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Patterns of International Cooperation and the Explanatory Power of Relative Gains: An Analysis of Cooperation on Global Climate Change, Ozone Depletion, and International Trade

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This article brings together the relative gains argument and the analysis of global environmental problems such as ozone depletion and global climate change. We develop an n-actor relative gains model for the provision of nonexcludable goods. In order to derive testable hypotheses we also develop a comparable n-actor specification for excludable goods such as international trade and derive hypotheses concerning the expected level of cooperation by using comparative statics. The models suggest that there should be a higher level of cooperation on trade and ozone depletion than on global climate change. After reviewing alternative explanations we confirm the explanatory power of the model by demonstrating that we observe a much lower level of cooperation for the climate case than either of the other two cases. We thus conclude that the case of global warming falls within the empirical domain of neorealism and that power-based explanations cannot be ignored.

Neorealist approaches are mostly dismissed by scholars working in the field of international cooperation and, particularly with regard to international environmental cooperation, neorealism is dismissed either with reference to a lack of explanatory power or the suggestion that environmental issues do not fall within the empirical domain of neorealist theory (e.g., Paterson 1996; Seaver 1997; Mol 2001).[1] As part of the wider debate on neorealism Legro and Moravcsik(1999) thus recently suggested we should refocus neorealism around its distinctive core assumptions in order to regain explanatory power in empirical investigations. This article attempts to do this. However, we argue that the relative gains argument is in fact one prime mechanism to specify the empirical domain of neorealism if applied in an appropriate manner. Specifying the neorealist argument on cooperation is of particular importance as there is uneasiness about the lack of consideration given to

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[1] There are some exceptions; Underdal (2001) notes that power can have an impact on the malignancy of a problem. However, this approach amalgamates a number of factors into "malignancy" and does not fully model a power-based proposition.

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power as an explanatory variable in the study of international regimes (Stokke 1997; Underdal 2001).[2] However, as the relative gains argument was developed with international trade in mind (Grieco 1990; Mastanduno 1991; Powell 1991, 1999; Snidal 1991b; Gowa and Mansfield 1993; Gowa 1994; Morrow 1997), the impact of relative gains considerations on global environmental cooperation has not been systematically worked out.[3] This paper attempts to remedy this situation by bringing together the debate on global environmental cooperation and the absolute versus relative gains debate in order to demonstrate the explanatory power of the relative gains argument by developing two *n*-actor relative gains models, one for nonexcludable goods such as a stable climate and intact ozone layer and one for excludable goods such as trade.[4] Employing comparative statics, we derive hypotheses concerning the level of cooperation to be expected in these issue areas and assess empirically whether these hypotheses are supported, thus determining the applicability of neorealism and neoliberalism.

Combining the insights that gains have to be big enough to impede security in order to induce a relative gains concern (Keohane 1993; Glaser 1995) and that the possibility of exclusion from benefits affects payoffs (Snidal, 1991a, 1991b; Costello 1996) with the effects of the nature of the good provided allows us to explain the varying success of three attempts at international cooperation: international trade, ozone depletion, and climate change. The model suggests the following for cases where states care to some degree about the future and where there are more than two actors: cooperation is less likely ceteris paribus if potential gains are big enough to be security relevant, thus inducing relative gains concern, and if at the same time the good provided does not permit defectors to be excluded from consumption, than in cases where either exclusion is possible or where possible relative gains are small and thus do not induce relative gains concern.

Intuitively, *when relative gains matter*, cooperation is more likely for excludable goods than nonexcludable goods, as in the excludable goods case defectors have to worry that other states will continue to cooperate in a subgroup, thereby realizing relative gains over the defector. If, however, the defectors cannot be excluded, as is the case for the provision of public and other nonexcludable goods, the defector is in no danger of falling behind in relative terms.[5] This argument allows us to explain the different levels of cooperation observed in the General Agreement on Trade and Tariff (GATT) and Kyoto protocol, respectively, as both cases are characterized by substantial costs and benefits which make them security relevant, especially when costs and benefits are accumulated. Estimates for trade suggest that full cooperation could lead to benefits of several percent of GDP (e.g., Cline 1995); similarly, avoiding global warming leads to benefits of several percent of GDP (e.g., Cline 1992; Meyer and Cooper 1995; Nordhaus and Boyer 2000). On the cost side estimates show that the cost of full cooperation reaches several percent of GDP (Meyer and Cooper 1995; Grub, Vrolijk, and Brack 1999) while estimates on the costs of implementing free trade suggest that the effects of forgoing optimal tariffs decreases welfare by a similar amount (Harrison and Rutström 1991). The model can therefore explain why we ceteris paribus expect a different level of cooperation for excludable and nonexcludable goods. But the relative gains argument can also

[2] Stokke suggests as much when he argues that the focus on hegemonic stability theory is "truncating the space devoted to the analysis of power" (1996:40), and Underdal shows his concern when arguing that he is "not prepared to dismiss the distribution of power [...] as largely irrelevant to the formation and operation of international regimes" (2001:33).

[3] Berejekian (1997) utilizes a relative gains argument, but this argument is not power based.

[4] This distinction is not absolute; some excludable benefits accrue to states from cooperation for public goods and some public benefits go along with the provision of excludable goods (e.g., Conybeare 1984).

[5] In an *n*-actor model of pure relative gains maximizers, Snidal (1991a) shows that the possibility of subgroup cooperation makes a crucial difference to the impact of relative gains. In this article we work out the implications for players that care about relative and absolute gains for different types of goods.

explain why cooperation for two public goods varies drastically. If gains are very small in terms of GDP, then security is not impeded and relative gains concerns do not arise (Keohane 1993; Glaser 1995). The crucial difference between the negotiations on ozone-depleting substances (Montreal protocol) and the global climate change negotiations (Kyoto protocol) is the size of the respective costs and benefits of effective cooperation. While we have already seen that the costs for implementing full cooperation on GHG are security relevant, estimates suggest that the costs of reduction of ozone-depleting substances such as chlorofluorocarbons (CFCs) would amount to about 0.001% of GDP per year[6] for the United States. They are thus not security relevant and do not induce a relative gains concern. As a consequence there is no additional incentive to defect due to relative gains concerns in the ozone case while there is an additional incentive to defect in the case of global warming. Cooperation on the ozone issue is therefore more likely than cooperation on global warming. The relative gains argument allows us to explain variations in the degree of cooperation between two different cases[7] of public goods provision.

