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# Rules for the Global Environment

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**Abstract:** The paper looks at the global environment as a public good and as a sink for $CO_2$-emissions. It discusses problems to be solved in institutional arrangements to protect global environmental media and looks at criteria for allocating the costs of emission reduction and emission rights. It analyzes institutional mechanisms that stabilize $CO_2$-agreements and reviews the Kyoto Protocol, the perspectives for its successor and EU emission trading. The paper also reviews arrangements for biodiversity and existing multilateral arrangements.

**Keywords:** Public good, Global warming, Emission reduction, Emission rights, Institutional Mechanisms, Kyoto Protocol, Post-Bali negotiations, EU emission trading, fauna and flora, existing multilateral arrangements

**JEL classification:** D62, F 02, H41, Q 02, Q54

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# Rules for the Global Environment

Horst Siebert

Whereas a rich institutional experience exists for the international trade order including factor markets, an international rule system for the global environment has not yet developed. In this domain, we have a problem quite different from the international division of labor. In trade, all countries can benefit individually from accepting rules. Each of them enjoys gains from trade. A country like China can expect that its benefit from trade will grow over time together with its internal development; with world economic growth, an individual country's gains will grow as well. Trade lifts all boats. The environment, however, is a different story. Take global warming. Each country incurs costs to prevent carbon dioxide ($CO_2$) emissions. Yet the benefits of an improved global atmosphere are diffuse and not noticeable for an individual country, except in specific cases, for instance for countries close to or even below sea level. Moreover, countries can behave as a free rider. In comparing the rule systems for these two areas, we can see how difficult it is to develop an institutional arrangement for the global environment.

National rules for using the environment and nature have attracted interest in the past fifty years. The rising awareness of environmental disruption, especially in Europe and there most pronouncedly in Germany, commencing in the early 1970s, has given prominence to institutional arrangements for the use of environmental media. In addition, the two oil crises of the 1970s and the stark rise of the oil price since 2005 have generated attention to the property rights of natural resources. Last not least, the discussion of the greenhouse effect in the natural sciences has shed light on the environmental degradation.

## *Private versus public goods*

With respect to international rules for the environment, the decisive questions are whether the goods or resources are private or public and whether they are national or global.

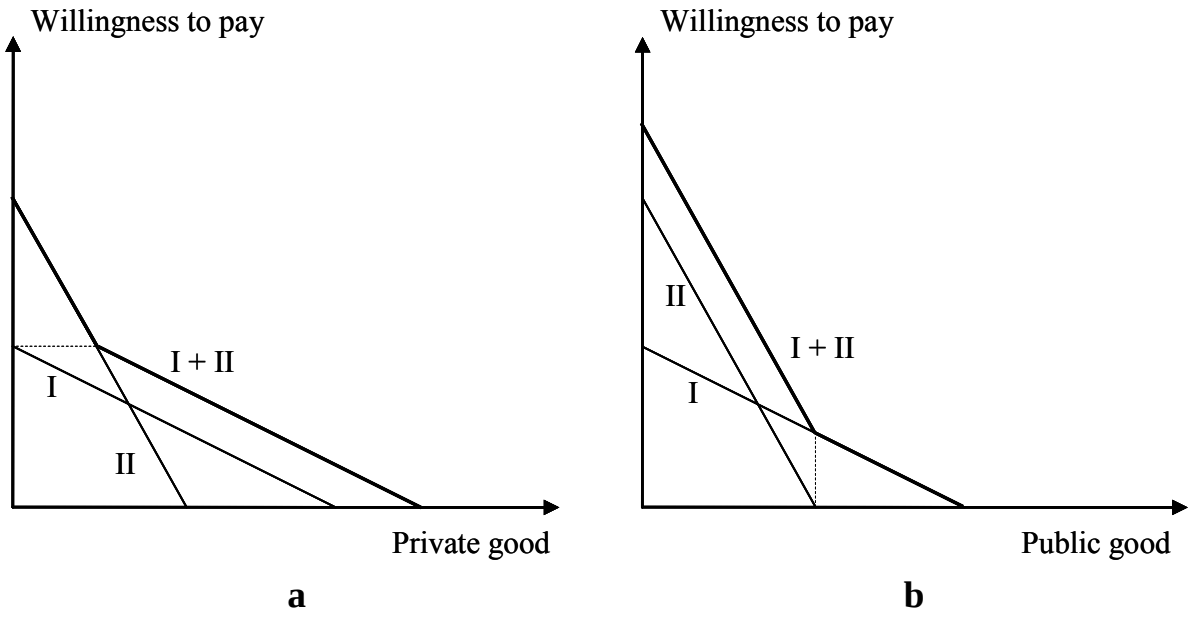
Private goods are characterized by the fact that rivalry in consumption prevails and that the exclusion principle applies. The pair of shoes I use is no longer available for you. Consequently property rights can be defined for this type of goods. It is usual that these property rights are defined nationally. Typical examples are natural resources such as

