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**THE NEED FOR BACK-UP STRATEGIES ON
CLIMATE CHANGE**

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Preface

The series of AECS White Papers are based on the assumption that human societies will not implement policies for coping with climate change until a critical mass of opinion leaders reaches consensus about the problem, about possible solutions, and about how solutions should be weighed against other valid concerns. Hence, strengthening the intellectual rigor of the policy dialogue is an essential first step toward finding and implementing solutions.

These papers are designed to offer the authors' judgments about the relative validity of various proposals and pieces of climate policy analysis. The intention is that the resulting controversy will clarify the issues. Although the reader will doubtless find many of the thoughts and theories implicit in the policy stance of AECS reflected in the analysis presented by the White Papers, the goal is more to elucidate a wide range of climate policy issues than to advance the cause of the particular policy preferences of AECS.

Progress in this endeavor is possible only because much excellent climate policy analysis is being done in academia and at a few of the many think tanks active on climate policy. The great difficulty is to make this sensible discourse audible above the noisy ideologically motivated cacophony. The AECS White Paper series will seek to highlight those areas where the academic literature can provide useful correctives to the "strong but wrong" arguments.

Executive Summary

INTRODUCTION

Even after a consensus on climate change mitigation finally emerges and is implemented among the most important developed countries, the most difficult work will still need to be done. The developed world cannot stabilize atmospheric concentrations of greenhouse gases while developing countries' emissions continue to grow. Moreover, the prospect of retarding the growth of greenhouse gas emissions in developing countries offers an opportunity for effective mitigation efforts sooner than would be likely if the effort had to be confined to developed countries. This paper looks beyond the current climate policy activity in the developed world to consider the longer-term prospects for climate change mitigation and possible fallback strategies if mitigation fails to avert harmful climate change.

CONTROLLING DEVELOPING COUNTRY GREENHOUSE GAS EMISSIONS IS CRITICAL

Efforts solely by developed nations will fail to stabilize global greenhouse gas emissions in the face of continuing business-as-usual emissions growth in the developing world. Therefore, a workable global system of climate change mitigation cannot succeed without strong developing country involvement. However, the refusal of most developing countries to commit to reducing greenhouse gas emissions growth constitutes a major roadblock to climate change mitigation. This roadblock diminishes the credibility of proponents of developed country action on climate.

CAN INDUSTRIALIZED COUNTRIES PAY DEVELOPING COUNTRIES TO REDUCE EMISSIONS?

The fact that developing country participation is essential for slowing the growth of greenhouse gas emissions does not necessarily mean that it will happen. All countries have an incentive to secure a free ride in the area of climate change mitigation. Mitigation is expensive, and the free rider cannot be excluded from any of the global benefits of others' mitigation efforts.

Developing countries, even more than most other countries, have economically rational and domestically politically popular reasons for preferring investments in economic development to investments in climate change mitigation. Given this reality, a successful international climate change mitigation settlement must induce the developing countries to substantially reduce the growth in their emissions in exchange for income transfers no larger than those that developed countries are actually willing to make.

The logic that explains why developing countries will have to be compensated for the costs of undertaking climate change mitigation also suggests that developing countries have incentives to insist on the highest possible price for each ton of greenhouse gas emissions to be reduced. Conversely, the difficult nature of the climate change problem, with initial costs and deferred, uncertain benefits, implies that developed countries will be willing to pay only a limited price for each ton of greenhouse gas emissions reduced.

CAN SANCTIONS SOLVE THE PROBLEM?

In theory, prospects for emissions reductions could be improved if developed countries could threaten to sanction those developing countries that refused to cooperate or insisted on excessive prices, as well as offer side payments for cooperation. Yet the willingness of developed countries to invoke such sanctions is likely to be limited because sanctions impose costs on the countries that impose them, as well as those subject to them.

Trade sanctions are the perfect example of the double-edged nature of a sanction strategy. If developed countries were to impose tariffs on exports from developing countries that remained recalcitrant on climate, it is developed country consumers who in the first instance would bear the cost in the form of higher prices. Industrial enterprises in developed countries seeking to expand into the rapidly growing Asian markets, especially those of China, may be equally injured. Many of these companies would be indifferent to the issue of climate, but fiercely opposed to the use of trade sanctions. Thus, attempts to use trade sanctions to enforce conformance with climate change mitigation will augment the ranks of the opponents.

