

Mohr, Ernst

Working Paper — Digitized Version

Burn the forest!: A bargaining theoretic analysis of a seemingly perverse proposal to protect the rainforest

Kiel Working Paper, No. 447

Provided in Cooperation with:

Kiel Institute for the World Economy – Leibniz Center for Research on Global Economic Challenges

Suggested Citation: Mohr, Ernst (1990) : Burn the forest!: A bargaining theoretic analysis of a seemingly perverse proposal to protect the rainforest, Kiel Working Paper, No. 447, Kiel Institute of World Economics (IfW), Kiel

This Version is available at:

<https://hdl.handle.net/10419/46968>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

Kieler Arbeitspapiere

Kiel Working Papers

Kiel Working Paper No. 447

BURN THE FOREST!:
A BARGAINING THEORETIC ANALYSIS
OF A SEEMINGLY PERVERSE PROPOSAL
TO PROTECT THE RAINFOREST

by Ernst Mohr*

November 1990

Institut für Weltwirtschaft an der Universität Kiel

The Kiel Institute of World Economics

ISSN 0342-0787

Institut für Weltwirtschaft
Düsternbrooker Weg 120
2300 Kiel 1

Kiel Working Paper No. 447

BURN THE FOREST!:
A BARGAINING THEORETIC ANALYSIS
OF A SEEMINGLY PERVERSE PROPOSAL
TO PROTECT THE RAINFOREST

by Ernst Mohr*

November 1990

Ag 3985 / 90
Weltwirtschaft
Kiel
ms

*I am grateful to Bert Hofman, Stefan Sinn and participants of a Kiel Institute staff seminar for very valuable comments on an earlier version of this paper.

Paper prepared for the Symposium on "Conflicts and Cooperation in Managing Environmental Resources", November 15-16, 1990, Freudenberg, FRG, sponsored by the Volkswagen-Stiftung.

The author himself, not the Kiel Institute of World Economics, is solely responsible for the contents and distribution of each Kiel Working Paper.

I. Introduction

Consider a country possessing a specific production factor in fixed quantity, producing in combination with land a stream of services through time. Some of these services are consumed domestically. The bulk of it, however, is consumed world-wide.

Despite the services the country provides to the world it does not earn any income from these exports. This is because it lacks a technology turning services produced into the exclusive property of the country. Possessing a sector which produces such a good, how can the country earn income from the services it provides?

This is a stylised description of the problem faced by countries which host the world's rainforests. As determinants of the global climate rainforests provide a multitude of environmental services.¹ Some of these services escape the home countries of forests, spill over abroad and are consumed there as a free lunch. In this sense, countries do not possess exclusive property rights over the forests they host. This global commonality of a national production factor creates a series of problems which endangers the environment.

Viewing the rainforests as part of national wealth one must expect that they are substantially undervalued by host countries compared to their global fundamental as the present value of their foreign services is nil. Hence, with given opportunity costs for the land which hosts the trees there is, from a global perspective, an insufficient incentive in these countries to preserve their environmental resources.

Financial compensation for the international services the rainforests provide or foreign aid to pay for their protection is therefore deemed helpful for their preservation.² Here, however, arises another problem. Although a global social planner would internalise all forestal services, decisions concerning financial compensation are made from a national

¹ For surveys of the ecological importance of rainforests see e.g. GUPPY [1984] and SIOLI [1987].

² For a survey of policy options see AMELUNG [1989]. A theoretical justification of financial compensation is e.g. given in RAUSCHER [1989].

point of view in the recipient countries of forestal services, trying to preserve the status quo of a free lunch.

In this situation, how can the host countries of the forests extract resources from the recipient countries of their services; and what determines the magnitude of these transfers which ultimately may contribute to the preservation of the forests?

