A BARGAINING FRAMEWORK FOR THE GLOBAL COMMONS

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ABSTRACT

The global commons represents a class of environmental problems that require international cooperation. Global environmental problems arise because the actions of some individuals or governments in one location hold serious implications for individuals and governments in other locations. There are global environmental policy problems because adversely-affected individuals (and governments) attempt to alter the behaviors of those responsible for global pollution.

We develop a framework with which to analyze such global environmental problems. Our goal is to craft a resource management policy that will satisfy both those who seek a change and those who prefer the current situation. This environmental incentive policy will align the interests of the two parties. Incentive alignment is the policy problem in the global commons. That is, we must find ways to align interests through realigning incentives for individual and group behaviors.

FOREWORD

This Working Paper is a product of the Environmental and Natural Resources Policy and Training (EPAT) Project funded by the United States Agency for International Development (USAID). EPAT is part of USAID's effort to provide environmental policy information to policymakers and practitioners in developing countries. The objective is to encourage the adoption of economic policies for promoting sustainable use of natural resources and enhancing environmental quality.

EPAT Working Papers are written for development professionals and policymakers in developing countries who are responsible for establishing and implementing policies on the sustainable use of natural resources and for civil servants, project officers, and researchers who are directly involved in the implementation of development activities.

This Working Paper deals with a class of environmental problems, called the global commons, that require international cooperation. They arise because the actions of individuals or governments in one location hold serious implications of individuals and governments in other locations. This paper develops a framework for analyzing such problems. The goal is to craft an environmental incentive policy that will align the interests of both those who seek change and those who prefer the current situation. Policymakers may find incentive alignment to be a useful strategy for modifying individual and group behaviors in order to deal with the problems of the global commons.

The contribution of USAID toward writing, printing, and distributing this document is estimated to be $8,000. The document is being distributed to more than 2,000 policymakers and

professionals in developing countries. We will assess its effectiveness by soliciting the views of recipients. An evaluation sheet is enclosed with each mailing of EPAT publications for that purpose.

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A BARGAINING FRAMEWORK FOR THE GLOBAL COMMONS

The global commons represents an environmental problem area that requires international cooperation (Bromley and Cochrane 1993). Individual and governmental actions in one location cause global environmental problems and seriously impact individuals and governments in other locations. Certain natural resource use threatens individual (and state) interests. There are global environmental policy problems because adversely-affected individuals (and governments) attempt to alter the behaviors of global polluters.

We develop a framework with which policymakers can analyze such global environmental problems. Our goal is to craft a resource

management policy that will satisfy both those who seek a change and those who prefer the current situation. This environmental incentive policy will align the interests of the two parties. Incentive alignment is the policy problem in the global commons. That is, we must find ways to align interests by realigning incentives for individual and group behaviors.

THE EMPIRICAL PROBLEM

We will focus on greenhouse gas emissions and their relationship to the world's forests. The link between the earth's atmosphere and forests is direct and critical to sustaining life. The interests of one group is at odds with the interests of another. Those who harvest trees and clear land for settlement in the Amazon Forest, for example, stand against those who seek to protect the forests.

The problem is global. For example, it has been estimated that: "...South and Southeast Asia contribute about 25% of the carbon dioxide emissions caused by burning wood, or about 6% of total carbon dioxide emissions (Archer and Ichord 1989: 13)."

The industrial world--with its fossil-fuel driven factories and automobiles--is a major contributor to the total annual production of greenhouse gases. It is reasonable to suggest that the wealthy citizens of the industrial North wish to protect the Amazonian "lungs of the earth" so it can process the carbon dioxide that arises from our self-indulgent lifestyle. Tropical forests have become a free waste-processing facility for richer nations--Japan and European and North American countries.

Human activities in the industrialized world generate large quantities of greenhouse gases. Tropical forests serve an important function by processing much of those gases. However, land uses in the agricultural tropics threaten the sustainability of that forest cover. These land-use decisions link agricultural nations with industrialized nations and their activities. Current energy consumption in the industrialized world imposes demands on the biosphere's resources, and tropical land-use activities threaten the sustainability of those resources. People in the industrialized North want to protect tropical forests to maintain the forests' ability to process their increasing greenhouse gas production.