minerals and crude oil being extracted from deposits in the ground. The fact that national private property rights exist for such resources does, of course, not mean that these property rights do not have international implications. As a matter of fact, the nature of property rights impacts on the international division of labor. The relevant example is the shift of property rights for oil in the 1960s.

Private goods may be scarce goods, but there are other categories of goods: There may be no demand for a good (as for the sand in the Sahara desert) and thus it does not command a price. This good then is a free good. Or property rights are not yet defined for a good so that it is a free access good or a common property good as the commons in the Middle Ages. Moreover, property rights may not be adequately defined because the good generates externalities or it has characteristics of a public good.
In contrast to private goods, public goods must be consumed in equal amounts by all; the exclusion principle does not apply. Typical examples are internal and external security, the lighthouse that can be used by all the fishermen of a region or environmental quality, for instance air quality.

To explain the difference between private and public goods, we use the demand curves for the two goods representing the willingness to pay. Let us consider two countries I and II. In Figure 1a, the willingness to pay for a private good is determined by aggregating the demand curves I and II horizontally. The resulting total demand curve I + II then is the horizontally aggregated demand curve for a private good of both countries. Now consider the public good "environmental quality". Since the public good must be consumed in equal amounts by all, the curves I and II indicating the willingness to pay of the two countries for the global environment are aggregated vertically (Figure 1b). Note that country I's willingness to pay for environmental quality differs from that of country II. The aggregated curves I + II denote the aggregated willingness to pay for the public good.

**Figure 1**: Aggregation of willingness to pay for private and public goods




## *Environmental quality - public good with private properties*

For the economist, the environment is indeed a scarce resource, but it is different from a pair of shoes that China exports to the US in order to get computer software in exchange. The environment has two different functions: Take the global atmosphere of the planet earth. It provides the air we breathe and produces the climate we enjoy. The air we breathe is different from a pair of shoes, which is used by only one person. The climate is consumed in equal amounts by all; it is a public good. However, the global atmosphere has a second function besides representing a public good. It receives $CO_2$ –emissions and other greenhouse gases, originating from heating homes or driving cars, and in this capacity, it is a receptacle of wastes. In this role, the environment is a private good. We can limit the discharge into it, for instance for a specific polluter. This means we can define property rights for using the environment as a receptacle of waste and these property rights are rivalrous. The environment is thus characterized by two different functions, and these two functions compete with each other. Note that public good does not mean that the good is provided by the government.

