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On the Self-serving Use of Equity Principles in International Climate Negotiations

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Equity Principles in
International Climate Negotiations**

Andreas Lange, Andreas Löschel,
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Nontechnical Summary

Bargaining situations and negotiations frequently look like a strife for fairness. While bargainers are arguing to get their “fair share” when they feel disadvantaged, the meaning of “fair” is often heavily debated. Negotiations therefore become more complicated when there is more than one justifiable fairness norm (Raiffa 1982, p.268). Here, negotiators could potentially pick those fairness principles which justify additional demands from their side. Besides being prevalent in daily life, equity criteria are also ubiquitously used in the international arena when it comes to negotiating multilateral agreements. In the international negotiations on the mitigation of climate change, different notions of equity have been proposed. The UNFCCC (UN Framework Convention on Climate Change) recognizes the principle of “common but differentiated responsibilities and respective capabilities”. Notions like “equal per capita emissions”, “polluter-pays”, or “sovereignty” all show different interpretations of fairness. When different conflicting fairness principles exist, the negotiations process involves a weighing and reconciliation of the different proposed equity bases for a potential agreement. However, the role and importance of equity criteria in shaping the negotiation process has drawn only limited attention in the literature.

This paper attempts to fill this gap by studying the importance of equity criteria in the formulation of negotiation positions of major parties in the UNFCCC process. It puts forward equity as an important structural element to understanding negotiation outcomes. We first advance bargaining theory to incorporate the self-serving use of equity. Agents are predicted to push equity principles which benefit them more than other parties, in particular those which are disadvantageous to parties with large bargaining power. Based on unique data from a world-wide survey of agents involved in international climate policy, we then study how participants assess the support of the equity criteria by major parties in the climate negotiations. Comparing these results with cost estimates from a POLES model, we find that the perceived equity preferences of the respective countries or groups of countries are in general consistent with our hypothesis of a self-serving use of equity criteria and thereby lend support for our theoretical model. While this self-interest is recognized by the participants of our survey for the positions of the USA and the G77/China as well as Russia, the EU manages to be seen as choosing (self-serving) equity arguments out of fairness concerns and in order to facilitate the negotiations.

On the Self-serving Use of Equity Principles in International Climate Negotiations*

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Abstract. This paper puts forward equity as an important structural element to understanding negotiation outcomes. We first advance bargaining theory to incorporate the self-serving use of equity. Agents are predicted to push equity principles which benefit them more than other parties, in particular those which are disadvantageous to parties with large bargaining power. Based on unique data from a world-wide survey of agents involved in international climate policy, we then study how participants assess the support of the equity criteria by major parties in the climate negotiations. Comparing these results with cost estimates from a POLES model, we find that the perceived equity preferences of the respective countries or groups of countries are in general consistent with our hypothesis of a self-serving use of equity criteria and thereby lend support for our theoretical model. While this self-interest is recognized by the participants of our survey for the positions of the USA and the G77/China as well as Russia, the EU manages to be seen as choosing (self-serving) equity arguments out of fairness concerns and in order to facilitate the negotiations.

Keywords: bargaining theory, equity criteria, self-serving bias, climate policy, survey data

JEL: C7; D63; H41

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“We talk on principle but we act on interest.”

— William Savage Landor (1775-1864)

1 Introduction

Bargaining situations and negotiations frequently look like a strife for fairness. While bargainers are arguing to get their “fair share” when they feel disadvantaged, the meaning of “fair” is often heavily debated. Negotiations therefore become more complicated when there is more than one justifiable fairness norm (Raiffa 1982, p.268). Here, negotiators could potentially pick those fairness principles which justify additional demands from their side. Besides being prevalent in daily life, equity criteria are also ubiquitously used in the international arena when it comes to negotiating multilateral agreements. However, their role and importance in shaping the negotiation process has drawn only limited attention in the literature. This paper attempts to fill this gap by studying the importance of equity criteria in the formulation of negotiation positions of major parties in the UNFCCC (UN Framework Convention on Climate Change) process. We both provide advances on bargaining theory by incorporating the self-serving use of equity and discuss empirical evidence based on a world-wide survey of agents involved in international climate policy.

Equity criteria are discussed in the literature in different ways. They are sometimes seen as guiding the negotiations (“focal points”, Schelling 1960) and thereby as means to reduce the negotiation costs. Bosello et al. (2001) study the stability of international agreements if based on a single equity rule but do not find major improvements upon the relatively pessimistic predictions from traditional economic models of coalition formation (Barrett 1994; Carraro and Siniscalco 1993; Hoel 1993). Lange and Vogt (2003) and Lange (2006) take a different approach and model preferences which trade-off payoffs with equity concerns. Such equity preferences can potentially increase cooperation rates but are based on the assumption that countries evaluate their position based on a single given equity criterion.

However, in the international negotiations on the mitigation of climate change, different notions of equity have been proposed. The UNFCCC recognizes the principle of “common but differentiated responsibilities and respective capabilities”. Notions like “equal per capita emissions”, “polluter-pays”, or “sovereignty” all show different interpretations of fairness. Referring to this variety of equity criteria, Ringius et al. (2002, p. 3) state that “notions of fairness can provide a basis for an international regime only if there is a certain minimum of consensus among its members about what is fair and what is unfair”.

The perception of fairness may however differ across parties. Several strands of economic as well as psychological literature indicate that the understanding of what is fair is – at least to a certain extent – driven by economic costs of the respective equity rules: Babcock et al. (1995) consider this “self-serving bias in judgments of fairness” in an experimental bargaining situation. Babcock and Loewenstein (1997) review psychological and experimental evidence for this interaction between fairness perceptions and material payoffs. Hennig-Schmidt (2002) shows the self-serving use of equity arguments in a video-bargaining experiment. When different conflicting fairness principles exist, the negotiations process therefore involves a weighing and reconciliation of the different proposed equity bases for a potential agreement. To our knowledge, this self-serving idea of equity use has not been incorporated into the theory of bargaining.

In this paper we start with the hypothesis that equity criteria are used by the respective parties to influence the negotiations process in their own (material) self-interest. We assume that due to the consensus driven nature of international cooperation, parties back their proposals with some notion of equity in order to increase their acceptability in the negotiation process. Statements about fairness thereby legitimate further demands in the bargaining process and permit “the pursuit of self-interest with minimal condemnation or other costs” (Albin 2001, p.19). We assume that the use of equity arguments is self-serving, i.e. purely tactical. Just as traditional views on bargaining in the game-theoretic literature assume a balancing of conflicting demands by self-interested parties, the bargaining process in this paper is seen as balancing of demands where the bargaining power of the respective parties depends on the possibility of using self-serving equity criteria supporting their demands. We therefore understand the exercise in this paper as putting forward equity as an important structural element to understanding negotiation outcomes.

Using our theory, we can show that agents will push equity notions which – on average – benefit them more than other parties. However, it could also be beneficial for a party to propose an equity principle which indicates that this party should receive a lesser surplus share if the equity criterion would be even more disadvantageous to other parties, in particular to those with large bargaining power. Our model also implies that it can be beneficial for a party to simultaneously support multiple equity criteria.

After providing a theoretical basis for our study, we use the POLES model (Criqui 2001) to provide cost estimates when the allocation of abatement obligations across countries is governed by different equity criteria. We concentrate on the following major parties involved

in climate negotiations: the European Union (EU), the Group of 77 including China (G77/China), Russia, and the United States of America (USA). Given our hypothesis of self-interested use of equity criteria, these cost estimates provide the basis for ranking the equity criteria with respect to their implied financial burdens for the respective countries or groups of countries. This generates our predictions for the use of equity in climate negotiations.

We then consider unique data from a world-wide survey of agents involved in international climate policy to assess the views of the negotiation positions of the respective countries or groups of countries. We find that the perceived equity preference is in general consistent with our hypothesis of a self-serving use of equity criteria. The EU, however, is seen as strongly supporting the poor losers rule as well. Looking into the implied costs of this rule, it becomes obvious that they are much larger for the USA and Russia than for the EU. Being “fair” therefore comes at a small price. The self-interested use of equity arguments by the parties is recognized by the participants of our survey for the USA and G77/China as well as Russia. The position of the European Union is seen as substantially driven by fairness notions and a desire to facilitate the negotiations.

The remainder of the paper is organized as follows: in section 2 we describe the different equity principles in international climate policy. We then proceed to provide a theory for the link between equity use and bargaining power in section 3. In section 4, we estimate the economic costs of the different equity criteria when strictly applied to determine the allocation of abatement burdens across the countries or groups of countries. Section 5 discusses our empirical findings based on the survey data. The final section concludes.

2 Equity principles in international climate policy

The nature of the climate change problem allows decomposing policy decisions into those on the climate target (i.e., the aggregate greenhouse gas emission reductions) and those on the distribution of cost burdens which is crucial in evaluating the equity consequences of any given proposal. While the strength of the climate target is certainly a major criterion for the acceptability of any future international climate agreement, negotiations in the past centered to a large extent around questions on how the burdens of some global abatement effort should be distributed. In this paper, we concentrate on the issue of distributing a given burden or – equivalently – of distributing an exogenously given surplus from concluding the agreement.