This paper entertains the view that such transfers are the result of negotiations between countries hosting rainforests and recipient countries of forestal services. Applying the strategic bargaining approach to negotiations (RUBINSTEIN [1982]) the paper investigates the determinants of a bargaining solution and the incentives as well as the opportunities of the countries hosting rainforests to strike a better deal. The strategic role of soft vs. hard development is analysed and it is shown that host countries may have an incentive to commit to environmentally "too" wasteful development. The environment, however, ultimately may benefit from this commitment as it helps extract more resources from the recipients of forestal services.

The paper is organised as follows. In Section II the bargaining model is developed. Section III analyses a basic bargaining situation and Section IV investigates the fundamental change in bargaining power which arises if countries obtain the technology to profitably develop the land hosting the forests. Section V investigates the incentive and opportunities of countries to improve on the negotiated transfer income. Section VI concludes the paper.

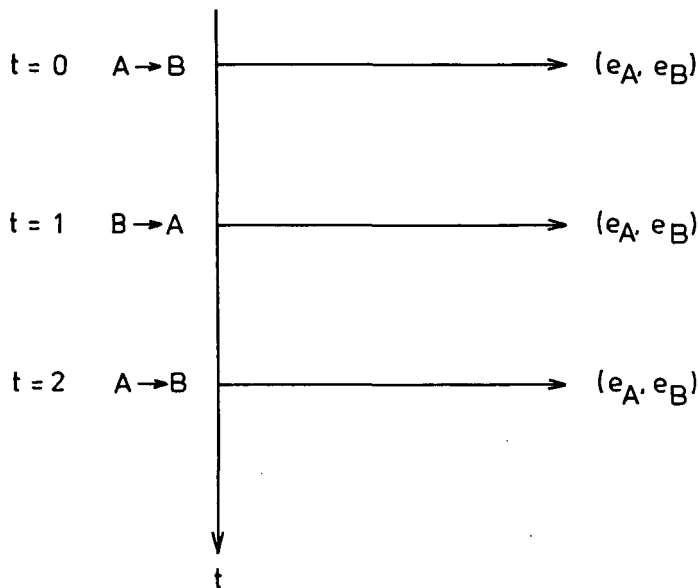
II. The Bargaining Model

Consider the two country bargaining game depicted in Diagram 1.³ At time $t=0$, country A hosting a rainforest, Amazonia, say, makes a proposal to country B, the recipient of forestal services, concerning the division of a cake which is defined by country B's benefit from forestal services. If country B does not accept A's offer it can

³ It is a modified version of the bargaining model in SUTTON [1986].

terminate negotiations and take an outside option which gives A a share e_A and B share e_B of the cake under negotiation. However, rejecting A's offer B may continue bargaining by making a counter-offer in period $t=1$. Country A then can accept B's offer, or terminate negotiations by taking the outside option e_A (implying e_B for B) or it can continue bargaining in the following period. The bargaining game continues until one country accepts a proposal made or until a country takes its outside option.

Diagram 1



Time costs of bargaining may occur because counter-offers can only be made after one period has elapsed. Let this be represented by a discount factor h_A and h_B , $0 \leq h_A, h_B \leq 1$, for country A and country B respectively.

Following the strategic approach to bargaining, a negotiated division of the cake at stake must be an equilibrium point of the game in extensive form, defined by the bargaining rules depicted in Diagram 1. Let m be the equilibrium share of the cake country A receives. It is shown in the Appendix that m is given by

$$(1) \quad m = (1-h_B)/(1-h_A \cdot h_B) \quad \text{if} \quad \begin{cases} e_A \leq h_A \cdot (1-h_B)/(1-h_A \cdot h_B) \\ e_B \leq h_B \cdot (1-h_A)/(1-h_A \cdot h_B), \end{cases}$$

$$(2) \quad m = 1-h_B \cdot (1-e_A) \quad \text{if} \quad \begin{cases} e_A > h_A \cdot (1-h_B)/(1-h_A \cdot h_B) \\ e_B \leq h_B \cdot (1-e_A), \end{cases}$$

$$(3) \quad m = 1-e_B \quad \text{otherwise.}$$

The division of the cake, m , being a perfect equilibrium ensures that a party's threat to leave the bargaining table and take the outside option does only influence the outcome of negotiations if such a threat is credible.⁴ The outcome hence differs as to whose outside option poses a credible threat. This is represented by equations (1)-(3). Equation (1) gives the equilibrium division of the cake if neither party possesses a credible outside option. If only country A has a credible outside option available, then the equilibrium partition is given by equation (2). And equation (3) represents the case where (only or in addition to country A) country B possesses a credible outside option.