Figure 1 shows the problem in simplified terms. (Graph will not transfer on internet. Please write to the author for a hard copy. See address at beginning of this paper.) In panel (a), Gs represents total greenhouse gas production from agricultural countries located in the southern hemisphere. Gn represents total greenhouse gas production from more industrialized economies primarily in Europe, North America, and Japan. For simplicity we will refer to these two general zones as North and

South or N and S.

G* represents the total level of greenhouse gas production that will not change the atmosphere's chemistry. Call G* the sustainable greenhouse gas level. The figure shows gas production from industrial nations holding constant into the foreseeable future. The figure also shows greenhouse gas production in the agricultural South increasing as those nations advance economically and as factories and automobiles become more common. Developing countries' increased reliance on fossil fuels can seriously impact carbon gas emission levels unless they also change their technology. For instance,

"...China's ratio of CO2 emissions to gross national product (GNP) is roughly five times that of Japan.... If China were to achieve even 60% of Japanese efficiency and carbon intensity levels in its new energy-producing and energy-consuming infrastructure, it could improve this ratio substantially in a relatively short time. The one major hurdle is obtaining the technical information, management assistance, and capital required to promote more efficient and less polluting supply and use of energy and other natural resources [Nitze 1990: 608]."

The line labeled G shows total greenhouse gas production over time (where G = Gn + Gs). The cross-hatched region in panel (a) shows excess gas production that the earth cannot absorb (G > G*). Here one sees the threat to both the industrial North and the agricultural South.

International efforts to impose a global production limit at G* would meet opposition from citizens in industrial nations because it would threaten their lifestyles. The industrialized world might argue that increased greenhouse gas production from the newly industrialized agricultural South has "created the problem." Similarly, a limit on total production concerns those in the agricultural South because it the industrial North might receive a more favorable allocation. Citizens in the agricultural South might argue that the rich wish to limit their (the southerner's) industrial ambitions.

There is something even more threatening in panel (a). Line G~ traces the earth's absorbent capacity for greenhouse gases assuming that industrializing southern tropical forests will include clearing and burning. That is, G* is no longer the long-run sustainable capacity to process greenhouse gases. Clearing Amazonian forests drives the absorbent capacity down to G~ . The shaded region in panel (a) shows the processing deficit resulting from land use changes in the southern agrarian nations. Together, the two marked areas between G and G~ show that excess greenhouse gases may significantly change the global climate.

Panel (b) illustrates a policy that cuts excess production. To do this, the industrial North must reduce total greenhouse gas production at the same rate as the newly industrial South increases production. Then total greenhouse gas production from both regions matches the predicted absorbent capacity (G = G*). As the South industrializes, it reduces forest cover so the

actual processing capacity is less than predicted ($G\sim < G^* = G$). A processing deficit still exists. As drawn, the industrial North, because of stricter environmental policies, has cut its total greenhouse gas production below that in the newly industrial South.

In panel (c), we do not assume massive forest clearing in the industrializing South or that compensating reforestation occurs in the North. So G^* remains the absorbent greenhouse gas capacity, and total global production matches that capacity. The hard part remains. How do we restructure international resource management policy to achieve the result in panel (c)?

There are two aspects of this challenge. First, there is the problem of agreement between these two artificial regions, "North" and "South." That is difficult enough. The second problem will concern changing behaviors of individuals within the two regions. To avoid discussing differing interests among countries, we will regard the "North" (N) as one state and the "South" (S) as another. This does not change the nature of the basic bargaining problem but simplifies it by reducing the number of policy units.

To simplify further, the policy problem of the global commons is finding incentives that will align the interests and, thus, individual behaviors in the North and South. That alignment of interests will become apparent when individuals agree to choices that will reduce two tendencies. The first tendency is one that threatens the earth's capacity to process greenhouse gases. In this paper, we consider the world's forests essential to that global absorbent capacity. For simplicity, we will focus on the Southern deforestation problem.

The second tendency is one that threatens to increase total greenhouse gas production in both regions. Notice that the physical aspects of atmospheric chemistry link individuals in both regions. More individual greenhouse gas production in the North, or South, increases the economic value of the forests.

Higher total greenhouse gas production in both hemispheres will reduce absorbent capacity. The resulting accelerated climate change will impose greater costs on the world. To avoid that climate change, the two regions will need to undertake expensive alternatives to the forests' processing capacity. Continuing to reduce the Amazonian forest and holding total greenhouse gas production at its present level, without other compensating reforestation, will carry serious costs.