THE NEED FOR BACK-UP STRATEGIES

The above discussion implies that welding international alliances and incentives into an effective emission control regime will be dauntingly difficult. Realistically global economic trends may far outpace the political effort to restrain the growth in emissions. If so, climate change would conceivably begin to impose serious costs. Yet rapid emission reductions are likely to remain difficult and expensive.

Thus, a realistic weighing of the political difficulties of emission control suggests the prudence of some considerations of back-up strategies. It is impossible to exclude the risk that climate change may prove to be more harmful sooner than is generally predicted. Thus, it is worth considering the possibility of fallback approaches that might be deployed if emission control strategies become hopelessly bogged down and delayed.

A detailed discussion of the pros and cons of such back-up strategies is beyond the scope of this paper. That at least two (not mutually exclusive) strategies exist is, however, worth mention. One possibility is preparing now to adapt to the more predictable kinds of climate change. But adaptation would be a far less adequate strategy should the climate system manifest a large and harmful discontinuity. In that case, it would be valuable to have a kind of relatively fast-acting climate change circuit breaker.

Several possible strategies have been grouped under the rubric of “geoengineering.” Although geoengineering strategies are speculative, a modest investment to explore them seems worthwhile. One analysis notes: “Such options include injecting particles into the atmosphere to increase the backscattering of sunlight and stimulating absorption of carbon in the oceans.” Geoengineering may not replace emission reductions as the preferred long-run strategy, but it deserves to be explored unless we are prepared to assign a zero probability to “nasty surprises” as a result of climate change.

Introduction: The Current Policy Impasse

THE NEED TO ACT

According to one of the most comprehensive economic analyses available, the present discounted value of the costs of global climate change amounts (in current 2002 dollars) to \$5 *trillion*.¹ At the same time, estimates of carbon emissions abatement costs are also very substantial. Another AECS white paper, “Costs of Greenhouse Gas Abatement,” discusses the evidence supporting these conclusions. Of course, neither the potential damages nor the likely costs of mitigation are large in comparison with future global economic output (to take as a metric an admittedly extreme upper bound).

Nevertheless, by less gargantuan standards, the problems of climate change and of finding cost-effective, rather than wasteful, solutions to it are important. Easy, however, they are not. This paper looks beyond the current climate policy activity in the developed world to consider the longer-term prospects. Its basic conclusion is that effective action to slow climate change will be long in coming. By inference, geoengineering alternatives, which manipulate the earth's climate through large-scale engineering technologies, warrant study as fallback measures.

THE CURRENT IMPASSE

In the United States, not even influential opinion leaders have concluded that the risk of global warming justifies paying the high costs needed to mitigate it. The evidence supporting this lack of consensus to incur costs in the cause of protecting the climate is overwhelming. The massive political unpopularity of the Kyoto Protocol in the United States is one illustration. The inability of the proponents of carbon controls for power plants to advance their agenda confirms that the problem extends well beyond the numerous flaws and defects of the Kyoto Protocol.

Even in Europe, the self-proclaimed leader on climate policy, a recent political analysis assessed the current situation thusly: "The European Union's climate policy is characterized by uncoordinated measures taken at [the] national level and a preference for inefficient instruments. The vanguard role taken by the EU in international climate negotiations stands in contrast to the lack of action in meeting far-reaching emissions-reduction targets on a European level."² Although a few individual EU states may be acting meaningfully, and perhaps more will in the future, when that may happen and to what degree remain speculative.

In both the United States and the EU, transformation of such a weak position into a social consensus will not happen swiftly. Consensus on controversial issues is usually slow to emerge even among opinion leaders, who are likely to decide well before the less attentive and less well-informed. Although events sometimes accelerate the emergence of consensus, various odd weather patterns have, so far, failed to evince rapid change in the attitudes toward climate, nor has the evolution of scientific thought on the subject.

THE REASON

Over a decade ago, Massachusetts Institute of Technology (MIT) political scientist Eugene Skolnikoff succinctly explained the root causes of what has become the climate policy impasse. He noted: "The central problem is that outside the security sector, policy processes confronting issues with substantial uncertainty do not normally yield policy that has high economic or political costs." Skolnikoff's statement is as true today as it was then.³ It is applicable to the climate issue, which remains bedeviled by the combination of potentially important, but uncertain, benefits and solutions that entail high costs and doubtful efficacy. To put the matter simply, the social consensus, without which societies are unwilling to bear significant costs, does not yet exist.