While the economic literature usually assumes that agents are exclusively concerned with the economic costs and benefits, equity arguments are frequently used in international

environmental negotiations. They can enter the negotiation position in different ways (Ringius et al. 2002, Albin 2001): actors might dislike being treated or treating others unfairly, equity could serve as constraint on the substantiation of bargaining positions, or equity criteria could serve as focal points. Consistent with payoff-maximizing behavior, in this paper we assume that the use of equity is driven by self-interest to influence the bargaining outcome in ones favor.

In this sense, for example, developing countries as well as environmental interest groups in industrialized countries claim that developed countries with high per capita greenhouse gas emissions are responsible for global warming and must take the lead in combating climate change. As a consequence, weaker obligations or complete exemptions of developing countries from emission reduction targets can be based on equity arguments. Another dimension of equity issues is concerned with a fair distribution of burdens among countries with comparable per capita GDP and industry structure. Here, often similar reduction targets are seen as fair: some proposals during the international climate negotiations allocated emission reduction targets based on present or recent emission levels (Raymond, 2003).

Several studies identify different typologies of equity principles. We follow Ringius et al. (2002) and concentrate on the following main equity principles which dominate the political and the academic debate on international climate policy:

- The egalitarian rule (EGA): this rule incorporates the principle of equal per capita emissions. It implies that a country whose population amounts to $x\%$ of the global population should get $x\%$ of the global entitlements for greenhouse gas emissions.
- The sovereignty rule (SOV): this rule incorporates the principle of equal percentage reduction of current emissions. It implies that a country whose greenhouse gas emissions amount to $x\%$ of the global greenhouse gas emissions should get $x\%$ of the global entitlements for greenhouse gas emissions.
- The polluter-pays rule (POL): this rule incorporates the principle of equal ratio between abatement costs and emissions. It implies that a country whose greenhouse gas emissions amount to $x\%$ of the global emissions should bear $x\%$ of the global abatement costs for reductions of greenhouse gas emissions.
- The ability-to-pay rule (ABI): this rule incorporates the principle of equal ratio between abatement costs and GDP. It implies that a country whose GDP amounts to $x\%$ of global

gross product should bear x% of the global abatement costs for reductions of greenhouse gas emissions.

Besides these main equity rules there are often two further, accompanying principles discussed, namely (as we call them) the poor losers rule and the stand alone criterion:

- The poor losers rule (POOR) can be seen as a principle of exemption due to GDP. It states that a poor country is exempted from any obligation for greenhouse gas emission reductions until a certain level of GDP per capita compared with the respective average of developed countries is reached.
- The stand alone rule (STAL) can be seen as a principle of no excessive emission entitlements. It states that the entitlements for greenhouse gas emissions of a country are not higher than its business-as-usual greenhouse gas emissions.

3 A theory on bargaining power and self-serving equity

In Nash's (1950) seminal work on bargaining, all the differences of the players were supposedly captured in the threat points and the shape of the bargaining set. Many other explanations for the bargaining power have been suggested since then – not least differences in time or risk preference (Roth 1979). However, if one follows many negotiation processes, parties often refer to “fairness” arguments in order to convince the other party to agree to their proposal.

There is substantial evidence that the perception of “what is fair” is correlated with the economic costs and benefits implied by the respective equity notions (e.g., Babcock and Loewenstein 1997). These differing perceptions also show in the use of the respective equity principles as arguments in bargaining processes (Hennig-Schmidt 2001). According to Babcock and Loewenstein (1997), self interest affects what is perceived to be fair and is then traded off against moral correctness. Therefore, a self-serving perception of equity can be essential in explaining bargaining outcomes when a party successfully influences the bargaining process in its favor by referring to equity arguments.

In this section we consider the bargaining process as a “black box” where the use of beneficiary equity arguments can shift the bargaining power in ones favor. We assume that there is a set of equity rules which can be defended with different ethical reasons. Now, if all these equity criteria would require for a country to receive a larger share of the surplus, this country is likely to be able to influence the bargaining outcome in its favor. Conversely, the

lack of an equity or fairness argument for one's position would in our view result in a reduction of bargaining power. The end result of negotiations can therefore hardly be understood without analyzing the underlying equity notions: the bargaining power of the parties is linked to the availability of accepted notions of equity which back their positions.

We illustrate these ideas on the role of equity in a pure bargaining setting. We study a cooperative game in which, for simplicity, we require unanimity. That is, the bargaining game is described by a set $N = \{1, \dots, n\}$ of players and a pair (S, d) where S is a subset of IR^n representing the attainable payoffs to the players and $d \in IR^n$ denotes the vector of outside options. We assume that $\{s \in S \mid s \geq d\}$ is compact and non-empty. For our illustrating purposes we normalize $d = 0$ and $S = \{(s_1, \dots, s_n) \mid \sum_{i \in N} s_i = 1\}$, i.e. S is the unit n -simplex and describes the surplus shares of the individual players.

The generalized Nash bargaining solution in this game would maximize

$$\max_{s \in S} s_1^{\alpha_1} \dots s_n^{\alpha_n} \quad (1)$$

where $\alpha_i > 0$ is a measure for the bargaining power and is driven by the risk and time preference of the respective player $i \in N$ (e.g. Roth 1979). The well-known solution would give

$$\bar{s}_i = \frac{\alpha_i}{\sum_{j \in N} \alpha_j} \quad \text{for all } i \in N. \quad (2)$$

We can reinterpret this as a balance of power between the respective players. Given any proposal, each player tries to influence the bargaining outcome in her favor. The strength of this pull by player i is proportional to the bargaining power parameter $\alpha_i > 0$ but also inversely related to the already obtained surplus. That is, condition (2) can be rewritten as

$$\frac{\alpha_i}{s_i} = \frac{\alpha_j}{s_j} \quad \text{for all } i, j \in N. \quad (3)$$

which indicates the balance of forces to change the bargaining outcome in any direction. We will use this interpretation to illustrate the impact of equity notions.

We assume that there is a set $\Sigma = \{\sigma_1, \dots, \sigma_T\}$ of morally justifiable, i.e. fair outcomes $\sigma_t = (\sigma_{t1}, \dots, \sigma_{tm}) \in IR^n$ with $\sum_{j \in N} \sigma_{tj} = 1$ ($t = 1, \dots, T$). Note that we do not require that the

respective equitable shares σ_{ii} are positive, i.e. a specific equity criterion could indicate that a player should get a payoff lower than its outside option.

We assume that each player can endorse some equity criteria, the strength of support of equity criterion σ_t by player $j \in N$ is denoted by $\lambda_{tj} \geq 0$. Total support for equity criterion σ_t is given by $\Lambda_t = \sum_{j \in N} \lambda_{tj} \geq 0$.

We model the effect of this use of equity as providing additional forces to change the current proposal in the directions given by the respective equity criteria such that the balance of power in condition (3) is changed to

$$\frac{\alpha_i}{s_i} + \sum_t \Lambda_t (\sigma_{ti} - s_i) = \frac{\alpha_j}{s_j} + \sum_t \Lambda_t (\sigma_{tj} - s_j) \quad \text{for all } i, j \in N \quad (4)$$

We offer two alternative interpretations of condition (4) which differ in the view of the effect of equity on the bargaining situation. On the one hand, condition (4) can be motivated from a (asymmetric) Nash-bargaining solution $\arg \max_{s \in S} \prod_{i \in N} (u_i(s_i) - u_i(d_i))^{\alpha_i}$ when agents have self-serving preferences for equity given by $u_i(s_i) = s_i \exp\left[-\sum_t \Lambda_t (\sigma_{ti} - s_i)^2 / 2\right]$.¹ On the other hand, condition (4) is obtained from an increase in the bargaining power depending on the availability of self-serving equity arguments: in the Nash-bargaining solution, bargaining power could be measured as the slope of the indifference curve of the Cobb-Douglas function which is given by $du_j / du_i = \frac{\alpha_j / s_j}{\alpha_i / s_i}$ (see (1)). This indifference curve now gets steeper if player i uses self-serving equity arguments, it is flatter if agent j uses equity notions to her advantage.²

We can now use condition (4) to discuss the effects of using equity to support the respective bargaining positions. We first consider two limiting cases. As said above, without considering

¹ Note, however, that this utility structure could generally result in a non-convex bargaining set in the utility space. Here, we follow Zhou (1996) who generalizes the Nash bargaining solution to non-convex sets. Zhou (1996) assumes the bargaining set to be closed, comprehensive and bounded from above. The (asymmetric) Nash bargaining solution is then given by $F(S, d) \in \arg \max_{\mu \in S} \prod_{i \in N} (u_i - d_i)^{\alpha_i}$ where α_i gives the surplus share if the bargaining set is the unit simplex (with threat point $d = 0$). It is implied by the following axioms: (i) invariance with respect to positive affine transformations, (ii) strict individual rationality, and (iii) independence of irrelevant alternatives.