From a realist point of view relative gains concern inhibits cooperation in an anarchic international system where the use of force cannot be ruled out (Waltz 1979; Grieco 1988a, 1988b, 1990; Mastanduno 1991; Mearsheimer 1995; Grieco and Ikenberry 2003). The technically most sophisticated attempt at modeling the absolute versus relative gains issue with regard to trade is based on a "guns and butter" model in which states can employ the gains from trade to adjust their defense spending and which suggests that unless either the gains are very heavily skewed or the traded goods can be used to the adversary's advantage in an immediate attack, relative gains do not impede trade (Morrow 1997; Powell 1999). The model is, however, not applicable to the environmental issues under consideration as in these cases the benefits of cooperation take the form of avoided costs far in the future. As a consequence the benefits cannot be used to bolster the allocation to the military, thus decreasing the amount of butter available (Vezirgiannidou 2003). Furthermore, the model is based on the unrealistic assumptions that there is no accumulation of gains, thus ignoring major effects of both trade and reductions in GHG, and that the probability of prevailing in war is determined by the current allocation to the military rather than the overall economic capabilities, which contradicts much realist reasoning (e.g., Waltz 2000) and is very dubious on empirical grounds.[8]

Given these limitations we re-visit some of the earlier formal contributions to the debate in order to develop two models from which we derive hypotheses about the patterns of cooperation. We first develop an n-actor specification of an infinitely repeated game in which players have a relative and absolute gains concern and cooperate over a public good. We then develop a similar model for the provision of excludable goods. In the excludable goods case we make full use of the n-actor specification when combining it with the feature of excludability by allowing states to exclude a defector from future benefits while continuing to cooperate in a subgroup rather than ending cooperation among all actors. This specification develops further Snidal's (1991a, 1991b) initial contributions.[9] We then compare the payoffs from the two models with regard to the likelihood that states will cooperate. It is at this stage that we draw on the insight from Powell (1991) that a relative gains concern is only induced if the gains are big enough to have security implications (Keohane 1993; Glaser 1995). As we argued above this is the case for

[6] Calculated from Sandler (1997:107).

[7] "Different cases" means different issue areas; the technology of production (Sandler 1997) is the same.

[8] It can be shown that an alternative game structure based on alternative assumptions leads to the conclusion that marginal relative gains can trigger war and thus prevent trade (Grundig 2003).

[9] In Snidal's (1991b) model all cooperation ceases as there are only two cooperators; in our model cooperation continues in a subgroup. See also Costello's (1996) arguments on specifying payoffs.

cooperation on global warming and trade but not for cooperation on ozone depletion. By setting the relative gains concern to 0 for the latter case we obtain a set of hypotheses from the comparative statics that suggest that states are less likely to cooperate in the case of global warming than the other two cases because in the former case the relative gains concern affects the incentive structure in a way detrimental to cooperation. For the ozone case this is not so as there is no relative gains concern and for the trade case the fear of others cooperating in a subgroup changes the relative gains dynamic in such a way that cooperation becomes much more likely for fear of relative losses compared with other states that continue to cooperate. After developing the models we discuss alternative explanations for variations in cooperation such as domestic factors (e.g., Sprinz and Vaahtoranta 1994; Grub, Vrolijk, and Brack 1999), scientific uncertainty, costs, temporal asymmetries, lack of hegemonic leadership, the number of players, the type of game played (e.g., Rowlands 1995; Fermann 1997; Sandler 1997; Underdal 2001) and show that none of these factors alone predicts the same pattern of cooperation as our model. In the final section, we evaluate the accuracy of our hypotheses by assessing the actual level of cooperation achieved in the three cases and demonstrate that power-based explanations should not be disregarded and that some environmental problems fall into the empirical domain of neorealism, just as trade does.[10]

The Models

In order to develop the models we need to clarify the strategies, explain the sequence of play, introduce some notation and define several terms. The notation introduced here is used for both the public goods and the excludable goods models.[11] However, the strategies, sequence of play, and specification of payoffs will be discussed in the relevant subsection.[12]

The games depicted here are infinitely repeated n-actor games based on the payoff structure of the Prisoner's Dilemma. The utility functions of states reflect their relative gains concern. Assume that any player i has a sensitivity coefficient r for relative gains which has the property $0 \leq r \leq 1$, whereby a value of 0 implies that there is no relative gains concern at all and a value of 1 that a state is only concerned about relative gains. Let ϕ be the discount factor with $0 \leq \phi < 1$. States are concerned with more than one state's relative gains. Let therefore w_{ij} be state i's relative gains concern for each state where $\sum_{j \neq i} w_{ij} = 1$. w_{ij} is thus the emphasis that state i places on state j's performance. There are $n - 1$ states in relation to which i has a relative gains concern.

Public Goods Model

The underlying technology of production for the public good provided is a summation technology (Sandler 1997). This means that the total amount of the good provided is the sum of the individual efforts. Let b_i be state i's benefits from the cooperation of all n players. Let b_i' be i's benefit from the cooperation of $n - 1$ players. Assuming that the size of benefits i derived from interaction with each player is identical,[13] the difference between b_i and b_i' is

[10] As the excludable goods model later on in the article will show, a high degree of cooperation in the trade case does not mean that relative gains are unimportant. Cooperation in n-actor settings can very well be explained with reference to the relative gains argument.

[11] The notation is similar to Snidal's (1991b).

[12] The notation allows us to compare the payoffs from the two models. As discussed earlier the costs and benefits are of comparable size for international trade and global warming in empirical terms.

[13] Note that this does not mean that each player gains the same, it just means that a player receives the same payoff from every interaction with each of all the other players, but this can be different for different i, j.

$(1/(n-1))b_i$.[14] This specification is in line with a summation technology of public good provision. Furthermore b_j and b'_j denote the payoff to any player j from cooperation if all n players cooperate and if $n-1$ players cooperate, respectively.

Costs occur if a player implements policies that are in line with a cooperative agreement, that is, costs only occur if a player cooperates (e.g., costly emission reduction). Denote the costs to i by c_i and the costs to any player j by c_j.[15]

States play grim trigger strategies, that is, they make simultaneous moves starting with cooperation. Players make their continued cooperation conditional upon the cooperative behavior of *all* other states in the previous round, that is, should any state defect in round t then all other states will defect forever from round $t+1$ onwards.[16]

State i's payoff in the case that all states conditionally cooperate from t_0 onwards is given by the following calculation:

$$(1-r)\frac{(b_i - c_i)}{1-\phi_i} + r\sum_{j\neq i} w_{ij}\left(\frac{(b_i - c_i) - (b_j - c_j)}{1-\phi_i}\right). \tag{1}$$

The first term is state i's payoff from absolute gains over an infinite time horizon; the second term is i's payoff from relative gains over an infinite time horizon. It equals the sum of all individual relative gains in relation to each of the other j players $(1, \ldots, n-1)$ for which i has a relative gains concern weighted by its particular importance, w_{ij} to i and multiplied with i's overall sensitivity coefficient r.

State i's payoff if it defects, in which case the cooperation would break down in the following round leading to a payoff of zero for all n players from t_1 onwards, is given by the following equation:

$$(1-r)b'_i + r\sum_{j\neq i} w_{ij}(b'_i - (b'_j - c_j)). \tag{2}$$

The benefits from cooperation are smaller than in (1) because i is not contributing to the provision of the public good and in the case of a summation technology of public goods provision such as global warming this leads to a decrease of benefits for all players. The costs to the cooperators remain, however, the same as the policies if cooperators incur the same costs as before. The defecting state incurs no costs as no contribution is made to the cooperative venture.

The strategy profile where all players use a grim trigger strategy is a Nash equilibrium if (1) is greater than (2), that is if:[17]

$$\phi_i \geq \frac{b'_i - b_i + c_i + r\sum_{j\neq i} w_{ij}(b_j - b'_j)}{b'_i - r\sum_{j\neq i} w_{ij}(b'_j - c_j)}. \tag{3}$$

Excludable Goods Model

In this case the players provide an excludable good (trade benefits). The size of total benefits to i depend (just as in the public goods model) on the number of contributing players (summation technology). Let b_i be state i's benefits if all other players cooperate with i. Unlike in the public goods model, where i only receives

[14] Put differently, b_i is the sum of benefits derived from each individual interaction multiplied by $(n-1)$, that is the number of players i cooperates with and receives benefits from. Consequently b'_i is the sum of benefits generated from cooperation with one player less.