This bargaining game will be applied in the following sections to different stylised representations of the conflicting interests between countries hosting rainforests and countries receiving their services. As a frame of reference from which to depart towards the analysis of more complicated cases we first analyse a bargaining situation which is particularly simple.

⁴ An outside option of a party is credible if and only if taking this option gives the party a payoff which is at least as high as the payoff it receives if it would not take this option.

III. Mock-Bargaining: The Case of the Good Old Days

To fix ideas, suppose in an initial situation country B receives a constant stream of forestal services, the period value in money terms of which is V . Suppose country A now initiates negotiations to extract some fraction of the cake V from country B.

Ceteris paribus, the process of bargaining does not affect the commonality property of the rainforest, i.e. it continues to provide country B with services valued at V . This implies that country B has no time costs of bargaining, that is

$$(4) \quad h_B = 1.^5$$

For $h_B=1$ the equilibrium partition, equations (1)-(3), simplifies to

$$(5) \quad m = 0 \quad \text{if} \quad \begin{cases} e_A \leq 0 \\ e_B \leq 1, \end{cases}$$

$$(6) \quad m = e_A \quad \text{if} \quad \begin{cases} e_A > 0 \\ e_B \leq 1 - e_A, \end{cases}$$

⁵ For $h_B=1$ country B is indifferent between making a deal worth $(1-m)$ today or tomorrow. If during negotiations country B receives V as a free lunch it in fact prefers to reach an agreement involving transfer-payments rather later than earlier. This would have to be represented by setting $h_B > 1$. This "play on time" game would potentially further improve the bargaining power of country B. The equilibrium partition m , derived from the "patience" game $h_B=1$ must therefore be interpreted as a limiting case, indicating the maximum country A can obtain from a "play on time" game involving $h_B \geq 1$.

$$(7) \quad m = 1 - e_B \quad \text{otherwise.}$$

If country A possesses no alternative opportunity to use its land besides hosting the rainforest, $e_A = 0$. Furthermore, in this case $e_B = 1$, as a breakdown of negotiations retains the status quo for country B of a free lunch worth V .

It is straightforward from our intuition and from equations (5)-(7) that in this case the equilibrium partition is given by $m=0$. The country exporting forestal services is unable to obtain a share of the recipient country's value of these services. The reason simply is that it has no bargaining power whatsoever if services continue to dissipate abroad as ever before during negotiations and if it cannot obstruct this flow after negotiations have broken down.⁶

This bargaining situation may be viewed as a good approximation to the situation Central African, South Asian or South American countries would have been in when trying to strike a deal on their forestal services before they possessed the resources to put their land to an alternative use. The model highlights the fundamental change that has occurred since those countries have obtained the ability to develop their rainforests. This change is not represented by an emerging necessity of the recipient countries of forestal services to negotiate for the protection of rainforests. Rather it is the newly obtained ability of host countries to rainforests to strike a deal on the distribution of the benefits which accrue to the world from their forests' services. We will investigate this in the remainder of this paper.

⁶ Similarly, in FERNANDEZ and ROSENTHAL [1988], in applying the strategic bargaining approach to sovereign debt reschedulings, it is presumed that the debtor country continues to service debt during debt renegotiations to the maximum of what lenders can expect. Furthermore, the debtor country has no credible outside option available. It is shown that in a bargaining equilibrium creditors reap the entire cake under negotiation. It is intuitively clear that this must be the outcome as lenders are in the best conceivable state of the world whatever happens.