RESOLVING THIS IMPASSE WOULD BE ONLY A FIRST STEP

Even after such a consensus finally emerges and is implemented among the most important developed countries, the most difficult work will still need to be done in the future. The developed world cannot stabilize atmospheric concentrations of greenhouse gases while developing countries' emissions continue to grow. Moreover, the prospect of retarding the growth of greenhouse gas emissions in developing countries offers an opportunity for effective mitigation efforts sooner than would be likely if the effort had to be confined to developed countries. The evidence suggests that there are large opportunities for inexpensive emissions abatement in

certain developing countries while such opportunities are quite limited among developed countries.

Controlling Developing Country Greenhouse Gas Emissions Is Critical

NON-PARTICIPATION OF DEVELOPING COUNTRIES IMPEDES CLIMATE POLICY CONSENSUS IN THE UNITED STATES

Opponents of the Kyoto Protocol in both the United States Senate and in the Bush Administration cite the lack of prospects that the developing countries will act to reduce their emissions as a major justification. On the one hand, there is no possibility that developing countries will act to reduce greenhouse gas emissions if the United States does nothing to reduce its own emissions. On the other hand, even strong proponents of domestic action cannot deny that emission controls by the United States and other developed countries ultimately would be futile unless the developing countries eventually answered in kind.

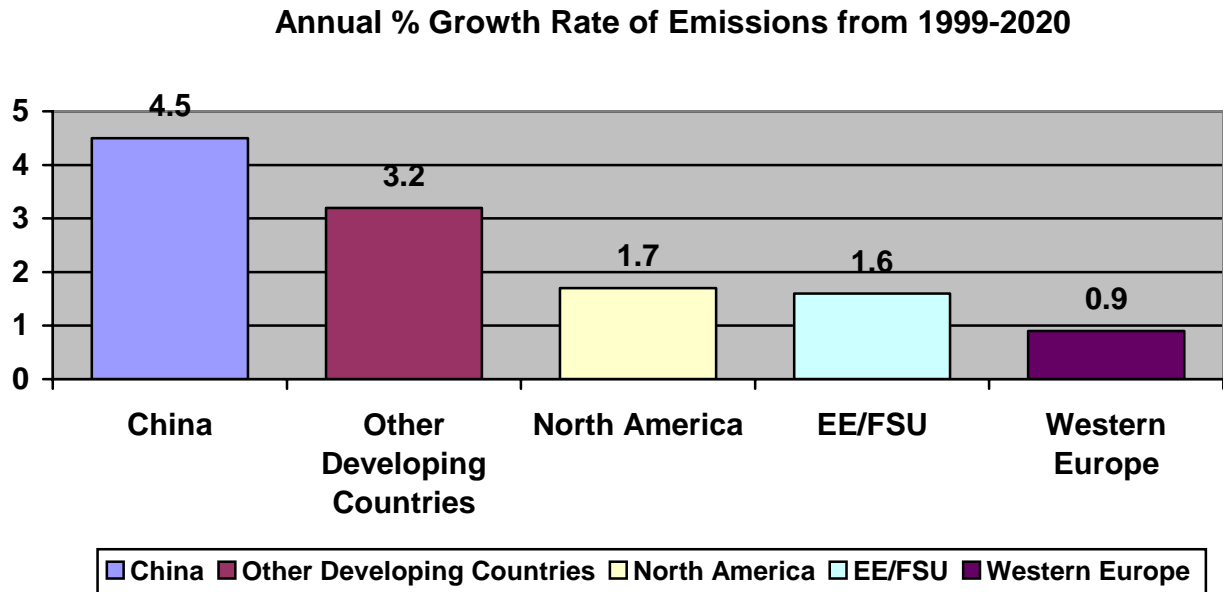
STABILIZING CONCENTRATIONS ABSOLUTELY REQUIRES DEVELOPING COUNTRY EMISSIONS REDUCTIONS

No amount of emission controls by Annex 1 countries — industrialized nations who have agreed to cap their emissions under the Kyoto Protocol — could stabilize global greenhouse gas concentrations without an active emissions reduction effort from developing countries.