[15] We assume throughout that $b > c$ for all players as investigating cooperation is pointless otherwise.

[16] Grim trigger strategies are subgame perfect unlike a tit-for-tat strategy (Barrett 1999); however, grim trigger is not re-negotiation proof (Fudenberg and Tirole 1991) or what Barrett calls "collectively rational" (Barrett 1999, 2003). We nevertheless employ the grim trigger strategy as it is in line with most of the current IR literature.

[17] This equilibrium is subgame perfect given the PD payoff structure and the assumption that all players play grim trigger. If i defects then all other states, sticking to the grim trigger strategy, defect in all future rounds and thus there is no incentive to play anything else than defect.

the maximal benefit from cooperation when i contributes to the provision of the good in the current round, i will receive the full benefits from access to the markets of other countries even if i defects in the current round by setting optimal tariffs. Let b'_j be j's benefit from cooperation of $n - 1$ players.

As with the public good, costs only occur when a player implements cooperation. In the excludable goods case, the costs any player incurs are related to the number of players involved in the interaction.[18] If i cooperates with all other players, then it incurs costs of c_i, irrespective of whether the $n - 1$ other players cooperate. Similarly any *cooperating* player j's costs from interaction of n players is c_j, while any cooperating player's cost from interaction of $n - 1$ players is c'_j. The latter means that the costs states incur after excluding a player from cooperation, and thus reducing the number of potential cooperators to $n - 1$, are smaller than costs of cooperating with all players (and so are the benefits).

The game depicted is again an infinitely repeated *n-actor* game based on Prisoner's Dilemma payoffs. The strategies of the players are slightly more complicated in the excludable goods case than in the public goods case. As above, players play grim trigger strategies. However, in this case the strategies are "individualized" in the sense that all players will cease to cooperate with any defector(s).[19] This in fact means that the defector will be excluded from the cooperative venture and its benefits forever.

The payoff from cooperation of all n actors to i is identical to the public goods case (see interpretation of equation [1]) and given by

$$(1 - r)\frac{(b_i - c_i)}{1 - \phi_i} + r\sum_{j\neq i} w_{ij}\left(\frac{(b_i - c_i) - (b_j - c_j)}{1 - \phi_i}\right). \tag{4}$$

However, the payoff from defection is quite different from the public goods case. In the case that i defects, all $n - 1$ other players will exclude i from future cooperative benefits and continue to cooperate among themselves, thus receiving a positive payoff while i's payoff is reduced to zero from t_1 onwards. This is possible in the excludable goods case exactly because benefits *are* excludable.[20] Thus i's payoff for defection is

$$(1 - r)b_i + r\sum_{j\neq i} w_{ij}\left(b_i - (b'_j - c_j)\right) - r\sum_{j\neq i} w_{ij}\frac{\phi(b'_j - c'_j)}{1 - \phi_i}. \tag{5}$$

In this case i receives the full benefits b_i in t_0 as it still capitalizes on the other players' cooperative trade policies; however, any player j will only receive b'_j as i is withholding benefits from all other players by violating the trade agreement. While i incurs no costs due to defecting, any player j still incurs the same costs as when cooperating as its cooperative policies have not changed. Thus the first term of equation (5) is the absolute benefit to i weighed by the importance of absolute gains. The second term shows the relative gains over all other players, realized through i's defection weighed by the importance of relative gains to i. The third term shows the relative loss i incurs from t_1 onwards due to defection. This is the infinite payoff of all other cooperators who continue to cooperate in a subgroup, thus excluding i from all future benefits. This payoff is weighed by the importance of relative gains to i.

[18] There is no interaction with excluded players once cooperation breaks down.

[19] We assume that a defector cheats on all other states and not just one individual state. Equation (5) reflects this fact: the defector gets the full payoff from cooperation in the current round but does not pay any costs.

[20] This is assuming that discount factors among other players are high enough to sustain cooperation in the subgroup; this is a reasonable assumption implying that not all states will have identically low thresholds for cooperation.

The strategy profile where all players use a grim trigger strategy is a Nash equilibrium if (1) is greater than (2), that is if

$$\phi_i \geq \frac{r\left(\sum_{j\neq i} w_{ij}(b_j - b_j')\right) - b_i + c_i}{(1-r)b_i}, \tag{6}$$

whether the minimum requirement for ϕ is greater in equation (3) or (6) is contingent. In order to analyze in which case cooperation is more likely, we best compare the payoffs for the two cases.[21] The payoff from cooperation is identical for the public goods and the excludable goods case; however, the payoff from defection is quite different. Subtracting (2) from (5) gives the following:[22]

$$(b_i - b_i') - r\sum_{j\neq i} w_{ij}\frac{\phi_i(b_j' - c_j')}{1-\phi_i}. \tag{7}$$

This expression tells us how much more (or less) a state gains by defecting in the excludable goods case than in the nonexcludable goods case ceteris paribus. If the expression is greater than zero then the incentive to defect is greater in the excludable goods case than in the nonexcludable goods case, that is, the excludable goods case will be more difficult to resolve. If the expression is smaller than zero then the incentive to defect is greater in the nonexcludable goods case than in the excludable goods case, that is, the nonexcludable goods case will be more difficult to resolve.[23]

Mathematically, expression (7) can, of course, be positive; however, for all realistic values of the n-actor cases under consideration, the expression will be negative, which means that cooperation for nonexcludable goods (global warming) is more difficult to achieve than for excludable goods (trade). To see this, recall that the first term of expression (7) is the benefit to i from cooperating *once* with *one* out of n players. The second term is the discounted payoff from *infinitely repeated* cooperation of *all* $n-1$ *other players* weighed by i's relative gains concern. In other words we would expect the first term usually to be very small in comparison with the second term.

We can now have a closer look at expression (7) and what it means for the likelihood of cooperation in the two different cases. To start with, the first term of expression (7) $(b_i - b_i')$ is always greater than zero in this model, and the second term of expression (7) is strictly negative as $b_j' - c_j'$ is greater than zero.[24] This means that whenever the second term is bigger than the first term cooperation for excludable goods is easier to achieve than cooperation for nonexcludable goods. The first (positive) term of equation (7), $(b_i - b_i') = b_i/(n-1)$ does not change with any variable other than the benefits. However, the magnitude of the second term varies with n, r, ϕ. Let us investigate the influence of these variables on the likelihood of cooperation in the two cases, starting with the number of the players, by looking at changes in the magnitude of the second term. The second term $(b_j' - c_j')$ is increasing with n since, given the summation technology, the difference between *total* benefits and *total* costs to j increase with the number of players n. Therefore, it is more likely that i would cooperate on excludable goods when it would not on nonexcludable goods with an increase in n. This is the case because the loss to the excluded state i from subgroup cooperation of other states increases. Second, a decrease in costs from cooperation to any state j ceteris paribus makes it more likely that i cooperates on excludable goods when it would not on

[21] Nothing meaningful can be extracted from comparing the conditions directly.