² Note that similar interpretations are usually offered Nash-bargaining solutions for risk-averse decision makers. Either one considers the utility space of risk averse decision makers ($u_i(s_i) = s_i^{\alpha_i}$) and keeps the symmetric Nash bargaining solution, or – alternatively – keeps the unit simplex as bargaining space and implements the asymmetric Nash bargaining solution given by $\arg \max_{s \in S} \prod_{i \in N} (s_i - d_i)^{\alpha_i}$.

equity ($\Lambda_t = 0$ for all t), we obtain $\bar{s}_i = \alpha_i / \sum_{j \in N} \alpha_j$. Fixing the relative importance of the equity criteria at $\bar{\Lambda}_t$ (where $\sum_t \bar{\Lambda}_t = 1$) and considering $\Lambda_t = \bar{\Lambda}_t \phi$, we obtain from (4)

$$s_i = \sum_t \bar{\Lambda}_t \sigma_{it} + \frac{\alpha_i}{\phi s_i} - c(\phi) \quad \text{for all } i \in N \quad (5)$$

where $c(\phi) = \frac{1}{n} \sum_{i \in N} \frac{\alpha_i}{\phi s_i} > 0$. This implies that for $\phi \rightarrow \infty$, i.e. an infinite weight on equity

$$\bar{s}_i = \sum_t \bar{\Lambda}_t \sigma_{it} - \bar{c} \quad \text{for all } i \in N \quad \text{with } \bar{s}_i > 0 \quad (6)$$

while $\sum_t \bar{\Lambda}_t \sigma_{it} \leq \bar{c}$ for $i \in N$ with $\bar{s}_i = 0$ where we denote the limits by $\bar{s}_i = \lim_{\phi \rightarrow \infty} s_i$ etc.

Straightforward calculation gives $\bar{c} = -\frac{1}{n_{>0}} \sum_{j: \bar{s}_j = 0} \sum_t \bar{\Lambda}_t \sigma_{tj} \geq 0$ where $n_{>0} = \#\{j : \bar{s}_j > 0\}$

denotes the number of players with positive shares. That is, countries get their “fair” share less a constant and those countries for which this would imply a negative share receive zero.

More specifically, if the weighted equity criterion indicates that all countries get a positive share, they will receive exactly this equitable share. If, however, the weighted equity criterion indicates that a party should receive a negative amount, i.e. less than its outside option, then this country receives zero surplus. As this increase in surplus compared to the “fair” share has to be deducted evenly from all other countries, it could happen that countries with a positive, but small $\sum_t \bar{\Lambda}_t \sigma_{it}$ also receive a zero share. This will be the case for a country i if $0 < \sum_t \bar{\Lambda}_t \sigma_{it} \leq -\sum_{j: \sum_t \bar{\Lambda}_t \sigma_{tj} < 0} \sum_t \bar{\Lambda}_t \sigma_{tj} / (n - \#\{j : \sum_t \bar{\Lambda}_t \sigma_{tj} < 0\})$.

We summarize these results in the following proposition:

Proposition 1: *If the weight on equity criteria gets infinitely large, all countries receive their equitable share minus a constant. Some countries might receive zero payoffs, in particular those for which the weighted criterion indicates that they should receive less than their outside option.*

An application where an equity criterion could indicate a negative surplus share would be the egalitarian criterion. If one applies this rule strictly, the developing countries would receive an allocation of allowances which leaves industrialized countries facing substantial costs and therefore most likely negative net benefits from climate policy. Therefore, this criterion could

not be applied in a strict way. However, it is more than questionable that the bargaining power would imply an infinite weight on such an equity criterion: there are alternative equity criteria which could be supported in favor of industrialized countries. We now consider which country would have incentives to support the respective equity notions.

For this, we study the derivative of condition (4) with respect to Λ_t . Simple calculus gives the following formula:

$$\frac{ds_i}{d\Lambda_t} \left(\frac{\alpha_i}{s_i^2} + \sum_t \Lambda_t \right) = (\sigma_{ii} - s_i) - \sum_{j \in N} \mu_j (\sigma_{ij} - s_j) \quad (7)$$

where

$$\mu_j = \frac{1 / \left(\frac{\alpha_j}{s_j^2} + \sum_t \Lambda_t \right)}{\sum_{l \in N} 1 / \left(\frac{\alpha_l}{s_l^2} + \sum_t \Lambda_t \right)} \quad (8)$$

Condition (7) immediately implies that a country benefits from supporting an equity criterion, if its distance from the fair share is larger than the μ -weighted distance of other countries. Therefore, the country with the maximal $\sigma_{ii} - s_i$ will definitely benefit from an increased weight on equity criterion σ_t , the country with the smallest (negative) $\sigma_{ii} - s_i$ will lose. However, condition (7) also implies that a country i might even benefit from supporting a specific equity criterion if this equity criterion implies that it should get less (if $\sigma_{ii} < s_i$ but $0 > \sigma_{ii} - s_i > \sum_{j \in N} \mu_j (\sigma_{ij} - s_j)$). The reason is that other countries might have an even worse position regarding this particular equity criterion such that relatively the bargaining power shifts towards country i . We will later see that such a situation might apply to the EU when supporting the egalitarian principle: the EU has an above average per capita greenhouse gas emission level, its position compared to other industrialized countries would benefit from the application of this criterion. To get some better insights in the effects of supporting a particular equity criterion, we now consider a couple of special cases based on the assumption that so far no equity criterion is used.

For the case where $\Lambda_t = 0$ for all t , and, for simplicity, normalizing $\sum_j \alpha_j = 1$, condition (7) reduces to:

$$\begin{aligned} \frac{ds_i}{d\Lambda_t} \frac{1}{\alpha_i} &= (\sigma_{ii} - \alpha_i) - \sum_{j \in N} \alpha_j (\sigma_{ij} - \alpha_j) \\ &= (\sigma_{ii} - \alpha_i) + n(\text{var}(\alpha_j) - \text{cov}(\alpha_j, \sigma_{ij})) \end{aligned} \quad (9)$$

Country i therefore benefits from the use of an equity criterion, if the equity notion implies that country i is more disadvantaged than an α -weighted average of all countries. In particular, if the equity criterion indicates that countries with large bargaining power should get less surplus ($\text{cov}(\alpha_j, \sigma_{ij}) < \text{var}(\alpha_j)$), even a country for which $\sigma_{ii} - \alpha_i < 0$ could benefit from this equity criterion. Conversely, if $\text{cov}(\alpha_j, \sigma_{ij}) > \text{var}(\alpha_j)$, country i could be worse off even if $\sigma_{ii} - \alpha_i > 0$. If, however, all countries have identical bargaining power in absence of equity use, i.e. $\alpha_j = 1/n$ for all j , then country i would benefit from pushing an equity criterion if and only if $\sigma_{ii} > 1/n$.

We can summarize our results in the following proposition:

Proposition 2: *A country can benefit from an increased weight on a specific equity criterion, if its distance from the implied equitable share is larger than a weighted average of other countries' distances. A country might benefit even though the equity criterion implies a smaller share. Conversely, a country's position might deteriorate even though the used equity criterion implies a larger share for the country.*

Note however, that these counterintuitive effects of pushing a favorable equity criterion can only occur in a multilateral bargaining setting. If one faces a bilateral bargaining situation, a country should always push those equity rules which imply a larger surplus share ($\sigma_{ii} > s_i$).

We finally turn to the question whether a country should support more than one equity criterion when it has limited resources, i.e. a larger weight on one equity criterion necessarily implies less support for the other and there is an implicit budget constraint on supporting equity criteria: $\sum_t \lambda_t \leq \bar{\lambda}_t$. Condition (7) implies that:

$$\frac{ds_i}{d\Lambda_t} - \frac{ds_i}{d\Lambda_{t'}} = \frac{(\sigma_{ii} - \sum_{j \in N} \mu_j \sigma_{ij}) - (\sigma_{t'i} - \sum_{j \in N} \mu_j \sigma_{t'j})}{\frac{\alpha_i}{s_i^2} + \sum_t \Lambda_t} \quad (10)$$

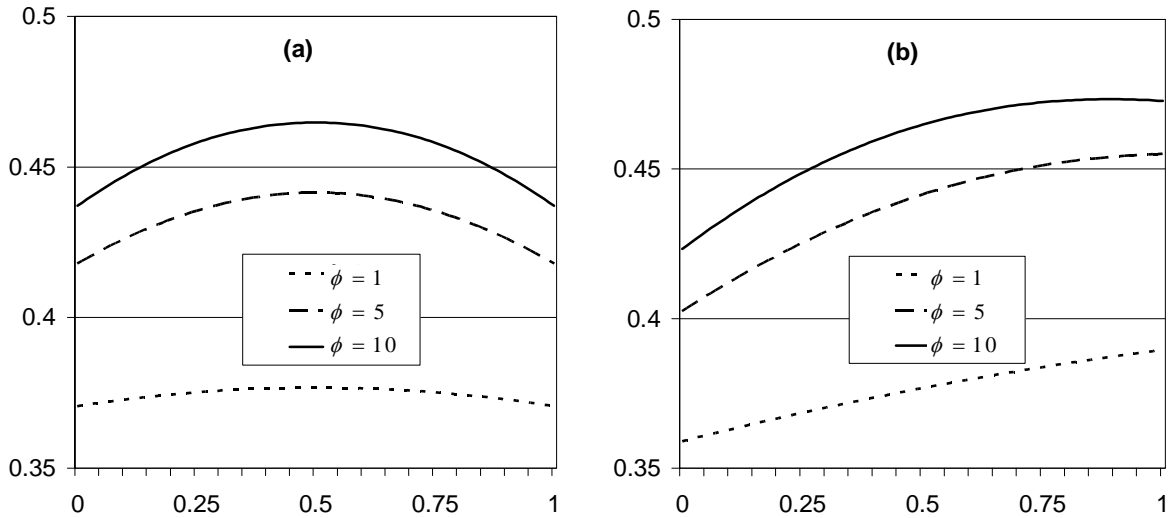
One should therefore always support the criterion t for which $\sigma_{ii} - \sum_{j \in N} \mu_j \sigma_{ij}$ is maximized. That is, a country chooses to support a criterion for which the difference between the implied

share and the weighted share of other countries is maximal. If simultaneously supporting two different equity notions t and t' ($\lambda_{ii} > 0$ and $\lambda_{t'i} > 0$) is optimal, then $\frac{ds_i}{d\Lambda_t} = \frac{ds_i}{d\Lambda_{t'}}$ or

$\sigma_{ii} - \sum_{j \in N} \mu_j \sigma_{ij} = \sigma_{t'i} - \sum_{j \in N} \mu_j \sigma_{t'j}$ necessarily holds in the optimum. In such a situation, a country implicitly pushes a weighted average of different equity criteria.

