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International Environmental Negotiations with Compensation or Redistribution

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**VOLKSWIRTSCHAFTLICHE
DISKUSSIONSBEITRÄGE**



**International Environmental Negotiations
with
Compensation or Redistribution**

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International Environmental Negotiations with Compensation or Redistribution

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International Environmental Negotiations with Compensation or Redistribution

Marlies Klemisch-Ahlert

Abstract

We present a model of environmental negotiations about emission abatement regulations between countries. The cost functions of the countries are dependent on the reduction level and are assumed to be different. This asymmetry may even lead to situations where one country (country i) does not have any incentive to negotiate about equal percentual reductions of the emissions and prefers the non-cooperative equilibrium to any agreement.

We assume that country i proposes another reduction procedure. This leads to a second set of feasible agreements among which there are alternatives that i prefers to non-cooperation.

The negotiation problem is now defined by the different regulation rules the countries prefer. Each rule can be interpreted as an aspiration of the country proposing it. We develop a theoretical solution concept for this problem. The compromise turns out to be a result of concessions that are proportional to the aspiration levels for attainable gains from cooperation for each country.

If it is impossible to realize the compromise as a mixture of the discussed rules, the countries have to agree upon one of the proposed procedures (e.g. country i 's) and an efficient level of regulation with respect to this one. In order to ensure the acceptance of this solution by the other countries, compensation payments are necessary.

In a next step, we consider negotiations where all countries are willing to use compensation payments as an instrument of redistribution. In these cases, the countries can even improve their gain from cooperation by choosing a different solution than in the model above. We show that side payments, that do not only compensate for non-realized aspirations but redistribute the maximal feasible common gain from cooperation, Pareto dominate any other type of agreement. In this model, too, a theoretical solution concept is formally presented.

1. Introduction

Our motivation to deal with the problem of international environmental negotiations comes from our theoretical and empirical work in bargaining theory. We would like to apply the ideas from these areas to environmental agreements and to find out to which results the normative and descriptive bargaining theories lead. In this paper we start our analysis with the application of some cooperative bargaining solution concepts and focus especially on the problem of compensating payments or redistributions of gains from cooperation.

We consider an international environmental problem, e.g. the pollution of air or water, and a given set of countries that are interested in an improvement of the current situation. This means that the countries agree that something has to be done to restrict the environmental damage. Let us assume that the pollution is caused by certain emissions. The countries then may discuss one or more instruments to reduce the amount of emissions. The models we will present can also be applied to negotiations about emission taxes or the allocation of tradeable permits. In negotiations about reduction levels it is often observed that only one rule is discussed, e.g. uniform abatement regulations. In general, there will be differences in the existing emission regulations and the costs of implementing a new regulation rule between the countries. Therefore, in the case of just one rule in discussion it is possible that there is at least one country that does not have an interest in any agreement that is based on this rule. This means that this country would do better without cooperation than signing a contract that defines prescriptions of reduction levels under the discussed regulation instrument. Examples of this problem are discussed by Barrett (1991, 1992). He points out that if side payments are possible, countries that do not have an incentive in an agreement of the proposed type can be compensated e.g. for their higher costs. A redistribution of the gains of the environmental contract can be used to guarantee that all countries have an interest in this contract. The advantages of side payments are also discussed by Eyckmans, Proost, and Schokkaert (1993). Now the question arises to which extend countries have to be compensated so that they are willing to agree. In Section 2 we present a bargaining model and solution concepts to solve this problem. Another question is how the compensation is organized. This could be done via monetary side payments like in the Rhine contracts, or the countries could combine trade treaties and environmental contracts. In this paper we will assume that side payments are used.

In Section 3 we will enrich the negotiation model by assuming that the countries discuss several types of regulation rules. One rule might be a uniform emission reduction defined by a certain percentage. The other rule could be an allowance of emissions defined per capita for each

country. These two rules played an important role in the discussion between industrial countries and developing countries in the conference of Rio.

Different countries will have different interest in a common regulation dependent on the utilities and the costs that are caused by it. The negotiation process will be influenced by goals and aspirations that each country derives from a regulation instrument this country prefers and perhaps proposes in the discussion. We will describe several bargaining solution concepts that can be applied to this problem. We show that in general the possibility of side payments is crucial to achieve efficient agreements.

In Section 4 we give a short overview over the solutions we have applied before, and we finish with an outlook on further research questions.

