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# Common Goods, Matrix Games and Institutional Response

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The provision of common goods poses collective action problems, which may imply that the actors do not provide the good on a voluntary basis. The collective action problem associated with common goods has traditionally been identified as the prisoner's dilemma. However, the analysis of common goods needs to look more closely at the characteristics of the goods and of the social context of their provision. Different characteristics lead to different collective action problems and thus require different institutional responses. If the strategic constellations in common good provision are represented as matrix games, clear implications for institutional responses to certain collective action problems are revealed. This approach will be demonstrated for the case of regulatory competition for environmental standards. A number of factors which characterize the situation are varied — the heterogeneity of preferences for environmental regulation of the countries concerned; the heterogeneity of their market shares; the type of standards used; and the prevailing trade regime. Different combinations of these conditions lead to different collective action problems and, thus, to different outcomes of regulatory competition. In some cases a 'race to the top' of environmental regulation can be expected; in other cases a 'race to the bottom' will occur; finally, there are cases where no convergence of regulation will take place at all.

## 1. *Introduction*

'Politics, it is usually agreed, is concerned with the common good, and notably with the cases in which it cannot be realized as the aggregate outcome of individuals pursuing their private interests.' As Elster (1986:

103) states, it is a widely held view in political philosophy and in political science that the provision of the common good and the solution of problems of collective action are at the heart of politics (cf. Mayntz, 2001). A similar view can be found in traditional neo-classic economics, where the role of the state is confined to the provision of public goods and the correction of market failure. Within this theoretical tradition two properties of goods have been considered as determining their publicness — non-rivalry of consumption, and non-excludability from consumption. The necessity for collective provision is based on these two properties of goods, because they create an incentive structure for rational individuals, which prevents the efficient private provision of such goods.

However, social situations where common goods are to be provided are characterized by many additional properties. In the analysis of common goods one needs to look at more properties of the goods and of the social contexts in which they are provided. Especially, it is important to analyse the consequences these properties have on the costs and benefits of the actors. Different cost and benefit structures lead to different strategic constellations, and these, in turn, make different opportunities available for institutional responses to the collective action problems posed by common goods. Thus, the provision of common goods does not necessarily imply the incentive structure widely known as the prisoner's dilemma. A single general theory for all common goods does not seem appropriate (Ostrom, 2002: 29). Because the strategic constellation is determined by many attributes of the social situation, those situations have to be analysed carefully before predictions are made to determine whether cooperation is possible and which institutions would be appropriate to solve the problem.

A systematic theoretical treatment is needed concerning how such attributes influence the strategic constellation. Basic differences in strategic constellations can be very clearly captured by 2 × 2 matrix games. From such clear structures it is easy to derive implications for possible institutional solutions to the collective action problems. Within this argument, two links are important — the relationship between common goods and matrix games and the relationship between matrix games and institutional responses of the collective action problems associated with the games. First, the characteristics of a common good and the social situation of its provision must be transformed into a game precisely, starting out from cost and benefit functions of the players. Once the game has been established, it can be classified as a type of strategic constellation that poses a certain collective action problem. These types of strategic constellation are tied to specific possibilities of the procedural or institutional solution for the respective collective action problem.

An approach along these lines has been pursued by Aggarwal and Dupont in their article on ‘Goods, Games, and Institutions’ (1999). It will not come as a surprise that, in general, I value the approach they have taken very much. However, particular factors in their theoretical framework are not properly specified. This in turn leads them to draw conclusions about cost, benefit and strategic constellations, some of which are not valid and some of which could be stated more precisely.

The basic approach will be developed in more detail in Section 2 of this article. Aggarwal and Dupont’s paper will be discussed in Section 3. First, this discussion shows that the theoretical transformation of goods into games has to be carried out carefully. Second, it serves to introduce two of the most important attributes of common goods provision which influence the strategic constellation — the relation of costs and benefits, and the aggregation technology of common goods.

Some more influential factors are introduced in Section 4. The approach is demonstrated by an application to regulatory competition in the case of environmental standards. As yet, the conditions under which either a regulatory ‘race to the top’ or a ‘race to the bottom’ will arise have not been fully identified (see Vogel, 1995; Scharpf, 1996, 1997; Drezner, 2001). Four characteristics of this common good provision situation will be varied in order to show how they determine the result of regulatory competition — the heterogeneity of actors with respect to preferences for the common good and with respect to market shares, the type of standards used, and the prevailing trade regime. Different conditions of these variables lead to different strategic constellations. These constellations produce typical game structures which allow us to draw conclusions about the requirements for institutional responses to the collective action problems associated with them (Section 5).

## 2. *The Approach*

The term common goods is used here to denote all goods characterized by the presence of externalities. This is a very wide definition, expanding to all goods that are not purely private. Thus, ‘common good’ is a collective noun for a number of sub-types of common goods, for example pure public goods, common pool resources, marketable public goods, club goods and network goods. A good belongs to the class of common goods, whenever it possesses one of the following properties to a certain degree — non-rivalry in consumption, non-excludability, or positive network externalities. The presence of these attributes of ‘commonness’ does not imply that something is necessarily a ‘good’, as the net benefits associated with it may be negative. Thus, there are common bads, as well. A common good is defined as a global or a transnational common good if the spatial scope of its externalities is global or transnational.[1]

Public goods are traditionally defined by two characteristics — there is non-rivalry of consumption, and nobody can be excluded from consumption. Both attributes lead to positive or negative externalities, a general characteristic of common goods. As a consequence of the externalities, if the provision of common goods is left to the market, they will not be provided in sufficient quantities. More specifically, non-rivalry is the cause of undersupply in the case of pure public goods, and non-excludability the cause of overuse in the case of common pool resources (CPRs) (Haveman, 1973). Provision by the state is traditionally legitimized by this market failure (Samuelson, 1954; Musgrave and Musgrave, 1976).

Game theoretic analysis of common goods leads to a similar result. The provision of common goods is generally thought of as strategic interaction of individuals within a certain strategic constellation, the prisoner's dilemma. Given this incentive structure, rational individuals choose the collectively and individually sub-optimal strategy, i.e. they do not contribute to the provision of the common good. In game theoretic terms, this problem can only be solved by an exogenous power, for example, the state.

This view of the problem of common goods must be qualified in three respects. First, it is not always possible for the state to solve common goods problems. When global common goods are at issue international negotiations are usually the only way out. Only if preferences and capabilities are distributed among the states such that unilateral provision is desirable and possible for a single state, unilateral provision may in fact take place instead of a negotiated solution (Olson, 1965; Conybeare, 1984; Barrett, 1999b; Aggarwal and Dupont, 1999). Second, both economics and game theory diagnose market failure, but it is still not clear whether state intervention leads to better results. Third, common goods can be provided and prisoner's dilemmas can be solved without the help of the state — experimental research shows that a substantial amount of cooperation takes place (Ledyard, 1995) and empirical case studies show that commons can be governed without the intervention of an exogenous power (Ostrom, 1990).

Furthermore, the two basic defining properties are not the only attributes to play a role in the provision of common goods. The need for common goods arises in a given social environment, and those goods have to be provided within a certain social setting. Social situations in which common goods are provided vary in many dimensions. The resulting strategic constellations may therefore be very different, and in some cases cooperation may be rational as a result of the strategic structure itself and not of 'irrational' cooperative behaviour. This means that these attributes also determine the type of dilemma the actors are exposed to (if there is a dilemma at all), as well as the possibilities for finding an institutional solution to the problem.

We already know that the strategic constellation associated with the provision of common goods is not necessarily a prisoner's dilemma. For example, Godwin and Shepard (1979) have shown that CPRs have many different characteristics and that the prisoner's dilemma does not properly represent all of them. Also, public goods, CPRs and other collective-action problems have been analysed as coordination games (e.g. Runge, 1984; Sandler and Sargent, 1995), and as volunteer's dilemmas (e.g. Weesie and Franzen, 1998; Rapoport, 1988; Diekmann, 1992). Hirshleifer (1983, 1985) has shown how aggregation technology — i.e. the way individual contributions add up to the socially available quantity of the good — affects the structure of the games (cf. Sandler, 1997; Holzinger, 2001). A similar argument has been put forward by Taylor (1987: 35–40).

However, there are many more properties of situations of common goods provision which have not yet been systematically analysed. Aggarwal and Dupont's observation that 'the links between the characteristics of goods, the nature of strategic interaction between actors, and the effectiveness or need for international institutions have not been systematically treated' (1999: 393) is still correct, at least in political science research. In economics some work of this kind has been done in recent years, for example, by Sandler (e.g. 1997, 1998), Barrett (e.g. 1998a, 1998b, 1999a) and Mäler and De Zeeuw (e.g. 1998). Nevertheless, Aggarwal and Dupont's statement is well taken, as it implies that much more of this type of work is needed (Sandler, 1998: 223).