Example 1: Consider a set of $n = 3$ agents with bargaining weights $\alpha = (1/3, 1/3, 1/3)$ or $\alpha = (1/3, 1/9, 5/9)$, respectively. Without any weight on equity, player 1 would receive a surplus share of $s_1 = 1/3$. We assume that there are two equity criteria $s_1 = (0.5, 0.5, 0)$ and $s_2 = (0.5, 0, 0.5)$. That is, the equitable share for agent 1 is always $\sigma_{i1} = 0.5$ while the equity criteria differ in the share assigned to agent 2 and 3. Figure 1 gives the payoff to player 1 for different weights on equity, $(\Lambda_1, \Lambda_2) = \phi \cdot (1 - \pi, \pi)$ for $\phi \in \{1, 5, 10\}$ which are calculated based on condition (4). Figure 1 shows that player 1 has incentives to support both equity rules. The weight to which she wants to support equity criterion $s_1 = (0.5, 0.5, 0)$ vs. equity criterion $s_2 = (0.5, 0, 0.5)$ depends on the initial bargaining power α of the other two players: for $\alpha = (1/3, 1/3, 1/3)$, player 1 optimally supports both equity principles to the same extent. If the bargaining power of player 3 is increasing, player 1 should shift the support of equity criteria towards criterion 2, which implicitly hurts player 3 and therefore reduces the initially large bargaining power of player 3. For $\alpha = (1/3, 1/9, 5/9)$ and $\phi = 1$, player 1 would only support equity rule 1.

Figure 1: Surplus share of player 1 as a function of his relative support of equity criterion 2 vs. criterion 1. Panel (a) is based on $\alpha = (1/3, 1/3, 1/3)$, panel (b) on $\alpha = (1/3, 1/9, 5/9)$.



Example 1 illustrates that a player might choose to support different equity principles with the respective weights depending on the potential to reduce the bargaining power of other players. We summarize our result in the following proposition:

Proposition 3: *A country should support an equity criterion which maximizes the distance between its “fair” share and the weighted share of other players. It could be beneficial for a country to support more than one equity criterion. Players optimally shift their support of equity criteria in response to differing bargaining power α .*

Note that in the theory we discussed only equity criteria which explicitly determine the distribution of surplus. In our empirical section we consider four main equity criteria which fall into this category (egalitarian, sovereignty, ability-to-pay, and polluter-pays). In addition, we study accompanying principles (poor losers and stand alone). These accompanying principles fully specify a distribution of surplus only in combination with the main equity criteria. Therefore, a country could very well want to support a combination of one main with one accompanying equity principle.

4 The economic costs of different equity principles

In order to produce predictions on the preferred equity criteria of the respective parties, we now turn to an assessment of the involved costs. We concentrate on CO₂ emissions and assume that the aggregate emissions target is fixed at different levels and an emissions trading system equalizes the marginal abatement costs across all countries. For any given overall

target (or equivalently, any given marginal abatement costs), the different equity criteria therefore imply a specific distribution of surplus but have no efficiency effects. In order to assess the distributions implied by the egalitarian, sovereignty, polluter-pays, ability-to-pay and the accompanying rules of poor losers and stand alone, we use information on abatement costs in the respective countries or groups of countries, population data, baseline carbon dioxide emissions, and GDP.

Our projections for GDP, emissions and populations for 2020 are based on DOE (2005). The mapping of the International Energy Outlook regions is described in Table A.1 (Appendix A). The GDP, CO₂ emissions, and populations in the reference case for 1990 and 2002, as well as the projections for 2020 are summarized for our model countries or groups of countries in Table A.2 (Appendix A). Table A.2 also states an accumulated measure of emissions between 1860 and 2002 which are taken from the Climate Analysis Indicators Tool (WRI 2005) and updated to 2020 using DOE (2005). Marginal abatement cost curves for 2020 are generated based on data from the POLES model, which embodies a detailed bottom-up description of regional energy markets and world-energy trade (Criqui 2001). Table A.3 (Appendix A) summarizes the abatement cost information for 2020 from POLES. Table A.2 and Table A.3 contain all relevant data which we use to calculate allowance allocations, total costs and costs per capita for the different global abatement scenarios (permit prices) in 2020.

The formulas for the allocation of allowances under the different equity rules are implemented as follows: for each country or group of countries $i \in \{EU, USA, Russia, G77/China\}$, we denote for 2020 the business as usual emissions as e_i^{2020} , the GDP as GDP_i^{2020} , and the population level as POP_i^{2020} . As we assume that any abatement scenario is implemented at minimal costs, i.e. with identical marginal abatement costs, the resulting permit price p defines the optimal allocation of abatement $a_i(p)$ for each i with resulting abatement costs $AC_i(p)$. The aggregate levels of all variables are denoted as E^{2020} , GDP^{2020} , POP^{2020} , $A(p)$, and $AC(p)$, respectively. With this we can calculate the permit allocation $\bar{e}_i(p)$ which is induced by the respective equity criteria. This allocation solves:³

³ Note that the total burden to a country is given by its abatement costs plus the payments for emission permit in excess of its allocation.: $AC_i(p) + p(e_i^{2020} - a_i(p) - \bar{e}_i(p))$,

$$\begin{aligned}
\text{EGA} & \quad \frac{\bar{e}_i(p)}{POP_i^{2020}} = \frac{E^{2020} - A(p)}{POP^{2020}} \\
\text{SOV} & \quad \frac{\bar{e}_i(p)}{e_i^{2020}} = \frac{E^{2020} - A(p)}{E^{2020}} \\
\text{ABI} & \quad \frac{AC_i(p) + p(e_i^{2020} - a_i(p) - \bar{e}_i(p))}{GDP_i^{2020}} = \frac{AC(p)}{GDP^{2020}} \\
\text{POL} & \quad \frac{AC_i(p) + p(e_i^{2020} - a_i(p) - \bar{e}_i(p))}{e_i^{2020}} = \frac{AC(p)}{E^{2020}}
\end{aligned} \tag{11}$$

For the additional criteria poor losers and stand alone we require that the net burden is zero for G77/China, i.e. $AC_{G77/China}(p) + p(e_{G77/China}^{2020} - a_{G77/China}(p) - \bar{e}_{G77/China}(p)) = 0$. The allocation to the remaining countries or groups of countries is adjusted accordingly such that the respective left hand sides in (11) are equalized for $i \in \{\text{EU, USA, Russia}\}$. Furthermore, we discuss the version of the polluter-pays principle based on the cumulated (historical and future) CO₂ emissions between 1860 and 2020. The corresponding formula for POL⁽¹⁸⁶⁰⁻²⁰²⁰⁾ can be obtained from (11) by replacing the denominators of the POL equation by cumulated emissions.

The resulting economic costs of strictly applying the equity criteria for the respective countries or groups of countries can be seen in Figures A.1 to A.4 (Appendix A).

Hypotheses on the EU

Figure A.1 shows clearly that a strict application of the egalitarian principle would be most cost intensive for the EU. Without accompanying equity rules, the EU would prefer the polluter-pays or, secondly, the ability-to-pay principle. If, however, exceptions for G77/China are granted such that those countries would be free of obligations (POOR) but also would be held at their original welfare level (STAL), the ranking of the equity criteria for the EU changes. With the stand alone and poor losers rules, the EU is predicted to prefer the egalitarian notion, followed by POL, SOV, and ABI. The total ranking for the EU is given by

$$\text{EGA}_{\text{STAL}} \succ \text{POL} \succ \text{ABI} \succ \text{SOV} \succ \text{POL}^{(1860-2020)} \succ \text{POL}_{\text{POOR}} \succ \text{SOV}_{\text{POOR}} \succ \text{ABI}_{\text{POOR}} \succ \text{EGA}$$

This reversal from the special treatment of developing countries occurs because the EU has a relatively low per capita emission level when compared to other industrialized countries. The use of equity criteria by the EU is therefore predicted to heavily depend on the way developing countries are included in the agreement. As an alternative to granting exemptions to developing countries, the EU might also push a version of the polluter-pays principle which

accounts for the historical, i.e. cumulated emissions: the costs implied by $POL^{(1860-2020)}$ are less than those from combining any other criterion with the poor losers principle.