We assume that tropical and other forests provide a resource service, waste assimilation, at a lower cost than alternative technologies. The only "cost" of using the forests for this purpose is preserving them. The cost then is that people cannot use the forest area in alternative ways and still maintain it. We are assuming that tropical forests are important assets in their own right, besides acting as greenhouse gas processors.

The policy problem requires introducing an action-forcing event.

Without it, there is no reason the current resource management policy cannot continue despite increasing evidence of higher greenhouse gas concentrations. We will begin by assuming that one of the governments (either N or S) determines that it is desirable to stabilize greenhouse gas production so total production balances with the earth's processing capacity. Panel (c), figure 1 shows G = G*. The government could make this decision autonomously or be "forced" into the decision by a rising internal political force. In November 1990, in Geneva, several industrial world governments agreed to stabilize total greenhouse gas production. The 1992 Rio Earth Summit carried this commitment one step further.

AGENCY THEORY AND BILATERAL NEGOTIATIONS

One possible mechanism for addressing greenhouse gas problems is to imagine that some international organization, for example the United Nations, receives the authority to impose emissions standards on all nations. Because of the historical experience with mandates from such organizations, we need to be cautious about the prospects for successfully enforcing emission standards.

Another method is to approach the greenhouse gas problem in a bargaining framework. We follow this argument and apply the economic model of agency (explained below) to the global commons problem. The usual examples in agency theory concern the problems of team production where monitoring costs of individual efforts are high. The standard employment contract embodies the essence of the agency problem. In this paper, we will apply agency theory both to the relationship between individuals and the state and to the relationship between one state and another.

The logic for this approach is straightforward. The legal foundations of an economy define a domain of individual choice for each of us. The presumption is that on the whole, these millions of independent choices will be in the "public interest."

This insight of Adam Smith and a policy of non-interference still requires that we recognize that markets cannot function without a clear and precise definition of who owns what (property rights), who may do what to whom (civil and criminal law), and who must pay whom to protect their interests (contract law). (So called "free markets" are clearly not free of collective definition of the choice range open to market participants (Bromley 1989).)

Assume that it is the government of N that seeks a new resource management policy to achieve sustainable greenhouse gas production as in figure 1 panel (c). In agency theory, we talk of the principal and of the agent. It is the problem for the principal to design an incentive policy that will align the agent's interests with the principal's.

Consider a simple example. A family may wish to have a neighbor's child weed their garden. However, the child will be working while the family is away for three weeks. The gardener is the principal; the child is the agent. The gardener problem is to design an incentive scheme that will align the child's interests with the gardener's own interests. Put more directly, the gardener wishes to design a compensation system so the child will carry out that task exactly as the gardener wishes.

Imagine the gardener says to the child: "I will pay you $1.00 per day to weed my garden. When I return in three weeks I expect to find the garden weed free. I will then pay you for the total days you worked." It is obvious that this scheme has an inherent incentive alignment problem. The gardener wants to have the garden weeded at the least possible cost. The child wants to earn as much money as possible. A person can easily imagine that the youngster has a strong incentive to inflate the actual time involved. It is also possible that this payment scheme will influence how aggressively the child works. The child may report days worked honestly, but how hard did she actually work during those days? Or, she may pull the weeds on the final day of the gardener's absence, meaning that the garden is weed free but that the plants are stunted. This payment scheme leaves the gardener bearing all the uncertainty.

An alternative, but impractical, payment scheme would be to pay the child a "piece rate," an amount per weed pulled. The monitoring costs of this approach are prohibitive. The obvious compromise is to pay her for the entire job. Both the child and the gardener will share the uncertainty. The gardener must estimate, from experience, how many hours the job might take. The child must also calculate the estimated hours. To maximize earnings per hour, the child has an incentive to work fast. However, the gardener has an incentive not to underestimate. Otherwise the child will not accept the job or may work so fast as to be careless. This compromise aligns the interests of both.

The gardener wants to have a weed-free garden and pay a "reasonable price" for it. The child wants to earn a fair wage yet have enough time to do the job well.

Many such services--leaf raking, lawn mowing, and house painting--operate precisely on this basis. The policy problem in garden weeding is to align the interests of the principal (the gardener) and the agent (the weeder). Agency theory deals with precisely this problem, whether applied to gardeners, home owners, business owners, or state governments.