**Table 1**: Characteristic of goods, resources and property rights

| | | Type of property right | |
|---|---|---|---|
| Type of good or resource | | National | Global |
| | Private | 1: Private goods/resources with national property rights | 3 : Private goods with international property rights |
| | Public | 2 : National environmental media | 4 : Global environmental media |

The analysis so far has shown that a good or a resource may be private or public in nature. As an additional characteristic, the property rights for goods can be defined nationally or globally (Table 1). The definition of property rights depends on the spatial dimension of the good. This results in the following classification of goods. In a first category, many goods, such as a pair of shoes are private goods and the exclusion principle applies (Box 1 in Table 1). Then property rights are national. We do not have a need for global rules of private goods. The subsidiarity principle requires that institutional rules for private goods are national or possibly even subnational. In a second category, public goods having a national dimension in space have nationally defined property rights such as national river systems (Box 2 in Table 1). In some cases of private goods, a third category is needed, for instance international property rights in the case of patents or software (Box 3). In a fourth category, public goods have a global dimension; they then require global property rights, including some coordination between national property rights (Box 4). Border crossing externalities are close to this category.

*Global aspects of environmental use.* In order to structure our analysis, we distinguish global environmental media with a spatial dimension extending to the earth as a whole, border crossing environmental media and national environmental media.

*Global environmental media.* Global environmental goods, i.e. public goods with a worldwide spatial dimension such as the earth's atmosphere, require an agreement of all countries as to what amount and what quality of these public goods should be supplied. How much of a public good we want to have cannot be determined by decentralized market decisions; there then would be an under-provision of the public good. Instead, the optimal provision must be determined by the aggregation of the countries' preferences in a bargaining solution. Institutional arrangements are needed for the process of establishing the desired quantity of the public good, i.e. for aggregating national preferences. Putting it differently, an

international agreement is needed on to which extent a deterioration in the quality of the public good is acceptable, for instance how much global warming we want to tolerate. Agreement is also needed on how the costs of the desired quality of the public good are allocated to individual countries and how free rider behavior can be prevented. Any solution represents *de facto* an international allocation of emission rights. Once these issues are solved, the market mechanism can be used to allocate the scarce resource to the different users.

*Border-crossing environmental media.* When the spatial dimension of the environment extends to two or more states, pollutants are transported from one country to the other, for instance through river systems or through atmospheric conditions. Examples are acid rain in Europe and the transport of potash from the mines in the Alsace, France, through the river Rhine affecting drinking water quality in downstream Netherlands. In such cases, negotiations have to lead to abatement activities in the upstream country. Often, the victim-pays principle is used, i.e. the pollutee offers a bribe to the polluter to induce a more environment-friendly behavior. If countries have joint interest in other policy areas, as is the case in the European Union, it is easier to find a solution that prevents free rider behavior.

*The environment as a national endowment.* If the environment is an immobile national endowment factor, the different environmental scarcities of countries can be expressed by different prices of environmental services. This is relevant when the absorptive and regenerative capacities of national environments vary, when a high population density makes it more difficult to spatially separate residential and recreational areas from environmentally degrading transport and production activities and when the preferences of countries for environmental quality differ. Signaling different national environmental scarcities by different national prices does not require an international rule system; the pricing can be left to national policies. A market economy approach to environmental policy which taxes emissions nationally or establishes prices for environmental services through national emission licenses is consistent with an institutional framework for the international division of labor. The more successful the environment is integrated into the scarcity prices of individual countries, i.e. the more successful welfare can be defined by also taking into consideration the environment, the better environmental policy can be incorporated into the international trade order.
If prices for national environmental use are not (or cannot be) applied and other measures such as administrative approaches, emission norms or product standards are employed by countries in order to protect their citizens' health and life and to conserve natural resources

(Article XX of the GATT Treaty), those measures must be non-discriminatory. Non-discrimination requires that in the case of market entry restrictions, regulations through production permits, facility permits and product norms must not give preference to domestic producers and domestic goods. Thus it should not be permissible, for example, with the aim of reducing health hazards, as in the Thailand cigarette case (1990), to restrict the import of goods or to tax them unless the same measures are simultaneously applied to like domestic goods. However, it is permissible to use policy instruments to protect the environment (see the Shrimp-Turtle case).