Hypotheses on the USA

Figure A.2 demonstrates that applying the egalitarian principle, with and without the accompanying rule, would be extremely cost intensive. The USA are therefore predicted to strictly oppose this criterion. The USA can also be predicted to reject the accompanying poor losers principle since its application would substantially increase costs. The remaining equity rules do not differ substantially in their associated costs. The total ranking is given by

$$ABI \succ POL \succ SOV \succ POL^{(1860-2020)} \succ ABI_{POOR} \succ SOV_{POOR} \succ POL_{POOR} \succ EGA_{STAL} \succ EGA$$

It should be noted that the preference for the ability-to-pay principle clearly depends on the assumed economic growth of the specific countries in the world. If this criterion were applied based on today's comparisons in GDP, then the burden implied for the USA would be substantially larger.

Hypotheses on Russia

Figure A.3 indicates that Russia would join the USA in opposing the application of the egalitarian principle even if accompanied with the stand alone criterion. Russia has lowest costs if the sovereignty, or secondly the ability-to-pay criterion is applied. The complete ranking of rules is given by

$$SOV \succ ABI \succ POL \succ SOV_{POOR} \succ POL^{(1860-2020)} \approx ABI_{POOR} \succ POL_{POOR} \succ EGA_{STAL} \succ EGA$$

The costs increase for Russia from the poor losers principle is also substantial such that Russia could be predicted to oppose exemptions of developing countries. When using equity arguments in its self-interest, Russia is therefore predicted to prefer the sovereignty or ability-to-pay principle and to strictly oppose the egalitarian principle.

Hypotheses on G77/China

We finally discuss the costs which are implied by the different equity rules for G77/China. Figure A.4 indicates these burdens. The ranking of the criteria is given as follows:

$$EGA \succ EGA_{STAL} = ABI_{POOR} = SOV_{POOR} = POL_{POOR} \succ POL^{(1860-2020)} \succ SOV \succ ABI \approx POL$$

It is obvious that G77/China would profit most from a strict application of the egalitarian principle. If acknowledging that the huge welfare transfers which are implied by EGA are not a feasible outcome of the negotiations, G77/China would agree to using EGA combined with STAL or to using any of the other equity criteria if accompanied by exemptions for poor countries. Further, G77/China would oppose a strict application of the polluter-pays and ability-to-pay principles. The latter is based on the predicted economic growth of G77/China over the next decades such that the ability-to-pay rule would be increased. Developing countries could, however, support POL⁽¹⁸⁶⁰⁻²⁰²⁰⁾.

General comments

Negotiations on climate change are clearly targeted towards a long term climate policy. Any acceptance of an equity criterion with accompanying principles like poor losers, could set a precedence for shaping future agreements. The ranking of POL, SOV, and ABI may therefore be largely driven by such a long run perspective, even if in the short run exemptions for developing countries are granted. EGA seems to be an exceptional case: the USA and Russia would suffer substantially higher costs than from other criteria even with an accompanying stand alone principle. The EU, however, should be in favor of this criterion if the stand alone criterion is applied to the developing countries.

5 Empirical analysis

In this paper, we are clearly far from “proving” our theory on the strategic use of equity criteria. However, in order to get some support for our hypotheses we conducted an empirical analysis on the perception of the negotiation position of the EU, G77/China, Russia, and the USA. For the success of the agreements, it is important how the negotiation positions are perceived by the respective participants in negotiations. We therefore assess the perception of the positions of countries or groups of countries regarding equity instead of looking through the proposals made by the respective parties (see Reiner and Jacoby 1997).

The data for our empirical analysis stem from a world-wide survey which was carried out with the help of a standardized questionnaire and which was sent in 2004 via e-mail to 1695 agents involved in climate policy. The addresses were taken from official UN documents available in the Internet, for example, different climate policy and IPCC workshops. Of the

1695 contacted persons, 230 participated in the survey.⁴ This is a fairly typical participation rate for surveys with individuals which are not interviewed face-to-face. The participants obtained an individual login and password for an Internet questionnaire. This procedure of sending out passwords allowed us to control the access to the survey and, in particular, ensured that each participant could fill out the questionnaire only once. Alternatively, the participants could fill out a Word-document or PDF and send it back via e-mail or postal mail.

After explaining the six equity rules (see section 2), the questionnaire consists of two parts. While the first part addresses the individual views on equity (these data are analyzed in Lange et al. 2007), the second part studies the perceptions of the negotiation position of the EU, G77/China, Russia, and the USA by the participants. This second part is the basis of our empirical analysis in this paper.

For each of the six equity rules, we first asked to which degree the respective countries or groups of countries are expected to favor incorporating the specified rule in international climate agreements on entitlements for greenhouse gas emissions. We concentrated on a time horizon of no more than 20 years. We differentiated between “a very high degree”, “a high degree”, “a moderate degree”, “a low degree”, and “no degree”.

Second, we asked which of the four main equity rules “egalitarian”, “sovereignty”, “polluter-pays”, and “ability-to-pay” is expected to be most important for the respective countries or groups of countries (again regarding a time horizon of no more than 20 years).

Third, we asked whether the following reasons are expected to play an important role for the respective countries or groups of countries concerning their position on incorporating this most important equity rule: (i) material self-interest, (ii) fairness considerations of the public, (iii) facilitation of international climate negotiations, (iv) pressure from industry, or (v) pressure from environmental NGO’s.

Finally, the questionnaire comprised some questions about the individual background, in particular regarding the nationality.

Results

⁴ It should be noted that some of the 230 participants in the survey did not answer all questions such that the number of observations in the empirical analysis is smaller.

Table B.1 (Appendix B) reports for each country or group of countries the relative frequencies that the respective equity principles should be reflected in the distribution of entitlements for greenhouse gas emissions to “a very high degree” or “a high degree”. Table B.2 shows the relative frequencies regarding the most important equity rule.

The position of the EU is largely perceived as being driven by the polluter-pays principle (78.2% of all respondents, see Table B.1). Accordingly, 54.6% of the participants see this as the most important equity rule for the EU (see Table B.2). This coincides with the prominent position which this criterion was predicted to have according to the cost estimates in the previous section. The relative frequencies for the sovereignty and the ability-to-pay rule are rather similar according to Table B.1 (50.9% vs. 55.7%). The sovereignty rule is seen by 22.4% as the most important equity criterion for the EU, while the ability-to-pay principle is perceived by only 10.9% of the respondents as the most important rule (see Table B.2). Thus, the ranking of the most important equity rule can completely be explained by the self-interest as discussed in the previous section.

Additionally, the EU is perceived by 53.3% of all participants (see Table B.1) as being supportive towards exemptions based on the poor losers principle. This differs substantially from the other industrialized countries (29.9% of the participants for the USA and 34.0% for Russia, see Table B.1). This perception coincides with the prevalent view that – at least in the past – the EU was trying to establish itself as a leader in international climate policy and also was willing to grant exemptions to developing countries. Here, the positions of the EU and G77/China are obviously in line. Interestingly, however, the egalitarian notion is perceived as relatively less supported by the EU. Although this is consistent with the cost estimates, the favorable combination of EGA and STAL is apparently not strongly perceived as being supported by the EU.

Turning to the perceived position of G77/China it is interesting to note that the position is largely consistent with arguments which reduce the abatement burdens of these countries: above all they are seen as claiming exemptions for poor losers (79.0% of respondents, Table B.1). According to Table B.2, the egalitarian notion is seen as the most important equity criterion (37.9% of the participants) for G77/China, followed by ABI (31.0% of the participants) and POL (23.0% of the participants). This ranking deviates from the predictions based on our cost estimates: both the polluter-pays as well as the ability-to-pay rule are seen as receiving large support although they imply large costs. This result could only be consistent with economic self-interest of G77/China if the polluter-pays principle is based on a

cumulated emissions measure (POL⁽¹⁸⁶⁰⁻²⁰²⁰⁾) and/or that survey participants do not take into account the economic changes over the next decades. Interestingly, the sovereignty principle is perceived to be less supported by G77/China (29.1% in Table B.1; 8.0% in Table B.2).

We now turn to the perceived position of the USA. Most obviously, it is seen that the USA supports to a less extent the poor losers rule (29.9% of all participants as compared to 53.3% for the EU, see Table B.1). The sovereignty principle is perceived as supported most by the USA (60.8% of the respondents according to Table B.1 and 52.7% according to Table B.2). That is, the USA is perceived as demanding similar reduction efforts from all countries. In fact, this is consistent with the major official reasons for not ratifying the Kyoto protocol as the USA demanded meaningful participation of developing countries. The polluter-pays principle is seen as getting much less support than the sovereignty criterion (41.0% of the participants according to Table B.1 and 24.2% according to Table B.2), also when compared to the EU. This cannot sufficiently be explained with self-serving equity notions unless participants interpreted POL as being based on emissions cumulated over time. The egalitarian criterion is basically seen as being rejected by the USA – much in line with the hypothesis in the previous section, similarly to the ability-to-pay principle. The latter is surprising as in the long run this criterion would potentially benefit the USA if the predicted economic growth of developing countries materializes.

We finally discuss the perceived position of Russia. First, Russia is seen as supporting the accompanying principles to a lesser extent (34.0% of all participants for POOR and 29.4% for STAL, see Table B.1). The expected strong support for the ability-to-pay criterion (52.8% of the respondents) and the sovereignty notion (54.3% of the respondents) according to Table B.1 is consistent with the hypothesis of self-interest driven use of equity criteria. The ranking regarding the perceived desire to incorporate the equity rules and the ranking regarding the most important equity rule is exactly in line with the ranking given by our cost estimates for Russia.

