levels by 2010. The conference went well beyond that proposal, and when it ended the industrialized nations had agreed to different targets for each country. Some industrialized nations would be allowed to increase CO₂ emissions beyond 1990 levels, while the U.S. would be required between 2008 and 2012 to reduce emissions to 7 percent *below* 1990 levels. Whether developing countries would have to reduce emissions as their income rises is under negotiation. The United States and 83 other nations have signed the Kyoto accord, but only eight small countries, none of them industrialized, have ratified it. It would become a binding treaty only if ratified by the industrialized nations responsible for at least 55 percent of CO₂ emissions in 1990.

"The U.S. would be required to reduce CO₂ emissions to 7 percent below 1990 levels."

As shown in Figure I, the U.S. Department of Energy has projected that the CO₂ emissions from the consumption of fossil fuels will increase more than 30 percent in the industrialized countries and 45 percent in all countries from 1990 to 2010.³ Thus compliance with a Kyoto treaty would substantially reduce the expected use of fossil fuels from what could otherwise be expected. However, lower fossil fuel prices resulting from reduced demand in the United States and other industrialized countries would spur greater fuel consumption in developing countries. My analysis indicates that, as a result, developing countries would consume nearly 12 percent of the fossil fuels the industrialized countries conserved to comply with the Kyoto accord. The net effect of emission reductions would be to slow the growth of global CO₂ emissions from the projected 45 percent to 30 percent between 1990 and 2010.⁴ Some analysts worry that compliance with the Kyoto accord would impose drastic costs on the industrialized countries with little or no proven benefit. Others worry that the Kyoto targets are too modest to prevent costly environmental problems. These concerns raise two basic questions.

FIGURE I
Annual Carbon Emissions



Source: Author's estimates and U.S. Department of Energy data.

“Carbon emissions are projected to increase 45 percent worldwide from 1990 to 2010.”

- What is the rationale for government intervention in markets to reduce CO₂ emissions?
- By how much does economic analysis suggest the United States should reduce its CO₂ emissions, and how do President Clinton’s proposal and the Kyoto accord compare with what is optimal?

The first question can be answered with simple economic theory. The second can be answered by combining estimates of the economic benefits of reducing CO₂ emissions with the opportunity costs of doing so.

Global Warming Theory

The theory of global warming holds that increased levels of atmospheric CO₂ are linked to generally rising temperatures around the world.⁵ To better understand global warming, consider the greenhouse effect. Sunlight heats the earth, but the earth would be far cooler without atmospheric water

vapor and greenhouse gases. The gases let sunlight through to warm the earth but trap as infrared radiation some of the heat escaping back into space. Thus the gases act like the glass walls and ceiling of a greenhouse.

The effect of increasing the level of atmospheric greenhouse gases mimics the effect of using thicker glass in the greenhouse: less heat escapes. Some scientists believe that the CO₂ released by human activities is enhancing the greenhouse effect and contributing to an increase in the earth's overall temperature. This increase is commonly called global warming.

Many scientists and others are concerned about global warming's potential effect on the environment. Among the predicted consequences are increased rainfall, melting polar ice caps, rising ocean levels, increased flooding and widespread crop failure. On the other hand, some scientists say the net effect of any global warming could be beneficial, enhancing crop production and reducing the onset of and death from some types of diseases.⁶

Scientists also disagree about the magnitude of the temperature change and the contribution — if any — of human-caused CO₂.

The Rationale for Restrictions on the Use of Fossil Fuels

Nature contributes more than nine-tenths of all CO₂ that enters the atmosphere.⁷ The principal way people contribute to atmospheric CO₂ is through the consumption of carbon-based fuels. These fuels include petroleum products, natural gas, coal and wood. Jointly, the first three are often identified as “fossil fuels.”

Deforestation, as trees are cut down for economic purposes, also contributes to increased levels of atmospheric CO₂. Scientists estimate that the world's forests remove about one-third of the current CO₂ emissions from fossil fuels. Thus large reductions in the world's forests could significantly increase the atmospheric levels of CO₂, although recent reductions have had little effect on atmospheric CO₂ in comparison with the effects from fossil fuel consumption.

The call for government action on global warming has arisen from the concern that increasing consumption of carbon-based fuels will boost levels of atmospheric CO₂ and that the resulting warmer temperatures will harm humans and the environment. Individually, consumers lack incentives to consider the global side effects of increased fuel consumption. Collectively, individual actions could be contributing to greater emissions of CO₂ than are desirable from the perspective of human well-being, environmental health and economic efficiency.

“Nature contributes more than nine-tenths of all CO₂ that enters the atmosphere.”

To some extent, the divergence between individual and global interests could be seen in the Kyoto debates. The representatives of each country jockeyed for advantage and criticized the others for not doing enough. The debate has been exacerbated by the fact that reducing energy consumption on a global scale yields gains for energy-importing countries, which will benefit from lower fuel prices and be able to shift some of the costs of conservation to the energy-exporting countries.

Evaluating Global Warming Policy: A Cost-Benefit Approach

Cost-benefit analysis, as the name implies, is a comparison of the estimated costs associated with an action with its estimated benefits. Cost-benefit analysis is useful in determining whether an action should be taken and, if so, what action will produce the best results at the least cost. Thus cost-benefit analysis is vitally important in making decisions about whether and how to reduce the impact of global warming (e.g., carbon taxes, mandatory fuel rationing or conservation, subsidies to non-carbon-based energies or some form of tradable emission quotas).

Estimating the Benefits of Reducing CO₂ Emissions. The expected benefits of reducing CO₂ emissions are the avoidance of the environmental damages that might result from those emissions. For example, fewer hurricanes mean less property damage; avoiding tidal flooding increases the value of coastal property; less crop destruction translates into lower food prices; fewer diseases mean lower health care costs. An emerging literature attempts to evaluate the economic costs associated with the potential environmental damage associated with CO₂ emissions.⁸ The analysts and researchers working in this endeavor use climate models to relate CO₂ emissions to global warming. They then attempt to relate global warming to possible environmental consequences and to estimate the economic costs associated with those consequences. Obviously, the analysts and researchers must contend with considerable uncertainty about the magnitude and direction of effect in each step of the analysis. That uncertainty is reflected in the analysis.

Comprehensive surveys of the emerging literature on the economic cost of global warming suggest that the worldwide marginal benefit of reducing CO₂ emissions in 2010 plausibly ranges from \$0 to \$300 per metric ton (in 1995 dollars).⁹ To put this into context, consuming a barrel of oil results in the emission of 0.1133 metric tons of CO₂, so the marginal benefit of reducing the emissions from one barrel of oil plausibly ranges from \$0 to \$33.75. Within this \$0 to \$33.75 range, the literature suggests that the most likely range of benefits (at a 95 percent confidence level) is 92 cents to \$6.61 per barrel of oil

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“The cost is expressed in the forgone economic opportunities from using less fossil feed.”