As in the literature quoted above, basic types of strategic constellations can be modelled as 2 × 2 matrix games, although this is a great simplification. In an actual common goods problem there are usually more than two actors. There are usually more than two strategies available, too. In general, actors will be confronted with some degree of uncertainty, and measuring costs and benefits will not be easy. Finally, in cases of repeated interaction and ongoing relationships among the actors, the single-shot game does not truly reflect the strategic situation: many equilibria are possible if the game is played repeatedly.

However, the 2 × 2 games have the merit of demonstrating a given strategic structure very clearly and parsimoniously. If the empirical problem that is modelled requires loosening the restrictive assumptions of matrix games, game theory provides further tools. It can be shown if and how a change in these assumptions changes the strategic constellation. There is thus no reason why the first step of modelling a collective action problem

*Table 1*

Aggarwal and Dupont's Framework Game

***Game Matrix*** *Player 2*

| | | *contribute* | *not contribute* |
|---|---|---|---|
| *Player 1* | *contribute* | $b_1 - c_1, b_2 - c_2$<br>or<br>$(- r_1 \le x_1 < 0), (- r_2 \le x_2 <0)$ | $b_1 - c, b_2$<br>or<br>$(- r_1 \le x_1 < 0), 0$ |
| | *not contribute* | $b_1, b_2 - c_2$<br>or<br>$0, (- r_2 \le x_2 <0)$ | $0, 0$ |

Where $b_1, b_2$ = benefits from the consumption of the good to player 1 and player 2;

$r_1, r_2$ = levels of resources of player 1 and player 2;

$c$ = cost of production of the good;

$c_1, c_2$ = shares of production costs in the case of joint provision; $c_1 + c_2 = c$;

$x_1, x_2$ = payoffs to player 1 and player 2.

should not be a 2 × 2 game. Something can still be learned by the analysis of single-shot games and of games of complete information.

Thus, the approach proposed here includes three steps — first, dominant characteristics of common goods and of the strategic context will be identified, modelled and varied. Second, the strategic constellations and the collective action problems associated with different conditions can be derived. Third, conclusions can be drawn for institutional responses. This is exactly the road Aggarwal and Dupont (1999) have taken.

## *3. Goods, Games and Institutions*

Aggarwal and Dupont intend to compare pure public goods and common pool resources (CPRs) and to analyse how actors' capabilities, i.e. their budget constraints, influence the strategic constellation. They start by defining a framework game. Later on the framework is applied to examples which vary levels of benefits and capabilities of the actors. There are several problems with this framework game, mainly relating to the way in which the notion of actors' capabilities for providing contributions to the good is represented in the game. Aggarwal and Dupont's formalization is given in Table 1.

### *The Framework Game*

In general, it is reasonable to assume that actors are subject to a capability or budget constraint and that they may not be able to afford a common good as a group or their contribution to a common good as an individual. This idea presupposes, however, that there is some fixed minimum total investment needed in order to provide the common good, or that there is a fixed cost for each actor's contribution. Thus, it presupposes that the good is indivisible or at least not continually divisible, i.e. that it cannot be provided continually at different quantity levels starting with a very small amount. Although there are many common goods of that type, this is not generally true for public goods or CPRs.

If we leave this aside, it is still questionable whether a group of actors will end up in a commons provision game at all, if the level of the resources of all actors is lower than the investment needed for provision of the common good. This is implied by the x payoffs, which result if the resources do not suffice for provision. Under conditions of complete information — which is a presupposition if a matrix game is used for analysis — they will simply not try to provide it. Aggarwal and Dupont state as assumption four (p. 397) complete information of players about their share of costs $c_i$ and their benefits $b_i$, but leave unclear whether there is also complete information about the levels of resources $r_i$. This is the first difficulty with their formalization of the problem. Formalization as a matrix game requires complete information regarding r, which is a component of the payoffs in their model. Given complete information, however, nobody would contribute to the good if the total level of resources is not sufficient to cover the minimum costs.

Under conditions of complete information the level of players' resources is a factor external to the game. It does not influence costs and benefits of the common good directly. The notion of a capability constraint may be accepted as the idea that sometimes the resources may not suffice to provide the good. Sufficient resources, however, are a necessary condition for the provision of a good, not a sufficient one. Whether the necessary condition is fulfilled is a question which is exogenous to the game. There are three distinct cases (c is the total cost of provision):

(1) $r_i + r_j < c$ provision of the good is not possible,
(2) $r_i + r_j \geq c$ provision of the good is possible, and
(2a) $r_i \geq c$ the good can be individually provided by at least one of the actors, or
(2b) $r_i < c$ the good can only collectively be provided by the players

Whereas in case (1) the resources of the players do not suffice, they do in cases (2a) and (2b). It would be like throwing money out of the window if a player contributed in case (1). Thus, the game will be played only in cases (2). In case (2a) player i has enough resources to provide the good unilaterally, in case (2b) both players are needed for provision. This is, in fact, more or less what Aggarwal and Dupont vary later on — they treat case (2b) under the heading of 'without the possibility of unilateral provision', as well as case (2a) under the heading of 'with the possibility of unilateral provision' (p. 398f.). However, the question to be answered by a commons provision game is — Will the players actually provide the good, given that they are able to? This depends solely on the relation of their costs and benefits. The level of their resources may be added to the payoff ($b_i - c_i$) in each cell, but this does not change the strategic structure.

Aggarwal and Dupont's formalization is neither plausible nor fully correct in terms of a matrix game, even if we assume that the players would make a contribution up to the level of their resources to the game, knowing that their total resources do not suffice, or that their individual resources do not suffice to pay their own share or the total costs. The first problem to arise here is cost sharing — Who determines the shares $c_i$? The only information given in the framework game is that the shares add up to the total cost c. From the examples later on it can be seen that the authors have an equal distribution in mind.

The second problem concerns $r_i$. In the model the payoff is $b_i - c_i$, if both contribute and the resources suffice; it is between 0 and $- r_i$, if the resources do not suffice. If only one contributes, the payoff for the contributor is $b_i - c$, if the resources suffice, and between 0 and $- r_i$ otherwise. The payoff for the non-contributor is $b_i$ and 0, respectively. The difficulty concerning $r_i$ is — Why is the loss (the payoff in the non-sufficient resources cases) given as a range? It remains unclear here what contributors actually contribute in these cases. Do they pay their share of the costs? Or do they put in all their resources? Why can it also be some other amount? The payoff remains similarly unspecified in the examples — sometimes contributors pay '$< 0$', sometimes they pay either their share $c_i$ or the total cost c, sometimes they pay $c_i$ or $r_i$. Instead of giving a range the authors could have formalized much more clearly and simply what they had in mind — the players pay either $c_i$ or $r_i$ (if $c_i > r_i$) whenever the other player contributes, or they pay $c_i$ or $r_i$ (if $c_i > r_i$) whenever the other does not contribute.

The third and main problem is the definition of the strategy 'contribute'. As one can see from the examples just quoted, contributing may mean doing three different things — paying c, $c_i$ or $r_i$. This is not a correct formalization of a strategy. While the strategy 'do not contribute' means simply 'do not pay anything' (and hope that the other player has enough resources to provide the good), the strategy ‘contribute’ is a wildcard. For player i it actually means:

- if player j pays $c_j$ — pay $c_i$;
- if player j pays $r_j < c_j$ — pay $r_i$ or $c_i$ (it is definitely not clear which, as there are no examples for this case);
- if player j plays ‘do not contribute’ - pay c if $r_i \geq c$, and pay $r_i$ if $c > r_i$.

The action itself is ‘divided’ into three different conditional actions. Not only does a player’s choice between the two strategies ‘contribute’ or ‘do not contribute’ depend on the other player’s strategy, but also, what the action ‘contribute’ looks like depends on the other player’s level of contribution — as well as on the resources of the player herself. The strategic element is somehow doubled — the conditional action not only depends on a non-strategic element, the level of resources, but also on a strategic one, the other player’s choice of strategy. This is inconsistent with the idea of a matrix game, which is a game of imperfect information. Imperfect information means that both players act without knowledge about what the other will do.

A scenario that could be imagined as a cover story for Aggarwal and Dupont’s game would look like this: both players conclude a contract with an independent agent. They commit either to contribute or not to contribute, not knowing which strategy the other player has committed to. After the commitments have been made the agent bills the players. A player who has committed to ‘do not contribute’ pays nothing. A player who has committed to ‘contribute’ pays either c or $c_i$ (depending on what the other player did) or $r_i$ (depending on her resources). But this is not a strategic game; this is — at least partly — a lottery.

### *The Variables*

In their example games Aggarwal and Dupont vary two factors — the level of resources (capability constraint) and the level of individual benefits $b_i$. What is the effect of the capability constraint on the payoff and the structure of the games in the examples? The main effect is that in the examples where unilateral provision is impossible (because $r_i < c$) the outcome represented by the upper right and lower left cells is ‘no provision’, while in those examples where unilateral provision is possible ($r_i > c$), the outcome represented by the same cells is ‘provision’.[2] However, only if individual benefits are greater than total costs is unilateral provision also an equilibrium. In the unilaterally non-sufficient resources cases the non-contributor does not derive a benefit from his free ride, while the contributor does not derive a benefit from his contributed resources. These outcomes are no equilibria, but if they were implemented money would be wasted, or, in the previous scenario, the independent agent would get the money. The whole idea implies that for some cells there is a 'no provision' condition which is external to the strategic interaction but which influences the payoffs of both players and, therefore, the equilibrium.