Result 1: *The perceived support for specific equity rules differ across countries or groups of countries. The USA is seen as favoring the sovereignty rule and, thereby, the inclusion of all countries, while other groups of countries are seen as being in favor of exemptions for poor losers (G77/China, EU). The respective supported equity notions are in large consistent with self-interest for the EU and Russia. The relative support of the polluter pays principle by the USA and G77/China is only consistent with self-interest if based on cumulated emissions over*

time. The strong support of the EU of the poor losers rule as an accompanying principle runs contrary to full self-interest.

It should be noted that Table B.1 and B.2 also report the decomposed relative frequencies for respondents from the EU and from G77/China.⁵ The tables show that the corresponding relative frequencies can differ between all respondents, the respondents from the EU, and the respondents from G77/China. For example, participants from the EU expect the EU to support STAL clearly less than participants from outside the EU (see Table B.1). Furthermore, G77/China is seen as supporting the incorporation of SOV to a very high or high degree by a larger fraction of respondents from G77/China than participants from outside G77/China (see also Table B.1).⁶

While we have found that the perceived positions of countries or groups of countries are largely consistent with a self-interest hypothesis, it is interesting to see whether this self-serving equity use is unmasked by the public. Table B.3 (Appendix B) reports the relative frequencies that material self interest and other reasons (fairness considerations of the public; facilitation of international climate negotiations; pressure from industry; pressure from environmental NGO's) play an important role for the incorporation of the most important equity rule in international climate negotiations

Consistent with the analysis above, the expected main driving force for using the most important equity rule by G77/China, Russia, and the USA is material self-interest (86.1%, 88.9%, 93.5% of all respondents). Interestingly, the answers depend on the nationality of the participants: 75.3% of the participants from G77/China state that material self-interest plays an important role for the use of equity criteria by G77/China, while 96.8% of the participants from the EU perceive material self-interest playing an important role in the position of G77/China.⁷ The corresponding EU position is seen by 51.9% of the participants from the EU as material self-interest driven while 70.8% of the participants from G77/China see the EU as

⁵ The numbers of participants from Russia and the USA are too small for a meaningful decomposition for these two countries.

⁶ The corresponding chi-squared tests in Table B.1 examine whether the distribution of the expected degree of incorporation of the respective equity rules (with parameter values “a very high degree”, “a high degree”, “a moderate degree”, “a low degree”, and “no degree”) differs between the respondents from the EU (or, alternatively, from G77/China) and the corresponding respondents from outside the EU (or, alternatively, from outside G77/China). Similarly, the chi-squared tests in Table B.2 examine whether the expected distribution of the most important equity rule (with parameter values “EGA”, “SOV”, “POL”, and “ABI”) differs between the respondents from the EU (or, alternatively, from G77/China) and the corresponding respondents from outside the EU (or, alternatively, from outside G77/China).

⁷ The corresponding chi-squared tests also show that the relative frequencies for the respondents from the EU (or, alternatively, from G77/China) significantly differ from the relative frequencies for the respondents from outside the EU (or, alternatively, from outside G77/China).

using self-serving equity arguments. This finding is consistent with the self-serving bias which has been found in several experimental studies (see introduction).

For the USA and Russia, pressure from industry is also perceived as playing an essential role (83.9% and 69.7% of all respondents). The incorporation of the most important equity principle by the EU is seen to be motivated by material self interest to a lesser extent. Rather, 87.9% of all participants expect that fairness considerations of the public and 78.9% of all respondents expect that pressure from environmental NGO's play an important role. Corresponding to the perception of the EU as a primary driving player in international climate negotiations, the reason of its use of equity rules is observed as a facilitator of international climate negotiations (83.1% of the respondents).

Result 2: *G77/China, Russia, and the USA are perceived to use equity rules primarily out of material self-interest. The USA and Russia are also seen to be driven by industrial interest groups. The EU is seen to use equity arguments due to fairness considerations of the public, pressure from environmental NGO's, and in order to facilitate the international climate negotiations.*

Result 3: *Differences in the expectations of participants on a use of equity principles out of material self-interest is consistent with a self-serving bias: participants from the EU (G77/China) perceive the position of the EU (G77/China) to be less driven by material self-interest than participants not coming from the respective groups of countries.*

The perception of the respective countries or groups of countries sheds an interesting light on the role of equity as seen by the participants of our survey. Although the perceived position of the EU is by large consistent with a self-serving use of equity arguments, the EU manages to be seen as a facilitator of negotiations and as being driven by fairness considerations of the public and pressure from environmental NGO's. The reason for this could be the perceivably relative strong support of the accompanying poor losers principle by the EU. This support clearly is not consistent with pure self interest – although the costs of supporting it are relatively small when compared to the costs implied for the USA and Russia. A major part of the negotiation was dealing with the participation of developing countries which are seen to strongly oppose major costs and to support the poor losers criterion. The perceived position of the EU is therefore indeed in between those of G77/China and the USA such that taking the role of being a facilitator comes at relatively small costs for the EU.

6 Conclusions

In this paper we put forward equity as an important structural element to understanding negotiation outcomes using the example of climate negotiations. We implemented the idea of self-serving use of equity in a bargaining model which guided our analysis. Our data from an international survey largely confirms our predictions based on a cost-ranking of the respective equity criteria for the different countries or groups of countries: the perceived support of equity criteria appears to be the stronger the less costly this criterion is compared to alternatives. Interestingly, the EU is seen as supporting the poor losers criterion which runs contrary to its self-interest. It could be this support which leads our participants to state that on average the EU is more seen as facilitating the negotiations and acting out of fairness considerations instead of following its material benefits. The USA, Russia, and G77/China are largely seen as pursuing their own self-interest.

While the findings in this study indicate that equity notions in international negotiations are mostly correlated with the self-interest of the negotiating parties, the question remains why exactly their use can influence the negotiation process. Our model gives a first illustration of a possible interaction between bargaining power and the potential of a favorable use of equity principles. We believe that this role of using equity criteria will be essential in generating a better understanding of bargaining processes – not only on climate policy. This study thereby opens interesting potential for further research.

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Appendix A – Abatement costs and predictions

Table A.1: *International Energy Outlook regions and mapping to survey countries or groups of countries*

International Energy Outlook regions	Survey countries or groups of countries
United States of America	USA
Other North America	ROW
Western Europe	EU
Mature market Asia	ROW
Russia	Russia
Other former Soviet Union	ROW
Eastern Europe	EU
Emerging Asia	G77/China
Middle East	G77/China
Africa	G77/China
Central and south America	G77/China

Source: DOE (2005)

Table A.2: *GDP, population, and carbon emissions for survey countries or groups of countries*

	Year	EU	G77/China	Russia	USA	ROW	World
GDP (Billion USD2000)	1990	8160	9871	2241	7113	5688	33073
	2002	10484	18449	1657	10075	6562	47227
	2020	15816	46555	3571	17634	11006	94582
Population (Million)	1990	498	3965	148	253	396	5260
	2002	513	4891	144	289	429	6266
	2020	514	6092	129	337	460	7532
Emissions (MtC)	1990	1229	1664	640	1361	959	5853
	2002	1166	2566	415	1568	942	6658
	2020	1299	4767	538	2035	1186	9825
Accumulated Emissions (GtC)	1860- 2020	98	115	32	117	75	438

Source: Own calculations based on DOE (2005) and WRI (2005)

Table A.3: *Summary of abatement cost assumptions in 2020*

	Marginal Abatement Costs (USD2000/tC)									
	40	80	120	160	200	40	80	120	160	200
Countries (groups of countries)	Abatement (MtC)					Total abatement costs (Bn USD2000)				
EU	72	128	175	216	250	1.4	4.7	9.4	15.0	21.2
G77/China	502	860	1137	1365	1558	9.5	30.7	58.2	89.9	124.7
Russia	63	109	142	167	190	1.2	3.9	7.1	10.7	14.7
USA	155	270	362	437	502	2.9	9.8	18.9	29.4	41.0
ROW	64	112	151	181	209	1.2	4.0	7.9	12.1	17.0
WORLD	856	1480	1967	2366	2709	16.2	53.1	101.5	157.2	218.7

Source: Own calculations based on POLES (Criqui 2001)

Figure A.1: Costs in 2020 implied by the respective equity criteria for the EU (in % of GDP)