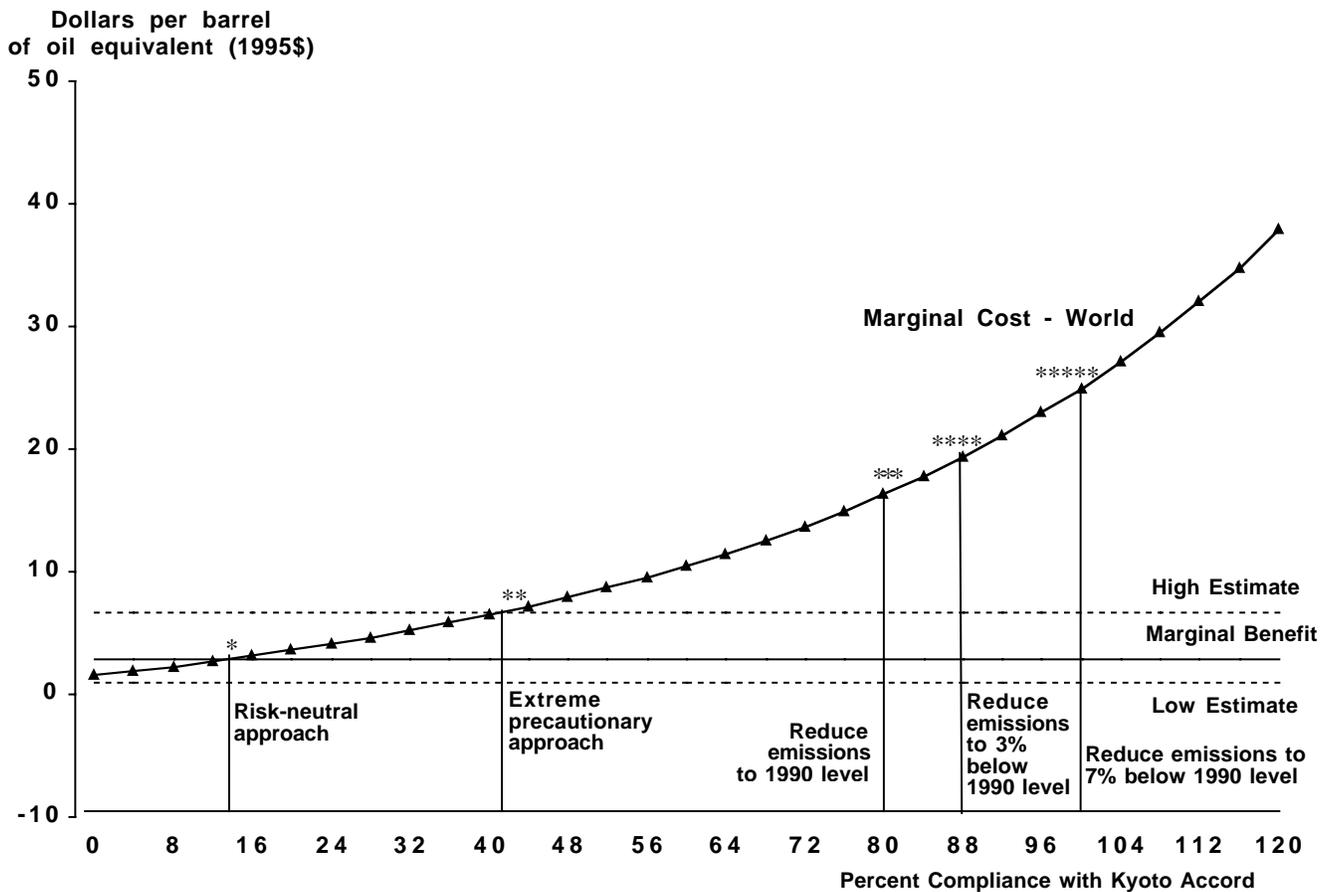
equivalent, shown in Figure II. The mean estimate is \$2.86 per barrel of oil equivalent.¹⁰

Given the considerable uncertainty about the benefits of reducing CO₂ emissions, some analysts have suggested that making the reductions is comparable to buying insurance. The costs of reducing emissions are fairly well known, but the benefits are not known and may not exist.

Estimating the Costs of Reducing CO₂ Emissions. The cost is expressed in the forgone economic opportunities from using less fossil fuel. Completing the cost-benefit analysis requires estimating the costs of reducing

FIGURE II

Estimated Benefits and Costs of CO₂ Abatement



- * 14 percent = 65 million metric tons.
- ** 45 percent = 200 million metric tons.
- *** 80 percent = 384 million metric tons.
- **** 88 percent = 424 million metric tons.
- ***** 100 percent = 478 million metric tons.

Source: Author's estimates.

“Only about 14 percent of the emissions reduction the Kyoto accord requires can be cost-justified.”

CO₂ emissions through the conservation of fossil fuels. Following several previous studies, estimates of marginal cost are obtained through the use of a welfare-theoretic framework (a method for measuring the cost of deviating from market efficiency) built on top of a simulation model of world energy markets.¹¹ The resulting estimates assume that all nations comply with the treaty to the same extent as the United States.¹²

The first marginal cost curve, shown in Figure II, represents the marginal costs to the world of the U.S. fossil fuel conservation necessary to reduce CO₂ emissions. Maximal economic well-being occurs at the level of CO₂ abatement at which the marginal cost equals the marginal benefit (i.e., 65 million metric tons or \$2.86 per barrel of oil equivalent). A risk-neutral approach equates marginal cost to the mean estimate of marginal benefit.¹³ An extreme precautionary approach to avoiding the risk of global warming uses the upper-bound estimate of the likely range as the measure of marginal benefit. As Figure II shows:

- The estimated marginal cost of CO₂ abatement equals the mean estimate of marginal benefit at about 14 percent (65 million metric tons) of the level set by the Kyoto accord.¹⁴
- The estimated marginal cost of CO₂ abatement equals the upper-bound estimate of marginal benefit at about 45 percent (200 million metric tons) of the level set by the Kyoto accord.

By comparison, both President Clinton’s earlier proposal to reduce U.S. emissions to 1990 levels by 2010 and the Kyoto accord’s requirement that the U.S. reduce emissions to 7 percent below the 1990 levels imply figures substantially higher than what is optimal under either measure of marginal benefits.

President Clinton’s proposal implies 384 million metric tons of CO₂ abatement. At this level, the marginal cost is more than \$16 per barrel of oil equivalent, substantially more than the mean estimate of marginal benefits of \$2.86 per barrel of oil equivalent or the likely upper-bound estimate of \$6.61.