Using the MIT integrated climate model, Zili Yang and Henry D. Jacoby found that *to stabilize global greenhouse gas concentrations at 550 ppmv while developing countries' emissions continued to grow at a business-as-usual pace, the Annex 1 countries would have to somehow achieve negative carbon emissions, that is, net storage, by 2035.*⁴ Assuming less ambitious targets for stabilization would only postpone the date at which the impossible would become imperative. Easier targets would not change the inherent unrealism of the approach.

Another illustration of the same point is that current projections show that although the United States is currently the world's leading source of carbon emissions, by 2020 emissions from the rapidly developing Asian countries will likely be almost half as large as those of the United States.⁵ Emissions from Mexico and the major economies of South America will be growing at between two and three times the annual rate of U.S. emissions.⁶

Figure 1.⁷



THERE ARE CHEAP TONS

The developing world is not only the location of the fastest growth in emissions, but also the place where emission reductions are cheapest. When a hypothetical ability to reduce emissions in developing countries is included in a mitigation strategy, the leading economic models all show that the costs of reducing emissions plummet to a mere fraction of what they would otherwise be.⁸ The least-cost path to reducing emissions is to seize the opportunity to reduce developing country emissions *before* these countries have invested in less-than-optimal technologies that already dominate the economic infrastructures of the developed world. Developed world emission reductions should be phased in more gradually to accommodate the retirement of these countries' large and valuable existing capital stocks.

Developing countries were they to adopt appropriate policies, could reduce their projected growth in greenhouse gas emissions without the high costs of retrofitting or even prematurely scrapping existing infrastructure, capital, or consumer durables. In countries where economic growth is rapid and little modern infrastructure is yet in place, replacing an old plant with a new one is likely to produce both emission reductions and economic benefits. Raising the energy efficiency of future investments above what they otherwise would have been, although not costless, would be much cheaper than retrofitting or scrapping already existing but relatively late-vintage plants that would be the only option in a developed country.

Another reason why it is cheaper to slow the growth of emissions in developing countries is that the developed countries often have very high taxes on energy. Developing countries often do not. In fact, they often subsidize energy use.⁹

Can Industrialized Countries Pay Developing Countries to Reduce Emissions?

CONFOUNDING WHO SHOULD PAY WITH WHERE ABATEMENT SHOULD HAPPEN

It is important to separate the issue of where emission reductions should take place from the issue of who should pay the costs of emission reductions. On the one hand growth in emissions can most cheaply be achieved in the developing countries. On the other hand, developing nations are clearly not going to incur the cost of foregone economic development that would be entailed by boosting fossil fuel prices to reflect the long-run risks of climate change.

The solution becomes obvious *in principle*, if not necessarily in practice. In order to stabilize atmospheric concentrations at even moderate levels, a large share of the change from business as usual levels must take place in developing countries. If those countries will not sacrifice economic growth for the sake of avoiding climate change, the developed countries could transfer enough income to developing countries to offset the economic sacrifices associated with emissions reductions. The discussion below, however, suggests that this task might be much harder to effect in practice than is suggested by the foregoing statement. In this way, the developed countries could reduce emissions much more cheaply than they could by confining their abatement initiatives within their own borders, and developing countries could be compensated for any sacrifice of economic growth.

Professor Robert Stavins of the John F. Kennedy School of Government at Harvard University has summarized the issue perfectly. The developing countries must assume an equal footing with regard to targets in the global emissions control regime. But they cannot be expected to pay the high costs of their own participation. “They must get on the train, but need not pay for their tickets.”¹⁰

EMISSIONS TRADING, CARBON TAXES, AND DEVELOPING COUNTRIES

Theoretically, either harmonized systems of emissions trading or harmonized carbon taxes could tap developing countries’ opportunities to inexpensively reduce emissions. In reality, attempts to extend emissions allowance trading to developing countries suffer from the legal systems of those countries that are insufficiently objective and transparent.

Economists debate the best approaches to solving these problems, but most believe that a substantial period of time would be required to work out a satisfactory system, particularly if it involved global trading of carbon emissions rights.¹¹ No doubt, some of these hypothetical arrangements are better than others, and time and resources will gradually erode purely technical problems. However, the mechanics of the eventual climate change mitigation regime are not the real issue. None of the various institutional options could be installed except as the technical superstructure resting on the foundation of what will necessarily be an immensely contentious *international political settlement*.