IV. Bargaining in the Face of Development

Suppose country A has available a project of developing the rainforest. Let Π be the period profit from undertaking the project. Suppose the period profit of the project is an increasing, concave function of the resources P , allocated per period to the project. Undertaking the project requires some destruction of the rainforest. This depletion of environmental resources causes environmental costs per period D_A in country A and D_B abroad. The magnitude of these costs depends on the environmental safeguards applied. Let the period costs of safeguards accruing to the country developing the rainforest be S . Let $D_B = D_B(S)$, with $\partial D_B / \partial S < 0$, $\partial^2 D_B / \partial S^2 > 0$, and let $D_A = D_A(S)$, with $\partial D_A / \partial S < 0$, $\partial^2 D_A / \partial S^2 > 0$.

The magnitude of environmental safeguards, S , may be viewed as representing the degree of "softness" of development. Soft development reduces the environmental costs associated with the project for both the country hosting the rainforest and the world. Soft development, however, requires the input of national resources by the country undertaking the project. Given total resources Y of size $Y = \bar{Y}$, the budget constraint for country A is $\bar{Y} = P + S$.

The optimal environmental safeguard, S^A , for country A, ignoring the positive global externalities satisfies

$$(8) \quad -\partial \Pi / \partial P - \partial D_A / \partial S = 0$$

with second order conditions

$$(9) \quad \partial^2 \Pi / \partial P^2 - \partial^2 D_A / \partial S^2 < 0,$$

and the project would be undertaken with safeguards S^A if $\Pi(S^A) - D_A(S^A) > 0$. Let this be the case.

A global social planner would choose safeguards, S^G , satisfying

$$(10) \quad -\partial \Pi / \partial P - \partial D_A / \partial S - \partial D_B / \partial S = 0.$$

If both the global and the national social planner had the same amount of resources, \bar{Y} , available for development and environmental protection then it immediately follows from (8) and (10) that

$$(11) \quad s^G > s^A,$$

implying the standard result that a public good is undersupplied if the social planner does not internalise all the positive externalities associated with the consumption of the good.

Furthermore, upon total differentiation of condition (8) and from condition (9) it immediately follows that

$$(12) \quad ds^A/d\bar{Y} > 0.$$

Bargaining over the distribution of the recipient country's benefit from forestal services in the face of above development project differs markedly from mock-bargaining.

As the project destructs some of the forest and hence reduces the benefit of the recipient country from forestal services, the size of the cake under negotiations is given by $V-d \cdot D_B(S)$ where

$$d = \begin{cases} 1 \\ 0 \end{cases}$$

if as a result from negotiations the project is

$$\begin{cases} \text{undertaken with safeguards } S \\ \text{abandoned} \end{cases}.$$

Note that the view underlying the definition of the cake of size $V-D_B(S)$ denies that the project as such is necessarily at stake during negotiations. Rather, the perhaps more realistic view is entertained here that countries hosting rainforests may be able to proceed with their development programs after an agreement. However, what may be influenced in this case by the prospect, the process or the result of

negotiations are the environmental safeguards the country is prepared to apply when undertaking development.

Development at varying degrees of softness in anticipation of or in response to different outcomes of negotiations can influence the relative bargaining power of the parties involved. In particular, the host country now has available an outside option of positive value to which it can take recourse if an agreement would be "too" disadvantageous for it.