U.S. compliance with the Kyoto accord would require an estimated 478 million metric tons of CO₂ abatement in 2010. If it all came from fossil fuel conservation, the marginal cost would be nearly \$25 per barrel of oil equivalent. The accord allows international trading in emission reduction credits and allows offset credits for helping another nation reduce, limit or avoid emissions. U.S. officials expect to use offsets and credits to reduce the burden from conservation of fossil fuels to 3 percent below 1990 levels. This implies 424 million metric tons of CO₂ abatement from the conservation of fossil fuels, at a marginal cost of just under \$20 per barrel of oil equivalent.

As can be seen from these estimates and from Figure II, the amount of CO₂ abatement that a Kyoto treaty would require from the United States is well above the optimum. The marginal benefit of emission reduction would remain \$2.86 per barrel of oil equivalent, but the marginal cost of compliance would rise to \$20 to \$25, depending on whether the United States is able to use offsets or credits. Thus the marginal cost of compliance would be seven to nine times the marginal benefit. At the upper-bound benefit estimate of \$6.61 per barrel of oil equivalent, the marginal cost would be three to four times the marginal benefit.

“The net effect of compliance would be to reduce total U.S. energy consumption by about 25 percent below the amount that would otherwise occur.”

By my estimate, compliance with Kyoto would necessitate a reduction of about 30 percent in U.S. fossil energy consumption below that projected for 2010 by the U.S. Department of Energy. Non-fossil energy consumption would rise slightly. The net effect would be to reduce total U.S. energy consumption about 25 percent below that projected for 2010 by the Department of Energy.

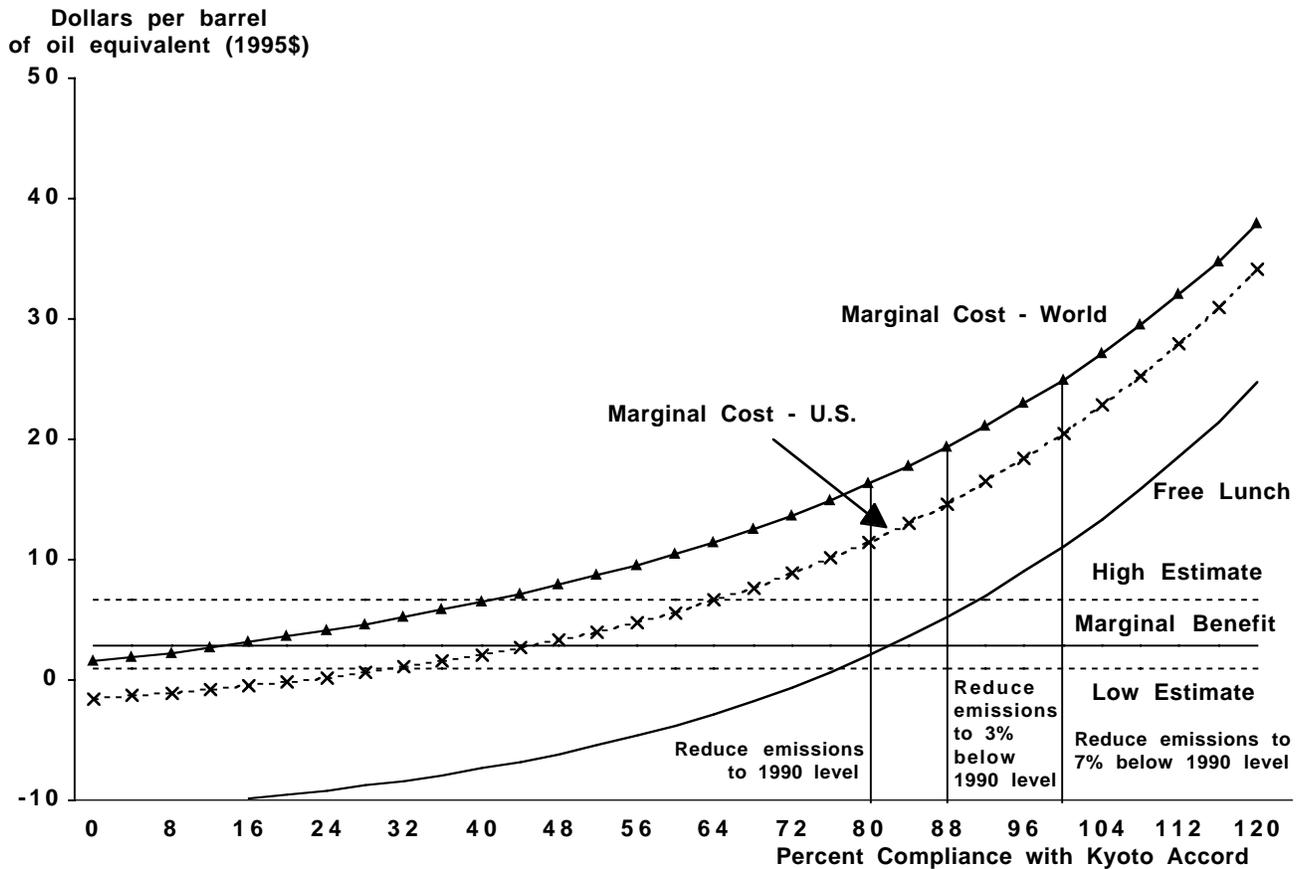
To give an idea of the impact of a reduction of that magnitude, 26 percent of the total consumption of all fossil and non-fossil energy in the United States in 1996 was for transportation, 36 percent for residential and commercial use and 38 percent for industrial and miscellaneous use.

Improved Terms of Trade. If the United States and other developed countries consumed less oil and natural gas, the prices of these fossil fuels would drop. As an importer of oil and natural gas, the United States would benefit from lower prices for those two fuels and simultaneously would shift some of the costs of its conservation to oil and natural gas exporters. In economics parlance, this shift of costs is known as “improved terms of trade.”

Because it can shift some of the costs of its oil and natural gas conservation to other countries, the United States would incur a lower cost for reducing CO₂ emissions than would the world. Some analysts would incorporate this cost shift into the analysis, and as shown in Figure III, the lower marginal cost implies that a greater reduction in CO₂ emissions would be optimal. Such a conclusion is flawed, however. Optimality cannot be found by equating the marginal benefit to the world with the marginal cost to the United States. This is like comparing apples to oranges. Sound analysis requires consistency in defining the incidence of costs and benefits.