## *Problems to be solved in institutional arrangements to protect global environmental media*

A whole set of problems have to be resolved in setting up an international rule system to protect global environmental media. It is, indeed, a complex matter to reach an international consensus on the allocation of global environmental media. √

*How to determine the goal to be obtained.* A major issue is to find an agreement on to which extent deterioration in the quality of the global public good is acceptable, for instance how much global warming should be tolerated. Countries contribute different volumes of greenhouse gases to global emissions; they have undertaken dissimilar efforts to avoid emissions in the past; they apply production processes with diverging emission intensities; they have transportation systems that are unalike in generating different volumes of emissions; the cost functions for the abatement of emissions differ from country to country; in the view of the countries, marginal cost of abatement include different target losses; countries have different preferences with respect to environmental protection; they are in different stages of development; they have different per capita incomes and thus have a different willingness to pay; they may be affected differently by improving the global environment, for instance countries at low sea level will be harmed more by a rise in the sea level; and some countries have large resource deposits whose use is crucial for their economic development, witness China as a country with large coal reserves. Under these conditions, it is difficult to reach an agreement on the target to be obtained.

*Least cost environmental protection.* As soon as an agreement on the tolerable level of global warming or the necessary volume of emission reduction is reached, it is required that the

target is arrived at with the lowest opportunity costs in terms of resources used. This means that the target has to be attained in an efficient way. If not, resources would be wasted. This means that preventing global warming can be achieved with lower costs. The theoretical approach is to determine the marginal global benefit of abatement (in terms of global damage prevented) and the marginal global cost of abatement. Both marginal benefit and marginal costs require an aggregation of the benefits and costs of all countries.

In a simple static two-country model, an efficient solution can be found if countries jointly maximize their aggregated benefit instead of maximizing their individual benefits. Let $B_1$ and $B_2$ denote the benefit of the two countries, let $R_1$ and $R_2$ represent resources used to reduce emissions in the two countries, with R standing for the resources of both countries, and let $C_1$ and $C_2$ indicate abatement costs in the two countries. Then we have the joint maximization problem:

Max $U = B_1(R) + B_2(R) - C_1(R_1) - C_2(R_2)$

s.t. $(R_1)+(R_2) - R = 0$

Maximizing the Lagrangean function

$L = B_1(R) + B_2(R) - C_1(R_1) - C_2(R_2) + \lambda [(R_1) + (R_2) - R]$

yields

$$\frac{\partial L}{\partial R} = B'_1 + B'_2 - \lambda = 0$$

$$\frac{\partial L}{\partial R_1} = -C'_1 + \lambda = 0$$

$$\frac{\partial L}{\partial R_2} = -C'_2 + \lambda = 0 .$$

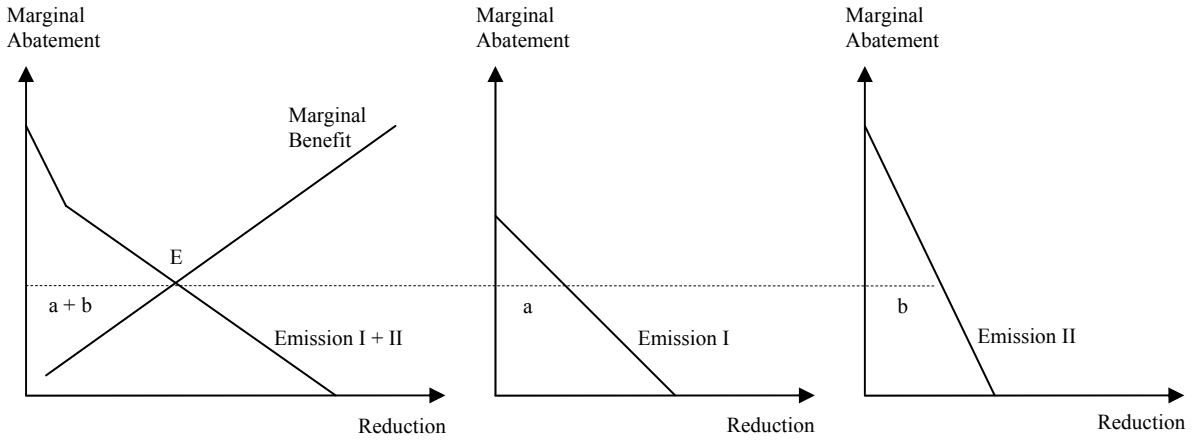
Consequently, we have as a result

$$B'_1 + B'_2 = C'_1 = C'_2 .$$

The condition requires that the marginal benefits of both countries are aggregated and the aggregated marginal benefit is equal to the marginal reduction costs in both countries (which