The consequences of the capability constraint for the strategic constellation, as modelled by Aggarwal and Dupont, are equivalent to those of a different determinant of the strategic structure of common goods provision problems — their aggregation technology (see Hirshleifer, 1983). The idea that unilateral provision is impossible because the actors do not have sufficient resources is strategically equivalent to the condition that both players are needed for successful provision of the good. Whenever *all*, or *at least n* players are required to provide a common good (which has a fixed benefit for each player) the corresponding symmetric matrix game is an assurance game (cf. for example Sandler and Sargent, 1995). The idea that each actor has sufficient resources is strategically equivalent to the condition that *one or n* players may provide the good on their own. Whenever *each* player is able to provide the good for all others (which again has a fixed benefit for each player and a positive net benefit for the provider) the corresponding symmetric game is a chicken game. There is a third category not treated by Aggarwal and Dupont. In this case each additional contribution adds to the benefit of the good for each of the other players, i.e. the good is fully divisible and the contributions are additive. There is no threshold to the contributions like 'one contribution is sufficient', or 'at least *n* contributions are required'. This condition is usually the basis of the analysis of public goods provision. The corresponding game structure is the prisoner's dilemma.

These results can also be seen in principle in Aggarwal and Dupont's examples. In all instances where the individual and collective net benefit is negative the game is a harmony (or deadlock)[3] game. The cases where unilateral provision is not possible are assurance games. The cases where each individual is capable of providing the good are chicken games.[4] Thus, the explanatory factors behind the effects of the capability constraint are the conditions formulated above.

Aggarwal and Dupont's framework game implies that a player who is capable of providing the good unilaterally pays the full costs if the other player does not contribute. It also implies that the players sacrifice their resources even if it is obvious that the resources do not suffice for the provision of the good. But are these assumptions plausible? Why should a player pay more than her share when the other player's resources are less than his share of the costs? Why should a player pay the total cost or her total resources if the other decides not to contribute? There are reasonable answers to these questions, e.g. player i will be ready to pay an amount larger than $c_i$ if her benefit $b_i$ exceeds this amount. Therefore it does not come as a surprise that in the examples unilateral provision is an equilibrium only if the individual benefit is greater than the total cost of the good. Similarly, bilateral provision is an equilibrium only if joint benefits are greater than total costs.

The last paragraph indicates which factor really determines the strategic constellation and the provision of the good. The game structures are determined by the relation of individual and collective costs and benefits. This is the factor that should have been systematically varied. Under conditions of symmetry, linearity, fixed costs for an indivisible unit of common good, and cost sharing as assumed by Aggarwal and Dupont, five cases can be distinguished:

1. $c_i > b_i$ & $c_i > b => c > b$ negative net benefit, individual costs higher than collective benefits
2. $c_i > b_i$ & $c_i i < b => c > b$ negative net benefit, individual costs less than collective benefits
3. $c_i < b_i$ & $c > b_i => c < b$ positive net benefit, total costs greater than individual benefits
4. $c_i < b_i$ & $c < b_i => c < b$ positive net benefit, total costs less than individual benefits
5. $c_i = b_i => c = b => c_i < b => c > b_i$ individual and collective net benefit is 0

In cases (1) and (2) the games are rambo[5] games, in case (3) it is a prisoner's dilemma, in case (4) a chicken game and in case (5) a zero-sum game with a Nash equilibrium in dominant strategies where neither player contributes. Only in case (4), where the individual benefit is higher than the total costs, unilateral provision equilibria exist. Aggarwal and Dupont vary these cases implicitly, as they analyse different levels of benefits while keeping costs constant. However, it is not the level of benefits that accounts for the variation but the relation of individual and collective costs and benefits as distinguished above.

### *The Results*

Aggarwal and Dupont present their results as a two-dimensional taxonomy based on the level of benefits for a player and on the relation of resources and costs of a good (capability constraint). The problems of both dimensions have already been discussed. The capability constraint as modelled by Aggarwal and Dupont corresponds with the conditions of how many players are necessary and sufficient to provide the respective common good. This is equivalent to the aggregation technology of common goods. These attributes determine the variation, irrespective of what the reasons for the conditions are. The level of resources might be one possibility. The absolute level of individual benefits as such does not account for variations in strategic constellation; rather it is the relation of benefits and costs. A systematic cost-benefit variation would produce more precise results.

As neither determinant of the variation of the game structures is properly identified, the conclusions drawn from the taxonomy (p. 401) are not valid. First, it is not 'large resources' and 'moderate benefits' that make a game a prisoner's dilemma. Second, it is not a 'high level of resources' that makes a game 'conflictive' (the chicken game). In general, matrix game structures are very sensitive to small changes. Many different combinations of assumptions may lead to a prisoner's dilemma, a chicken game and so on. Thus, assumptions must be carefully analysed. An example of how to transform the properties of a good into a matrix game is given in the next section.

The institutional conclusions drawn by the authors are mainly correct. As Aggarwal and Dupont point out (p. 403), no institutions are necessary if common goods, which would actually be common bads, are not provided as a result of the incentive structure. It is also true that institutions should be strong if the strategic constellation is a prisoner's dilemma or a chicken game. I would not agree, however, with the statement that institutions are of little use in cases of multiple Nash equilibria but without incentive to free ride (the assurance games). Here, institutions can help to coordinate behaviour such that the Pareto-superior equilibrium is achieved. Also, as already argued above, the conclusion that sharp asymmetry in power is equivalent to unilateral provision is not valid. Being capable of providing a common good is not the same as being willing to provide it. As will be shown in the following sections, more specific conclusions for institutional solutions can be derived.

## *4. An Example: Regulatory Competition for Environmental Standards*

Regulatory competition in the environmental field serves as an example to show how different attributes of the situation affect the strategic problem and thus the outcome. The following characteristics will be considered and varied — the relation of costs and benefits of the common good in question, the heterogeneity of the countries' preferences, their heterogeneity in market shares, the type of environmental standard and the trade regime. All of these variables affect the payoffs of the game. The analysis shows that even more assumptions have to be made in order to be able to clearly predict a certain strategic constellation. Before I go on to present the models, I will consider why regulatory competition can be viewed as a common goods problem.

### *Regulatory Competition as a Common Goods Problem*

How is regulatory competition for environmental standards related to common goods? The argument has four steps. First, environmental goods are common goods in most cases. Second, depletion of the environment is a common bad. Third, environmental standards are means to protect common goods and are thus common goods themselves. Fourth, competition for environmental standards poses a common goods problem for the concerned states.

Examples of environmental goods are clean air, non-contaminated soil, the absence of noise, transboundary bodies of water and the climate, to name a few. In many cases environmental goods are CPRs, which means that consumption is rival but not excludable. These goods are increasingly being destroyed, for example through emissions from products or production processes. The emissions can be qualified as public bads, since they produce negative externalities that are usually non-rival and non-rejectable. As a consequence, the quality of the particular environmental good is decreasing, and it may no longer be sufficient for some uses. Depletion of the environment is thus a common bad (for examples of global common goods and corresponding bads, see Kaul, Grunberg and Stern, 1999b: 454f.; Heal, 1999: 222).

Contributions to the preservation or restoration of environmental goods consist, first of all, in reducing emissions, or, less specifically, in restricting the destructive activities. Since we are talking about common goods, there is a free rider problem. Therefore, the reduction will not be achieved by voluntary or market behaviour, but only by the regulatory activity of the affected jurisdiction. State regulation — for example, an emission standard — can thus be viewed as providing the common good within the jurisdiction. As Barrett (1999b: 192) puts it: ‘Reductions in the use of ozone-depleting chemicals and in the emission of greenhouse gases are global public goods’ — and so are regulations which prescribe those reductions. At the international level, the regulations of the individual states must be interpreted as the states’ contributions to the common good.

Thus, there is ‘commonness’ at three levels. An example may help to understand the complex relationship. First, there are the environmental goods themselves, like a body of clean water. It is a rival good with respect to its use for extracting other goods (e.g. fish, drinking water) or its use as a reservoir for wastes like polluted wastewater. Second, wastewater emission is a public bad — it is distributed in the water and its negative effects on the other users of the water are non-rival, as the extraction of water by one does not improve the quality for the other users, and it is non-rejectable. Third, voluntary emission reductions or state regulation of such a problem are attempts to preserve or restore the original common good. Thus, the regulation or environmental standard itself might be called a *secondary* common good. It is a public good, as its positive effects on the body of water are non-rival and non-excludable (see Sandler, 1998: 222).