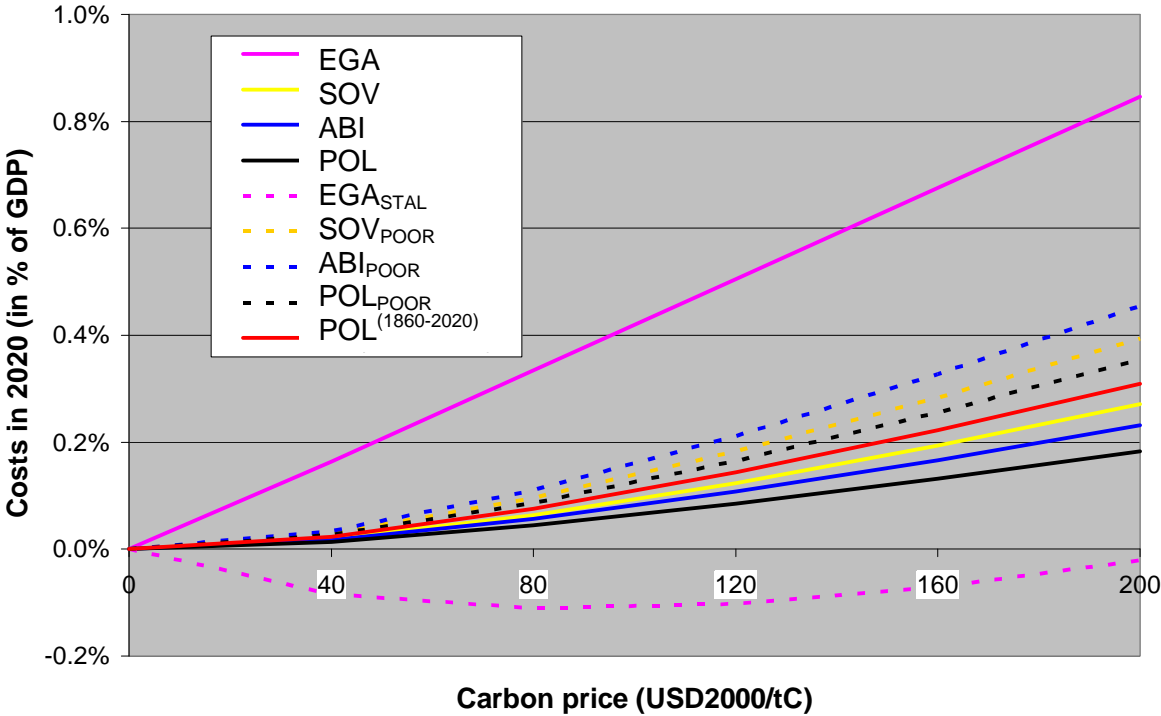


Figure A.2: Costs in 2020 implied by the respective equity criteria for the USA (in % of GDP).

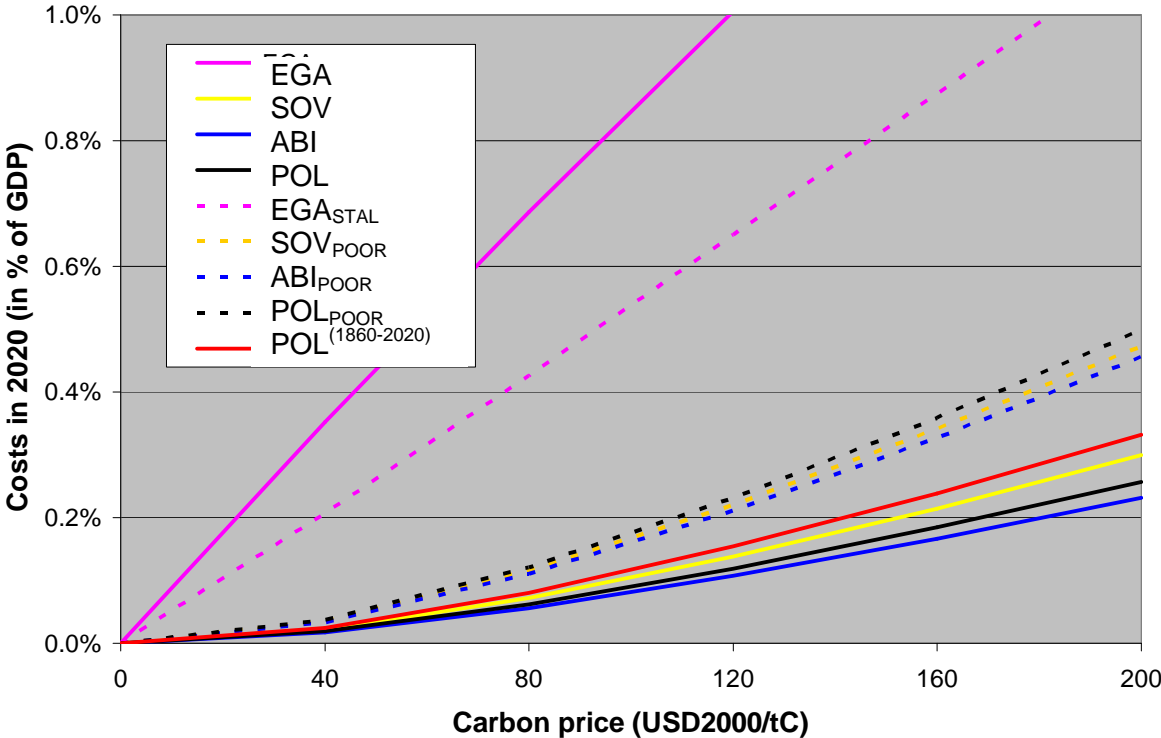


Figure A.3: Costs in 2020 implied by the respective equity criteria for Russia (in % of GDP).

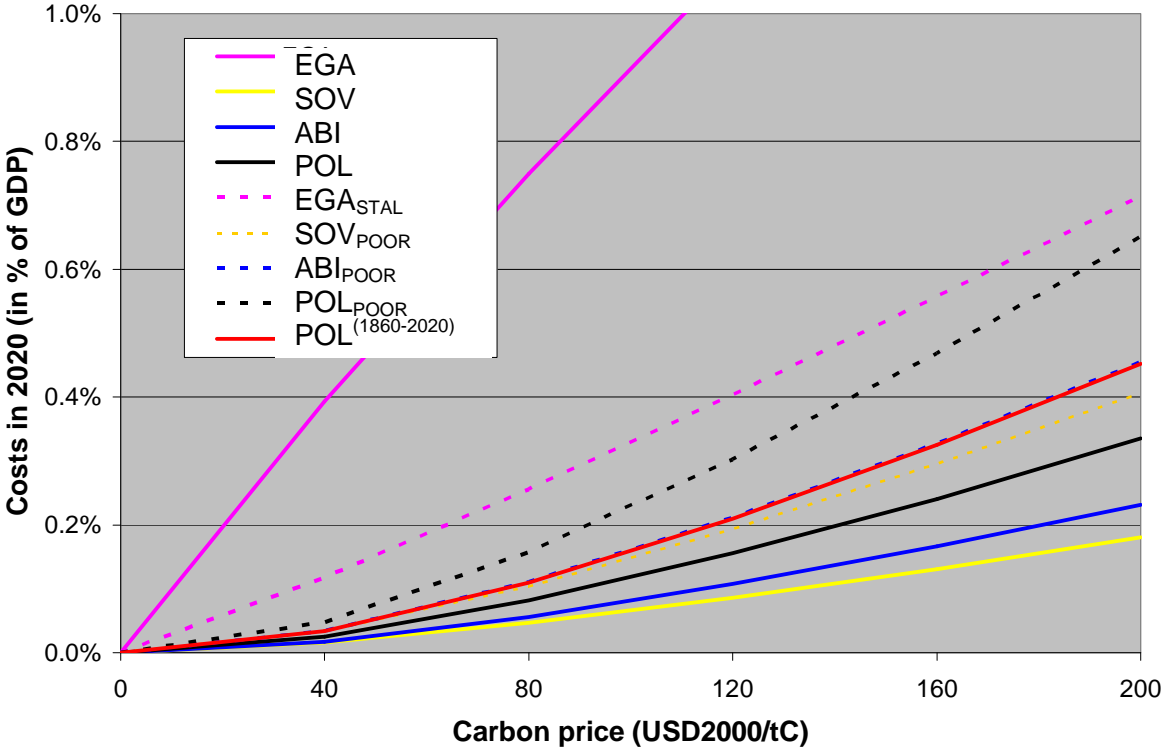
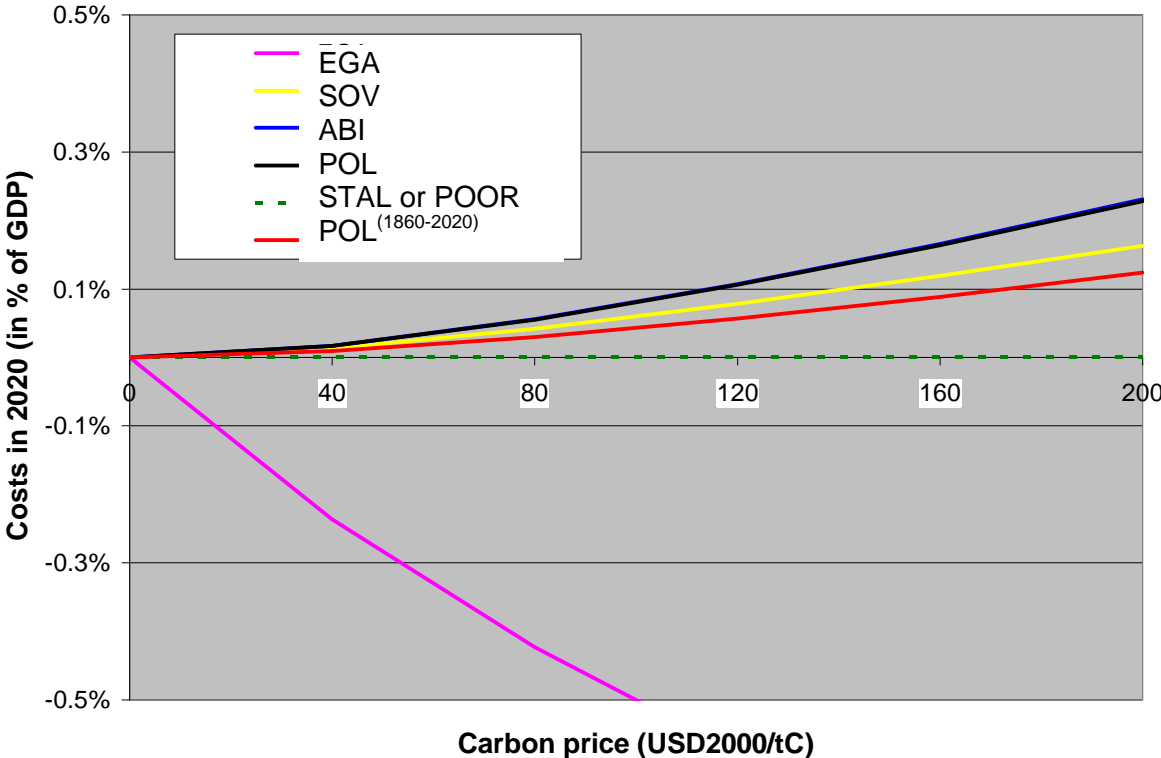


Figure A.4: Costs in 2020 implied by the respective equity criteria for G77/China (in % of GDP).