If country A upsets negotiations by terminating bargaining before having reached an agreement it can proceed with the project. Furthermore, in this case it is optimal for the country to allocate the optimal amount S^A of its resources of size \bar{Y} for environmental safeguards. Hence the value of country A's outside option is given by

$$(13) \quad e_A = [\Pi(S^A) - D_A(S^A)]/[V-d \cdot D_B(S)].$$

If negotiations break down and development is undertaken with safeguards S^A then country B obtains a benefit from forestal services equal to $V-D_B(S^A)$. If under an agreement country A applies environmental safeguards equal to S if the project is undertaken, then the recipient country's outside option is given by

$$(14) \quad e_B = [V-D_B(S^A)]/[V-d \cdot D_B(S)].$$

Hence country A's choice of environmental safeguards in case an agreement on the implementation of the project is reached influences country B's gains from a breakdown of negotiations and hence its inclination to give leeway during negotiations. In particular, country B's direct gains from forestal services under an agreement involving the implementation of the project exceed those under a breakdown of negotiations if $S > S^A$. Hence for $S > S^A$ country B is willing to accept some payments to country A even if country A undertakes the project.

The magnitude of environmental diligence applied to development when an agreement is reached depends on country A's ability to commit to certain environmental safeguards. If commitment is infeasible then a promise by country A to undertake safeguards different from the safe-

guards which satisfy the optimality condition (8) is incredible. In this case it is rational for country B to expect that after the agreement is reached country A will undertake development with safeguards satisfying condition (8).

However, the optimal safeguards under non-commitment, S^{nc} , undertaken after an agreement has been reached exceed the safeguards, S^A , undertaken after a breakdown if under the agreement country A receives some transfer payments, M , from country B. This is because transfer payments increase the resources of the country hosting the forest from $Y=\bar{Y}$ to $Y=\bar{Y}+M$. Replacing S^A by S^{nc} and \bar{Y} by Y in condition (12) it follows that these additional resources are partly used to finance a somewhat softer development.

The situation is different if country A can commit itself before entering negotiations to the application of certain environmental safeguards after an agreement has been reached. In this case the size of the cake under negotiations is under control of country A by a commitment to safeguards $S=S^C$. A commitment to softer development for the time after a negotiated agreement on the implementation of the project has been reached increases the size of the cake and hence the transfer payments received for any given positive equilibrium share m . Hence for a given share m of the cake of variable size the host country now faces a trade-off between securing a higher project income through hard development and a higher bargained income from providing forestal services through soft development.

To see that a commitment option gives an incentive to softer development under an agreement on the implementation of the project note that disposable resources are given by $Y=\bar{Y}+M$, where the transfer income is given by $M=m \cdot [V-D_B(S^C)]$ and where S^C satisfies the optimality condition

$$(15) \quad - \partial \Pi / \partial P \cdot \partial D_B / \partial S^C - \partial \Pi / \partial P - \partial D_A / \partial S^C = 0.$$

As the first term in condition (15) is positive it follows from a comparison with condition (8) that

$$(16) \quad S^C > S^{nc},$$

where S is replaced by S^{nc} in condition (8).

The equilibrium partition m is now easily determined from equations (5)-(7). The central difference to mock-bargaining is that country A's outside option, equation (13), is now positive. Hence the equilibrium partition is given by equations (6) or (7) depending on which party's outside option is credible. Replacing e_A and e_B in (6) and (7) by equations (13) and (14) and noting that country A's transfer income from the bargaining equilibrium, M , is given by $M=m \cdot [V-d \cdot D_B(S)]$, it follows that

$$(17) \quad M = \begin{cases} \Pi(S^A) - D_A(S^A) \\ D_B(S^A) - d \cdot D_B(S) \end{cases} \quad \text{if } D_B(S^A) - d \cdot D_B(S) \begin{cases} \geq \\ < \end{cases} \Pi(S^A) - D_A(S^A),$$

where $S=S^{nc}$ or $S=S^c$, depending whether commitment is possible or not.

The equilibrium transfer (17) is easily interpreted. $D_B(S^A) - d \cdot D_B(S)$ is the net environmental loss in money terms for country B from lost forestal services due to a breakdown of negotiations, or vice versa the net environmental gain from reaching an agreement. Hence, country A is able to negotiate a transfer income up to the minimum of country B's net environmental gains from the agreement and its own net total project income, $\Pi(S^A) - D_A(S^A)$, in case an agreement would not be reached.