Environmental protection standards are the subject of environmental regulatory competition among states. The aim of an environmental protection standard is to preserve a certain environmental common good with respect to a certain pollutant or with respect to other forms of deterioration. What these goods have to have in common, in order to be considered relevant for regulatory competition, is their transnational or global nature. 'Purely domestic' regulations, for example, local noise standards set to preserve the good of a quiet environment, lie outside the scope of the following analysis. Transnational common goods affect several states which may regulate the use of the environmental good on their own. However, because of the externalities between the states that result from the transnational nature of the goods, the individual regulations will not be efficient. The common good problem reappears at the level of the states. As the spatial scope of the goods is determined by biological and physical conditions, it cannot easily be adapted to political borders. Thus, some form of cooperation is needed in order to preserve the good. If there is no cooperation, we are in a state of regulatory competition.

In times of a globalized economy not only are environmental goods transboundary, so are economic processes. Commodities that are subject to environmental regulation are traded internationally. Firms and economies are subject to international competition. In states with stricter environmental regulations, productions costs for firms are higher and the firms consequently suffer a competitive disadvantage in comparison to firms in states with laxer standards. At least, this is usually assumed in the literature on environmental regulatory competition.

The classical research question about regulatory competition is whether and under which conditions this situation leads to a regulatory 'race to the bottom' or to a 'race to the top'. In the case of transnational environmental problems there is evidence of both outcomes (Vogel, 1995, 1997; Levinson, 1996; Zürn, 1997; Jänicke, 1998; van Beers and van der Bergh, 1999; Kern, 2000; Drezner, 2001). However, a convincing explanation and clarification of the conditions that lead to one or the other result is still missing. Some important factors have been dealt with in the literature, such as the distinction between product and production standards (Scharpf, 1996, 1997, 2000), but most factors have not been systematically analysed. Since this article only concentrates on four variables, it will not be able to fully fill this gap in the research. However, it shows that the type of trade regime and the heterogeneity of actors may contribute to the explanation.

For the following analysis it is not necessary to specify the environmental good, the cause of its deterioration and the type of regulation. However, for the purpose of illustration we may think of clean air in Europe polluted by the emission of nitrogen oxides. Nitrogen oxides cause long-range air pollution; the primary sources are large combustion plants and vehicles. They are regulated by limit values set to the emission of nitrogen oxides from large combustions plants, as well as by limit values for car emissions, among them nitrogen oxides.

### *Assumptions and Basic Game with Heterogeneous Preferences*

The problem of regulatory competition is modelled by 2 × 2 matrix games. The players are two states, which regulate a transboundary environmental good by emission standards. They have two strategies, namely employing high (strict) or low (lax) standards. This is analogous to making 'a large contribution' and 'a small contribution' to the common good. The high standards (H) are assumed to be equivalent to two units of contribution to the environmental good, the low standards (L) are equivalent to one unit.

There are two further assumptions which have to be made. The first is about the relation of costs and benefits of the contributions. Two cases can be distinguished — first, the benefits per unit of contribution are higher than the costs per unit, or second, the costs per unit are higher than the benefits per unit. The first case is not very interesting, as it poses no social dilemma. The strategic constellation is a harmony game which has a unique equilibrium in dominant strategies and a unique Pareto-optimal outcome. Therefore it represents an ideal incentive structure where the collectively optimal outcome is achieved without any cooperation or exogenous action. The second case leads to a prisoner's dilemma which has its unique equilibrium at the Pareto-inferior outcome. While in the first case a regulatory 'race to the top' would be the consequence, in the second case the result is a 'race to the bottom'.

Both cases rest on the assumption of homogeneous actors, which is not realistic in the regulatory competition example. The second assumption is therefore heterogeneity of actors. Two kinds of heterogeneity will be distinguished. First, the states have different preferences for the common good that is protected by the regulation. Second, the two states have a significantly different share of the market concerned by the regulation. While the first kind of heterogeneity is introduced later, the second kind of heterogeneity will be introduced only at the end of the section.

I start by assuming that the two states have different preferences for the respective environmental good. As a result, they prefer different strategies, either low or high standards. Empirically the heterogeneity will be caused by two factors. First, there are states which place a greater value upon the environmental good. Their benefit from the preservation or restoration of the good is higher than that of other states. Second, there are states which have lower contribution costs than others. It is cheaper for them to achieve a certain environmental standard. For the examples, these two factors need not be distinguished. We can simply assume that one of the states has strong preferences for the environmental good and thus prefers high standards (country A), while the other has weak preferences and prefers low standards (country B).

In the model, heterogeneity can be captured very simply. The benefit of the environmental good per unit is now higher for the 'environmentalist' country ($b_A$) when compared to the other country ($b_B$). The costs per unit contribution are equal. They imply $c > b_B$ for country B and $b_A > c$ for country A. Thus, the variation in the payoffs is only a result of the different valuation of the environmental good. This way, the asymmetry of payoffs is sufficiently represented. The assumption of different cost structures does not change the incentive structure as long as country B values the costs of the contribution more than its benefits and the reverse is true for country A. The payoffs for each possible outcome and the game are shown in Table 2. In the last column ordinal payoffs are given because the strategic structure is easier to see this way.

The result is no surprise. The equilibrium is attained when country B chooses low standards and country A high standards. It is a Pareto-optimal equilibrium in dominant strategies. There is a second Pareto-optimal outcome, where both states use the high standards. There is no dilemma between individual and collective rationality and there is no problem in selecting the equilibrium. This type of game has been called rambo game (Zürn, 1992). It poses only distributional problems.[6] Country B gets its first preference, namely low standards within its own jurisdiction and high standards within the other country's jurisdiction. As a consequence, different standards apply over the whole area. There are two regulatory areas, and in the case of product standards the market becomes segmented. There is neither a 'race to the top' nor a 'race to the bottom'.

### *The Influence of Market Segmentation*

So far it has been implicitly assumed that market segmentation or non-segmentation by different standards does not affect the national economies. However, the industries concerned are affected by market segmentation in

## *Table 2*
## Regulatory Competition with Heterogeneous Preferences

Assumptions $b_B < c < 2b_B$ for country *B*

$b_A > c$ for country *A*

| | Strategy Combination | | Benefits | Costs | Payoff B | Payoff A | Ordinal B | Ordinal A |
|---|---|---|---|---|---|---|---|---|
| *Countries* | H | H | 4b | 2c | $4b_B - 2c$ | $4b_A - 2c$ | 3 | 4 |
| *B and A* | H | L | 3b | 2c | $3b_B - 2c$ | $3b_A - 2c$ | 1 | 2 |
| | L | H | 3b | c | $3b_B - c$ | $3b_A - c$ | 4 | 3 |
| | L | L | 2b | c | $2b_B - c$ | $2b_A - c$ | 2 | 1 |

***Game Matrix***

| | | *Country A* | |
|---|---|---|---|
| | | *High standards* | *Low standards* |
| *Country B* | *High standards* | $4b_B - 2c$, $\underline{4b_A - 2c}$<br>3, $\underline{4}$ | $3b_B - 2c$, $\underline{3b_A - c}$<br>1, 2 |
| | *Low standards* | $\underline{3b_B - c, 3b_A - 2c}$<br>$\underline{4, 3}$ | $\underline{2b_B - c}$, $2b_A - c$<br>$\underline{2}$, 1 |

two respects — the first question is if and in which state differentiated standards lead to competitive advantages or disadvantages for the industries. Different standards, both product or production standards, may cause different costs for the industries concerned. If firms from both states trade their products within the whole market, different standards lead to competitive advantages for the firms in country B as well as to competitive disadvantages for the firms in country A. The competitive disadvantage regarding product standards vanishes for country A if barriers to trade are permitted for environmental reasons. In the case of production standards there is no way to escape the disadvantage for the industry in country A.

The second question is whether a common standard for the whole market implies harmonization advantages (i.e. segmentation costs). Advantages through harmonization can be expected if *products* are subject to different national environmental standards, if licensing procedures are different for these products and if they have to be produced with different variations in each state. This is the case if the prevailing trade regime allows the states to wall off foreign products that do not fulfil the domestic environmental standards. In such a situation the harmonization of standards leads to economic gains for the industries concerned as the average costs decrease. The example of limit values for car exhaust emissions fits into this pattern — they are product standards, the respective product is globally traded, and producing different varieties, and different licensing procedures cause high costs. Thus, market segmentation is very expensive for car producers, which is the reason why car emission limits have been harmonized on a voluntary basis ever since the 1950s within the institutional frame of the United Nations Economic Commission for Europe (ECE). US standards for car emissions played a role as benchmark, because the US market for cars is an important market also for European car producers — the harmonization of US and EU standards promised efficiency gains (Holzinger, 1994: 190–4).

There are no harmonization advantages when there is a rule of mutual recognition of the products and when the protection from foreign products is not permitted for environmental reasons. Products that are licensed according to different standards can be sold throughout the entire market. Production standards in general do not lead to any harmonization advantages or segmentation costs. The regulation of nitrogen oxides from large combustions plants is an example of this.