[22] Using $(1-r) + r = 1$ and $\sum_{j\neq i} w_{ij} = 1$.

[23] Recall that this is the case as the payoff from cooperation is identical in both cases, so we just need to compare the payoffs from defection.

[24] Recall that we earlier (see footnote 16) assumed that throughout this model $b > c$ for all players.

nonexcludable goods. This is so as the relative loss to the excluded state i from continued cooperation of other states increases with a decrease in costs from cooperation to those states. Third, if the discount factor ϕ increases, it is ceteris paribus more likely that i will cooperate on excludable goods when it would not on nonexcludable goods because the relative loss to the excluded state i from continuing cooperation of other states weighs more heavily in its calculations. Fourth, with an increase in the overall relative gains concern r, it is ceteris paribus more likely that i would cooperate on excludable goods when i would not cooperate on nonexcludable goods as the relative loss to the excluded state i from continued cooperation of other states features more strongly in i's calculations. This suggests that cooperation is ceteris paribus more likely for the excludable goods case than the nonexcludable goods case if n, r, and ϕ are not all low.[25]

Therefore if relative gains matter (as we argued they do for trade and global warming) and if states care to some degree about the future and n is greater than two, then cooperation for excludable goods is more likely than cooperation for nonexcludable goods, suggesting that it will be more difficult to resolve the global warming issue than the trade issue. It is important to note that the reason why relative gains make cooperation on global warming difficult is *not* because states care more about relative gains in the global warming case than in the trade case. In fact we assume an identical relative gains concern when we compare the cases. Rather the reason is that the *same* relative gains concern has a stronger effect on nonexcludable goods settings due to the nature of the incentive structure.

Some might say that we do not have to rely on relative gains arguments to establish this; rather the differing nature of the goods produced might serve as an explanation. However, the relative gains argument derives part of its strength from the fact that it also allows us to explain the varying level of cooperation of two public goods that are both produced with the same "technology of production," that is a summation technology. In order to see why the ozone issue is easier to resolve than the global warming issue, we return to expression (3). We argued earlier that the ozone case does not warrant a relative gains concern as the size of the possible relative gains are very small in terms of percentage of GDP and thus not security relevant, even if accumulated over decades. This means that we can set r at zero, which applied to expression (3) means that the necessary condition for cooperation is always easier to fulfill for the ozone than for the global warming case.[26]

To complete our analysis we finally have to look at the alternative hypothesis, that is what would the model predict if states had no relative gains concern in either of the cases. Setting the relative gains concern to zero suggests that the necessary condition for cooperation in the ozone and global warming case are the same. Furthermore, by setting r to zero in expressions (3) and (6) shows that the necessary condition for cooperation in the excludable goods model is ceteris paribus always easier to fulfill than the necessary condition for the public goods models, suggesting that it should be easier to resolve the trade issue than either the ozone or global warming issue.[27]

Evidence

It is notoriously difficult to come by clear empirical evidence in favor of relative or absolute gains. Joseph Grieco (1990) made an important contribution by reminding

[25] In the extreme case that n is smaller than 3, no subgroup cooperation is possible, approximating Snidal's model (Snidal 1991b). If ϕ is 0, that is states do not care about their future payoffs at all, then the second term is also 0, and thus cooperation for excludable goods is more difficult to achieve than cooperation for nonexcludable goods. In this case, however, cooperation would not be possible at all in the PD. For $r = 0$, see below.

[26] This is the case as the denominator is ceteris paribus always bigger, and the numerator is always smaller for the ozone case than for the global climate change case.

[27] This is the case as the numerator in (3) is always bigger, and the denominator always smaller than in (6).

us of the importance of attempting an empirical evaluation. However, his study was dismissed by leading neoliberal writers for not being able to reject the neoliberal hypothesis (Keohane 1993). In principle the aim is to derive mutually exclusive hypotheses and test them in order to falsify one theory and support the other. One is, however, not likely to arrive at watertight conclusions given the number of variables and possible combinations thereof from which we can derive hypotheses.[28] Thus the aim of this paper is to show that no conventionally employed variable on its own predicts the same variation in the level of cooperation as our model and that the evidence does not contradict a well specified relative gains argument. We devise a test for the relative gains argument by specifying hypotheses about the expected level of cooperation based on the comparative statics results derived in the theory section above. By using comparative statics we investigate what happens when only one variable changes (i.e., the nature of the good in comparing global warming and trade and the relevance of relative gains in comparing ozone depletion and climate change) while holding other independent variables constant. As a consequence the variation in the dependant variable (level of cooperation) can be attributed to the independent variable, which changed in value. We can employ the measurement of the level of cooperation after roughly two decades of regime operation as empirical evidence as the relative and absolute gains assumptions lead to different predictions about the pattern in the level of cooperation for the three cases.[29]

In order to do so and to evaluate the hypotheses empirically, we have to reformulate the hypotheses derived above, which predict that it is more difficult to achieve cooperation in the case of climate change than in the cases of ozone depletion or trade. This conclusion was derived from an analysis of the magnitude of the discount factor required to maintain cooperation in the three cases. In order to be able to use the level of cooperation achieved we have to reformulate the hypothesis. We have to ask what the highest achievable level of cooperation would ceteris paribus be in each case.[30] Thus reformulated, the hypotheses derived from the model suggest that if relative gains matter, as is the case for global warming or trade, then there will ceteris paribus be less cooperation for nonexcludable goods then for excludable goods. Furthermore, there will be less cooperation for a nonexcludable good if relative gains matter (global warming) than if relative gains do not matter (ozone depletion). This implies that we should see less cooperation on global warming than on either trade or ozone depletion. The alternative absolute gains hypotheses suggest that we should observe a similar level of cooperation for the ozone and climate change case, and a lower level of cooperation for the ozone and climate change case than for the trade case.

Relative Gains and Other Accounts of Variation in the Level of Cooperation

As the evidence will show, the relative gains argument predicts the pattern in the level of cooperation accurately. However, there are a number of other variables to be considered that have been employed in the literature in order to explain cooperation. The discussion of these variables will serve two purposes. First, it will show that it is justified to use comparative statics as there is no relevant variation in the variables discussed which could explain the variation in the dependent variable. Second, by implication this shows that none of the conventionally cited variables

[28] Barratt (2003:221) comes to a similar conclusion.

[29] This is the current methodological standard (e.g., Helm and Sprinz 2000; Underdal 2001). A shortcoming of Grieco's study was the lack of comprehensive assessment; it is likely that we will always find inconclusive evidence that can be interpreted as either relative or absolute gains seeking when looking at particular aspects of negotiations. Specifying competing hypotheses about the overall level of cooperation avoids this problem.