Returning to the global commons problem, consider the government of N that faces two "agency" problems. The first is to induce its own citizens to alter their behavior in producing greenhouse gases. Call this the domestic policy problem for N. The second agency problem concerns the government of S. That is, how can the government of N induce the government of S to limit individual citizens' choices (individual decisionmakers) in S? Call this the international policy problem. This hierarchical

agency problem has two "agents"--the government of S and the citizens in S. That is, the government of N is the principal to its own citizens as well as to the government of S. Note that the government of S, besides being an agent for the government of N, is a principal for its own citizens (who are, in turn, agents to the government of S).

Government of N
Principal to its citizens and to S

Citizens in N
Agents to N

Government of S
Agent to N; Principal to its citizens

Citizens in S
Agents to S

Within this hierarchical problem, we assign to the government of N the role of ultimate principal, recognizing that wealth affords N greater freedom in action. Thus, the event that forces action and leads to a policy initiative will most likely be found in N.

This event may be that scientists in N have discovered that trends in atmospheric greenhouse gas levels may seriously impact life, particularly in the industrialized world. This revelation focuses public attention, in N, on the issue. The result is that the government of N declares that it seeks to change the resource management policy that over produces greenhouse gases.

While there may be public concern about greenhouse gas production, we assume it is unimportant to many individual citizens of both N and S. This is because an individual contributes only minimally to the problem. It is the cumulative effect that concerns us. There is no great incentive for an individual to alter behavior. Indeed, there may be strong incentives in other directions, particularly in S. The government may want to increase economic development at the expense of the tropical forests (and their processing services). That policy would also increase greenhouse gas production through accelerated industrialization.

As the principal, the government of N is not only challenged to modify the millions of individual decisions within N but to do the same within S. The difference lies in the inability of the government of N to develop direct behavior modifying policies in S. Generally, without applying direct physical force against S, the government of N may only develop policies that affect S at the border. The government of N must work through the government of S to encourage policies that require internal enforcement or other action. Therefore, the government of N faces both a domestic and an international problem.

THE DOMESTIC POLICY PROBLEM

Initially, certain individuals in N can ignore the interests of others in N who care about total greenhouse gas production. In more formal language, we would say that those concerned about high greenhouse gas production have no rights, while those well served by the current resource management policy have privilege (Bromley 1991: 17). By privilege we mean individuals can act without regard for others. If those alarmed about greenhouse gases were to take legal action to prevent continued emissions, the court would say, "Sorry, there is no law against the greenhouse gas production. You have no right to seek relief."

Current resource management policy is that the air is an open access resource. Anyone who wishes to partake of its services may do so freely. The costs that arise from greenhouse gas emissions are of little concern to those responsible. Of course, some citizens in N care about such emissions. They have tried to pressure their government to change the current resource policy. As noted, the court told them that they had no right to prevent such emissions.

We can define the domestic policy problem concerning greenhouse gas emissions in terms of a change in the air resource policy. Those now in a situation of no right gain a right, and those now with privilege gain, instead, duty. That is, the policy changes the economy's legal structure so that those with air emission privileges acquire a duty to consider the harm their emissions are causing others. The state may set limits on gas emission limits or ban them altogether. It may require compensation for greenhouse gas emissions, perhaps in taxes. The state may also offer subsidies to encourage change to cleaner technologies. In the language of resource policies, the state can use various actions to create rights and corresponding duties. They include:

* a right to be free of emissions and a duty to refrain from emitting them,
* a right to compensation and a duty to pay it,
* a right to receive funds to purchase cleaner equipment and a duty to provide those funds by paying taxes.

In each case, the government's aim is to alter the resource policy structure to realign incentives and encourage particular actions.

Consider the air emissions policy example in southern California.

It incorporates a variety of incentive realignment measures. The state established a greenhouse gas emissions ceiling for firms but permitted them to meet this ceiling several ways. The Amoco oil company delayed reducing its own emissions by purchasing older, heavily polluting automobiles from individuals. This enabled the individuals to purchase newer and cleaner cars. By

eliminating Amoco's privilege to emit greenhouse gases and by replacing that privilege with a duty to respect newly established rights to be free of such gases, the government redefined Amoco's economic environment. The government did not, however, simply specify levels of gas particular Amoco factories could emit. Instead, it specified a broad emissions limit that Amoco was free to meet in several ways. Amoco found it cheaper to cut emissions from older polluting automobiles than to refit its refineries. Amoco met the goal, of both citizens and the government, at a presumably lower cost than they could have if the government simply mandated that all emissions reductions take place in Amoco factories.