Thus, the incentive structures for the preservation of an international common environmental good vary with two additional properties:

1. Are the instruments used to achieve the common good product standards, or are they production standards?

*Table 3*
Type of Standards and Trade Regimes

| | Product standards | Production standards |
|---|---|---|
| | (1) | (4) |
| Trade barriers | harmonization advantage | no harmonization advantage |
| | no competitive dis/advantage | small competitive dis/advantage, in/decrease of turnover |
| | (2) | (3) |
| Free trade | no harmonization advantage | no harmonization advantage |
| | competitive dis/advantage | competitive dis/advantage |

2. Does the prevailing trade regime permit trade barriers for the sake of the environment, or is it possible to enforce the mutual recognition of products?

Four cases can be distinguished (see Table 3). How do the incentive structures in these four cases differ? In case 1 there is a harmonization advantage for both states. However, there are no competitive advantages or disadvantages because the product prices — as far as they are determined by the environmental standard — are the same for both states. In cases 2 and 3 there are no harmonization advantages, as markets are not segmented. Country B enjoys a competitive advantage, country A suffers from a disadvantage. It does not make a difference here whether product or production standards are concerned. In case 4 there are no harmonization advantages, as only production facilities are affected. Country B has a competitive advantage, as it has lower production costs. However, this advantage is restricted to its own territory if country A is able to erect trade barriers against products from country B where production is subject to low-level regulation. As a consequence, within A's territory there is a loss of turnover for B's industry. The reverse is true for country A. Its competitive disadvantage is restricted to country B's territory, and its domestic turnover increases.

*Case 1: Product Standards and Trade Barriers.* The following specific assumptions will be made — the industries in both states sell their products throughout the entire market and have an equal share of the market. Furthermore, the harmonization advantage is the same for low and high standards, which is a plausible assumption. The following models rest on these and further symmetry assumptions, as they assume that all other factors, like production costs, are equal for both states.

The harmonization advantage is the same for both countries. I shall assume that it weights less for the countries than their benefits of an additional unit of the common good, but more than their net benefits per unit. This is equivalent to saying that the economic advantages of a non-segmented market are valued more highly by the national regulators than the difference in net benefits from the common good between high and low standards. If the condition holds true for country A with its positive net benefit per unit, it is trivially true for country B, whose net benefit per unit is negative.[7] The harmonization advantage becomes relevant where both states choose the same strategy, that is, high or low standards, respectively.

This modelling leads to an assurance game, provided the harmonization advantage is sufficiently large ($h > b_i - c$).[8] It has two equilibria, one Pareto-optimal, the other sub-optimal. The game is symmetric although the players are heterogeneous. The harmonization advantage drives their interest in the same direction. The optimal equilibrium represents the solution with harmonized high standards, the sub-optimal one, the outcome with harmonized low standards. Segmentation is no equilibrium. The problem is one of coordination — if the states communicate, they will easily agree to introduce high standards, as both states realize their highest payoff then. This situation leads to a 'race to the top' regarding environmental standards. Without communication, however, there is a certain chance that the states will choose different strategies and 'miss each other' (see Table 4).

*Case 2: Product Standards and Free Trade.* In a free-trade regime the mutual recognition of products manufactured according to different environmental standards can be pushed through.[9] There are no market segmentation costs for the national industries. However, there is a competitive advantage for the country which applies the low standards if the other country chooses the high ones; and there is a competitive disadvantage for the country applying the high standards if the other country introduces the low ones. This is true as long as different environmental standards lead to different costs and product prices. There is no effect on competition if both states choose high or low standards. For simplicity, a symmetric competition effect (e) is assumed, where the competitive advantage and the disadvantage are of the same size. As in case 1 with the harmonization effect, it will be assumed that the competition effect is smaller than the benefit b from an additional unit of the common good, but higher than the net benefit of the difference between the high and low standards (see Table 5). In this case the states are in a classical prisoner's dilemma constellation. Both

*Table 4*

Regulatory Competition with Product Standards and Trade Barriers

Assumptions $b_B < c < 2b_B$ for $B$; $b_A > c$ for $A$; $h > b_i - c$; $h < b$

| | Strategy Combination | | Benefits | Costs | Harmonization | Payoff B | Payoff A | Ordinal B | Ordinal A |
|---|---|---|---|---|---|---|---|---|---|
| *Countries B and A* | H | H | 4b | 2c | h | $4b_B - 2c + h$ | $4b_A - 2c + h$ | 4 | 4 |
| | H | L | 3b | 2c | 0 | $3b_B - 2c$ | $3b_A - 2c$ | 1 | 1 |
| | L | H | 3b | c | 0 | $3b_B - c$ | $3b_A - c$ | 3 | 3 |
| | L | L | 2b | c | h | $2b_B - c + h$ | $2b_A - c + h$ | 2 | 2 |

***Game Matrix***

| | | *Country A* | |
|---|---|---|---|
| | | *High standards* | *Low standards* |
| *Country B* | *High standards* | $\underline{4b_B - 2c + h, 4b_A - 2c + h}$<br>$\underline{4, 4}$ | $3b_B - 2c, 3b_A - c$<br>1, 3 |
| | *Low standards* | $3b_B - c, 3b_A - 2c$<br>3, 1 | $\underline{2b_B - c + h, 2b_A - c + h}$<br>$\underline{2, 2}$ |

### *Table 5*
### Regulatory Competition with Product Standards and Free Trade

Assumptions $b_B < c < 2b_B$ for $B$; $b_A > c$ for $A$; $e > b_i - c$; $e < b$

| | Strategy Combination | | Benefits | Costs | Competition | Payoff B | Payoff A | Ordinal B | Ordinal A |
|---|---|---|---|---|---|---|---|---|---|
| *Countries B and A* | H | H | 4b | 2c | 0 | $4b_B - 2c$ | $4b_A - 2c$ | 3 | 3 |
| | H | L | 3b | 2c | – e | $3b_B - 2c - e$ | $3b_A - 2c - e$ | 1 | 1 |
| | L | H | 3b | c | e | $3b_B - c + e$ | $3b_A - c + e$ | 4 | 4 |
| | L | L | 2b | c | 0 | $2b_B - c$ | $2b_A - c$ | 2 | 2 |

***Game Matrix***

| | | *Country A* | |
|---|---|---|---|
| | | *High standards* | *Low standards* |
| *Country B* | *High standards* | $4b_B - 2c, 4b_A - 2c$<br>3, 3 | $3b_B - 2c - e, \underline{3b_A - c + e}$<br>1, $\underline{4}$ |
| | *Low standards* | $\underline{3b_B - c + e}, 3b_A - 2c - e$<br>$\underline{4}$, 1 | $\underline{2b_B - c, 2b_A - c}$<br>$\underline{2, 2}$ |

countries choose the low standards. If all the above conditions are met, the free-trade regime will result in a 'race to the bottom'.[10]

*Case 3: Production Standards and Free Trade.* Whenever environmental regulations affect the production processes and not the products themselves, there is no market segmentation, and consequently no harmonization advantage. The production is stationary in each state, but the products are traded throughout the entire territory. The products themselves do not have different properties, but are produced with different manufacturing processes. There is a dilemma for the country with high standards — on the one hand, in a free-trade regime, trade barriers based on environmental considerations are not permitted on product properties themselves. On the other hand, in most cases the production processes cannot be monitored, and even if it is known that the products are produced according to lax production standards, the only possible reaction is to reject the products from this country. In a free-trade regime, however, a complete ban on the products is considered discriminatory, thus it is not permitted. As a consequence, country A has a competitive disadvantage, while country B (applying low standards) has a competitive advantage. The strategic constellation in case 3 is thus the same as in case 2 — namely a prisoner's dilemma. Both states choose low standards.

It is possible that the consumers in country A have such a high preference for the environment that they buy the more expensive domestic products because such products are more environmentally friendly. Then the industry in country B would experience a decrease in turnover of its foreign sales, as their products do not find customers in country A. As a consequence the industry in country A has an increase in domestic turnover. The situation is similar to a situation in which trade barriers apply — the game is the same as in case 4 below.[11]

*Case 4: Production Standards and Trade Barriers for Environmental Reasons.* In general, it is practically impossible to erect trade barriers against production standards even if they were permitted, because it is difficult to monitor production processes. Nevertheless, there are examples of trade embargoes for environmental reasons (Vogel, 1997). If country A does not allow B's products to be admitted into its market, the competitive advantage of country B is restricted to its own territory. In the same way, the competitive disadvantage of country A arises only in B's territory. However, country B's industry suffers a loss in turnover, as they cannot sell their product in country A. As a consequence, country A's industry experiences an increase in domestic turnover.[12] Then, the turnover effects offset the competition effects, as long as the symmetry assumptions about market

*Table 6*
Results of the Analysis for Heterogeneous Preferences

| | Product standards | Production standards |
|---|---|---|
| Trade barriers | (1)<br>assurance<br>'race to the top' | (4)<br>rambo<br>'no race' |
| Free trade | (2)<br>prisoner's dilemma<br>'race to the bottom' | (3)<br>prisoner's dilemma<br>'race to the bottom' |

shares are retained. Therefore, the game structure associated with this is once again the rambo game. There is an equilibrium in dominant strategies, where country A chooses the high standards and country B the low ones.