2. Negotiations about one Emission Reduction Procedure

In this section we consider the case of a group of n countries negotiating about the extend to which an emission regulation should be introduced. We describe the bargaining situation of the countries in an n -dimensional utility space. Here utility is defined to be the net utility of each country derived from the abatement benefits a given reduction level would cause and from the costs to obey the obligations. The set of possible reduction levels (or taxes or allocations of tradeable permits) leads to a feasible set of utility n -tupels. The cost-benefit structure of the countries is assumed to be different, so that in general the representation of the negotiation problem in utility space is asymmetric.

If the instrument under discussion is e.g. a uniform reduction of emissions, variations of the level lead to an n -dimensional curve in utility space. Figure 1 shows a situation with two countries (or groups of countries) with asymmetric cost-benefit representation (cf. Barrett 1991, 1992).

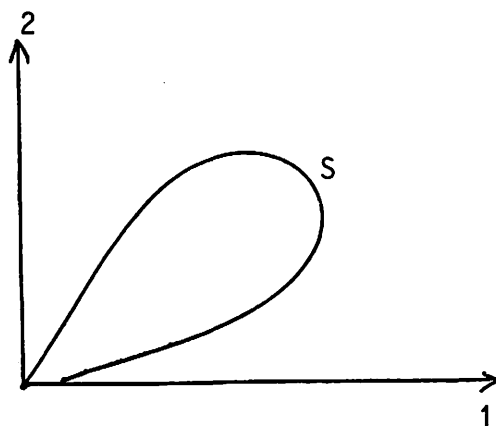


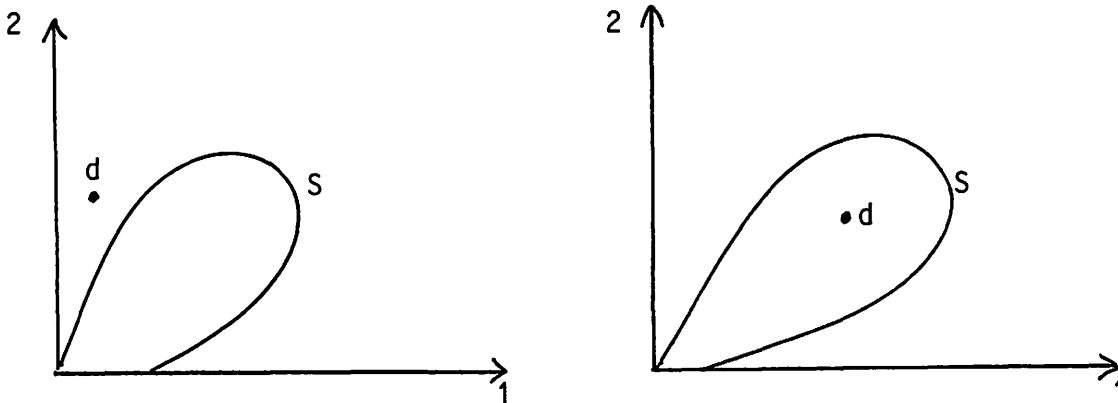
Figure 1

Let the reduction level be $L \in [0,1]$. Then $S(L)$ is the feasible net utility n -tuple for the n countries under reduction level L and $S = \{ S(L) \mid L \in [0,1] \}$ is the set of all feasible utility n -tuples. If the negotiation fails we assume that no cooperation between the countries or subgroups of countries will take place. In this case the net utility for each country is defined by the net utility each country would gain if it chooses its own way to handle the environmental problem. This point in utility space is called d (cf. Figure 1).

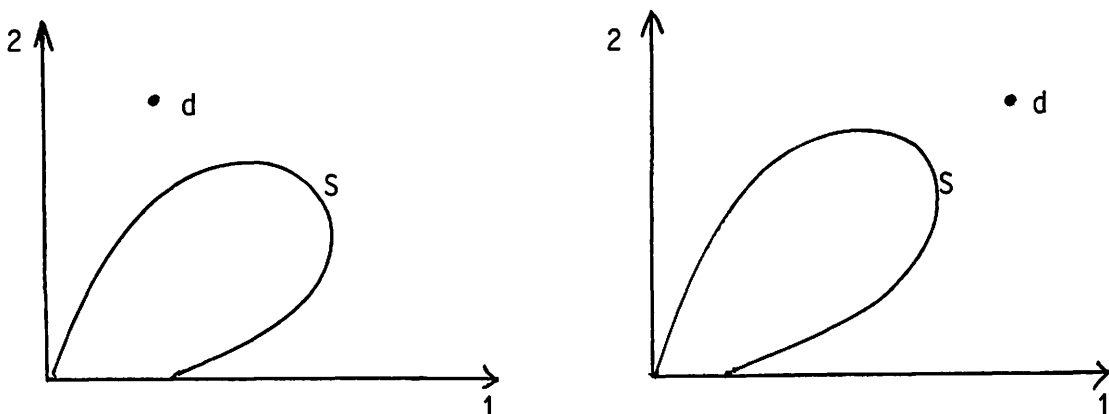
We have to distinguish between two different ways the positions of d and S can be related. Let $d = (d_1, \dots, d_n)$ and $s = (s_1, \dots, s_n) \in S$ be elements of the n -dimensional utility space.