[30] This means that we hold the discount factor constant now.

individually predict the same pattern in the level of cooperation as our model does as variation in the dependent variable can only be explained by a variation in the independent variable.[31]

It has often been said that the costs of abatement in the global warming case is comparatively high, while the cost of abatement is comparatively low in the ozone case (e.g., Fermann 1997; Sandler 1997). Indeed we make this argument above in order to illustrate that the ozone case is not relative gains relevant. Similarly it could be argued that the benefits from trade will be reaped in the near future, while the benefits from addressing global warming and ozone depletion will mostly be reaped after several decades, thus suggesting that such differences might lead us to expect different levels of cooperation. However, neither argument implies that rational actors will not take any action; after all investments in markets vary along the same dimensions. What matters is the discounted return on the investment and cost–benefit assessments show that inaction in all three cases leads to a loss in welfare. It is sometimes also said that net benefits from action and the benefits to costs ratio are higher in the ozone case than in the climate case (Barrett 2003). This argument is based on conservative estimates (e.g., Nordhaus and Boyer 2000) of benefits from reducing global warming, which are highly disputed (Meyer and Cooper 1995; Azar 1998). On the other hand, the major factor determining the magnitude of benefits from avoiding ozone depletion is the cost from excess skin cancer and eye cataract cases (Barrett 2003). However, the damage estimates are dramatically inflated and causal relations are far from clear thus overstating the net benefit from action.[32] As a consequence net benefits from preventing global warming are arguably greater than those of ozone depletion and trade.[33]

Scientific uncertainty in the knowledge base can have detrimental effects on environmental cooperation (Fermann 1997; Underdal 2001). However, both the ozone case and the global climate case have been affected by such uncertainty. Before the signing of the Montreal protocol there was still significant scientific uncertainty about the causal mechanism of ozone depletion (Rowlands 1995; Sprinz 2001); however, the Montreal protocol was agreed upon. The global climate regime, on the other hand, is characterized by a successive watering down of targets in the light of decreasing scientific uncertainty, culminating in the breakdown of negotiations in The Hague even though the chair of the International Panel on Climate Change stated that scientific experts overwhelmingly believe that climate change is already occurring (Watson 2000). Therefore there is little difference in the uncertainty in the knowledge base in these cases. It is thus doubtful, both on theoretical and empirical grounds, whether the level of uncertainty can account for the difference between the three cases.

[31] Some of the figures and arguments employed below may well be contested. However, even if one disagrees with our assessments, this neither invalidates our theoretical argument nor our empirical evidence as we use the most conservative estimates for our assessment in the empirical section. All it means is that the alternative explanation based on the variable in contention cannot be rejected either.

[32] Less conservative estimates of the consequences of global climate change suggest that the benefits from addressing climate change are ten times higher than estimated by Nordhaus and Boyer (2000), thus suggesting that the benefits exceed the costs by tens of trillions (e.g., Meyer and Cooper 1995; Azar 1998) and top even net benefits from trade. The estimates regarding benefits from ozone depletion on the other hand are inflated. Estimates on excess skin cancer cases, for example, unrealistically assume that there will be no change in peoples' behavior regarding sun exposure. Such changes in behavior would lead to a dramatic fall in cases and thus dramatically reduce benefits from protecting the ozone layer due to reduction of deaths, each of which was valued at 3 Mio U.S.$ in the study (Barrett 2003). Nonhealth-related benefits from reducing ozone-depleting substances, however, barely exceed the costs of action. Additionally there is significant uncertainty surrounding the relationship between skin cancer and increases of UVB radiation caused by the depletion of the ozone layer, suggesting that the cases of excess deaths may have been overstated by 50% (Gruijl and Leun 2000).

[33] This is true for global costs and benefits; side-payments might have to be made available to individual states to take action if individual costs exceed individual benefits.

It is usually argued that an effective global climate regime will be more difficult to achieve because the number of players is greater than in the ozone case, thus increasing transaction costs (Axelrod and Keohane 1985; Sandler 1997). With regard to transaction costs during the negotiation process, this argument is somewhat misleading as in the global warming case most states negotiate as part of a coalition (Young 1993). More importantly, the number of players that have to be bound into an agreement in order to achieve a relatively high level of cooperation is 20 for both the ozone and the global warming case (Sprinz 2001), and this is also roughly the number of participants of the GATT in the 1940s and 1950s.

Just as the importance of the number of players is well founded, so is the importance of the game structure (e.g., Sandler 1997). However, international cooperation over global commons is believed to have the structure of a Prisoner's Dilemma game (e.g., Fermann 1997; Sandler 1997) and similarly international trade can usefully be characterized as a Prisoner's Dilemma (Conybeare 1984; Powell 1991; Snidal 1991b). As a consequence the nature of the game cannot serve as an explanation for the differences in cooperation observed.

It has also been argued that hegemonic leadership, or lack thereof, explains the low level of cooperation in the case of global warming. However, besides the lack of convincing evidence for the theory of hegemonic stability generally (e.g., Stokke 1997), there is also a question regarding the dimension on which a state has to have a preponderance of power. Military power is generally unimportant as leverage in multilateral environmental and trade negotiations; however, economic power can be very useful as it allows for side-payments. As a consequence the issue of hegemonic leadership does not suggest a difference in the level of cooperation between the ozone and global warming case because no state participating in the ozone negotiations qualifies as a hegemon given that there was no qualitative difference in the economic strength of the EC and the United States. However, the difference between the trade and global warming case can partially be accounted for by hegemonic leadership. There is little doubt that U.S. hegemonic leadership played a role in establishing the postwar economic order, including the GATT, and at least the first trade round in 1947 (Geneva Round) is characterized by the United States making concessions to other countries. Thereafter there is little evidence of hegemonic leadership in the trade case. Hegemonic leadership is thus perhaps best characterized as a catalyst (Rowlands 1995).[34]

In the light of the importance of the functions hegemonic leaders perform, it is useful to consider the role of institutional design which can provide side-payments and enforcement. Barrett (2003) argues that unlike the Montreal protocol the Kyoto protocol has severe design faults with regard to incentives and enforcement mechanisms, such as a lack of trade sanctions for noncompliance. While this is true and has perhaps far reaching consequences, the fundamental question remains why the Kyoto protocol was designed this way. Realists argue that the reasons come down entirely to states' interests and power considerations (Mearsheimer 1995; Jervis 1999; Waltz 2000) as it is states that design international institutions in the first place and thus arguments based on institutional design remain weak.

Domestic politics is often acknowledged to play a role, neorealist and neoliberalist theoretical premises of unitary actors notwithstanding. It is difficult to see how domestic politics distinguishes the three cases considered here as there was serious opposition and support by important and powerful domestic players to each of the

[34] The negotiations in the following trade rounds were mostly characterized by reciprocal concessions or by concessions of accession countries (Grimwade 1996) rather than side-payments or threats by a benign or malign hegemon. It is also important to note that the post-World War II economic order was, of course, characterized by the onset of the Cold War, which constrained the behavior of Western GATT members. The Cold War also explains why the United States did not mind relative gains by some GATT members as much as it otherwise might have, in line with pure theory as economic cooperation in the West was essential to containing the SU.

three regimes in any number of countries at various stages of the negotiation and implementation process (e.g., Winham 1986; Grub, Vrolijk, and Brack 1999; Benedick 1999). Theoretical accounts such as Sprinz and Vaahtoranta's (1994) work based on domestic compliance costs and ecological vulnerability face the typical methodological problems of reductionist accounts, and findings emerging from this type of work are probably best understood within the context of leadership competition.[35]

The discussion above illustrates that none of the conventional variables taken on their own predict the same pattern in the level of cooperation as the relative gains model, even though a combination of variables might. Given the current state of evidence in the discipline it is unlikely that we will be able to decide whether the relative gains model or an alternative multi-variable approach is more adequate to explain these three cases. However, the fact that the relative gains argument emanates from one of the most prominent theories in international relations (IR) and, given that it can demonstrate that the variation in the level of cooperation in a "nonrealist" issue area can be explained by a realist-based theory, gives the explanation strong credence.