So far, the analysis has shown that regulatory competition in the environmental field may lead to several different outcomes, depending on the exact conditions. In the symmetric case, the outcome is a result of the relation between costs and benefits of the individual contributions to the common good. If the costs are lower than the benefits, we end up with a harmony game. If the benefits are lower than the costs, the actors are in a prisoner's dilemma, and a 'race to the bottom' of the environmental standards has to be expected. If the actors have heterogeneous preferences, the strategic constellation is a rambo game. Each state applies its most preferred standards. This leads to market segmentation.

The analysis becomes more complex if assumptions about the trade regimes and the type of environmental standard are introduced on the basis of heterogeneous preferences (see Table 6). In a free-trade regime where mutual recognition of products is the rule, regulatory competition leads to a 'race to the bottom', as all states choose the low standards, irrespective of the type of standards. The incentive structure is a prisoner's dilemma. In a trade regime where products can be excluded if they are manufactured according to low production standards, the market will become segmented. In the rambo game one state will introduce high standards, the other low ones. There is no 'race' in either direction. Finally, if it is also possible to apply domestic product standards to foreign products, it is in the interest of both states to coordinate their action and to apply the high standards. The related game is an assurance game. A 'race to the top' regarding environmental standards can be achieved in this constellation.

These outcomes are a result of varying effects of harmonization of standards and competition among the countries' industries in a common market. Whenever the harmonization and the competition effects are very small compared to the benefits and costs of providing the common good, a rambo game results, where each country employs its most preferred standards. In this case neither a 'race to the bottom' nor a 'race to the top' can be expected. This corresponds to empirical observations. A general 'race to the bottom' has not occurred (Jänicke, 1998), and there are some clear cases of 'races to the top', especially in the field of car emissions regulation (Vogel, 1997; Holzinger, 1994). The analysis carried out here offers some suggestions for explanations. First, if the industry concerned has a lot to gain from harmonized product standards in global markets, a 'race to the top' is a likely and rational result. Second, in the case of production standards, one would not expect a clear movement of regulations in either of the two directions, as long as there is no rigid free-trade regime that is relevant for the products of the regulated facilities. Third, in practice no strict free-trade regimes exist with respect to many environmental matters. Both under EU and under World Trade Organisation rules, trade barriers can often be justified on the basis of health and environmental reasons (Epiney, 2000; Sandhoevel, 1998). Finally, even if a strict free-trade regime applies, the costs of environmental standards are often too low to be a relevant competition factor (Vogel, 1997). There are a number of other factors characterizing the market and institutional environment which have been held constant in this analysis. Some of them will also be important for the strategic constellation and may thus contribute to the explanation of the fact that there is obviously no universal trend in regulatory competition for environmental standards. The most important of these factors is relative market size of the countries. The effects of different market size are analysed in the next section.

### *The Effects of Heterogeneous Market Shares*

The idea of regulatory competition for environmental standards presupposes the presence of trade among the countries concerned. In the two-country model the presence of trade, in turn, presupposes heterogeneous market shares. Strictly speaking, if two countries have an equal share of a certain product market, implying that both their share of production (supply) and their share of sales (demand) is equal, there will be no trade. *Ceteris paribus* each of the countries will supply its domestic demand. Similarly, if each country's share of total supply in the market equals its share of total demand there will be no trade, even if the market share of the two countries differs. As long as domestic supply satisfies domestic demand, different market size does not matter for regulatory competition.

If the shares of supply and demand of each country differ, however, trade will take place. In the two-country model three cases can be distinguished — first, the two countries can have an equal share of supply but differ in their share of demand ($d$, $0 < d < 1$). In this case the country with the lower demand ($d < \frac{1}{2}$) will export the surplus of the domestic production to the country with the higher demand ($d > \frac{1}{2}$). Second, the countries can have an equal share of demand but their share of supply may be different ($s$, $0 < s < 1$). In this case the country with the higher share of supply ($s > \frac{1}{2}$) will export its surplus in supply to the country with the lower share of supply ($s < \frac{1}{2}$). Third, the countries may differ both in their shares of supply and of demand. In this case, the country with the higher share of supply (and at the same time lower share of demand) will export the surplus of products to the country with the lower share of supply and the higher share of demand.

Consequently, two types of countries have to be distinguished for a regulatory competition model under the condition of heterogeneous market shares — exporting countries (E) and importing countries (I). From the above discussion it follows that the condition for being an exporter is $d \leq \frac{1}{2}$ and $s \geq \frac{1}{2}$; the condition for being an importer is $d \geq \frac{1}{2}$ and $s \leq \frac{1}{2}$. For modelling the incentives in situations in which market size differs it is sufficient to assume that one of the countries is the exporter, the other the importer.[13]

How are the various components of the payoff functions used in the previous models affected by different national shares of total supply and total demand of a product? First, different market shares of the countries affect the level of benefit achieved from the common good protected by environmental regulation in the market concerned. As the good in question has been assumed to be non-rival, the level of benefit for both countries is the same whenever both countries choose high (2b) or low standards (b). The level of benefit varies, however, for the split strategy combinations. If the country with the large market share chooses high standards and the other country chooses low standards, the common benefit of all countries is higher than the common benefit would be in the situation in which the country with the large market share chooses the low standards and the other country the high ones. The larger the market share of the high-standard country, the larger the benefit for all. Thus, the benefit has to be weighted by the market share in the payoff function.

Which is important, the share of supply or the share of demand? This depends on the kind of standard used. In the case of production standards the share of supply determines how much benefit is achieved (sb). Production standards regulate domestic production and the amount of domestic production determines the amount of reduction of environmental pollution achieved by each country. For example, if there are many more power plants in one country than in the other the regulation of nitrogen oxides leads to a higher environmental benefit created by this country. In the case of product standards we can assume that the benefits are achieved by the consumption or use of a product. Therefore, the share of demand determines how much benefit is achieved (db). For example, regulating the exhaust gases of cars creates more environmental benefit in the country in which a greater number of clean cars are sold and used.

Different market shares also affect the additional costs caused by the environmental regulation. In the case of production standards again the share of supply is relevant. The amount of production will determine the total cost of the environmental regulation in a country. In the case of product standards the trade regime influences the costs of contribution to the common good as well. In a free-trade regime domestic goods must be accepted in the foreign country no matter which standards apply there. Thus, it can be assumed that the total domestic supply is produced according to the domestic standard. Therefore, the total domestic supply is the basis for calculating the environmental costs in a free-trade regime.

The situation is different if trade barriers for products are permitted. As long as both countries use the same standard, either high or low, they need only produce one type of the product. In these situations, the cost of the environmental regulation can also be calculated for each country on the basis of its share of supply. If both countries use different standards, however, the industries must produce different types of the product, one for domestic sales and one for foreign sales. Otherwise they cannot sell their product in both countries. Therefore, the environmental costs are calculated on the basis of the share of demand in each country. The contribution costs of a country consist of the environmental cost share for domestic sales (dc) and the environmental cost share of the exports ((s – d)c). For example, if a country applies domestically the high standards (2c) and the foreign country applies the low standards (c), this country's costs are 2dc + (s – d)c.

The harmonization advantage (h) plays a role only if the environmental regulation concerns products and trade barriers are permitted. It does not depend on the relative market share; at least this is difficult to claim in general. The size of the product series is less important for the costs of market segmentation than the number of different series that have to be produced. In the model the number of different product series is one for the importer and two for the exporter. The importer can be assumed to have no harmonization advantage, whereas the exporter has an advantage if both countries use the same standards.

The competitive advantage ($e > 0$) or competitive disadvantage ($e < 0$) is correlated with the share of export or import. If the exporting country applies domestically the high standards for production or products its export suffers from a competitive disadvantage — given that the foreign country applies low standards. The competitive disadvantage amounts to $-e(s-d)$. Likewise, if the exporting country applies the low standards and the other country the high ones, the export enjoys a competitive advantage ($e(s-d)$). The same applies vice versa to the importing country.

Finally, there may be turnover effects, whenever in the case of production standards trade barriers have been erected. It has been mentioned above that this is not a very likely case. It may occur, however. When products coming from a country applying low production standards are walled off by the country using the high standards, the exporting country suffers a negative turnover effect ($-t(s-d)$). The importing country has a positive turnover effect ($(d-s)t$), as it will raise production to cover the gap between domestic supply and demand — at least in the long run. There is no turnover effect if the exporter uses the high standards and the importer the low ones. The same is true if both countries apply the same standards.

Given these changes in the payoff functions for two countries with heterogeneous shares of markets, which strategic constellations result for the four conditions that have been dealt with above? I will develop the game model only for case 1 (product standards and trade barriers) in order to demonstrate how the payoff configurations have been derived. For the three other cases only the results in terms of the strategic constellation and its consequence for the outcome of regulatory competition will be presented and discussed.