THE GENERAL INCENTIVE TO A FREE RIDE

The fact that a solution is theoretically available does not necessarily mean that it will happen. More fundamental than the institutional problems of verification is the challenge of reconciling the conflicting interests of all the nation states that must be induced to cooperate:

Climate change is truly a global commons problem. Because the location of greenhouse gas emissions does not affect the global distribution of damages, free riding problems plague unilateral or multilateral “solutions.” Further, nations will

not benefit proportionately from greenhouse gas abatement policies. In fact some countries – such as Canada and Russia - might experience no benefits from control since they actually stand to gain from climate change (due to the effects of increased temperature and precipitation on agricultural production.) Thus for some countries, costs of control may exceed benefits. This means that for a voluntary international mechanism to be successful, it must include a mechanism for transferring gains to countries that would otherwise not benefit from joining an agreement.¹²

In any negotiation to forge such an agreement, however, each country would have an incentive to shift the costs of emissions reductions onto others. So far, most developing countries have followed this approach.

INITIAL INCENTIVES OF DEVELOPING COUNTRIES

At first sight, this reaction seems to contradict the observation that climate change may eventually pose much harder challenges for developing countries than for developed countries.¹³ Nevertheless, developing countries' reticence about emissions reductions may be quite rational. Many poor countries may prefer to reduce their vulnerability to climate change by becoming richer and more economically developed than by reducing emissions. Economic development can diminish a country's dependence on agriculture, forestry, and other outdoor oriented activities. In so doing, it can reduce economic vulnerability to climate change. It may also provide additional resources that would allow new public works, enhanced public health infrastructure, or other investments that would assist in coping with the ill effects of climate change, but may also yield more ancillary benefits than would greenhouse gas emissions reductions.

By inference, developing country governments are acting rationally in their reluctance to act to reduce greenhouse gas emissions. Because their reluctance is rational, it will persist at least until developing countries' concerns about climate change become so intense as to rival their concerns about economic development, which will not be likely for a very long time.

CAN DEVELOPED COUNTRIES PAY CONTROL COSTS?

Developed countries could, in principle, solve this problem by paying developing countries just enough to offset the development losses associated with greenhouse gas emission abatement. This is the concept behind the Clean Development Mechanism developed in the Kyoto Protocol. In reality, this strategy is of limited applicability. Any system that rewards developing countries for reducing emissions below a baseline creates an incentive to overstate the baseline emissions in order to increase the size of the rewards. In a recent analysis, three economists have described the reasons for skepticism about proposals under which developed countries pay the incremental costs of emissions reductions:

This proposal, which looks like a win-win strategy for the developing and the industrialized countries without harming the environment, is actually inefficient. The reason is that this implicitly penalizes 'good' behavior and subsidizes 'bad' behavior. Hence, host countries gain from pretending not to care at all about energy efficiency. As a consequence, the net effect of actually reducing global CO₂ emissions will be small compared with the reported reduction. The likelihood of misrepresenting the true willingness to invest in energy efficiency by developing countries is increased by the fact that the industrialized country benefits from this cheating too. As a consequence, this proposal will presumably trigger little actual factual reduction in global CO₂ emissions.¹⁴

A country, or an agency overseeing this strategy may seek to curtail this strategic behavior, but it will always be at a disadvantage about what would have happened without the subsidy. Thus, controls will work very imperfectly by excluding some valid transactions and including some bogus ones. By the very act of attempting to control fraud, the agency will increase the transaction costs, reducing the attractiveness of the program as a whole.

Even more fundamentally, however, much of the developing countries' resistance to the introduction of policies to control emissions is likely to be based on politics, not economics. For example, removing energy subsidies, which still exist in several important developing countries, would benefit the economy as well as reduce greenhouse gas emissions. Yet subsidies persist because they serve useful political functions for the governments that provide them.

Removing energy subsidies and other policies to reduce greenhouse gas emissions implies a degree of interference with the lives of very large numbers of individual citizens.¹⁵ Yet especially in developing countries, “[s]tates often lack the capacity and legitimacy to effectively intervene at the local level.”¹⁶ Even with the help of money from abroad, these regimes may have insufficient governmental capacity and inadequate political legitimacy to impose effective emission controls.

