POLICY FORUM: CLIMATE CHANGE

Global Warming Economics

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In a surprising development, 178 of 179 countries decided at Bonn, Germany, on 23 July 2001 to move ahead with implementing the Kyoto Protocol. The sole holdout was the United States, which moved from being a leading advocate of global-warming policies under the Clinton administration to the lonely skeptic under the Bush administration. If all proceeds according to schedule, the Kyoto Protocol will go forward with all countries, other than the United States, implementing their original commitments. This Policy Forum examines the environmental and economic impact of the new agreement and compares it with the original Kyoto Protocol.

In addition to its original provisions, the Kyoto Protocol as revised in Bonn (the Kyoto-Bonn Accord) added two new items: First, countries are allowed to subtract from their industrial carbon emissions certain increases in carbon sequestered in "sinks" such as forests. These offsets are limited, however, to a total of 55 million tons of carbon per year for the period 2008 to 2012. Given that the total annual allowable emissions for that period are about 2500 million tons, this amounts to a relaxation of about 2% of emissions (all these numbers exclude the United States).

A second key provision involves the ability to trade emissions allowances (*1*). Economists have emphasized that allowing countries (and businesses inside countries) to buy and sell emissions allowances can reduce abatement costs by between 50 and 75%. Those who object to trading have argued that there should be limits on "supplementary measures" coming from purchased emissions permits or programs in developing countries. This issue remains unresolved except that no credits will be allowed for substituting nuclear for fossil power in developing countries.

The present analysis shows that the accord will accomplish relatively little in emissions reductions without U.S. participation—reducing global carbon-dioxide emissions by about 1% relative to no policy in the first period, 2008 to 2012. The United States was scheduled to bear the largest share under the original protocol, and its costs are now negligible. Notwithstanding its high costs, the accord may nonetheless be useful as an experiment in institutional innovation or as the first step toward more efficient approaches that rely on harmonized carbon taxes.

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Application of the RICE 2001 Model

To estimate the economic impact of the Kyoto-Bonn Accord, I have relied on an updated version of the "RICE" model (regional integrated model of climate and the economy) of the economics of global warming. The RICE model is an integrated assessment model that incorporates an eight-region model of the economy and greenhouse-gas emissions, along with a module for the carbon cycle and climate change. The model is based on a standard neoclassical growth model augmented by a climate externality and an environmental sector. Governments here reduce emissions either by using carbon taxes or through auctions of emissions allowances.

The structure is an updated version of the RICE-99 model called the RICE-2001 model. The new version uses the same economic and environmental structure as the original but incorporates two sets of changes (*2*). First, it updates the emissions and economic projections to reflect the latest data. The major changes are more rapid projected economic growth in the United States and Europe and slightly higher rates of autonomous carbon-saving technological change in the United States. Second, it runs the RICE-2001 model both with and without U.S. participation. Note as well that the simulations assume that the Kyoto limits extend beyond 2010 at the same level.

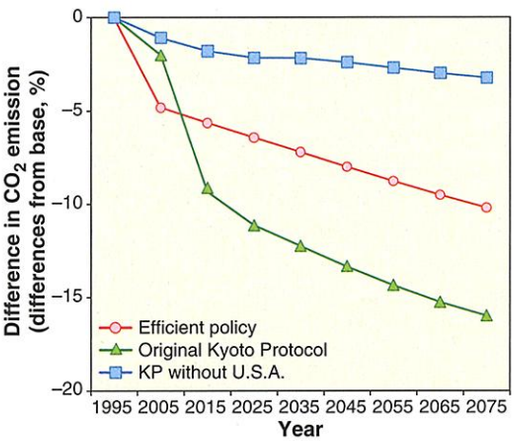

Fig. 1. Estimated emissions reductions under different scenarios. Numbers are for total global industrial emissions of carbon dioxide and measure the percent reduction relative to a "business-as-usual" path of no emissions reductions (or zero carbon emissions prices). The "efficient policy" path is one that balances estimated costs and benefits of emissions reductions. The "original Kyoto Protocol" shows the impact of the protocol with U.S. participation. "KP without U.S.A." shows the impact of removing the United States from the protocol. The estimates are for the decades centered on the listed year. Estimates do not include reductions in targets due to new provisions regarding sinks and other technicalities contained in Decision 5/CP.6, approved by the U.N. Framework Convention on Climate Change conference at its 15th Plenary Meeting on 23 July 2001.