In the model there are two countries with homogeneous preferences for the environmental common good. For both of them the costs of producing one unit of the common good are higher than the benefits from one unit of the good ($c > b$). The countries have different shares in the relevant product market (in the nitrogen oxide example — cars in case of product standards and electricity in case of production standards). The exporting country E has a larger share of supply and a lower share of demand ($d_E \leq \frac{1}{2}$; $s_E \geq \frac{1}{2}$) than the importing country I ($d_I \geq \frac{1}{2}$; $s_I \leq \frac{1}{2}$). As in the previous models the harmonization advantage for the exporter is assumed to be higher than the difference of benefits and costs of one unit of common good. In Table 7 the payoffs for both countries and their preference order are given.

The first preference of the exporting country is that both countries apply low standards, and its second preference is that both apply high standards. Its third preference is to introduce low standards while the importing country uses high standards; finally, its last preference is applying high standards domestically while the importer uses low standards. The preference order of the importing country differs only with respect to the first and

## *Table 7*
## Heterogeneous Market Shares: Product Standards and Trade Barriers

Assumptions $c > b; h > c - b; d_E \leq \frac{1}{2}; s_E \geq \frac{1}{2}; d_I \geq \frac{1}{2}; s_i \leq \frac{1}{2}; d_E + d_I = 1; s_E + s_I = 1$

| | Strategy Combination | | Benefits | Costs | Harmonization | Payoff | Ordinal |
|---|---|---|---|---|---|---|---|
| *Country E* | H | H | $d_E2b + d_I2b$ | $s_E2c$ | h | $2b - s_E2c + h$ | 3 |
| | H | L | $d_E2b + d_Ib$ | $d_E2c + (s_E - d_E)c$ | 0 | $d_E2b + d_Ib - d_E2c - (s_E - d_E)c$ | 1 |
| | L | H | $d_Eb + d_I2b$ | $d_Ec + (s_E - d_E)2c$ | 0 | $d_Eb + d_I2b - d_Ec - (s_E - d_E)2c$ | 2 |
| | L | L | $d_Eb + d_Ib$ | $s_Ec$ | h | $b - s_Ec + h$ | 4 |
| *Country I* | H | H | $d_I2b + d_E2b$ | $s_I2c$ | 0 | $2b - s_I2c$ | 4 |
| | H | L | $d_I2b + d_Eb$ | $d_I2c$ | 0 | $d_I2b + d_Eb - d_I2c$ | 1 |
| | L | H | $d_Ib + d_E2b$ | $d_Ic$ | 0 | $d_Ib + d_E2b - d_Ic$ | 2 |
| | L | L | $d_Ib + d_Eb$ | $d_Ic$ | 0 | $b - s_Ic$ | 3 |

**Game Matrix**

| | | *Country E* | |
|---|---|---|---|
| | | *High standards* | *Low standards* |
| *Country I* | *High standards* | $\underline{2b - s_I2c, 2b - s_E2c + h}$<br>$\underline{4, 3}$ | $d_I2b + d_Eb - d_I2c,$<br>$d_Eb + d_I2b - d_Ec - (s_E - d_E)2c$<br>1, 2 |
| | *Low standards* | $d_tb + d_E2b - d_Ic,$<br>$d_E2b + d_Ib - d_E2c - (s_E - d_E)c$<br>2, 1 | $\underline{b - s_Ic, b - s_Ec + h}$<br>$\underline{3, 4}$ |

*Table 8*
Results of the Analysis for Heterogeneous Market Shares

| | Product standards | Production standards |
|---|---|---|
| Trade barriers | (1)<br>battle of the sexes<br>'race to the top or bottom' | (4)<br>asymmetric dilemma<br>'no race' |
| Free trade | (2)<br>rambo<br>'no race' | (3)<br>asymmetric dilemma<br>'race to the bottom' |

second preference — the importer likes best the situation in which both countries use high standards, and second-best the situation in which both use low standards.

The game associated with this combination of preference orders is the battle of the sexes (see Scharpf, 1996). It is a game with two Pareto-optimal equilibria. One of the two equilibria must be selected. As each country prefers a different equilibrium, however, there is a risk that the two countries fail to arrive at one of them. Thus, the game combines a distributional and a coordination problem. The countries agree in that they prefer the harmonized strategies (high/high and low/low) to the split strategies (high/low and low/high). They disagree, however, with respect to which of the harmonized strategies will be selected. As a consequence both countries may apply high standards or both may apply low standards. A 'race to the top' is possible but the same is true for a 'race to the bottom'. The countries may even 'miss each other' — either one applying a different standard.

Table 8 gives the results for the four cases introduced above: Product standards lead to a battle of the sexes game if trade barriers are permitted; however, they lead to a rambo game if there is a strict free-trade regime. This implies that the market will be segmented — the exporting country will apply the low standards and the importing country the high ones. No 'races to the top or bottom' will take place. In the case of production standards the game is an asymmetric dilemma, both in a free-trade regime and in a situation where trade barriers can be erected against countries applying low production standards. Asymmetric dilemmas are very similar to prisoner's dilemmas. The difference is that only one country has an incentive to defect. Although the strategic constellation with production standards is an asymmetric dilemma irrespective of the trade regime, the equilibria are different in the two games. In a free-trade regime both countries prefer low standards in the equilibrium and thus we can expect a 'race to the bottom'. In the case of trade barriers the importing country will apply high standards while the exporting country uses low standards and thus we have a segmented market again.

Compared to the situation with heterogeneous preferences it is less likely to achieve a 'race to the top' with heterogeneous market shares. A 'race to the top' seems possible only with product standards and trade barriers. While in the heterogeneous preferences condition we end up with an assurance game where both countries are best off by applying high standards, in the heterogeneous market share condition we end up with a battle of the sexes — there is disagreement between the countries whether to coordinate on high or on low standards. On the other hand, a 'race to the bottom' will appear only in the condition of production standards and free trade. In the remaining two cases (2 and 4 in the table) different standards will be applied in the two countries. This corresponds to the empirical observations that there is no clear trend towards convergence of environmental regulations (Drezner, 2001; van Beers and van der Bergh, 1999).

The variation of some of the properties of the situation — the relation of costs and benefits to the actors, the heterogeneity of preferences and market shares, the trade regime in place and the type of standards — has shown that the strategic situation varies widely. Thus, no simple and generally valid prediction can be made about the consequences of regulatory competition. This is true even under very limited assumptions and on the basis of a very simplified model of reality. In order to have a realistic model the analysis of even more properties of the situation would be necessary. To mention only a few important ones — empirically, both heterogeneous preferences and heterogeneous market shares may be present. In most cases regulatory competition is an *n*-player game. The game has a dynamic nature and some kind of repetition may have to be taken into account, although it is not clear that it would be an infinitely repeated game under all circumstances. The assumptions made here about cost and benefits for 'the countries' also simplify the picture, as there are different groups within a country, for example, the firms subject to the environmental standards, environmental groups and the regulators, each with their own distinct and partly conflicting interests. The game is thus a two-level game (Putnam, 1988) with a complicated structure at the national level. It is not the purpose of this article, however, to give a full account of all contingencies of regulatory competition. Rather it intends to illustrate how strongly such properties of the situation influence the strategic constellation, the outcome of the game and the possibility of institutional reactions.

## 5. *Institutional Response*

The variation between the conditions discussed in this article leads to six different strategic constellations — the pure harmony game, the prisoner's dilemma, the asymmetric dilemma, the assurance game, the battle of the sexes and the rambo game. The strategic constellations pose different social problems, which require different solutions. The six game structures are of a universal nature. They do not necessarily arise only as a result of the conditions varied here; they may also result from completely different attributes of the contexts in which common goods are provided.

In general, pure harmony games result if the costs of provision are higher than benefits on the aggregate level and if benefits are greater than costs on the individual level. As harmony games pose no dilemma between individual and collective rationality, there is no collective action problem to solve. In the context of regulatory competition the harmony game is associated with a 'race to the top'. There is no need for international collective action.

### *Defection Problem*

The prisoner's dilemma is dominated by a problem of defection. The same is true for asymmetric dilemmas. Communication between the players is not sufficient to achieve the socially optimal outcome whereby both players contribute to the common good. Even if they negotiate and come to the conclusion that it would be individually and collectively best to contribute, the incentive to free ride remains. In theory a binding contract and an external actor who is capable of securing compliance is required to solve a single shot prisoner's dilemma.[14] In practice this implies a state solution or a self-governance solution 'in the shadow of hierarchy', where the state threatens to intervene should the self-governance solution not work. In the context of regulatory competition, the prisoner's dilemma structure implies that a common solution for all the countries within the territory affected by the respective environmental problem must be found. The 'race to the bottom' can only be stopped by international negotiations and by establishing political institutions in which a common environmental goal can be found — which is easier in the homogeneous than in the heterogeneous preferences case. The regime that is finally found must include institutions that can secure compliance.