Free Lunch: There Is No Such Thing. A number of energy analysts argue that the United States can cut its energy consumption by 25 percent and achieve a cost saving at the same time. The curve labeled “Free Lunch” in Figure III shows that President Clinton’s pre-Kyoto target for reducing CO₂ emissions would be very close to optimal if a free lunch did exist. Some analysts who consider this cost curve accurate and who favor the extreme

FIGURE III
Estimated Benefits and Costs of
CO₂ Abatement — Free Lunch Scenario



Source: Author's estimates.

“Analysts who believe in the ‘free lunch’ use conceptually flawed studies to support their claims.”

precautionary approach to reducing CO₂ emissions have criticized the president’s target as too conservative. As shown in Figure III, reducing CO₂ emissions from fossil fuels to 3 percent below 1990 levels would have a marginal cost that is above the mean estimate of marginal benefit but below the likely upper bound.

Analysts who believe in the free lunch use conceptually flawed studies to support their claims.¹⁵ Also they are unable to explain why a free market would leave such cost saving on the table rather than adopt conservation measures without government prodding. Instead, they offer vague explanations of market barriers including inappropriate lifestyle choices and demand government regulation to reduce what they see as wasteful use of energy.¹⁶

Hidden Costs of Policy. Economic policy often carries costs that are not captured by traditional welfare-theoretic measures. Regulatory inefficiency is one way costs can escalate. When regulation instead of broad market incentives such as taxes is used, the lowest-cost methods of energy conservation can be ignored.

Interference in free trade is another way policies to reduce CO₂ emissions can have hidden costs. Broad programs of energy conservation permit energy-importing countries to improve their terms of trade with energy-exporting countries — a fact that has not been lost on the Organization of Petroleum Exporting Countries. The countries that are the most dependent on imported energy have been the most aggressive in promoting global cooperation to reduce CO₂ emissions. More self-sufficient countries, such as the United States, have been more reluctant to participate. Within the United States, energy conservation has a decided tilt toward the conservation of oil, the fuel for which we are most import-dependent.

Rent-seeking behavior — using government to gain what could not be obtained in a free market — is a third source of hidden costs. Changes in policy create winners and losers. Both groups have an incentive to expend real resources to achieve their objectives by influencing the political process, which can add sizable costs to policy.

A method for estimating the costs of rent-seeking behavior was first suggested by economist Gordon Tullock.¹⁷ Using his approach, I estimate the potential hidden costs of policy, which captures only the costs of rent-seeking behavior. As shown in Figure IV, these costs can be sizable. With the hidden costs incorporated, the marginal cost of reducing U.S. CO₂ emissions is more than \$30 per barrel of oil equivalent at zero abatement and more than \$80 at full compliance with the Kyoto accord. If the potential for hidden costs were taken seriously, the cost of reducing CO₂ emissions would greatly outweigh its benefits at any level of attainment.

Aggregate Economic Consequences for the United States

In terms of forgone economic opportunities, the energy conservation associated with CO₂ abatement is equivalent to increasing the price of energy and potentially slowing economic growth. Most economists agree that gross domestic product is a poor way to measure economic well-being, particularly when evaluating environmental policy. Nevertheless, slower economic growth would subject fiscal and monetary authorities to significant political pressure to offset the slowdown. Yielding to that pressure could lead to higher inflation.

“The energy conservation required is equivalent to increasing the price of energy and potentially slowing economic growth.”

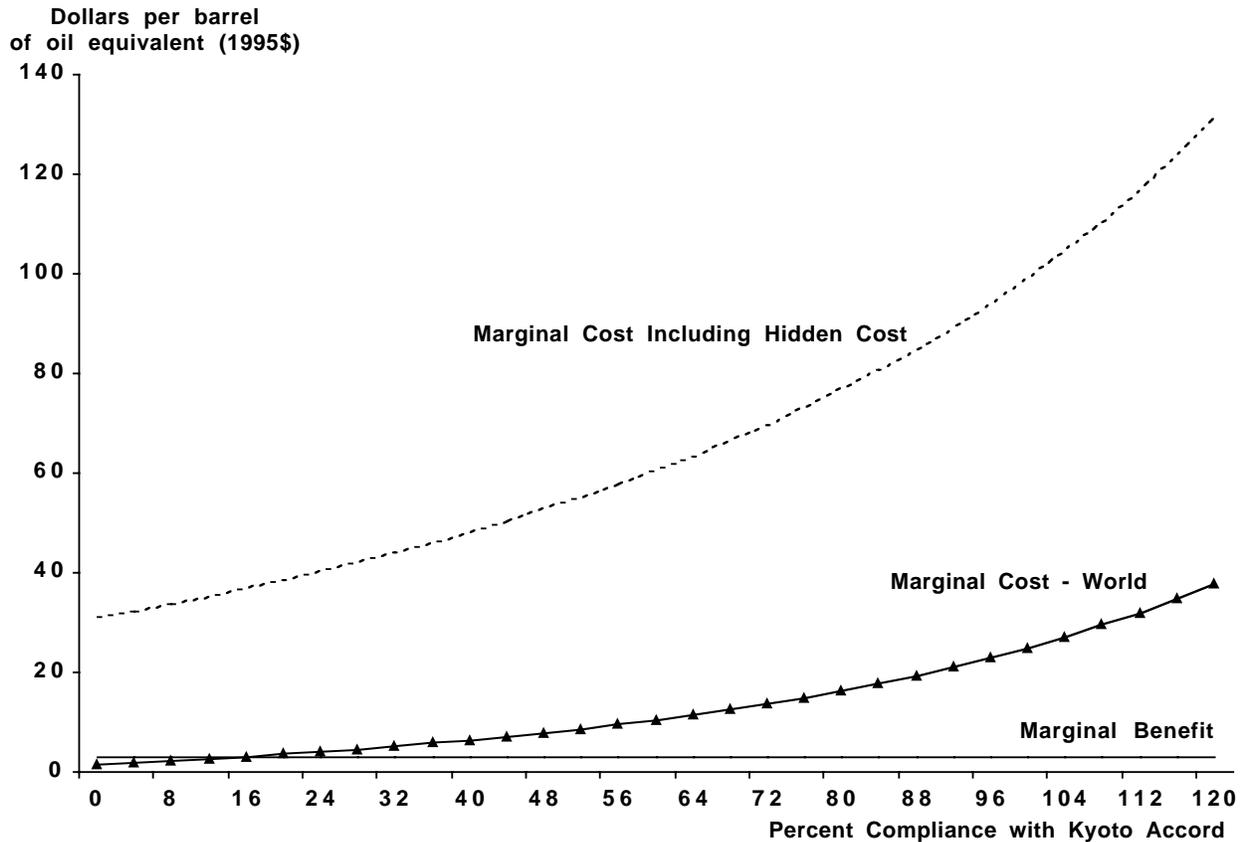
“Hidden costs can be sizable.”