In the preceding agency examples, the principal could manipulate the agent's actions by offering or withholding various forms of payment. It was the payment form that was particularly interesting. By changing the form of payment the principal was able to minimize monitoring and enforcement costs. In domestic policy, the government of N faces a similar problem. While it can enact a resource policy with new rights and duties, its form will have important monitoring and enforcement implications. Consider a hypothetical example in which the government fails to give adequate attention to monitoring and enforcement costs.

Suppose the government requires people to stop driving their automobiles once they emit a certain amount of emissions that year. The advantages of cheating, particularly for the poor who could not easily afford to purchase cleaner cars, would be great.

To enforce such a policy, the government would need to take three steps. It must require meters on all vehicles. It must inspect all vehicles to assure that people did not operate them beyond the mandated limit. And it must conduct additional inspections to assure that vehicle operators did not tamper with emissions meters. The cost of such a policy would be prohibitive.

As an alternative to emissions management at the individual vehicle owner level, government might alter incentives to vehicle manufacturers. The government might require manufacturers to install catalytic convertors to reduce emissions. And it could easily monitor their presence before vehicles are sold. Of course, that does not completely eliminate monitoring and enforcement problems. Not only would the new policy require frequent exhaust inspection, but the government may also levy stiff fines on those who disconnect (or tamper with) their vehicle's catalytic converter. These inspections and litigations have costs that the public must pay to maintain the resource policy.

THE INTERNATIONAL POLICY PROBLEM

Two general strategies are available to N at the international

level. One involves the creation of an authority that could mandate and enforce policies in both N and S. The authority of this organization would supersede that of both the N and S governments. The policy actions available to this organization would be little different from those previously mentioned. This approach would end the hierarchical nature of the agency problem since this authority would not need to work through the governments of N and S. It could presumably implement policies directly affecting individuals in both states. The absence of this organization, and the difficulties faced by international bodies such as the United Nations, reveals the difficulties of establishing an authority that presently sovereign states would accept as a ruling body.

Without an international authority, the problem of the global commons remains hierarchical. To change individual behaviors in S, the government of N needs to work through the government of S.

The government of N does not have the authority to change the behavior of citizens in S. So, policy methods appropriate to the government of N in domestic policy are not available. We must find new methods to align incentives. Decisionmakers must coordinate the policies within N with policies between N and S. They must consider the problems S will face when implementing such policies at its own citizens' level. We consider two aspects of this problem, the first relates to efficiency concerns, and the second relates to a possible hierarchical bargaining solution.

Efficiency

In figure 2, we consider the relationship between actions in N and S. (Graph will not transfer on internet. Please write to the author for a hard copy. See address at beginning of this paper.) Consider panel (a) of figure 2. Here we show, as in figure 1, the earth's sustainable assimilative capacity for greenhouse gases, G*. The curve Gn shows emissions over time in N assuming N begins effective domestic policies. Notice that the policy path in N is a function of the policy path in S, and vice versa. That is:

* if the total production of greenhouse gases (G*) has been identified as the policy target,

* then it follows, by definition, that $Gs^*|Gn = G^* - Gn$,

* where Gs* is the policy target level of greenhouse gas production in S, and

* where G* is fixed because the area of tropical and other forests remains constant at its current level.

We will assume that an integral part of any policy agreement between N and S entails maintaining the earth's assimilative

capacity at present levels by preserving existing forests. We, therefore, leave it to others to argue the questionable merits of relying on "backstop" technologies that might replace the earth's forests. We also assume for the moment that S responds to the emissions level of N to meet policy goal G*, leaving aside for the moment why S might do so.

The distance (G* - Gn) between the two curves in panel (a) of figure 2 represents the assimilative capacity for greenhouse gases available for use by individuals in S. Notice that should the government of N have a more lax policy regarding greenhouse gases, then the production path Gn' applies. The obvious implication is that total production of greenhouse gases from S must be significantly less under Gn' than would be possible in N.