Straightforwardly, country B is never prepared to accept transfers in excess of its own net environmental loss in case of a breakdown. Likewise, country A cannot extract transfers in excess of the net project value in case of a breakdown because for as long as negotiations continue the project is kept on hold. Which of these two constraints determines the equilibrium depends on which of them is the binding one.

If A's outside option is credible it receives a transfer income making it indifferent between the bargaining solution $\Pi(S^A) - D_A(S^A)$ and taking its outside option. This then requires that in exchange for receiving the equilibrium service income country A sacks the project. Hence the world continues to receive forestal services worth V , however, at the price $\Pi(S^A) - D_A(S^A)$. Transfer payments ensure the survival of paradise.

However, under a bargaining solution the project need not be cancelled. If B's net environmental damage from a breakdown of negotia-

tions, $D_B(S^A) - d \cdot D_B(S)$, is smaller than A's non-cooperative project value, $\Pi(S^A) - D_A(S^A)$, then it is too expensive for B to bribe A out of the project. In this case the project is undertaken with safeguards S and $d=1$. Country B accepts transfer payments, $D_B(S^A) - D_B(S)$, making it indifferent between the agreement implying the project be undertaken under cooperative safeguards S and non-cooperative safeguards S^A . The total gain to country A from the bargaining enterprise then is given by $\Pi(S) - D_A(S) + D_B(S^A) - D_B(S)$. Whether this gain exceeds the non-cooperative project value depends on whether the country chooses safeguards in excess of S^A or not.

If commitment is possible then country A's negotiated transfer income from the provision of forestal services is strictly positive even if the project is undertaken. This follows from the equilibrium transfer (17), condition (16), $\partial D_B / \partial S < 0$ and the fact that the non-commitment optimum must satisfy $S^{nc} \geq S^A$. Hence the option of commitment to different degrees of softness in developing the rainforests provides a country with a technology to extract some of the world's benefits from forestal services provided.

The equilibrium safeguards, S^C , exceed the non-cooperative safeguards S^A . This has the consequence of reaching an agreement which involves transfer payments to the country hosting the rainforest. In this precise sense, international payments for the services provided by the rainforests contribute to the protection of these environmental resources.

If commitment is infeasible matters are a bit more complicated. In this case the equilibrium safeguards S^{nc} must be a fixpoint $S^{nc} = Z[Y(S^{nc})]$, being itself the optimal safeguards $Z(Y)$ in reaction to some given total income $Y = \bar{Y} + M$ and reproducing this income as a bargaining equilibrium $Y(S^{nc})$.

Apparently $S^{nc} = S^A$ is such a fixpoint as from the equilibrium transfer (17) $M = D_B(S^A) - D_B(S) = 0$ if $S = S^{nc} = S^A$, in which case $Y = \bar{Y}$, and $S^{nc} = S^A$ is indeed optimal. Hence the autarky equilibrium level of safeguards may result from bargaining if the country hosting a rainforest is unable to commit to an environmental protection program when developing the forest.

However, there may exist additional fixpoints with the property $S^{nc} > S^A$. In such an equilibrium a country hosting a rainforest can extract some of the foreign gains from the forest's services because

other countries anticipate that some of their transfer payments are invested into the protection of the forest. In this precise sense, international payments can contribute to the protection of the rainforests.

V. The Incentive to Commit to Environmentally Wasteful Development

The previous analysis suggests that environmental gains for the recipient country of forestal services from a negotiated solution may provide the host country of forests with some transfer income. A natural question for such a country then is what it can do in order to increase this transfer income. In fact, in above analysis commitment to a softer development in case an agreement on the implementation of the project is reached provided a technology to reap and increase such transfers.