- (i) $\exists s \in S$ such that $\forall i \in \{1, \dots, n\} \quad d_i \leq s_i$.
- (ii) $\exists i \in \{1, \dots, n\}$ such that $\forall s \in S \quad d_i > s_i$.

In case (i) there exists at least one reduction level such that every country can improve its situation by agreeing to this level. In case (ii) there exists at least one country that does not have an incentive to agree to any reduction level. This country would do better if the negotiation fails. Figures 2 and 3 show situations fulfilling condition (i), Figures 4 and 5 show examples of condition (ii).



Figures 2 and 3

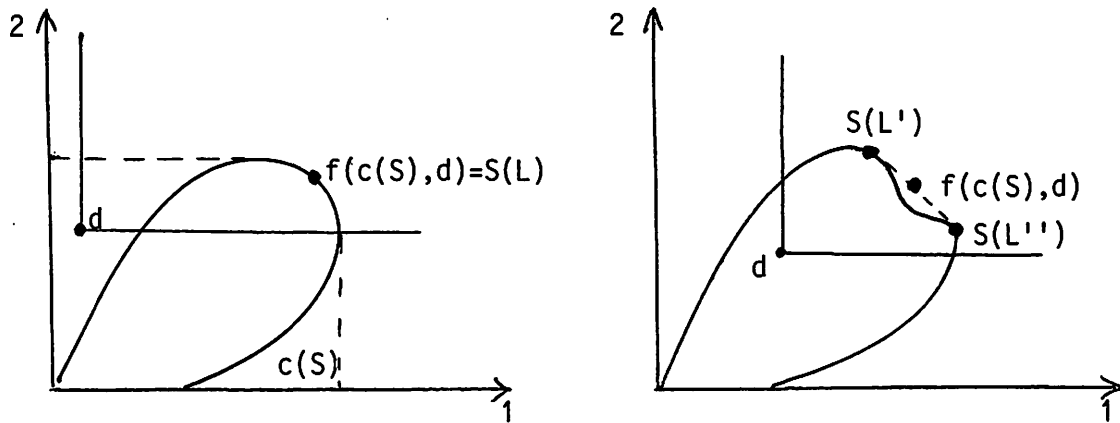


Figures 4 and 5

In Figure 5 no country has an incentive to agree to any point in S . In this case no negotiation will take place.

In situation (i) we can apply the traditional solution concepts like the Nash solution (Nash 1950) or proportional solutions. To make sure that there will be no technical problems in applying these solutions we only consider set of alternatives that are bounded from below by a minimal utility level for each country. Within this space we use the convex and comprehensive hull $c(S)$ of S as the set of feasible utility n -tupels, and we want $c(S)$ to be compact. These assumptions can be interpreted as follows. Convexity means that we allow mixtures of alternatives (i.e. lotteries) and that we implicitly assume that the utility functions are of v.Neumann-Morgenstern type. Comprehensiveness means that reductions of utilities are possible and lead to feasible alternatives as long as these reductions do not lead to a utility level below the minimum. Compactness has the function to assure boundedness of the set of feasible utility n -tupels from above. If we have got a representation of the negotiation problem in a monetary space, we may assume comparable utilities of the countries. If comparability of utilities is given we can apply the egalitarian solution.

The bargaining situation is defined by the pair $(c(S), d)$, and each solution f picks an agreement point $f(c(S), d) \in c(S)$ that can be realized by some reduction level (cf. Figure 6) or by a lottery between several reduction levels (cf. Figure 7).



Figures 6 and 7

In situation (ii), where at least one country has an incentive to negotiate, the question arises whether side payments might lead to feasible utility n -tupels that every country prefers to the point of non-cooperation (cf. Barrett 1992). Assuming that utilities are expressed in money, side payments can be applied to every point $x = (x_1, \dots, x_n) \in c(S)$. The side payments lead to feasible points that form a hyperplane $H(x) = \{ y \in \mathbb{R}^n \mid y_1 + \dots + y_n = x_1 + \dots + x_n \}$ which is defined by the constant sum $x_1 + \dots + x_n$ of utilities of the countries.