### *Coordination Problem*

The assurance game poses a pure problem of coordination. Communication should be sufficient to ensure that both states coordinate at the Pareto-optimal equilibrium. As this is not only collectively but also individually the best solution, there is no incentive to defect after an arrangement has been made. For the same reason, it should not be difficult to achieve the arrangement. Only consultation is needed. A coordination committee may be a sufficient institution for this. Thus, it is easy to coordinate the standards of several states so that a ‘race to the top’ is achieved. Coordination is substituted for regulatory competition. From the normative perspective, a regime which allows the erection of trade barriers for environmental reasons would be second-best if legal harmonization were not possible, for example, because of a lack of political structures. With respect to product regulation, the result will be harmonization on a voluntary basis.

### *Distributional Problem*

The rambo constellation does not pose a collective action dilemma. The equilibrium is Pareto-optimal and there is no coordination problem, as it is a unique equilibrium. However, the problem with a rambo game is its distributional consequences. While in the first example of a rambo game (heterogeneous preferences) country B gets its first preference, country A gets only its third preference. The negative environmental externalities are forced on country A. In general, this is a very hard problem to solve, as country B has a dominant strategy. In a way, country B’s payoff can be seen as a result of the ‘law of the jungle’. Country A might negotiate for the high standards or for a compromise, but if it does not offer compensation, country B has no reason to accept these. In our example, country A can easily afford compensation payments — for in absolute terms it gains much more from a shift to high standards than country B loses. A solution of this type would be a positive-sum game, and the contract would be self-enforcing as long as country B is better off with this contract than with the rambo outcome.[15] However, the compensation payment must be closely coupled with the introduction of the high standards in country B, otherwise it still has an incentive to defect. The outcome would then be the harmonized solution with high standards. This solution implies a ‘race to the top’ and avoids market segmentation. In the second example of a rambo game (heterogeneous market shares) internal compensation does not seem possible. A negotiated solution is only realistic if there is compensation based on external means.

### *Disagreement Problem*

The battle of the sexes game implies both a coordination aspect and a distributional aspect. The actors agree insofar as both prefer the coordinated strategy combinations. However, they disagree with respect to which of the two coordinated strategy combinations is desirable. This problem can be solved by negotiations, provided the conclusion of enforceable contracts is possible. If the same actors face this strategic structure repeatedly, turn-taking may also be a solution — first, country E's preferred equilibrium is played, next, country I's preferred equilibrium, and so on. As in regulatory competition a repeated situation of this kind (the same countries are often in the same position) is not very realistic, a negotiated solution may be the best way out. However, in a negotiation it will be necessary to compensate the country which does not get its preferred equilibrium. Whether a solution can be found depends therefore on the availability of some kind of compensation.

## 6. *Conclusion*

The approach of this article starts from the assumption that it would be helpful for the analysis of common goods to look more closely at the properties of the goods and of the social situations of their provision and to analyse the consequences of these properties on costs and benefits for the actors. Different cost and benefit structures lead to different strategic constellations, and these, in turn, lead to different opportunities for institutional solutions to the common good provision problem.

This is also the approach taken by Aggarwal and Dupont. The discussion of the article by Aggarwal and Dupont has shown, however, that it is important to carefully analyse which factors determine the strategic structure of the games. It has also been shown that it is possible to draw more specific conclusions for institutional solutions for various types of social dilemmas. On the other hand, it became clear from the example used for illustration of the argument that the analysis of one specific attribute of a good or one property of the social situation will in general not suffice to capture the strategic constellation in a way such that it predicts empirical behaviour.

The exact strategic constellation that determines whether regulatory competition leads to a 'race to the top' or a 'race to the bottom', or to neither one, varies with several factors. It has been shown that the following factors are important — the relation of the costs and benefits caused by environmental regulation, the homogeneity or heterogeneity of the actors' preferences or market shares, the exact object of the regulation — namely products or production processes — and the prevailing trade regime. Other factors have been held constant. Games have been assumed to be one-shot two-player games and not dynamic many-player and multi-level games. All these factors would otherwise also influence the game structure. Additionally there are 'hidden' variables. For example, the contributions to the common good were treated as purely additive. Other aggregation technologies might change the game completely.

Predicting whether regulatory competition in the environmental field leads to a 'race to the top' or to a 'race to the bottom' requires that many variables be taken into consideration. Taking into account the peculiarities of each situation implies that the predictions are necessarily less general than the classical predictions based on the analysis of common goods provision as a prisoner's dilemma. However, this way the predictions might be empirically more valid. Applying this approach to the case of regulatory competition in the environmental field, we have seen that no general 'race to the bottom' can be predicted — thus, it does not come as a surprise that it cannot be observed empirically.

## *Notes*

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1. Kaul, Grunberg and Stern (1999a: 11) present a much more demanding definition of a global public good: 'A pure global public good is marked by universality — that is, it benefits all countries, people and generations.' It does require that all countries value something as a good, not only some countries or a certain region. Moreover, it does require that all social *strata* within each country and also future generations benefit from the good. This concept defines in fact a universal common good.
2. In the asymmetric cases provision is possible in the upper right cells but not in the lower left cells.
3. Since I am going to talk of harmony games, where Aggarwal and Dupont use the term deadlock, I must explain why. Aggarwal and Dupont claim that there are no incentives to cooperate in these games, but I think that the players cooperate very nicely. The public good in these cases is not collectively desirable, as both the individual benefit from the good is lower than its costs ($b_i < c_i$), and the social benefit is lower than the social costs ($b < c$). The good is not 'a public bad' as such, as it has some positive value, but its net benefit is negative. Therefore bilateral non-contribution is a collectively optimal solution. It is the Nash equilibrium, too. Such a game is a pure harmony game — the unique Nash equilibrium is identical with the unique Pareto optimum. The game is perfectly incentive compatible, there is no dilemma here and, thus, no institutional solution is needed. It does not make much sense to talk about 'deadlock' in such a case. That the term has been used for games of this type is presumably a result of its use to model the arms race (Downs, Rocke and Siverson, 1986: 122). Here the term deadlock is justified as a description if the empirical situation modelled

is looked at from the outside (normative) perspective. Still, the interests of the players are in perfect harmony (see also Zürn, 1992: 159).

4. There is one deviation in the middle game which is a result of the idea that the actor contributing unilaterally pays the full costs, whereas the costs are shared in case of bilateral provision. If this assumption is abandoned, the middle game is chicken as well. The actual common good and the circumstances of provision determine whether the assumption of cost sharing is plausible. It is not plausible in general. For example, as we are playing a game of imperfect information, it might be that in cases of bilateral provision of an indivisible good, which costs a fixed amount of resources, both pay this amount. As a consequence the resources of one of the players would be wasted.
5. For an analysis of rambo games see Section 4.
6. A rambo game is a 2 × 2 game with a unique and Pareto-optimal equilibrium where the equilibrium outcome is ranked differently by the two players. In rambo games either one or both players have a dominant strategy. Rambo games are similar to what has been labelled ‘suasion game’ in the literature. According to Lisa Martin (1993: 104), ‘suasion problems have equilibrium outcomes that leave one actor dissatisfied’. In the suasion game Martin provides, only one actor has a dominant strategy to cooperate. If this is a crucial characteristic of suasion games, suasion games are a subclass of rambo games. Both groups of games share the characteristic of leaving one actor dissatisfied.
7. If I assumed the harmonization advantage to be smaller than the net differential benefit between levels of standards it would have no substantial effects on the strategic constellation.
8. If h is very small ($h < b_i - c$) the game will become a rambo game.
9. It should be noted that in this model free trade is a *condition* that influences the provision of the environmental common good by the concerned states; it is not the good itself. In a very interesting article Conybeare (1984) has made two points with respect to free trade. First, free trade is a good for the nations but does not usually possess characteristics of publicness. Second, free trade may pose a prisoner’s dilemma for the nations but it does not necessarily do so. In an approach very similar to the one pursued here, he showed that many contextual factors may change the strategic structure of the game. For example, if countries differ in size the game is an assurance (stag hunt) game rather than a prisoner’s dilemma (pp. 14f.).
10. If the competition effect is small ($e < b_i - c$), the game changes once again to the original rambo game.
11. In practice there might be environmentally friendly buyers in both countries. The more there are in the whole market the less is the industry of the country applying the strict standards (A) disadvantaged. We can assume, however, that there are significantly more environmentally friendly buyers in country A, as their presence is surely part of the background for the country’s high preference for strict standards.
12. Here I shall leave aside the consideration that in political practice the poor country may react to the embargo by erecting a similar barrier.

13. Empirically, there will be export and import on both sides in most markets, as the products are usually not fully homogeneous. This need not be taken into account in the model, however.
14. In an infinitely repeated prisoner's dilemma cooperation is possible without sanctions or external actors; however, mutual defection also remains possible.
15. For the pros and cons of compensation solutions see, for example, Raiffa, 1985 or Holzinger, 1997.

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