As shown in Figure V, the effect on aggregate economic activity in the United States depends on the amount of CO₂ abatement.¹⁸

- The amount of energy conservation required to reduce 2010 CO₂ emissions to the 1990 level (President Clinton’s original proposed target) would imply that U.S. GDP would be 2.7 percent to 3.7 percent lower in 2010 than it would otherwise be, representing an aggregate loss of \$247.6 billion to \$339.4 billion (in 1992 dollars) or \$829 to \$1,135 per capita.
- Without any offsets or credits, reducing emissions to 7 percent below 1990 levels in compliance with the Kyoto accord would imply that U.S. GDP would be 3.6 percent to 5.1 percent lower in 2010, representing a loss of \$330.2 billion to \$467.8 billion or \$1,105 to \$1,565 per capita.

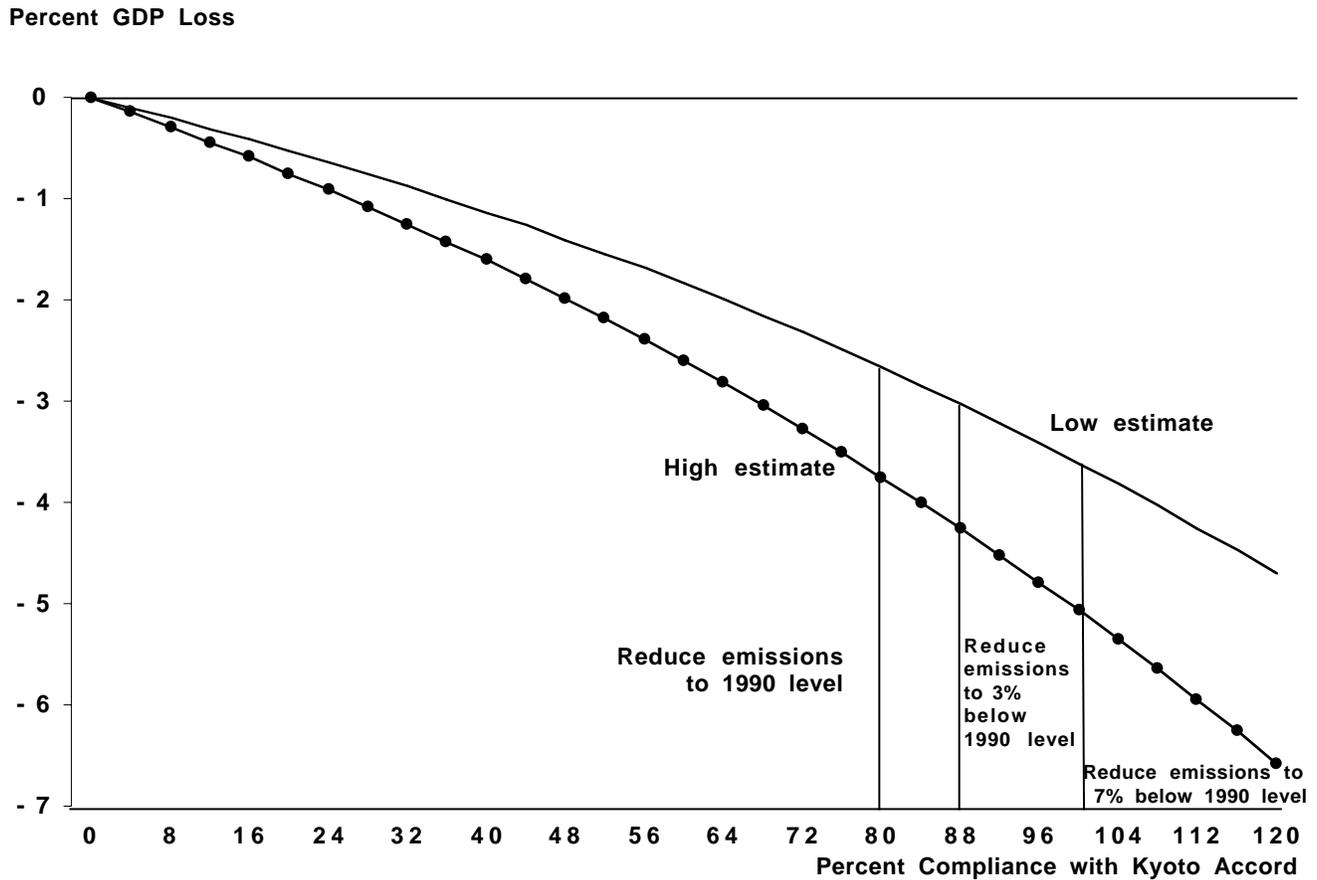
FIGURE IV

Estimated Benefits and Costs of CO₂ Abatement Including Hidden Costs



Source: Author's estimates.

FIGURE V
U.S. CO₂ Abatement and GDP Losses



Source: Author's estimates.

“U.S. GDP growth would be from \$27.5 billion to \$36.7 billion lower per year.”

- Even assuming the United States could use offsets and credits, compliance with the Kyoto accord would imply a U.S. GDP 3 percent to 4.3 percent lower in 2010, representing a loss of \$275.2 billion to \$394.4 billion or \$921 to \$1,320 per capita.
- These estimates imply that if the United States embarked on a 10-year program to achieve compliance with a Kyoto treaty, U.S. GDP growth would be 0.3 percent to 0.4 percent — from \$27.5 billion to \$36.7 billion — lower per year.

Conclusions

Various facts partially support global warming theory. More evidence is needed to determine whether rising atmospheric levels of CO₂ resulting from the use of carbon-based fuels is causing global warming. Nevertheless, most scientists who study the issue think the use of fossil fuels contributes to

“Cost-benefit analysis suggests that the requirements of the treaty represent too much insurance against global warming.”

the global warming that appears to be occurring. Still, considerable uncertainty remains about both the magnitude and the environmental consequences of global warming.

Given the uncertainty, reducing CO₂ emissions is like purchasing insurance against global warming and its possible environmental consequences. Under most current proposals, the industrialized nations would buy all or most of the insurance. Developing nations would possibly be asked to contribute only when their income levels rose.

Cost-benefit analysis suggests that reducing U.S. emissions of CO₂ to comply with the Kyoto accord or to reach the more modest target proposed by President Clinton represents too much insurance. Analyses for the other industrialized countries yield similar results. It is not surprising, therefore, that the Kyoto accord remains unratified.

NOTE: The views expressed here are those of the author. Nothing written here should be construed as necessarily reflecting the views of the Federal Reserve Bank of Dallas, the Federal Reserve System or the National Center for Policy Analysis, or as an attempt to aid or hinder the passage of any bill before Congress.