The governments of developing countries are not generally subject to domestic political pressures on the subject of climate change. Transnational survey results and voting patterns both confirm that environmental concerns are highly correlated with income.¹⁷ Thus, these concerns are weakest in poorer countries. Furthermore, the example of India (where environmental concerns are highly localized) suggests that such environmental constituent pressures that do emerge in developing countries tend to be of a local nature.¹⁸

Suffice it to say that none of these barriers to the introduction of government policies to reduce emissions can be dealt with by developed country payments that offset the economic costs of emission abatement. Making such policies acceptable to developing country governments would require extra inducement, large enough to offset the loss of governmental popularity and legitimacy that is implied by imposing costs and interference on citizens who have no actual interest in climate change mitigation. This is the actual justification of these policies.

ARE SIDE PAYMENTS THE ANSWER TO POLITICAL COSTS?

Superficially, the problem presented by the *political* costs of emissions control policies would also be susceptible to a solution of side payments from developed countries to developing ones. Again though, political considerations counsel caution. As long as developing countries are unconstrained by domestic political pressure to act on climate, their incentive is to extract the maximum payment from the developed countries for the minimum acceptable emissions reductions. Indeed, even if developing countries were more concerned about climate than they currently appear to be, their best strategy, once the prospect of side payments had emerged, would be to conceal their interest.¹⁹

Moreover, no effective emissions reduction strategy is possible without the cooperation of the key developing countries, most importantly China.²⁰ As illustrated above, the developing countries' emissions are growing so fast that left unconstrained, they will swamp any emissions control efforts of the developed world. If the latter were to attempt to compensate by increasing the stringency of their own emissions control efforts, the result would simply be to accelerate the flight of energy-intensive industries to the developing countries — the problem referred to as “leakage.”

Furthermore, because the developed countries' willingness to transfer income to the developing world is demonstrably limited, there is a high likelihood that a rewards-only bargaining strategy would produce, at best, the most limited carbon emissions reductions. Richard Cooper has noted that the sense of international community is not great enough to sustain large international wealth transfers, "[I]ndeed it is not that great within the United States today."²¹

The problem of developed countries' willingness to transfer income to developing countries is especially acute in the most important case, China. It would be very difficult to win political acceptance in the United States for any program that transfers substantial amounts of wealth to China. After all, China is a country whose regional and perhaps global ambitions conflict with those of the United States. Its regime has characteristics inimical to American values on such issues as human rights, and its large and persistent current accounts surpluses with the United States seem guaranteed to generate persistent friction. It would seem fair to conclude that hypothetical emission rights trading schemes that would depend on large income transfers from the United States to China for their efficiency are no more than fairy tales for economists.

Thus, if only rewards are available for bringing large developing countries into an international emissions control regime, the results are likely to be extremely modest at best.

CAN SANCTIONS SOLVE THE PROBLEM?

SANCTIONS ARE AN OBVIOUS ALTERNATIVE

In theory, prospects for emission control policies could be improved if developed countries could threaten to sanction those developing countries that refused to cooperate or insisted on excessive prices, as well as offer side payments for cooperation. Without the developed countries being willing to at least *threaten* to sanction non-cooperators, developing countries would be foolish not to hold out for maximizing the gap between the actual costs of reducing emissions and the payments from developed countries for cooperating. The example of the Russian "hot air" deal in the Kyoto Protocol, and later even expanded in Marrakech,²² suggests that this strategy has some prospects of success at least with the Europeans.

The threat of sanctions, therefore, would be essential if the developing countries are to get significant emissions reductions within the constraint of their electorates' limited willingness to pay. It is conceivable that the sanctions may not actually have to be applied. But prudence would dictate that the developed countries not threaten sanctions unless they are actually willing to implement them.

A broad array of sanctions is available, in fact, to developed countries wishing to deter developing country non-cooperators or would-be exploiters of emissions rights market power. They include expressions of symbolic disapproval in areas such as the Olympics and other kinds of cultural exchanges. Government backing for actions such as consumer boycotts could both impose some costs and send signals about the prospects of other actions. International aid organizations such as the International Monetary Fund and the World Bank could be used to threaten the flow of non-climate related aid as a sanction for climate non-cooperation. Finally, some recent developments in the World Trade Organization seem to open a way for trade sanctions as well.²³

THE DISADVANTAGES OF SANCTIONS

Yet the willingness of developed countries to invoke such sanctions is likely to be limited because sanctions impose costs on the countries that impose them as well as those subject to them. Trade sanctions are the perfect example of the double-edged nature of a sanction strategy.