Since $c(S)$ is compact, there exists a point $x^* \in c(S)$ such that the sum of the components is maximal in $c(S)$. If x^* is not an element of S it is a convex linear combination of a finite number

of elements in S . Therefore, it exists an x^{**} in S such that the sums of the components of x^* and of x^{**} are equal. Thus we can assume that x^* is an element of S . This alternative is the collectively best one the countries can choose. Every point on the hyperplane $H(x^*)$ is feasible if the total sum $x^*_1 + \dots + x^*_n$ is distributed in an appropriate way. This means that x^* is the alternative that is realized through an agreement on reduction levels and that simultaneously an agreement about side payments has to be found. The final agreement will be an allocation z in $H(x^*)$. The side payments are used to compensate countries i with $z_i > x^*_i$. And countries j with $x^*_j > z_j$ have to pay the amount $x^*_j - z_j$. Figure 8 shows this situation for two countries.

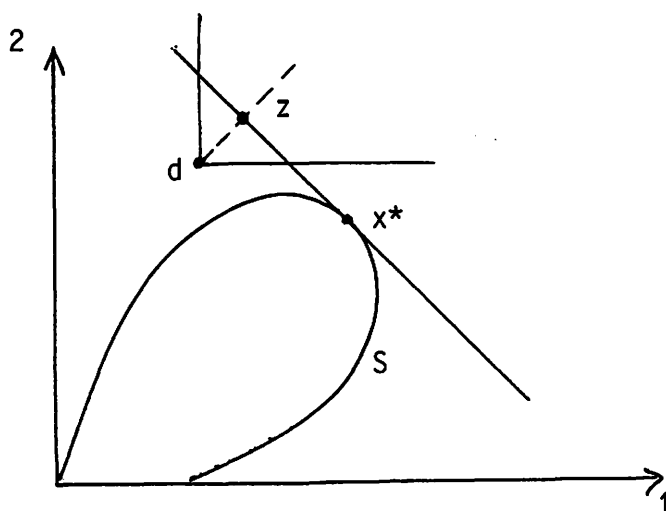


Figure 8

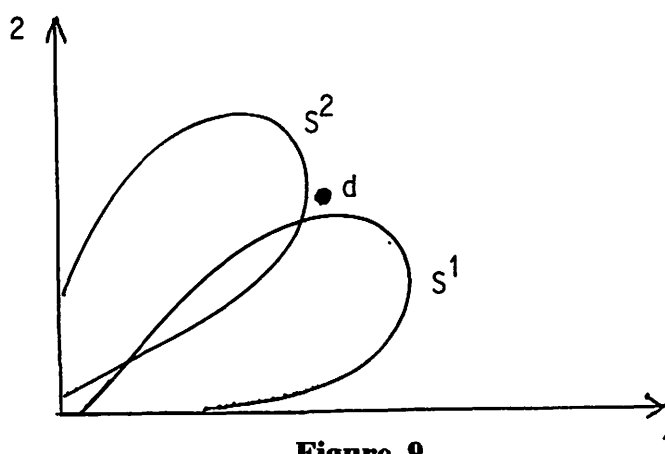
Now the question arises which solution should be applied in this case. The first idea is to apply the traditional solution concepts to the bargaining situation $(c(H(x^*)), d)$, where the set of feasible allocations is the comprehensive hull of $H(x^*)$ and the status quo or point of disagreement is d . Barrett (1992) applies the Nash solution to this situation. All Pareto efficient, symmetric solutions lead to the agreement point z which is defined by equal gains for all countries in comparison to d , i.e. $z_i - d_i = z_j - d_j \quad \forall i, j \in \{1, \dots, n\}$. This solution has the property that it is independent of the shape of S . The only information that matters to find z is the collectively best point in S . In our opinion, it is not obvious that the countries do not use the differences in their cost-benefit structures as arguments in the negotiation.

However, in the model presented above there is no information available that could be used to enrich the bargaining solution concept. Everything that counts is net utilities of non-cooperation and the maximal sum of utilities of all countries under the discussed regulation instrument. A general criticism on the informational content of the traditional bargaining model was raised by several authors (e.g. Sen 1970, Rawls 1971, Roemer 1986). The challenge is how to overcome this criticism and how to construct a simple framework that allows to model at least some aspects of the arguments or the aspirations of the countries.

3. Negotiations with Several Proposed Reduction Procedures

In the model of Section 2, a country i that needs a compensation to have an incentive to agree to a certain reduction level needs an argument to achieve side payments that makes it better off than just $d_i + \epsilon$. What could this argument be? It might arise from a proposal of a different emission reduction instrument preferred by country i .