That is, total "allowable"greenhouse gas production from S is now given by:

Gs*|Gn' = G* - Gn'
where Gn' > Gn

Panel (b) of figure 2 shows these two situations as Gs*|Gn and as Gs*|Gn'. These two functions suggest a policy domain for the two governments. If we think of:

* the function Gn' as depicting the most lax feasible policy outcome in N,

* and the function Gn as depicting the most severe yet still feasible policy outcome in N,

* then these two outcomes represent, in essence, the range of bargaining open to the government of N in its discussions with the government of S.

By similar logic, the government of S will regard the two functions Gs*|Gn and Gs*|Gn' as defining its own bargaining domain, given the two constraints that:

* the total area of tropical and other forests remains at its current level, and

* S responds to N to meet the G* policy.

Another way to regard this bargaining domain between Gs*|Gn and Gs*|Gn' is to consider the difference in costs that will fall upon individuals in S if the governments of both N and S try to set a resource management policy in S as a function of Gn' rather than of Gn. We show that extra cost in panel (c) of figure 2. We may expect that this amount represents the minimum willingness to accept compensation on the part of the government of S for adopting a sustainable resource management policy regarding greenhouse gases. That is, if the government of S is to preserve its tropical forests and require its citizens to reduce greenhouse gas production, it will insist that the government of N recognize the costs of pursuing a more stringent policy that fits N's domestic policy.

In panel (c) of figure 2 C(Gs*|Gn), the lower curve, represents baseline costs within S of maintaining the tropical forests in their rather pristine condition to process greenhouse gases. We base this lower-cost view on the assumption that a Gn emissions policy exists in N. Then S must absorb its forest preservation costs but can pursue a lax greenhouse gas emission policy. If, however, N pursues a less stringent emissions policy of Gn', then S must absorb higher emissions control costs to meet the overall emissions policy of G*. The upper curve in panel (c) of figure 2 represents higher costs in S. The difference in costs is the extra amount S is likely to demand from N. This would happen if the government of N fails to impose upon its own citizens a strict emission reduction policy. These higher costs in S result from N's failure to do all it can to solve the greenhouse gas problem.

Figure 3 shows the bargaining domain for the governments of both N and S. (Graph will not transfer on internet. Please write to the author for a hard copy. See address at beginning of this paper.) In panel (a), we show the present-valued costs of various reduction levels in the total greenhouse gas production from S. As greenhouse gas emissions increase along the horizontal axis, the present-valued cost of emissions reduction decreases along the vertical axis. Figure 3 also shows the fixed tropical forest maintenance cost to S at a level of Ts. In panel (b), we show the same relationship for N though we assume N is not incurring its own forest maintenance costs. We show the sustainable emissions policy G* for both states. It is a function of the forest cover Ts. Thus, if we alter the level of forest cover in S, then the positioning of G* also would change.

The relationship between figures 2 and 3 is critical for policy formulation between N and S. We can see this by placing panels (a) and (b) of figure 3 together. Invert panel (a) and place it on top of panel (b) so that the cost curves are tangent. The horizontal dimension then is equal to policy limit G*. Along the lower abscissa (NG*), the far right point (G*) shows the situation if N could use all of the greenhouse gas assimilative capacity. Individuals in S would not have any access to that assimilative capacity. Similarly, along the upper abscissa (SG*) we see the situation again at G* if S could use the entire atmospheric assimilative capacity. This assumes N will not emit any greenhouse gas. The left and right ordinates show, respectively, the present-valued costs to N and S from reductions in their citizens' greenhouse gas production.

We can next consider the two levels of greenhouse gas production within N from before. We continue to assume that S will maintain its forests at a level Ts as in panel (a), now represented by the dashed horizontal line in panel (c). We also continue assuming that S will respond to emissions from N to meet policy goal G*. Thus emissions from S are determined by emissions from N. If N pursues a rather lax greenhouse gas policy, earlier referred to as Gn', it will be necessary for S to pursue a very restrictive policy of Gs*|Gn' with implied costs for S of C(Gs*|Gn'). This domestic policy is very expensive for S (reading down the right ordinate) but cheap for N (reading up the left ordinate) since

N's costs will be only C(Gn'). Alternatively, if N pursues a more restrictive domestic policy regime, earlier referred to as Gn, then N's costs will be much higher, C(Gn), while costs to S will be considerably less, C(Gs*|Gn).