Effectiveness and Cooperation

The major focus of regime theorists over the last few years has shifted to the question of regime effectiveness, and the Oslo–Potsdam solution is one prominent approach (Helm and Sprinz 2000; Underdal 2001; Hovi, Sprinz, and Underdal 2003; Underdal and Young 2004). The Oslo–Potsdam solution assesses the effectiveness of regimes by relating the actual regime performance to two benchmarks, the no-regime counterfactual and the collective optimum for the group. Regime effectiveness is conceptualized as the degree to which a regime moves the actual outcome from a no-regime situation toward the collective optimum (Helm and Sprinz 2000; Underdal 2001).[36] One of the main features of the study of regime effectiveness is to establish that the *regime* altered the behavior of actors. The notion of cooperation and regime effectiveness are related but the two concepts are not identical. To establish the level of cooperation we do not have to show that a regime has brought about such cooperation, while for the study of regime effectiveness this would be essential. Rather we have to establish how far the actors have moved from the noncooperative outcome to the collective optimum of the game.

In our assessment of the collective optimum we employ both operationalizations suggested in the literature, the collective cost minimum for the group (Helm and Sprinz 2000), and the technical optimum (Hovi, Sprinz, and Underdal 2003) and arrive at the same conclusions concerning the level of cooperation achieved in the three cases. However, using the technical optimum makes our results even stronger as it reduces the level of cooperation achieved under the Kyoto protocol to virtually zero. With regard to the noncooperative outcome we employ the fully noncooperative Nash equilibrium as the benchmark.[37]

Below we establish the actual policy for each case, which is then held against the benchmarks of the noncooperative Nash-equilibrium and the Pareto-efficient fully cooperative outcome to assess the level of cooperation. We do this by first establishing the degree to which a fully implemented agreement would address the issue at hand, second by assessing whether there are any loopholes that detract

[35] Ward, Grundig, and Zorick (2001) show how domestic veto groups can be included in such a model.

[36] This can be measured by establishing a no-regime counterfactual (NR), the actual policies pursued (AR), and a collective optimum (CO). The effectiveness score is AR–NR divided by CO–NR.

[37] See Underdal (2001). This means, for example, the business as usual scenario for environmental cases and previously prevailing tariffs for the trade case.

from the level of cooperation, and third by looking at the implementation of obligations. It is important to note that the implementation of especially the Kyoto protocol, but also parts of the Montreal protocol, cannot be fully judged yet. Should the current assessments turn out to be incorrect in the future due to a dramatic change in behavior, then this could impact on the conclusions we draw.

One further problem of measurement concerns the differences in the length of operation of the regimes in question. A comparison of the level of cooperation achieved in 2005 would bias the results and lead us to overestimate the level of cooperation achieved in the trade case. We therefore assess the actual policy in each case at a similar stage, measured in real negotiation and implementation time or roughly 20 years after the inception of the regime. In the case of the climate regime this date lies in the future, but it is extremely unlikely that the commitments for 2012 will be tightened beyond the Kyoto protocol. Thus the assessment periods are 1992–2012 for the climate regime, 1985–2003 for the ozone regime,[38] and 1947–1972 for the trade regime. Nineteen seventy-two marks the end of the implementation of the Kennedy Round and granting the GATT 25 years is essential to maintaining a well-balanced comparative assessment as the period between 1947 and 1958 was exceptional in that the lack of fully convertible currency was just as big a problem as tariffs (Keohane 1984; Brown 2003) thus arguably slowing down the process of trade liberalization.

Actual Policy: Trade

Over the first 25 years the GATT (1947) governed trade relations between the major Western industrialized countries and a number of developing countries. The GATT 1947 included the principles of nondiscrimination, negotiations on tariff reductions on a reciprocal basis, and the prohibition of quantitative restrictions (GATT 1947; Winham 1992). Among the first six rounds of negotiation, the Geneva Round in 1947 and the Kennedy Round (1963–1967) are the most important rounds. Besides substantial achievements on tariff reduction, the Kennedy Round was characterized by a first attempt to develop behavioral codes relating to nontariff barriers to trade[39] culminating in an antidumping code (e.g., Berrod and Gippini Fournier 1996).

To assess how far these tariff cuts achieved potential static welfare gains, we undertake calculations further below. In order to undertake these calculations, we have to determine the initial average tariff levels and the percentage cut in tariff levels over the period we are assessing. Average tariffs among the major GATT countries before the Geneva Round in 1947 were about 25%[40] and decreased to average tariff levels of just 8.7% by the end of the Kennedy Round (e.g., Grimwade 1996). This amounts to a cut of 65% from the initial tariff base, which applied to at least two-thirds of all dutiable products, thus leaving about one-third of goods with less or no reduction in tariffs.[41]

The reductions in tariffs discussed above certainly suggest that the trade regime achieved a high degree of cooperation, but we have to ask whether there were any significant loopholes and how these were addressed. The GATT 1947 had some loopholes[42] that were economically not particularly significant (Paemen 1996).

[38] We assess the ozone regime for 2003 due to the availability of specific data. This move will under rather than overestimate the level of cooperation of the ozone regime.

[39] NTBs became important in the mid-1970s when the multilateral trading system came under heavy strain.

[40] Calculated from Jackson (1998:74), Grimwade (1996:43), and Woytsinsky and Woytsinsky (1955:292) based on GATT data derived from the standard trade classification of the time.

[41] The "at least" 2/3 coverage of tariff cuts is roughly estimated from Jackson (1998), Grimwade (1996), Preeg (1970), and Berrod and Gippini Fournier (1996). As the data is sketchy and partially contradictory, we erred on the side of caution and excluded a number of estimates, which favor our hypotheses.

[42] Such as article XIX article XX (e.g., GATT 1947; Croome 1995).

However, there were cases in which GATT members invoked GATT clauses. The United States, for example, made use of the safeguards measures when she declared a 10% surcharge on import tariffs in 1971, a move which was temporary and only marginally influenced the level of cooperation during the period under investigation. Similarly, the creation of the EEC led to some trade diversion as the external tariffs of the six member states were averaged (according to GATT rules), leading to an increase in some tariffs and to a decrease in other tariffs, which harmed some countries while it benefited others. Quantitative restrictions in agriculture and the textile industry on the other hand, led to more significant welfare losses over the period assessed here and are already included in our estimate presented below. Major restrictions of trade in textiles only commenced in 1974 when the long-term agreement on international trade in cotton textiles, which had been in place since 1963, was replaced by the more comprehensive Multi Fiber Agreement (Jackson 1998).[43] The welfare gains forgone due to quotas in agriculture are certainly substantial, even though tariffs on agricultural products were reduced during the 1950s and 1960s (albeit at a slower pace than tariffs on industrial products).[44] In any case, the loss in welfare in these areas is dwarfed by the welfare gains from trade in industrial products as the estimates below will show.[45]

Undoubtedly, the trade regime had its fair share of implementation disputes. Nevertheless, the GATT's mere existence and development over the decades testifies to its success in implementing the GATT rules. Moreover, when looking at compliance with panel reports it becomes clear that implementation was generally good (Winham 1992). Panel reports, which are a legal interpretation of the GATT rules, are a more useful indicator than compliance with council decisions, which each country involved in the dispute can veto.