Let us now consider a negotiation with n participating countries where $m > 1$ instruments are discussed which all could be used to reduce the emissions. Each instrument k leads to a feasible set S_k in the n -dimensional utility space. The point of non-cooperation is again named d . Figure 9 shows a case with $n=2$ and $m=2$, i.e. with two countries, each of them proposing a procedure.



We have to make an assumption concerning the position of the point of non-cooperation in this model. We assume that for each country there exists a proposal having realizations that this country prefers to a failure of the negotiation. This means that each country has an incentive to participate in the negotiation. It can have the goal or the aspiration that its proposal will be chosen.

We will apply three different types of bargaining solution concepts to this situation.

In the first model we define the feasible set T of alternatives to be the convex and comprehensive hull of all sets S_k , $k=1, \dots, m$, i.e. $T = c(\bigcup S_k)$, together with the assumptions we have made in the model with one reduction procedure. Knowing the disagreement point d , we receive the bargaining situation (T, d) which is a situation in the traditional bargaining concept. Therefore, we can apply any n -person bargaining solution f to this situation in order to define an agreement point $f(T, d)$. In general, an agreement will consist of a mixture of different reduction instruments. Figure 10 shows a case with $n=2$ and $m=2$.

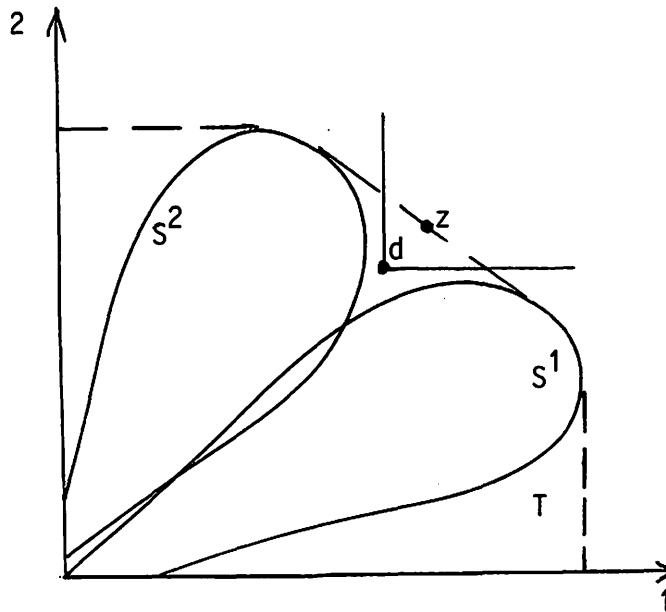


Figure 10

Which solution concept is the appropriate one? We think that information on the shapes of the sets S_k is important to model the arguments in the negotiation process, since these sets describe the net benefits each country can get from instrument k . If we model the agreement to be a solution for a situation (T, d) , any solution concept neglects the separated cost-benefit properties of the single instruments. These properties are summarized in the set T . We interpret the proposed regulation rules to be an expression for some kind of aspiration of each country. We assume in a first simple step that each country i proposes a rule i and chooses the maximal utility it can get from its proposed rule to be a benchmark for the negotiation. (It is possible that different countries propose the same rules.) The maximal values can be chosen from the whole set S_i , or if this is too demanding from the individually rational part of S_i . Individual rationality means, that only allocations where each country would achieve a utility value greater or equal to the value in the point of non-cooperation are considered when the countries search for their best allocation. The first procedure leads to an ideal point $b = (b_1, \dots, b_n)$, the second one to the ideal point $a = (a_1, \dots, a_n)$ which are collections of the maximal utility values for each country with respect to the two types of maxima.

Using these informations on the sets S_i , we are able to apply the Kalai-Rosenthal solution (1978) or the Kalai-Smorodinsky solution (1975) to the problem. This implies that the agreement point is defined by equal proportions of utility gains for all countries on the Pareto optimal boundary of T . The proportions are calculated with respect to the ideal gains of each country i , $a_i - d_i$ in the case of the Kalai-Smorodinsky solution, and $b_i - d_i$ in the case of the Kalai-Rosenthal solution. Figure 11 shows these solution concepts applied to a situation with two countries and two proposed instruments.