The cooperative efficient policy to pursue is one in which marginal (not total) costs of emission reduction are the same between the two countries. We define efficiency as that level of emissions where neither state is willing to pay the amount required to induce the other to reduce emissions further. Since the curves Cn and Cs are the total costs of emission abatement, we know that their slopes are the marginal cost of greenhouse gas abatement. We also know there is a unique point at which the slopes of Cn and Cs are identical when G* is satisfied (along a vertical line through the box). This is also the point of tangency between Cn and Cs when we align panels (a) and (b) as in panel (c). That point yields the efficient level of reduced greenhouse gas production for the two states. For N the efficient production level (or, conversely, abatement) is at Gn."

Hence the efficient level for emission reductions in S is at Gs*|Gn." Here C(Gn") shows the costs for N, while C(Gs*|Gn") shows the costs to S. There is no other possible cross-state production and abatement distribution that will cost less. Of course "efficiency" as determined here is silent about each region's capacity to incur these reduced production costs.

Feasibility

And this brings us back to our hierarchical principal-agent problem. We have repeatedly assumed that S will follow a policy of maintaining its forests at a level Ts and respond to N's emissions level to satisfy the policy G*. But it may not be in the interest of S to do so unless N takes further action.

We assume that N is the principal in seeking a new resource management policy more to its liking and that S is the agent. But of course the government of S is also the principal regarding its own citizens. The early resource management policy, in which N must persuade the citizens and government of S to incur costs of C(Gs|Gn"), requires some sustainable agreement. N must be able to count on S ensuring that its new environmental policies both sustain the tropical forests and persuade or require its citizens to reduce their total greenhouse gas production.

As noted earlier, unlike domestic policy for N (or S), international policy has no authority system that can force the government of S to abide by the interests of the government of N.

But, the two governments have mutual interests. The problem here is to explore their nature and extent. Let us assume that the government of S has scant interest in preserving the tropical biomass. Preserving such forests may not allow the government to earn large amounts of foreign exchange. Biomass preservation

also may force the government of S to undertake other economic development policies to address the problems of landless peasants wanting new land.

Indeed, preserving tropical forests may require the government of S to seize large estates of wealthy ranchers and redistribute them to the landless. The tropical frontier provides a "safety valve" allowing the government of S to offer land to the poor without confronting the landed gentry.

Preserving the present tropical forest cover is largely a goal of the principal not the agent. The problem is that the forest of interest to the principal (N) lies within the sovereign territory of the agent (S). We must remember that this "problem" would not be so pressing if the principal had not already cut most of its own domestic forests. We have assumed there is no motivation within S to preserve the forest at the level Ts specified in figure 3 panels (a) and (c). Figure 3 panel (c) is the same as figure 4 panel (a), with the addition of a new, lower level tropical forest cover, Ts-, that S must maintain. (Graph will not transfer on internet. Please write to the author for a hard copy. See address at beginning of this paper.) The government of N could persuade S to preserve its forests at the higher level TS by paying C(Ts) - C(Ts-). Further payment of C(Gs*|Gn") - C(Ts) also would be necessary to persuade S to reduce emissions to the efficient level. We are assuming S otherwise would be unwilling to take emissions-reduction measures. Finally, N would acquire costs C(Gn") to persuade or compel its own citizens to reduce emissions to the efficient sustainable level.

Figure 4 panel (b) shows the outcome if N does not adopt a policy of payments to S. Without payments, S permits deforestation until Ts-. Because of the reduced forest cover, emissions can only be sustained at level G*-, which results in a reduced domain of choice. To achieve its goal of emission sustainability without paying S, N must now incur costs C(Gn-) to persuade its own citizens to reduce emissions. Note that if C(Gn-) is greater than C(Gs*|Gn") - C(Ts-) + C(Gn"), then N must persuade S to preserve its forests.

We could have as easily drawn panel (b) so the cost curve for S intersected the C(Ts-) line outside the box. Without payments from N, S alone would emit more than the sustainable greenhouse gas quantity. This latter situation presumably would have much harsher consequences for N. Perhaps N would need to begin a reforestation policy to compensate.

The government of N need not rely exclusively on inducement policies toward S, however. Figure 4 panel (c) shows a punitive policy, perhaps including trade sanctions, imposed by N if S refuses to preserve its forests without inducements. Assuming the trade volume with S is inconsequential to N, but important to S, the panel suggests high costs of C(Ps) to S from the sanctions but only the smaller costs of C(Pn) to N. Note the assumption implicit in panel (c) that S would preserve even less forest once sanctions are imposed. This would reduce further the dimensions of the policy arena.