If developed countries were to impose tariffs on exports from developing countries that remained recalcitrant on climate, it is developed country consumers who in the first instance would bear the cost in the form of higher prices. Industrial enterprises in developed countries seeking to expand into the rapidly growing Asian markets, especially those of China, may be equally injured. Many of these companies would be indifferent to the issue of climate, but fiercely opposed to the use of trade sanctions, which might invite Chinese government retaliation directed at the Chinese operations of U.S. corporations. Thus, attempts to use trade sanctions to enforce conformance with climate change mitigation will augment the ranks of the opponents.

Not all of the costs are likely to be economic. The most important developing country emitters, China and India, are typically very important to the United States and the other developed countries for many reasons other than climate. Should the developed countries expend their limited ability and willingness to impose punishments on China and India on the issue of climate? How does the importance of the climate issue compare with those of discouraging international aggression, arms proliferation, illegitimate trade practices, or human rights abuses?

The more concessions demanded of such countries in the name of climate protection, the fewer that could be exacted in the other important areas of policy. Will the electorates of developed countries actually rank climate change high enough on their political agendas to ignore what would be inevitable charges of eco-colonialism? If they do not, the prospects for significantly slowing the growth in emissions become far dimmer.

IS THE WTO A MODEL?

Some observers have suggested that the gradual development of the GATT and then the WTO represents a template for climate protection. At the least this success story in long run institutional development, seems to suggest that something similar might be applied to climate. So even if it proves imprudent to use WTO rules to impose climate protection policies on the unwilling, the line of thought might run, perhaps the WTO experience contains hints about how to structure a separate climate regime.

Unfortunately a closer examination suggests that the WTO regime for enforcement works because it relies on features that are quite different than those inherent in the climate issue. In the case of violations of trading rules there are specific offended parties who acting on self-interest will undertake the burden of punishing rule breakers with retaliatory action. And the nature of rule breaking is concrete and limited so that it is possible to define proportionate sanctions.

Thomas Schelling has pointed out that an emission control regime does not have these advantages. Describing the WTO Schelling writes:

Because it is essentially a system of detailed reciprocal undertakings and because most infractions tend to be bilateral and specific as to commodities, offended parties can undertake retaliation and make the penalty fit the crime (thus exercising the principle of reciprocity). ... In contrast if a greenhouse-regime nation fails to meet its target, there is no particular offended party to take the initiative and penalize the offender – and if there were, it might be difficult to identify an appropriate “reciprocal” retaliatory” measure.²⁴

Thus it seems to be the case that the kind of challenge presented by a climate protection regime is inherently different from the kind of challenge presented by an international trading regime. And the latter provides no particular guidance for designing the former.

CLIMATE SCIENCE RESEARCH

Thus there are some modest steps that developed countries might take to encourage action by developing countries. The rich countries could impose domestic emission controls in order to set an example. But these controls would have to be very moderate to avoid creating incentives for the relocation of emission sources from developed to developing countries.

The developed countries can offer to offset some of the development penalty associated with imposition of emission controls in developing countries. But these efforts are likely to be plagued with a fair degree of inefficiency. And sanctions are unlikely to offer a remedy.

In some sense the best solution is the most obvious one. Developing countries must decide that emission reductions are in their own best interest. To the extent that improved understanding of the climate system and the economics of climate change confirms the view that developing countries are the likely first victims of climate change the problem of creating incentives for developing country emission reductions can be translated into the politically easier one of aiding them to take action. Developed country Investments in climate science may be the best strategy for encouraging developing country participation in emission controls.

OTHER IMPLICATIONS FOR RESEARCH PRIORITIES

EMISSION CONTROL MAY FALL SHORT

To sum up climate change mitigation absolutely requires a major emission control effort in developing countries. The developed countries will have to take the lead in creating the incentives needed to call forth this effort. It is unclear, however, whether the political will and skill to solve the myriad political problems implied by this task will in fact emerge.