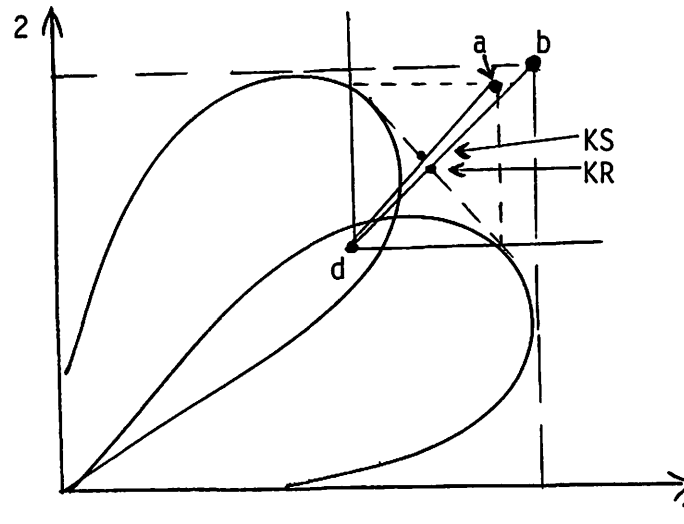


Figure 11

The solution concepts above presuppose that combinations of different instruments are possible. This means that one part of the emission regulation is defined by some rule proposed by country i , other parts are defined by rules that have been proposed by other countries. If these mixtures are impossible because the instruments can not easily be used together, the countries have to agree upon one regulation instrument. Such an agreement can be achieved by using side payments.

Let us assume that utilities are expressed in terms of money. Let z be the alternative that would be chosen under one of the solution concepts above, like the Nash solution, the egalitarian solution or a proportional solution with some ideal point. If z is a combination of alternatives y^i from the sets S_i , then there is a y^j such that $y^j_1 + \dots + y^j_n$ is maximal for all y^i , $i=1, \dots, n$. This implies that the countries can realize z by choosing regulation rule j , thus realizing gains with respect to the allocation y^j , and choosing compensation payments to ensure at least the net benefits z_k for all countries with $z_k < y^j_k$. Figure 12 shows this solution concept for the case of two countries.

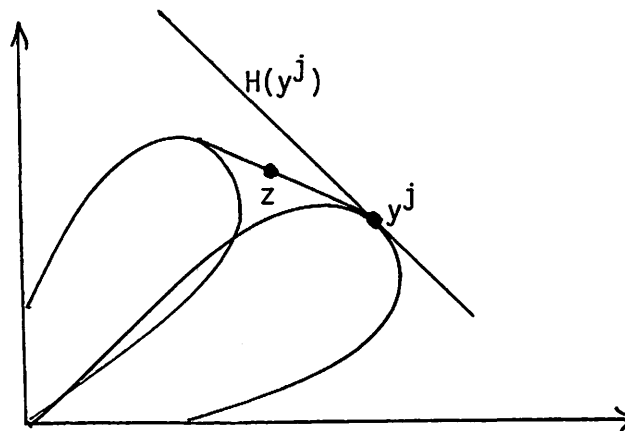
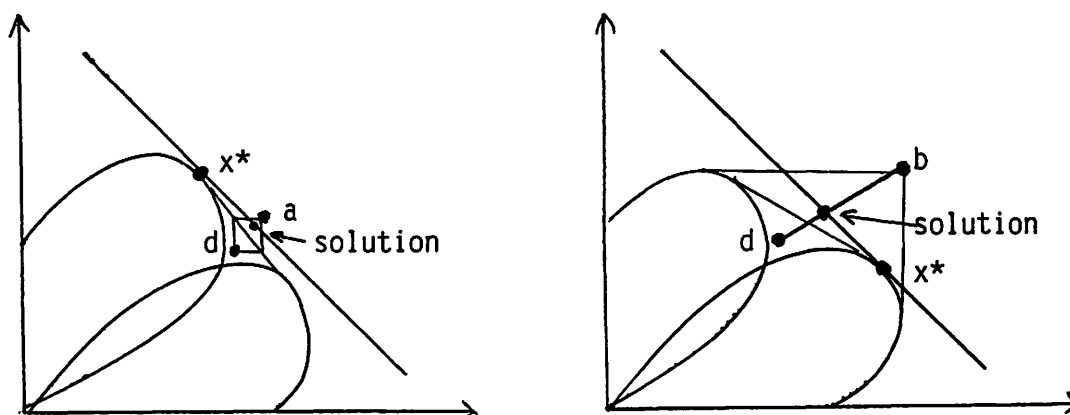


Figure 12

Since there is now more to be distributed than $z_1 + \dots + z_n$, the agreement point has to be found on the hyperplane of constant sum of components going through y^j . How would the countries deal with this additional surplus? In our opinion they would choose another way.