We have abstracted from many additional costs that might fall upon N from this further reduction in tropical forest cover. They would include the natural forest value to citizens of N or any eventual pharmaceutical value from destroyed species. These additional costs weaken the credibility of N's threat of punitive sanctions. The costs of this sanction policy to N (if imposed) are at least C(Pn) + C(Gn|P), assuming that S will not cooperate with N while sanctions are in force.

The hope of N, of course, must be that its threat is credible. S would then find it helpful to avoid punitive sanctions by preserving its forests voluntarily, while N would incur little if any cost. If N may incur great costs in imposing sanctions on S, S will probably not believe the threat.

Figure 3 suggests a policy that seems the most palatable. It preserves the forest and entails a politically acceptable transfer of funds from wealthy N to the less-wealthy S. This path preserves the earth's diminishing forests at present levels.

It also takes into account a wide variety of benefits--intrinsic, pharmaceutical, and others--that all the earth's citizens receive when we maintain those forests. It seems reasonable that the government of S might want increased economic aid to promote economic opportunities for its landless poor. That is, foreign aid may be useful in making the difficult choice between seizing haciendas and savaging the forest. Similarly, if preserving the forests implies confronting the powerful timber concessionaires, it is possible that S could use payments from N to redirect these contractors into other work.

It may be that the area of mutual interests is too restricted to accomplish what the principal (N) seeks. Perhaps political pressure on the government of S to continue its timber concessions is too severe for payments (or policy concessions) from N to overcome. If the exported (S) timber is imported into N, the solution is straightforward. The government of N could decide to ban exports from S. This would be consistent with the situation proposed in figure 4 panel (c). If, however, S exports timber to a third country, the government of N will need to negotiate with that third region. Such punitive policies are the last resort because they create "winners" and "losers." The essence of international policy is seeking results that allow all governments to view their new positions as "winners."

CONCLUSIONS

Agency theory provides a set of organizing concepts to define the nature of the policy problem in the global commons. We see the important difference between domestic policy in the two states. We also see also how the domestic component of the two states

informs and defines the international sphere. The interests of the principal drive the bargaining process. Yet, we see that the domain for new rules on emissions really depends on the two political entities (N and S) and their individual citizens' interests and importance. It is a mistake to imagine that governments simply order their citizens around. Indeed, recent failure of the USSR's economy suggests that unless governments get the incentives right, individual choices of the citizens can be counterproductive.

The policy problem in the global commons is realigning interests by redesigning domestic and international institutional arrangements that result in new behaviors. It is not a matter of directing individual decisionmakers. Such a policy requires huge monitoring costs. The powerful incentives for defecting from the newly-imposed policy make these monitoring costs necessary.

Rather, the ideal policy is one that uses inducements to change the individual choices of millions of people. When people change their behaviors in producing and processing greenhouse gas, we will solve the problem of the global commons. There is no magic wand that will produce a new international policy. Currently there is no all-powerful supra-state to impose a new institutional policy that will affect the daily lives of millions who farm or work in the South's emerging industrial centers or those who live in the already industrialized North's cities. There is only the long process of changing incentives to alter individuals' choices.

In the authoritative work on international policies, Young talks of three possible origins of policy formation - spontaneous, negotiated, and imposed (Young, 1989). This discussion has focused on the second and third origins. It is possible that the governments of N and S both will come to realize the seriousness of greenhouse gases and begin to change their domestic policies accordingly. This would represent the spontaneous case. That case is not very interesting for the problems of the global commons. It suggests that governments will immediately recognize the problem of greenhouse gases and independently solve it. While this would be a wonderful situation, it is also not very realistic. Independent states have different interests in how their citizens' behaviors relate to the natural environment and, hence, the global commons. So the second two sources--negotiation and imposition--are much more likely. These two classes of international policy origins have included the nature of the approach followed here.

Young also points to the obvious result that negotiated and imposed regimes usually avoid the temptations offered by changing circumstances. Spontaneous policies are only as durable as the separate calculations of the interests of the respective parties.

In that sense, this approach, based on agency theory, offers a conceptual guide to solve the problems of the global commons.

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