Notes

¹ The author would like to thank Frank Berger, Sterling Burnett, Mike Canes, Roger Heminghaus, Hill Huntington, Don Norman, Steve Prowse, Cece Smith, Ron Sutherland, Lori Taylor, Mine Yücel, Carlos Zarazaga, John Goodman and Dorman Cordell for helpful comments and discussions without implicating them in the conclusions.

² For a comprehensive treatment of emissions other than CO₂, see Darwin C. Hall, "Preliminary Estimates of Cumulative Private and External Costs of Energy," *Contemporary Policy Issues*, No. 8, July 1990, pp. 283-307; and Darwin C. Hall, "Social Cost of CO₂ Abatement from Energy Efficiency and Solar Power in the United States," *Environmental and Resource Economics*, Vol. 2, No. 5, 1992, pp. 491-512.

³ Atmospheric CO₂ has increased approximately 36 percent since the beginning of the Industrial Revolution. Other greenhouse gases whose recent increase in the atmosphere is due to human activities include methane, nitrous oxide, chlorofluorocarbons and aerosols. All combined account for 2 to 6 percent of the greenhouse gases in the atmosphere; natural water vapor makes up the other 94 to 97 percent.

⁴ The Department of Energy projection that world CO₂ emissions from fossil fuels would increase about 45 percent from 1990 to 2010 anticipates accelerated growth and industrialization in the developing world.

⁵ All of the other greenhouse gases make up such a small percentage of atmospheric greenhouse gas concentrations that they are known collectively as "trace gases." Methane has increased dramatically (150 percent) in the atmosphere over the last 100 years and has 30 times the warming potential of CO₂. However, it is short-lived, makes up only 0.00016 percent of the atmosphere by volume and its emissions and concentrations have inexplicably leveled off in the last year. Nitrous oxides are long-lived gases with 200 times the warming potential of CO₂ that, with the exception of downturns due to volcanic eruptions, have increased modestly in recent years. However, most atmospheric nitrous oxides have natural sources and they make up less than 0.000001 percent of the atmosphere. Chlorofluorocarbons (CFCs) and aerosols have both increased in recent years, with mixed effects. For instance, in the upper atmosphere CFCs have a cooling effect; in the lower atmosphere they tend to trap heat. On balance, CFCs and aerosols have probably moderated any recent warming. See Intergovernmental Panel on Climate Change (IPCC), *Climate Change 1995, Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analyses* (Cambridge, Mass.: Cambridge University Press, 1996), pp. 122, 118.

⁶ See, for example, Thomas Gale Moore, "Health and Amenity Effects of Global Warming," Working Paper No. 96-1, January 1996, Hoover Institution; and Sylvan H. Wittwer, "Flower Power: Rising Carbon Dioxide Is Great for Plants," *Policy Review*, No. 62, Fall 1992.

⁷ In fact nature, through such activities as the decomposition of organic matter on land and in the oceans, contributes 93 to 97 percent of the atmospheric CO₂. Out of approximately 160 billion metric tons of CO₂ exchanged in the atmosphere every year, humans contribute only 5.6 to 8.6 metric tons. IPCC, *Climate Change 1995, Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analyses*, p. 77.

⁸ For examples, see Samuel Fankhauser, "The Social Costs of Greenhouse Emissions: An Expected Value Approach," *Energy Journal*, Vol. 15, No. 2, 1994, pp. 157-84; Chris Hope and Phillip Maul, "Valuing the Impact of CO₂ Emissions," *Energy Policy*, March 1996, pp. 211-19; William D. Nordhaus, "A Sketch of the Economics of the Greenhouse Effect," *American Economic Review*, Papers and Proceedings, May 1991, pp. 920-37; William D. Nordhaus, "To Slow or Not to Slow: The Economics of Global Warming," *Economic Journal*, July 1991, pp. 920-37; William D. Nordhaus, "The DICE Model: Background and Structure of a Dynamic Integrated Climate Economy Model of the Economics of Global Warming," Cowles Foundation Discussion Paper No. 1009, New Haven, Conn., February 1992; William D. Nordhaus, "Optimal Greenhouse Gas Reductions and Tax Policy in the 'DICE' Model," *American Economic Review*, Papers and Proceedings, May 1993, pp. 313-17; Stephen C. Peck and Thomas J. Teisberg, "CO₂ Emissions Control: Comparing Policy Instruments," *Energy Policy*, March 1993, pp. 222-30; and Stephen C. Peck and Thomas J. Teisberg, "Global Warming Uncertainties and the Value of Information: An Analysis Using CETA," *Resource and Energy Economics*, March 1993, pp. 71-97.

⁹ In "The Social Costs of Greenhouse Emissions: An Expected Value Approach," Fankhauser did a comprehensive survey of the studies predicting the costs of carbon abatement policies to develop his range of estimates. In a more recent survey of the literature, Hope and Maul, "Valuing the Impact of CO₂ Emissions," confirmed Fankhauser's original range of estimates. None of these analyses considers increased CO₂ beneficial.

¹⁰ These estimates of benefits (damages avoided) are adapted from Stephen P. A. Brown and Hillard G. Huntington, "Some Implications of Increased Cooperation in World Oil Conservation," *Federal Reserve Bank of Dallas Economic Review*, Second Quarter 1998, pp. 2-9. Previous analysis suggests a flat marginal benefit curve. Summarizing the previous literature, Stephen

C. Peck and Thomas J. Teisberg, "CETA: A Model for Carbon Emissions Trajectory Assessment," *Energy Journal*, Vol. 13, No. 1, 1992, pp. 55-77, explain that marginal benefit costs are essentially unaffected by the emissions levels in any given decade. This conclusion rests on the finding that temperature change depends on gas concentration, which is not greatly affected by emissions levels in any given decade. I follow this characterization by assuming horizontal benefit curves that depict a constant level of benefits for any level of CO₂ abatement. Brown and Huntington derived the \$2.86 (in 1995 dollars) mean estimate per barrel of oil equivalent from Fankhauser, "The Social Costs of Greenhouse Emissions: An Expected Value Approach."