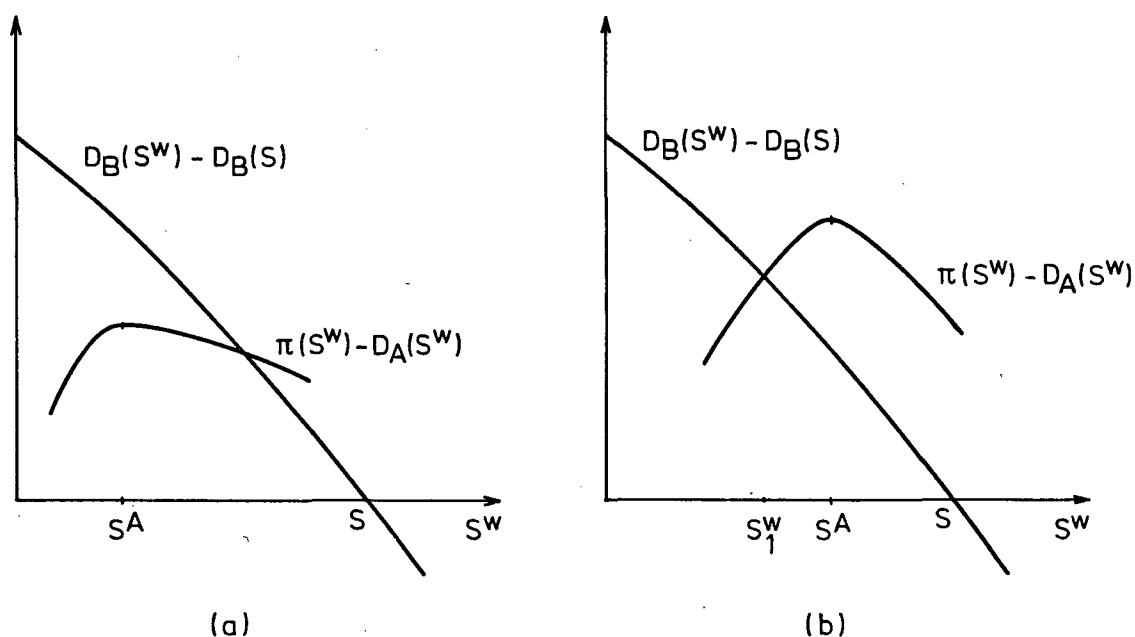
However, this need not be a country's sole instrument. A commitment to particularly environmentally wasteful development in case an agreement is not reached may instead or in addition increase a host country's share in the cake under negotiation. Surprisingly, such a commitment to wasteful development may in fact contribute to the protection of the forests.

To see this, consider the equilibrium transfer (17). An environmentally wasteful development of the rainforest in case the parties fail to reach an agreement would be a commitment to safeguards S^W , where S^A is replaced by S^W in (17) and where $S^W \leq S^A$.

If country A's outside option is credible then from (17) $M = \Pi(S^W) - D_A(S^W)$. As S^A maximises the development gains net of national environmental costs it is optimal for the country to set $S^W = S^A$ in order to maximise the transfer income. Hence in this case the country does not have an incentive to commit to wasteful development. This is depicted in Diagram 2a.

However, this is no longer the case if the value of country B's outside option determines the equilibrium transfer country A receives. If $M = D_B(S^W) - D_B(S)$, $\partial M / \partial S^W < 0$ as $\partial D_B / \partial S^W < 0$. Hence, a commitment to safeguards below the unilaterally optimal safeguards S^A increases the gains for country A from a negotiated settlement.

Diagram 2



The optimal commitment to environmentally wasteful development is depicted in Diagram 2b. There is an incentive for the country to reduce environmental safeguards to S_1^W where country B's net environmental benefit from reaching an agreement is equal to country A's net project profit in case the parties fail to reach an agreement. For $S^W = S_1^W$ both countries are indifferent between the agreement and the non-cooperative solution. A further reduction in committed safeguards would make country A's outside option become the credible threat. This would link the equilibrium transfer to the value of country A's outside option. A commitment to safeguards below S_1^W in Diagram 2b would therefore be suboptimal.