If all countries find the instrument of side payments acceptable, any agreement they would realize by the procedure above would in general be non-Pareto efficient. There would be more to be distributed if the countries would choose the set of feasible agreements to be anything that can be achieved via choosing any proposed regulation and redistributing afterwards. This model uses the collectively optimal regulation procedure and level from $\cup S_i$ which is represented by an n -tuple x^* . The set of feasible allocations of money is $c(H(x^*))$. Of course we could just apply solution concepts to the situation $(c(H(x^*)), d)$, but as we argued above, some information on the shapes of the situations S_i does matter. Again we restrict ourselves to the information given by the ideal points a or b in $T = c(\cup S_i)$. This means that the countries form a type of bargaining goal by looking at the alternatives in T and choosing their best payoffs in the individually rational part of T or in T itself. We apply a proportional solution concept (cf. Klemisch-Ahlert 1993a, 1993b) that leads to an agreement point z on $H(x^*)$ where all countries receive payoff gains with equal proportions with respect to their ideal gains. The agreement consists of a realization of the regulation instrument that belongs to the allocation x^* and a redistribution via side payments such that in the end z_i is the payoff of country i , $i=1, \dots, n$. Figure 13 shows this solution concept for the ideal point a and Figure 14 for the ideal point b .



Figures 13 and 14

These solutions can be interpreted as generalized versions of the Kalai-Smorodinsky solution or the Kalai-Rosenthal solution. The advantages of this type of solution are that it is applied to the set of all feasible allocations of money under any proposed regulation rule, that it uses the instrument of side payments (assuming that this mode is accepted by all countries), and that it incorporates goals or aspirations the countries have in mind when they enter the negotiation

process. We confess that the information on goals that we use is very simple. It is a certain maximal gain a country would receive if its proposed regulation rule would be chosen. The bargaining concept itself, however, could be enlarged if there were more information available on how countries formulate their bargaining goals. In this case, too, the solution would be defined by equal proportions of gains of all countries with respect to the gains that are defined by their goals. The formal representations of the discussed solutions are given in Section 4 and by Klemisch-Ahlert (1993a).

The theory does not supply us with many arguments which special solution concept should be chosen to model the environmental negotiations. The only criterion that can be applied for sure is the Pareto criterion. From this point of view a solution point on the collectively best hyperplane $H(x^*)$ can never be dominated by any other procedure described above. And for any given bargaining concept with an agreement y we can find a point on $H(x^*)$ that Pareto dominates or equals y . These considerations may serve as an argument to underline the advantage of including the possibility of side payments into international environmental negotiations. All models and solution concepts above can also be applied when only the cost structure of the environmental problem is considered: In this case our paper develops an argument in favor of negotiations about sharing the collectively minimal costs, or at least bargaining about compensation payments.

4. Solution Concepts

In this section we give a short overview over the different solution concepts we have applied in the sections above. We describe and define the cooperative bargaining solutions on their specific domains, and we name some of their important properties that can be used to characterize these bargaining solutions axiomatically. The aim is not to present a complete list of solutions and properties, but to point out some of the main theoretical differences between the concepts we have mentioned.

The traditional type of cooperative n -person bargaining solution is defined on the set of bargaining situations (S, d) with $S \in \mathbb{R}^n$, $d \in S$, where S is convex and compact and there exists an $s \in S$ such that $s > d$ ($>$ is defined componentwise). S can be interpreted as the set of feasible n -tuples in utility space, d as the image of the alternative of disagreement in utility space. The last condition means that there exists a bargaining incentive for every person. A bargaining solution is a mapping f that assigns to every situation (S, d) an outcome $f(S, d) \in S$ which is the utility representation of the agreement..

The Nash solution (Nash 1950) chooses the individually rational point in S that maximizes the product of the utility gains of the n persons. It can be characterized by the axioms of scale invariance, symmetry, weak Pareto optimality and independence of irrelevant alternatives. This solution can be applied if we do not want to use information on maximal feasible gains of the persons. The axiom of independence of irrelevant alternatives implies that this type of information is irrelevant for the Nash solution.

Then there are proportional solutions that are defined on the space of all bargaining situations (S,d) , sometimes with the additional property that S is comprehensive (i.e. any utility reduction leads to a feasible point in S).

The Kalai-Smorodinsky solution KS (1975) is constructed by equal proportions of utility gains in comparison to the ideal gain. The ideal gains are defined by the difference between the ideal point $a(S,d)$ and d . $a(S,d)$ has the components $a_i(S,d) = \max\{s_i \mid s \in S, s \geq d\} \forall i = 1, \dots, n$. KS(S,d) is the point y in S such that

$$\frac{y_i - d_i}{a_i(S,d) - d_i} = \frac{y_j - d_j}{a_j(S,d) - d_j} \quad \text{for all } i, j = 1, \dots, n, \text{ and these ratios are maximal.}$$

Let $b(S,d)$ be the ideal point defined by the components $b_i(S,d) = \max\{s_i \mid s \in S\} \forall i = 1, \dots, n$.