Economic models, whether of the economics of global warming or of other phenomena such as business cycles, have great difficulty incorporating the many "frictions" that arise in real-world markets. In the present case, frictions are likely to plague the emissions market and to prevent equalization of carbon prices (that is, the prices of permits to emit carbon dioxide) in all participating countries and industries. Important frictions include impediments to trade, such as the limits on supplementary measures discussed above; the inability of countries to get full credit for "forestry" options if regulations are tightly written; limits on the sale of permits by countries to ensure that "overbooking" of allowances does not occur; and a host of features such as transactions costs, regulatory and tax differences, risk and uncertainty, and unfamiliarity. Such frictions will force carbon prices to diverge in different regions or industries and thereby lead to higher costs of attaining the accord's emissions reductions targets. Notwithstanding their importance, frictions are omitted from the present simulations.

The RICE model is but one of many that investigate the economic implications of climate-change policies. Modeling agreements such as the Kyoto Protocol is particularly challenging because the impacts depend upon the difference between targeted emissions and a highly uncertain variable—emissions in the 2008 to 2012 period. Like much forecasting in economics, the results should therefore be viewed as suggestive rather than definitive and continuously subject to revision as new information arrives.

Impact of the Accord

According to the RICE model, global emissions under the Kyoto-Bonn Accord will be very close to "business as usual"—global emissions in 2010 are estimated to be 1.5% lower than those in a scenario having no

controls if the new forestry offsets are ignored (Fig. 1) and around 0.8% of global emissions with forestry offsets (not shown). The reductions are less than half of those mandated by the original protocol. The less ambitious targets will be reflected in the carbon prices, where carbon prices are measures of the market prices and marginal costs of reducing carbon emissions in different countries. Carbon prices in the implementing regions are projected to be sharply lower under this version without the United States compared with the original version (Fig. 2), declining from around $55 per ton carbon in 2010 in the original version to around $15 in the Kyoto-Bonn Accord. (Of course, for the United States the decline will be from $55 to $0.) With the United States out of the picture, the price of permits in Europe falls dramatically (but emissions reductions also decline sharply).

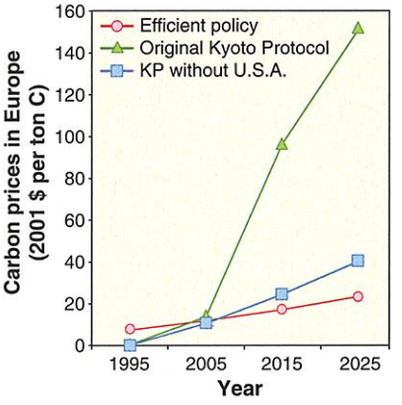

Fig. 2. Carbon prices in Europe and other countries implementing the Kyoto Protocol. Labels are as described in Fig. 1. Note: Emissions permits are "free" in developing countries under both versions of the Kyoto Protocol, and are "free" in the United States when it does not participate. Carbon prices are the estimated market prices of permits to emit carbon dioxide measured in 2001 U.S. dollars per ton carbon. These results assume full trading.

The impact of the U.S. withdrawal on abatement costs is striking (Fig. 3). Global discounted abatement costs (*3*) are projected to fall by 85%. Most of the decline is due to the nonparticipation of the United States, whose discounted abatement costs over the coming decades fall from $2.5 trillion to essentially zero. (On an annualized basis, the U.S. cost falls from approximately $125 billion per year to around zero.) Other countries' costs (or, in the case of Russia and Eastern Europe, benefits) fall significantly as well. The reason for the decline in costs, of course, is that the revised Kyoto-Bonn Accord achieves very little in emissions reductions.

For reference purposes, the figures also show the calculated "efficient" climate change policy. Economic efficiency refers to an outcome where emissions reductions and carbon prices are set so as to balance the marginal costs and marginal benefits of emissions reductions. As explained in the references in (*2*), determining efficient policies in this setting is extremely challenging, particularly because of uncertainties about future damages of climate change. The overall assessment of the accord is that it pays a high price for very small reductions in carbon emissions.

Conclusions

The Kyoto-Bonn Accord will make little progress in slowing global warming while incurring a substantial cost. But make no mistake: if the Kyoto-Bonn Accord is implemented as designed, there is trouble ahead. The accord is particularly optimistic in assuming that countries will willingly transfer tens of billions of dollars to Russia and other Eastern European countries to buy phantom emissions. It is likely to engender trade disputes because it widens the already large disparities in energy prices between Europe and the United States. Above all, it will lead to unrelenting pressure on the Bush administration to produce a serious policy to what it admits is a serious global issue.