Assessing the Level of Cooperation on Trade

The collective optimum is free trade with zero tariffs and no NTBs. This is the case whether we conceptualize the collective optimum as a technical optimum or a collective cost minimum as adjustment costs from trade liberalization are outweighed by gains from trade over time. In line with the conceptual discussion of the noncooperative outcome above, we take the initially prevailing tariffs before the GATT as our counterfactual.[46]

The actual level of cooperation in the case of the GATT after 25 years of operation is characterized by successive reductions in tariffs and a first agreement on NTB codes. In order to assess the degree to which welfare-diminishing obstacles to trade were addressed, we can undertake some calculations based on Cline (1995).[47] Given a reduction in tariffs of two-thirds of dutiable

[43] This is included in the calculations below as textiles fall within the 1/3 of products for which we assumed no elimination of tariffs (even though cuts of 20% or more occurred).

[44] Even though tariffs on agricultural products were cut over the years, we treat agriculture as if there had been no tariff cuts as it is impossible to get estimates on the welfare effects of the quantitative restrictions in place for some agricultural products.

[45] Trade in agricultural products accounted for 18% of trade; however, 36% of agricultural products were duty free at the end of the Kennedy Round (Preeg 1970:250).

[46] It is worth noting that the problems facing free trade after World War II should not be underestimated. And while the United States might have implemented some aspects of the Geneva round unilaterally in the absence of the GATT, the United States was not making other unilateral tariff concessions under the GATT (Grimwade 1996). Furthermore, as Preeg (1970) noted, failure of the Kennedy Round, for example, might have lead to higher tariffs and more restrictive deals and might also have encouraged "exclusive regional blocs" (260).

[47] Cline (1995:21) derives the following simple formula for estimating the welfare gains as a ratio z of the total import base. With α being the degree of the tariff cut (e.g., -0.65 for a 65% cut) and t the original tariff level; furthermore η is the import price elasticity (which is conventionally set at -2; see e.g., Preeg 1970; Cline 1995)

goods[48] by 65.2% from an initial tariff of 25%, we calculate that the eliminated static welfare loss from tariffs equals 58.6%.

The figure of roughly 59% certainly appears high and was probably not fully achieved. However, the loopholes and exceptions in the first 25 years played a rather minor role with big exceptions not occurring before the mid-1970s. In the first 25 years of the GATT, the postwar shortage of fully convertible currencies (until the mid-1950s) and tariffs played a more important role as obstacles to trade, while NTBs were not as important yet given the level of average tariffs up to the late 1960s. Thus an elimination of welfare losses of roughly 50% seems a reasonable estimate.

Actual Policy: Global Warming

The Kyoto protocol to the United Nations Framework Convention on Climate Change was adopted in 1997. It establishes differentiated legally binding emission reduction targets for industrialized countries (Annex I countries) for the period between 2008 and 2012 amounting to an overall reduction of 5.2% in Annex I countries. Kyoto failed to reach agreement on many technical details of calculating emissions and emission reductions.[49] Agreement on these issues was postponed until later conferences of the parties. After the subsequent breakdown of negotiations and withdrawal of the United States from the Kyoto protocol, agreement was reached on most outstanding issues at COP-6bis and COP-7, but the agreement was watered down significantly in the process (ENB 2001; Nordhaus 2001). The protocol has since entered into force without U.S. participation and Nordhaus (2001) has estimated that if fully implemented it would lead to a 0.8% reduction of global GHG emissions below BAU. This estimate includes an assessment of all known loopholes, and we can thus turn to prospects for implementation, which are bleak since the Kyoto protocol suffers from a weak implementation regime. Decisions of the enforcement branch will not be legally binding. Moreover, the compliance procedure has few other teeth as there is no "legally binding compliance eligibility requirement to use the mechanisms" (ENB 2001:16). Nevertheless we will make our assessment below assuming full implementation.

Assessing the Level of Cooperation on Global Warming

We need not take a separate look at the noncooperative outcome as it is implicitly estimated in Nordhaus (2001).[50] As far as the collective optimum is concerned, the most commonly cited model with regard to optimal GHG reductions are the DICE

$$z = ((\alpha + 0.5\alpha^2)\eta)\frac{t^2}{1+t}.$$

In order to derive the degree to which all possible static welfare gains were achieved, we calculate z for the partial elimination of tariffs and divide this figure by the ratio z for the full elimination of all tariffs. This will give us the degree to which the partial elimination of tariffs approaches the optimum of having eliminated all tariffs while using the initial tariff base as the non-cooperative outcome. Note that the percentage of eliminated welfare gain is greater than the percentage by which the tariff was reduced, "because the welfare costs of protection rise approximately quadratically with the size of the tariff" (Cline 1995:11), which means that cuts at higher tariff levels lead to disproportionate welfare gains.

[48] As mentioned above, we treat both textiles and agriculture as if no tariff cuts had taken place even though this is inaccurate. The reason is that quantitative restrictions operated even though there were tariff cuts and there are no estimates available for the net impact. Thus we erred on the side of caution.

[49] This issue is of special importance in the case of sinks, land use, and land-use changes, forestry changes (LULUCF) and emissions trading.

[50] Nordhaus estimates the business as usual scenario and compares it with the optimal policy.

and RICE models,[51] which determine the optimal emission path from an economic efficiency point of view (e.g., Nordhaus and Boyer 2000; Nordhaus 2001). The RICE 2001 model suggests that the efficient level of reduction would be around 6% of global emissions by the end of the first commitment period (Nordhaus 2001). Nordhaus' estimates belong to a set of conservative estimates that are based on discount factors derived from long-term market interest rates and are in line with the idea of the collective optimum as a global cost minimum. Using such a pure rate of time preference means that the effects of global warming in the next century and beyond do not affect policies today and thus violates sustainability criteria. A number of scholars have therefore argued that a zero discount rate should be employed when assessing optimal abatement to guarantee that future generations are taken into account (Cline 1992; Tol 1994; Schultz and Kasting 1997; Azar 1998). This conceptualization is more in line with a collective optimum as a technical optimum. Optimal abatement paths are up to five times higher than Nordhaus' estimates if a zero discount factor is employed (Schultz and Kasting 1997). If we use Nordhaus' conservative estimate, and assume Kyoto is fully implemented, then the actual policy would go about 13% toward the collective optimum. The level of cooperation can thus only be described as very poor. The impact on the environment would be negligible.[52] On the other hand if we take something closer to the technical optimum as the collective optimum and employ a zero pure rate of time preference, then the fully implemented protocol hardly moves away from the noncooperative outcome.

Actual Policy: Ozone Depletion

The Montreal protocol and its amendments[53] specify reductions of ozone-depleting substances (ODS) in participating countries while granting developing countries a 10-year grace period. The Montreal protocol is characterized by a successive tightening of provisions in the light of new evidence and the inclusion of additional ODS such as hydrochlorofluorocarbons (HCFCs) and methyl bromide (MB) over time leading to phase-outs of most ODS in the mid-1990s in developed countries.