Commitment to environmentally wasteful development when negotiations fail can increase the transfer income from providing the world with forestal services. These excessively high environmental costs are, however, avoided if an agreement is reached. More so, this prospective environmental feeding of the hogs contributes in fact to an additional protection of the rainforests when the project is undertaken. This follows immediately from total differentiation of the optimality condition (15), from which we obtain $dS^C/dM > 0$ if S^C in fact is a maximum. The

opportunity to commit to wasteful development when negotiations fail creates an incentive to commit to softer development when negotiations succeed. In this sense, a commitment to burning the forest helps protect the environment.

Even if the country can only commit itself to safeguards for the situation when negotiations fail but not when they succeed, the environment may benefit from this adverse incentive. This case may represent a country which can create a situation in which it cannot prevent a kind of "wildcat development" of the rainforest by private parties if negotiations fail, although this would be in the domestic interest once negotiations have broken down. In this case, if there exists a bargaining equilibrium S^{nc} , where $S^{nc} > S^A$, it follows from replacing \bar{Y} by Y and S^A by S^{nc} in (12) that this commitment to wasteful development gives an incentive to apply tighter environmental safeguards after an agreement has been reached.

VI. Conclusions

This paper entertained the view that profitable but environmentally costly development projects give countries hosting rainforests an opportunity to repatriate some of the benefits the forests' services provide to the world for free. It has been shown that these countries may have an incentive to commit themselves to a particularly damaging development program should negotiations about the distribution of the global benefits, accruing from the rainforests, fail. Such a commitment to environmental apocalypse need not be damaging to the environment as it creates an incentive to apply greater environmental safeguards to development when negotiations succeed. In this sense, haggling on the back of nature need not be at nature's costs.

Appendix

If m denotes the supremum of the share of the cake under negotiation which country A can reap in a negotiated settlement in period 2, say, then, by backward induction, the shares country A and country B can reap by an earlier settlement are depicted in Box 1,

Period	Offer made by	Country A receives at most share	Country B receives at least share
$t = 0$	A	$m = \begin{cases} 1-h_B \cdot (1-X) \\ 1-e_B \end{cases}$	$1-m = \begin{cases} h_B \cdot (1-X) \\ e_B \end{cases}$
$t = 1$	B	X	1-X
$t = 2$	A	m	1-m

Box 1

where

$$X = \begin{cases} h_A \cdot m \\ e_A \end{cases} \quad \text{if A} \begin{cases} \text{does not take} \\ \text{takes} \end{cases} \quad \text{the outside option.}$$

Solving the first row in Box 1 for m , we obtain the share country A receives in a subgame perfect bargaining equilibrium. It is given by equations (1)-(3) in the main body of the paper.

References

- AMELUNG, Torsten [1989], "Zur Rettung der tropischen Regenwälder: Eine kritische Bestandsaufnahme der wirtschaftspolitischen Lösungsvorschläge", Die Weltwirtschaft, 1989, Heft 2, 152-165.
- FERNANDEZ, Raquel and Robert W. ROSENTHAL [1988], "Sovereign Debt Renegotiations: A Strategic Analysis", NBER Working Paper No. 2597.
- GUPPY, Nikolas [1984], "Tropical Deforestation: A Global View", Foreign Affairs, 62, 928-965.
- RAUSCHER, Michael [1990], "Can Cartelisation Solve the Problem of Tropical Deforestation?", Weltwirtschaftliches Archiv, 126, 378-387.
- RUBINSTEIN, Ariel [1982] "Perfect Equilibrium in a Bargaining Model", Econometrica, 50, 97-109.
- SIOLI, Harald [1987], "The Effects of Deforestation in Amazonia", Ecologist, 17, 134-138.
- SUTTON, John [1986], "Non-Cooperative Bargaining Theory: An Introduction", Review of Economic Studies, 53, 709-724.