Then the Kalai- Rosenthal solution KR (1978) is the point z in S with equal ratios of utility gains that are maximal, and it is defined analogously to KS, but with the ideal point b instead of a . The difference between these solutions comes from their different ideal points.

Other proportional solutions can be defined by using a claim point c that is exogeneously given and independent of the bargaining situation (S,d) (cf. Thomson and Chun 1992). We do not apply this concept in this paper because it is not clear how to define a general claim point c in the environmental negotiations. We prefer models with claims that depend on the given bargaining situation.

The solutions KS and KR are not independent of irrelevant alternatives, they depend on some information on the set S and on the point d . The axiom of independence of irrelevant alternatives has to be replaced e.g. by some kind of monotonicity axiom in order to characterize these solutions. Monotonicity here means that certain improvements in the set of feasible utility n -tuples lead to improvements of the utilities assigned to the new agreement.

The egalitarian solution e needs interpersonally comparable utilities to be applied. This means that it does not have the property of scale invariance. The solution equalizes the utility gains of all persons. $e(S,d)$ is a point x in S such that $x_i - d_i = x_j - d_j$ for all $i, j = 1, \dots, n$, and such that these differences are maximal. An application of this solution makes sense if the negotiation problem is presented in a monetary space. e does not use information on aspirations or goals, it presents the simple, but frequently applied justice norm of equality of gains.

The solution concept we would like to propose (Klemisch-Ahlert 1993a, 1993b) uses information on the given set S of feasible alternatives in utility representation and also faces the redistributive possibilities generated from the given alternatives. The redistributive alternatives are mapped into the utility space, too. These utility n -tuples form the set E which is assumed to be convex, compact, comprehensive, and $S \subseteq E$. E is called an envelop to S . Since E is important for the agreement the solution has to be defined on tripels (S, E, d) . A solution f then picks a point of the Pareto optimal boundary of E such that the proportion of the gains of all persons are equal. Here proportions are calculated with respect to maximally feasible gains in the individually rational part of S . In Figure 15 we present the solution for the two person case.

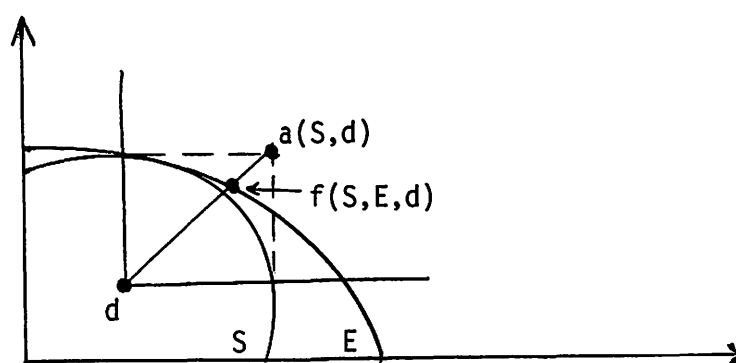


Figure 15

The axiomatic characterization of the solution for two persons can be given in the spirit of the characterizations of other proportional solutions using monotonicity axioms dealing with improvements of one person with respect to the set of feasible alternatives S . This means that higher justified aspirations or goals of one person lead to an outcome in E where this person's utility level is not worse than before. In the general case of n persons we use the axiom of restricted independence of the set of alternatives. This axiom defines the important information of the given situation (S, E, d) to be the ideal point in S . Additionally we need a monotonicity axiom for the set of redistributive possibilities E . This axiom says that an enlargement of the set E leads to an agreement where no person has a lower utility level than before.

5. An Outlook

As we have argued in the first three sections, aspirations or goals of the negotiating parties should be included into the theoretical analysis of international environmental negotiations. In the theories above, we presented simple methods to derive goals. It would be interesting to do some empirical research to find out which types of aspirations and goals are really used.

Another open question is how side payments are treated in these negotiations. It is obvious that they were not used as often as they could have been used. From the theoretical analysis it can be derived that via side payments Pareto improvements are often possible. What are the reasons that countries hesitate to formulate contracts that include side payments or compensations for high costs? Can these reasons be included into the model so that the irrationality of Pareto inefficient agreements without side payments disappears? In any case, the theoretical analysis above gives a strong indication that being open for contracts that include redistributions in international environmental negotiations would be to the benefit of all participating countries.

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