¹¹ The author developed the analytical framework and simulation model with Hillard G. Huntington of Stanford University. Many analysts use U.S. Department of Energy (DOE) projections as a reference standard for analysis, and the simulation model is calibrated to reproduce DOE's 1997 projections for world energy market conditions in 2010. The DOE projections represent one of many possible world energy outlooks for 2010. Additional parameters for the model were adapted from a variety of sources including an Energy Modeling Forum study, "International Oil Supplies and Demands," EMF Report 11, 1991, Stanford University, that compared 10 major world oil market models, as well as Douglas Bohi, *Analyzing Demand Behavior: A Study of Energy Elasticities* (Baltimore, Md.: The Johns Hopkins University Press for Resources for the Future, 1981); Brown and Huntington, "Some Implications of Increased Cooperation in World Oil Conservation," Stephen P. A. Brown and Mine K. Yücel, "Energy Prices and State Economic Performance," *Federal Reserve Bank of Dallas Economic Review*, Second Quarter 1995, pp. 13-21; James M. Griffin, "OPEC Behavior: A Test of Alternative Hypotheses," *American Economic Review*, December 1985, pp. 945-63; Carol Dahl and Mine K. Yücel, "Testing Alternative Hypotheses of Oil Producer Behavior," *Energy Journal*, Vol. 12, No. 4, 1991, pp. 117-38. Hillard G. Huntington, "Inferred Demand and Supply Elasticities from a Comparison of World Oil Models," in Thomas Sterner, ed., *International Energy Economics* (London: Chapman and Hall, 1992), pp. 239-61; and Hillard G. Huntington, "OECD Oil Demand: Estimated Response Surfaces for Nine World Oil Models," *Energy Economics*, January 1993, pp. 49-66, provide an overview of the Energy Modeling Forum study. The projected energy demand conditions depend on a variety of assumptions about economic growth and the extent of energy-saving technological change in the absence of price change. Cost estimates are obtained by computing the welfare costs of policies under which the United States works in concert with other developed nations to reduce global CO₂ emissions through fossil fuel conservation. The modeling framework allows world energy prices to adjust to the conservation of fossil energy to restore a balance between supply and demand conditions in each market. Analytically, carbon taxes are used to reduce the consumption of fossil fuels in the developed economies. The tax approach implies that an incentive to conserve is applied across all uses of fossil energy. Values from these simulations are used to construct marginal cost curves for U.S. abatement of CO₂ emissions. This methodology follows the welfare-theoretic approach previously employed by Stephen P. A. Brown and Hillard G. Huntington in "The Economic Cost of U.S. Oil Conservation," *Contemporary Economic Policy*, July 1994, pp. 42-53; "LDC Cooperation in World Oil Conservation," *Energy Journal*, Special Issue, 1994, pp. 310-28; and "Some Implications of Increased Cooperation in World Oil Conservation," and in Stefan Felder and Thomas F. Rutherford, "Unilateral CO₂ Reductions and Carbon Leakage: The Consequences for International Trade in Oil and Basic Materials," *Journal of Environmental Economics and Management*, September 1993, pp. 162-76. The resulting cost curves take into account a number of factors, including the direct welfare costs of U.S. conservation efforts, transfers of wealth between countries, the effect lower energy prices would have in stimulating energy consumption in nonparticipating countries and the economic cost of OPEC cartelization. The present analysis abstracts from a number of considerations featured in other studies of energy conservation. Michael Hoel, "Efficient International Agreements for Reducing Emissions of CO₂," *Energy Journal*, Vol. 12, No. 2, 1991, pp. 93-107; and David M. Newberry, "Should Carbon Taxes Be Additional to Other Transport Fuel Taxes?" *Energy Journal*, Vol. 13, No. 2, 1992, pp. 49-60, consider the effects of other taxes and redistributive policies. Peter Bohm, "Incomplete International Cooperation to Reduce CO₂ Emissions: Alternative Policies," *Journal of Environmental Economics and Management*, May 1993, pp. 258-71; Brown and Huntington, "LDC Cooperation in World Oil Conservation;" Johan Eyckmans, Stef Proost and Erik Schokkaert, "Efficiency and Distribution in Greenhouse Negotiations," *Kyklos*, Vol. 46, No. 3, 1993, pp. 363-97; Michael Hoel, "Global Environmental Problems: The Effects of Unilateral Actions Taken by One Country," *Journal of Environmental Economics and Management*, January 1991, pp. 55-70; Michael Hoel, "Efficient Climate Policy in the Presence of Free Riders," *Journal of Environmental Economics and Management*, November 1994, pp. 259-74; Alan S. Manne and Thomas F. Rutherford, "International Trade in Oil, Gas and Carbon Emission Rights: An Intertemporal General Equilibrium Model," *Energy Journal*, Vol. 15, No. 1, 1994, pp. 57-76; Heinz Welsch, "Incentives for Forty-Five Countries to Join Various Forms of Carbon Reduction Agreements," *Resource and Energy Economics*, November 1995, pp. 213-37; and John Whalley and Randall Wigle, "Cutting CO₂ Emissions: The Effects of Alternative Policy Approaches," *Energy Journal*, Vol. 12, No. 1, pp. 109-24, consider alternative policies for distributing conservation goals across countries and gains from cooperation. Felder and Rutherford, "Unilateral CO₂ Reductions and Carbon Leakage: The Consequences for International Trade in Oil and Basic Materials," and John Pezzey, "Analysis of Unilateral CO₂ Control in the European Community and OECD," *Energy Journal*, Vol. 13, No. 3, pp. 159-71, allow for different types of goods.

¹² This conservative assumption yields lower estimates of the costs than assuming the United States acts independently.

¹³ A policy is risk-neutral when the risks of overestimating the cost are equal to the risks of underestimating.

¹⁴ By 2010, if the U.S. takes no carbon abatement actions (a business-as-usual scenario), U.S. carbon emissions are expected to be 384 million metric tons greater than in 1990. Since under the Kyoto Protocol the U.S. is required to cut carbon emissions to 7 percent below 1990 levels, the U.S. would have to cut more than 478 million metric tons to meet Kyoto's requirements.

¹⁵ A recent report issued by the U.S. General Accounting Office found that the Department of Energy's Five-Lab Study, on which the Clinton administration based its free lunch negotiating strategy in Kyoto, was flawed. The GAO found that the study relied on unsubstantiated assumptions concerning the future competitiveness of wind and solar power and solar- and battery-powered vehicles. In addition, the study did not consider the full costs to the economy of the energy taxes that it suggested. Finally, it relied on implausible scenarios concerning the feasibility of near-term replacement of power plants and other capital. In short, all of the study's major assumptions were either unrealistic or overly optimistic. See "Climate Change, Information on Limitations and Assumptions of DOE's Five-Lab Study," GAO, Washington, D.C., September 1998.

¹⁶ See Stephen P. A. Brown, "Directions for U.S. Energy Conservation and Independence," *Business Economics*, October 1996, pp. 25-30.

¹⁷ Gordon Tullock, "The Welfare Costs of Tariffs, Monopolies, and Theft," *Western Economic Journal*, June 1967, pp. 224-32.