Even if these political problems can somehow be overcome, avoiding the risk of harm from greenhouse gas emissions requires that global emissions eventually be confined to no more than approximately 40 percent of 1990 levels and kept there indefinitely. Realistically, then, global economic trends may far outpace the political effort to restrain the growth in emissions.

If so, climate change might begin to impose serious costs. The recent report of the National Research Council *Abrupt Climate Change: Inevitable Surprises* suggests that the record of past climate change demonstrates the possibility of abrupt climate shifts: "Large abrupt climate changes have repeatedly affected much or all of the earth, locally reaching as much as 10 degrees C change in 10 years."²⁵ Yet rapid emission reductions are likely to remain nearly impossible.

By inference it would be prudent to conduct research on back-up strategies that might be needed to restrain climate change or adapt to it on a time scale shorter than that possible with emission reductions. Two kinds of such strategies are worth considering, adaptation and geoengineering.

ADAPTATION

Adaptation implies finding ways of minimizing the net costs of climate change. Concretely there is a great deal of research that could be undertaken now that would make adaptation to climate change easier.

It [adaptation] means inter alia pushing ahead with both the basic science and applications of genetic engineering in many areas, especially agriculture, but also to provide potential substitutes for possible useful species that may be lost. That could be

supplemented by a systematic program for collecting, cataloguing and storing genetic material, mainly but not exclusively from plants, in the form of seed banks and DNA.²⁶

Other options that would aid adaptation would be to take steps to slow the rate of change, involving strategies such as massively seeding fast-growing tree species from the air while climate change extends the area that can support them. More unconventionally, it may be possible to fertilize barren portions of the ocean so that microscopic carbon-consuming plants may flourish.²⁷

While adaptation can certainly play an important part in coping with climate change, it has its limitations. For one thing, it is likely to work best if the climate change is rather slow and continuous. It seems a less satisfactory strategy should the climate system manifest some large and harmful discontinuity. In that case, it would be valuable to have a kind of relatively fast-acting climate change circuit breaker.

GEOENGINEERING

Several possible technologies have been grouped under the rubric of geoengineering. Whatever the terminology, as William D. Nordhaus and Joseph Boyer note:

A radical technological option would be geoengineering, which involves large-scale engineering to offset the warming effect of greenhouse gases. Such options include injecting particles into the atmosphere to increase the backscattering of sunlight and stimulating absorption of carbon in the oceans. The most careful survey of this approach by the 1992 report of the U.S. National Academy concluded, “Perhaps one of the surprises of this analysis is the relatively low cost at which some of the geoengineering options might be implemented.”²⁸

Several technologies have been suggested as possible ways to withdraw carbon from the atmosphere and to store it permanently in natural sinks. Similarly several technologies offer ways of increasing the reflection of sunlight away from the earth and thus offsetting the warming caused by increasing combinations of greenhouse gasses. (In addition to the injecting light scattering particles into the atmosphere it might be possible to position reflective materials in the atmosphere or even in space.

Obviously, the concept of geoengineering is, at this point, speculative. There is no solid proof that it would work or that it might not entail unacceptable side effects. However, having compared the costs of various emission control strategies with those of geoengineering, Nordhaus and Boyer conclude that: “The difference between the geoengineering results and the results for the other policies is so dramatic that it suggests that geoengineering should be more carefully analyzed.”

As the FCCC process evolved toward Kyoto, there was a tendency for discussion of geoengineering to fade from the policy debate.²⁹ But more sober evaluation of the prospects for action on emission control suggests that the issue of fallback strategies needs revisiting. It is not that geoengineering is likely to replace emission reductions as the preferred long-run strategy, nor is it that geoengineering approaches should be implemented soon. But geoengineering deserves a coherent, although not large, research program unless we are prepared to assign a zero probability to “nasty surprises” as a result of climate change.³⁰

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Endnotes

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- ² Axel Michaelowa, “The Political Economy of Climate Policymaking in the European Union” (Hamburg: Institute für Wirtschaftsforschung, nd), p.1.
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- ⁴ Zili Yang and Henry D. Jacoby, “Necessary Conditions for Stabilization Agreements,” (Cambridge: MIT Press, 1997), p.4
- ⁵ Energy Information Administration, *Energy Outlook 2002*, (Washington, DC: U.S. Department of Energy, 2001), p.189, Table A10
- ⁶ Ibid, p.189
- ⁷ Ibid, p.189
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