Appendix B – Results

Table B.1: Relative frequencies that the respective equity criteria should be reflected in the distribution of entitlements for greenhouse gas emissions to “a very high degree” or “a high degree”

Equity rule	EGA	SOV	POL	ABI	POOR	STAL
Expectation about the EU						
All respondents	40.1% (n=167)	50.9% (n=167)	78.2% (n=174)	55.7% (n=174)	53.3% (n=169)	32.5% (n=151)
Respondents from the EU	36.5% ^{***} (n=63)	42.9% (n=63)	79.1% (n=67)	54.5% ^{**} (n=66)	54.7% (n=64)	18.2% ^{**} (n=55)
Respondents from G77/China	46.0% ^{**} (n=74)	50.7% (n=73)	76.6% (n=77)	60.3% ^{**} (n=78)	55.4% (n=74)	43.3% ^{**} (n=67)
Expectation about G77/China						
All respondents	59.5% (n=173)	29.1% (n=172)	61.0% (n=177)	65.5% (n=174)	79.0% (n=176)	28.5% (n=151)
Respondents from the EU	61.9% (n=63)	17.2% ^{***} (n=64)	61.2% ^{**} (n=67)	75.4% ^{**} (n=65)	83.1% (n=65)	21.2% (n=52)
Respondents from G77/China	50.6% ^{**} (n=79)	34.6% ^{***} (n=78)	62.0% ^{***} (n=79)	55.1% ^{***} (n=78)	78.8% [*] (n=80)	39.7% ^{**} (n=68)
Expectation about Russia						
All respondents	31.4% (n=159)	54.3% (n=162)	42.7% (n=164)	52.8% (n=163)	34.0% (n=159)	29.4% (n=143)
Respondents from the EU	19.7% ^{**} (n=61)	54.8% (n=62)	29.5% [*] (n=61)	57.4% (n=61)	26.7% (n=60)	19.6% (n=51)
Respondents from G77/China	42.0% ^{***} (n=69)	46.4% (n=69)	54.2% [*] (n=72)	47.9% (n=71)	43.7% [*] (n=71)	43.8% ^{**} (n=64)
Expectation about the USA						
All respondents	35.7% (n=171)	60.8% (n=171)	41.0% (n=173)	29.8% (n=171)	29.9% (n=167)	32.4% (n=148)
Respondents from the EU	26.6% [*] (n=64)	58.7% (n=63)	29.2% ^{**} (n=65)	17.5% ^{**} (n=63)	29.0% (n=62)	24.0% (n=50)
Respondents from G77/China	49.3% ^{**} (n=75)	60.5% (n=76)	47.4% (n=76)	39.5% [*] (n=76)	34.2% [*] (n=73)	37.9% (n=66)

Note: * (**, ***) means that the distribution of the expected degree of incorporation of the respective equity rules (with parameter values “a very high degree”, “a high degree”, “a moderate degree”, “a low degree”, and “no degree”, irrespective of the relative frequencies) differs between the respondents from the EU (or, alternatively, from G77/China) and the corresponding respondents from outside the EU (or, alternatively, from outside G77/China) at the 10% (5%, 1%) level of significance according to the appropriate chi-squared test

Corresponding ranking regarding the perceived incorporation of the equity rules:

EU: POL > ABI > SOV > EGA
 G77/China: ABI > POL > EGA > SOV
 Russia: SOV > ABI > POL > EGA
 USA: SOV > POL > EGA > ABI

Table B.2: *Relative frequencies regarding the most important equity rule in the distribution of entitlements for greenhouse gas emissions*

Most important equity rule	EGA	SOV	POL	ABI
Expectation about the EU				
All respondents (n=174)	12.1%	22.4%	54.6%	10.9%
Respondents from the EU** (n=64)	6.3%	14.1%	67.2%	12.5%
Respondents from G77/China (n=80)	12.5%	26.3%	50.0%	11.3%
Expectation about G77/China				
All respondents (n=174)	37.9%	8.0%	23.0%	31.0%
Respondents from the EU** (n=65)	47.7%	4.6%	13.8%	33.9%
Respondents from G77/China*** (n=79)	22.8%	12.7%	36.7%	27.8%
Expectation about Russia				
All respondents (n=156)	7.7%	43.6%	22.4%	26.3%
Respondents from the EU (n=57)	7.0%	45.6%	14.0%	33.3%
Respondents from G77/China*** (n=70)	4.3%	37.1%	34.3%	24.3%
Expectation about the USA				
All respondents (n=165)	17.6%	52.7%	24.2%	5.5%
Respondents from the EU (n=60)	11.7%	65.0%	20.0%	3.3%
Respondents from G77/China** (n=74)	25.7%	39.2%	28.4%	6.8%

*Note: * (**, ***) means that the distribution of the expected most important equity rule (with parameter values “EGA”, “SOV”, “POL”, and “ABI”) differs between the respondents from the EU (or, alternatively, from G77/China) and the corresponding respondents from outside the EU (or, alternatively, from outside G77/China) at the 10% (5%, 1%) level of significance according to the appropriate chi-squared test of independence*

Corresponding ranking regarding the most important equity rule:

EU: POL > SOV > EGA > ABI
G77/China: EGA > ABI > POL > SOV
Russia: SOV > ABI > POL > EGA
USA: SOV > POL > EGA > ABI

Table B.3: *Relative frequencies that some reasons play an important role for the incorporation of the most important equity rule in international climate negotiations*

	Expectation about the EU	Expectation about G77/China	Expectation about Russia	Expectation about the USA
Reason: Material self interest				
All respondents	62.7% (n=153)	86.1% (n=166)	88.9% (n=162)	93.5% (n=168)
Respondents from the EU	51.9% ^{**} (n=54)	96.8% ^{***} (n=63)	93.5% (n=62)	96.9% (n=64)
Respondents from G77/China	70.8% [*] (n=72)	75.3% ^{***} (n=73)	81.7% ^{***} (n=71)	90.8% (n=76)
Reason: Fairness considerations of the public				
All respondents	87.9% (n=157)	58.9% (n=158)	41.3% (n=150)	44.4% (n=151)
Respondents from the EU	87.9% (n=58)	44.8% ^{***} (n=58)	20.0% ^{***} (n=55)	35.1% [*] (n=57)
Respondents from G77/China	88.9% (n=72)	67.1% ^{**} (n=73)	54.5% ^{***} (n=66)	43.9% (n=66)
Reason: Facilitation of international climate negotiations				
All respondents	83.1% (n=160)	46.9% (n=160)	49.3% (n=142)	30.8% (n=159)
Respondents from the EU	80.7% (n=57)	28.1% ^{***} (n=57)	32.7% ^{***} (n=52)	18.3% ^{***} (n=60)
Respondents from G77/China	83.3% (n=72)	63.5% ^{***} (n=74)	67.7% ^{***} (n=62)	32.4% (n=68)
Reason: Pressure from industry				
All respondents	52.9% (n=153)	45.0% (n=151)	69.7% (n=145)	83.9% (n=168)
Respondents from the EU	49.1% (n=61)	61.1% ^{***} (n=54)	77.8% (n=54)	85.7% (n=63)
Respondents from G77/China	54.5% (n=66)	32.9% ^{***} (n=70)	61.9% [*] (n=63)	80.8% (n=73)
Reason: Pressure from environmental NGO's				
All respondents	78.9% (n=166)	31.3% (n=144)	29.7% (n=138)	47.4% (n=154)
Respondents from the EU	76.7% (n=60)	19.2% ^{**} (n=52)	13.5% ^{***} (n=52)	33.9% ^{**} (n=56)
Respondents from G77/China	85.7% ^{**} (n=77)	43.5% ^{***} (n=69)	46.7% ^{***} (n=60)	60.6% ^{***} (n=66)

*Note: * (**, ***) means that the relative frequencies that a reason plays for a country or group of country an important role for the incorporation of the most important equity rule in international climate negotiations differs between the respondents from the EU (or, alternatively, from G77/China) and the corresponding respondents from outside the EU (or, alternatively, from outside G77/China) at the 10% (5%, 1%) level of significance according to the appropriate chi-squared test*