¹⁸ GDP loss estimates are obtained through elasticities that measure the sensitivity of aggregate economic activity to energy prices (i.e., the rise or fall of economic activity as energy prices rise and fall). The elasticities were chosen to represent the range of estimates from a number of prominent economic studies. See Bert G. Hickman, Hillard G. Huntington and James L. Sweeney, eds., *The Macroeconomic Impacts of Energy Shocks* (Amsterdam: Elsevier, North-Holland, 1987). Real GDP in 2010 (1992 dollars) is forecast to be \$9,171.9 billion. Population is forecast to be 298.9 million. Energy Information Administration, U.S. Department of Energy (1997), *Annual Energy Outlook*, U.S. Government Printing Office, Washington, D.C.

About the Author

Stephen P. A. Brown is Senior Economist and Assistant Vice President at the Federal Reserve Bank of Dallas. He holds a B.S. in economics from California Polytechnic State University and an M.A. and Ph.D. in economics from the University of Maryland. Dr. Brown is the author of numerous articles on economic policy, economic theory and business conditions. His research focuses primarily on energy economics and economic activity. His articles have appeared in such publications as *Business Economics*, *Energy Journal*, *Contemporary Economic Policy*, *Economic Review*, *Journal of Environmental Economics and Management* and *Southwest Economy*. His work has received national and international attention from academia, the business community, government and OPEC. He has been quoted in various regional publications, as well as *Business Week*, *The Economist*, *Financial Times*, *Newsweek*, *New York Times*, *Time*, *Wall Street Journal* and Marilyn vos Savant's book, *The Power of Logical Thinking*. He also has appeared on various regional broadcasts in addition to CNN's *Financial Report*, ABC's *Financial World*, the *McNeil/Lehrer Newshour*, Public Radio International's *Market Place*, and the PBS series *Man, Energy and the Environment*. He has made numerous presentations to academic, civic and professional groups including members of the British Parliament. Dr. Brown joined the Federal Reserve Bank of Dallas in 1981, after working as an energy economist for Brookhaven National Laboratory and teaching economics at several universities.

About the NCPA

The National Center for Policy Analysis is a nonprofit, nonpartisan research institute founded in 1983 and funded exclusively by private contributions. The mission of the NCPA is to seek innovative private-sector solutions to public policy problems.

The center is probably best known for developing the concept of Medical Savings Accounts (MSAs). Sen. Phil Gramm said MSAs are “the only original idea in health policy in more than a decade.” Congress approved a pilot MSA program for small businesses and the self-employed in 1996 and voted in 1997 to allow Medicare beneficiaries to have MSAs.

In fashioning the 1997 budget deal, members of Congress relied on input from the NCPA’s Center for Tax Policy. The Balanced Budget Act incorporated key NCPA ideas, including the capital gains tax cut and the Roth IRA. Both proposals were part of the pro-growth tax cuts agenda contained in the Contract with America and first proposed by the NCPA and the U.S. Chamber of Commerce in 1991. Two other provisions — an increase in the estate tax exemption and abolition of the 15 percent tax penalty on excess withdrawals from pension accounts — also reflect NCPA proposals.

The NCPA has also developed the concept of taxpayer choice — letting taxpayers rather than government decide where their welfare dollars go. Sen. Dan Coats and Rep. John Kasich have introduced a welfare reform bill incorporating the idea. It is also included in separate legislation in the House sponsored by Rep. Jim Talent and Rep. J. C. Watts.

Another important area is entitlement reform. NCPA research shows that elderly entitlements will require taxes that take between one-half and two-thirds of workers’ incomes by the time today’s college students retire. A middle-income worker entering the labor market today can expect to pay almost \$750,000 in taxes by the time he or she is 65 years of age, but will receive only \$140,000 in benefits — assuming benefits are paid. At virtually every income level, Social Security makes people worse off — paying a lower rate of return than they could have earned in private capital markets. To solve this problem, the NCPA has developed a 12-step plan for Social Security privatization.

The NCPA has also developed ways of giving parents the opportunity to choose the best school for their children, whether public or private. For example, one NCPA study recommends a dollar-for-dollar tax credit up to \$1,000 per child for money spent on tuition expenses at any qualified nongovernment school — a form of taxpayer choice for education.

The NCPA’s Environmental Center works closely with other think tanks to provide common sense alternatives to extreme positions that frequently dominate environmental policy debates. In 1991 the NCPA organized a 76-member task force, representing 64 think tanks and research institutes, to produce *Progressive Environmentalism*, a pro-free enterprise, pro-science, pro-human report on environmental issues. The task force concluded that empowering individuals rather than government bureaucracies offers the greatest promise for a cleaner environment. More recently, the NCPA produced

New Environmentalism, written by Reason Foundation scholar Lynn Scarlett. The study proposes a framework for making the nation's environmental efforts more effective while reducing regulatory burdens.

In 1990 the center created a health care task force with representatives from 40 think tanks and research institutes. The pro-free enterprise policy proposals developed by the task force became the basis for a 1992 book, *Patient Power*, by John Goodman and Gerald Musgrave. More than 300,000 copies of the book were printed and distributed by the Cato Institute.

A number of bills before Congress promise to protect patients from abuses by HMOs and other managed care plans. Although these bills are portrayed as consumer protection measures, NCPA studies show they would make insurance more costly and increase the number of uninsured Americans. An NCPA proposal to solve the problem of the growing number of Americans without health insurance would provide refundable tax credits for those who purchase their own health insurance.

NCPA studies, ideas and experts are quoted frequently in news stories nationwide. Columns written by NCPA experts appear regularly in national publications such as the *Wall Street Journal*, *Washington Times* and *Investor's Business Daily*. NCPA Policy Chairman Pete du Pont's radio commentaries are carried on 290 radio stations across America. The NCPA regularly sponsors and participates in *Firing Line Debate*, which is aired on 302 public broadcasting stations. The NCPA each year sponsors several one-hour televised debates on the PBS program *DebatesDebates*.

According to Burrelle's, the NCPA reached the average household 10 times in 1997. More than 35,000 column inches devoted to NCPA ideas appeared in newspapers and magazines in 1997. The advertising value of this print and broadcast coverage was more than \$90 million, even though the NCPA budget for 1997 was only \$3.6 million.

The NCPA has one of the most extensive Internet sites for pro-free enterprise approaches to public policy issues. All NCPA publications are available online, and the website provides numerous links to other sites containing related information. The NCPA also produces an online journal, *Daily Policy Digest*, which summarizes public policy research findings each business day and is available by e-mail to anyone who requests it.

What Others Say about the NCPA

"...influencing the national debate with studies, reports and seminars."

— **TIME**

"...steadily thrusting such ideas as 'privatization' of social services into the intellectual marketplace."

— **CHRISTIAN SCIENCE MONITOR**

"Increasingly influential."

— **EVANS AND NOVAK**