There are some small loopholes such as essential use exemptions for meter-dose inhalers and one more serious loophole related to MB used for quarantine and preshipment (QPS) treatment, which is exempted from the protocol (Benedick 1999). The MB issue has yet to be addressed properly by the parties to the protocol; however, even if not addressed it does not undermine the protocol in a major way although it is a serious problem (WMO 1998).

The implementation of the Montreal protocol has been hampered by the collapse of the former SU and the following noncompliance by major producers and emitters. This was, however, a temporary problem that has been addressed (Victor 1998). According to the most recent reports of the implementation committee, major producers and emitters such as Russia are in compliance. The number of countries in noncompliance and potential noncompliance which have substantive obligations for 2003 is small and restricted to Azerbaijan, Chile, Iran, Pakistan, Philippines, Thailand, and a few small developing countries with low emissions (UNEP 2004).[54] Latest atmospheric measurements also confirm that emissions are in line with data reported by the parties to the protocol (UNEP/WMO 2002), which

[51] DICE and RICE are optimization models in which rational actors have to make decisions about greenhouse gas reductions and capital accumulation at the same time.

[52] Estimates suggest that Kyoto will lead to a reduction in global warming by a negligible 0.01°C.

[53] The protocol was amended at the meetings in London (1990), Copenhagen (1992), Vienna (1995), Montreal (1997), and Beijing (1999).

[54] That is violations or potential violations of control measures for 2003; it is important to stress that most of these countries are in noncompliance for 2003 obligations only, that is they have implemented prior reduction targets.

suggests that compliance issues are limited to the few parties mentioned above. Illegal trade in ODS was another issue hampering implementation, especially in the United States in the 1990s. However, the issue was addressed (Benedick 1999).[55] But even if illegal trade on the levels estimated for the United States and the EU persisted for another 20 years, this would only increase the cumulative ozone loss by about 3–4% (WMO 1998:19).

Assessing the Level of Cooperation on Ozone Depletion

There is no academic literature on the optimal abatement path of ODS, and thus we will take control measures which achieve the return to the pre-1980 ozone concentration (or a return to less than 2 parts per billion [ppb] chlorine abundance in the atmosphere) as the collective optimum. It seems reasonable to assume that this is a useful approximation for the collective optimum as a cost minimum and a technical optimum.[56] As a noncooperative scenario we can take the BAU scenario as identified by the scientific assessment panel. According to their estimates the abundance of chlorine radicals in the atmosphere would have reached more than 16 ppm by 2050 and rising[57] (UNEP/WMO 2002).

In order to assess how close the Montreal protocol comes to achieving the collective optimum after 18 years of operation, we can look at the percentage by which the cumulative ozone loss[58] between 2003 and full ozone recovery of the ozone layer could still be reduced. The latest scientific assessment reports identify only limited further options for improvement (UNEP/WMO 2002). The percentage of cumulative ozone loss that could still be avoided by stopping all emissions of regulated ODS by 2003 is 38% (UNEP/WMO 2002:13). It needs to be emphasized that the possible improvement by 38% is relative to an already significantly reduced scenario (Beijing amendment) and not relative to the noncooperative outcome (BAU).[59] This therefore suggests that the Montreal protocol got relatively close to the collective optimum. This assessment is also supported by the analysis of loopholes, illegal trade, and compliance.[60]

The evidence presented thus overall confirms the patterns of cooperation predicted by the relative gains model. There is clear evidence that significant cooperation was achieved in both the ozone and the trade case, while the level of cooperation achieved in the global warming case is negligible.

Conclusion

The model presented in this article shows that the relative gains argument can explain the patterns of cooperation observed in the issue areas of trade, global warming, and ozone depletion. The model suggests that we should see less

[55] Rising CFC prices in the mid-1990s suggest that CFCs are scarcer than they used to be, indicating a decline in illegal trade (Benedick 1999).

[56] With the exception of a quick HCFC phaseout and the reduction of MB for QPS all reduction options seem to be economically feasible.

[57] One might argue that unilateral action by the United States is not sufficiently taken into account in the BAU scenario. Note, however, that even under the original Montreal Protocol provisions, which go beyond what the United States could have achieved unilaterally, abundance would have reached almost 10 ppm by 2050 and rising.

[58] Cumulative ozone loss is a useful measure as there is a relationship between the loss of ozone at any point in time and the damage from UV radiation, and thus the cumulative ozone loss that can be avoided is a useful approximation of welfare gained.

[59] There is no data on the percentage by which cumulative ozone loss could be improved by action beyond the Beijing amendments compared with the BAU. But given that the concentration of chlorine would have reached 16 ppm by 2050 and that the maximal concentration is 4 ppm around the year 2000 and 2 ppm in 2050 under the Bejing amendment, it is likely that the possible improvements toward the collective optimum that can still be made are single figure percentages; of course this does not take into account implementation and loopholes.

[60] This is also the conclusion of assessments by Wettestadt (2001) and Barrett (2003).

cooperation in the case of global warming than in the case of ozone depletion, as in the latter case there is no relative gains concern due to the fact that the economic impact is not significant for a state's security, while there is such an impact in the former case. Similarly the models suggest that even though both cases induce relative gains concerns we should observe more cooperation on trade than on climate change as long as states care about the future to some degree and as long as there are more than two actors. This is the case because a defector can be excluded from benefits from trade and thus is in danger of losing out relative to the remaining cooperators, while the opposite applies to nonexcludable goods such as the provision of a stable climate. The article also demonstrates that these hypotheses are supported by the empirical evidence from the cases.

While institutionalists have made great strides in explaining the varying success of regime formation, implementation, and effectiveness, this article demonstrates that neorealist reasoning clearly has a contribution to make toward the explanation of economic and environmental cooperation, especially as the absolute gains hypothesis makes inaccurate predictions and no other individual variable can explain the pattern of cooperation observed. Unfortunately the conclusions to be drawn from the relative gains argument suggest that the current impasse in reaching a high level of cooperation on reducing greenhouse gases is not just a stage in the bargaining process or a problem that can possibly be manipulated by policy makers; rather, it suggests that this issue is unlikely to be resolved effectively unless action can be achieved at costs that have no security implications.[61]

The paper also contributes to our understanding of IR theory more generally by helping us to specify the empirical domain of neorealism and thus the conditions under which neorealist assumptions can help us understand IR. Essentially, neorealism taken seriously means that only big economic and environmental issues with big costs and benefits, which can have a real impact on the economy, fall within its domain. The model developed for global warming in this article is a powerful illustration of this point. However, even if a case falls within the empirical domain of neorealism, this does not necessarily mean that cooperation is inhibited, as the trade case shows. This insight is particularly important with regard to enhancing empirical testing of theories on cooperation. In the end we will only find a "complete" and empirically valid theory of cooperation if we include power in the analyses.

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[61] There have been suggestions by governments and academics (e.g., Nordhaus and Boyer 2000) that money should be directed toward finding cheap ways of disposing of carbon dioxide; while this would also make cooperation more likely from a neoliberal point of view, this would be essential to resolving the issue from a neorealist point of view.

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