Economic analyses of the accord have pointed to its inefficiencies, especially the shortcomings from using pure quantity-type instruments such as emissions constraints with no price caps or tax instruments (*4*). Given the accord's high costs and small benefits, it might be preferable to redesign the accord along the lines of a globally harmonized carbon tax (*4*).

Given the current emphasis on yet a different "global public good"—security from transnational terrorism—it seems unlikely that a grand coalition will be assembled in the near term to rewrite the rules on global warming. In this circumstance, the major merit of the new accord is that it is the first experiment with market instruments in a truly global environmental agreement. There is little appreciation of the importance of "institutional innovations" of this kind, and even less appreciation for the fact that there are no mechanisms for dealing with economic global public goods like global warming. For this reason, the Kyoto-Bonn Accord may be a useful if expensive guinea pig. Operating the Kyoto-Bonn mechanism will provide valuable insights on how complicated international environmental programs will work. It is hard to see why the United States should not join with other countries in paying for this knowledge.

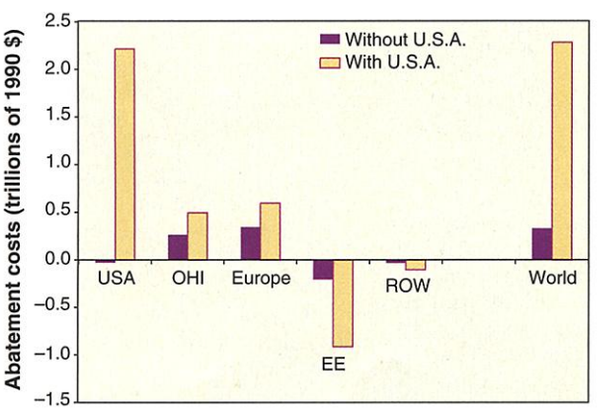

Fig. 3. Abatement costs of Kyoto Protocol for different regions with and without U.S. participation. Costs are the total discounted future abatement costs [for a definition of discounted costs, see (*3*)]. They assume that emissions targets are extended in future periods at 2010 levels. Abbreviations: OHI for other high-income countries (principally Japan, Canada, and Australia), EE for Russia and Eastern European countries, Europe for the European Union, and ROW for the rest of the world.

References and Notes

1. The relevant provision of the Kyoto Protocol states, "For the purpose of meeting its commitments under Article 3, any Party included in Annex I may transfer to, or acquire from, any other such Party emission reduction units ... provided that: ... the acquisition of emission reduction units shall be supplemental to domestic actions for the purposes of meeting commitments under Article 3." See www.cop4.org.
2. These runs were made with the RICE-2001 model, which is a slightly modified version of the RICE-99 model described in W. Nordhaus and J. Boyer, *Warming the World: Economic Modeling of Global Warming* (MIT Press, Cambridge, 2000). The methodology and results of the original runs are presented in chapter 8 of the book. The book is available in full in electronic form at www.econ.yale.edu/~nordhaus/homepage/dicemodels.htm. The version of the RICE-2001 model used for the base run of these calculations can be found under "RICE-2001: Science: baseline run" at that Web site.
3. Discounted abatement costs are calculated as the present value of consumption of different regions or countries over the next 30 decades discounted at a consumption discount rate of approximately 5% per year. Note that the very long time horizon is not essential to the results but is necessary to ensure that slight changes in the timing of abatement do not distort the measure of costs.
4. Like much environmental policy, the Kyoto Protocol relies primarily on "quantitative restrictions" in the form of emissions reductions. Such restrictions have the deficiency that the global constraints operate completely independently of the costs of meeting the constraints. Economists have pointed to the advantage of "price-type" regulations, particularly when there are many participants and many potential approaches for meeting the objectives. For a discussion of the pitfalls of quantitatively oriented approaches in the context of global-warming policy, see William Nordhaus, "After Kyoto: Alternative Mechanisms to Control Global Warming," June 2001, available at www.econ.yale.edu/~nordhaus/homepage/recent_stuff.html.
5. Development of the RICE-99 and RICE-2001 models was supported by the National Science Foundation and the Department of Energy.