must be equal.) This implies that both countries together obtain the maximum amount of benefits and that abatement occurs where it is most efficient. An alternative to aggregating benefits is to rely on scientists and to accept their evaluation on the necessary emission reduction. Once the solution is determined, the world market can play to determine the price for emissions. Such a price per unit of $CO_2$-emission ensures that emissions are avoided or reduced at the most efficient spot in the world. This condition is portrayed in figure 2 where figure 2a describes aggregated marginal benefit and aggregated marginal abatement cost in the two countries, with point E as the equilibrium point. The two other figures represent emission abatement costs in the individual countries I and II. Note that the emission abatement costs are aggregated horizontally, i. e. the distance a (from Figure 2b) plus the distance b (from Figure 2c) yields a + b (in Figure 2a). In contrast, the marginal benefit curve has been aggregated vertically (see Figure 1).

**Figure 2:** Efficient emission reduction




This approach describes the solution that has to be obtained. In order to implement such a solution agreement is needed on many crucial factors: the scientific model explaining the link between $CO_2$-emissions and global warming; the total number of $CO_2$-emissions that are tolerated as an indicator for the goal of reducing the likehood of global warming; the actual initial level of $CO_2$-emissions; a base year or base period; the current and future contribution of the countries to the total number of emissions; the time available to implement the solution; the time-path of global emission reduction, for instance by a certain percentage per year;

alternatively, the time available to reduce the given stock of pollutants; the policy instruments that can be used to get to the desired situation; and the allocation of emission reduction obligations to the different countries, which is equivalent to how the emission rights are allocated to countries if a cap and trade approach is used. When all these questions are answered in the spirit of the efficiency approach, marginal benefit of emission reduction (in terms of global warming prevented per unit of $CO_2$-emission) and marginal costs of abatement are identical. Then it is possible to use prices for $CO_2$-emissions to stimulate prevention and abatement and to steer production, investment and consumption.

Unfortunately, this approach of the economist to aggregate the benefits and costs does not find political support even though it shows the way to use the environment with a minimum of global economic costs or, as one can also put it, at a minimum of environmental losses. The economist's solution requires that countries consider the use of the environment as an allocation problem where environmental scarcity is the crucial guide to the solution. It implies that in a long-run equilibrium a developing country uses the same amount of resources per unit of $CO_2$-emission abatement as a developed country. All countries pay the same price for using the global environment as a receptacle of $CO_2$-emissions. In this capacity, the environment is treated like energy, for instance oil, for which developing countries pay the same price per unit.

## *Criteria for allocating the costs of reduction and emission rights*

In a short-hand version, this approach is also labelled the cap and trade approach, in which a cap is established for the total volume of emissions and where emission rights can be traded. It is crucial how the total quantity of emissions is allocated to the emission obligations of individual countries. This means to decide on the distribution of emission rights for countries. These emission rights determine future costs of abatement, the development potential of a country, especially the development potential from its own resource deposits. Emission rights can be interpreted as representing rents which decide on the income distribution between countries.

A case in point is China which possesses huge coal reserves that are a factor determining its development potential in the future. The time profile of emission rights influences its

economic growth, representing opportunity costs in terms of lower growth rates. It is therefore a major question how a country such as China can be incentivized to join an international arrangement.

According to the historical approach, the given level of emissions of a specific date or reference period is used as a starting point from which emission reductions for individual countries are defined. This version of the cap and trade approach starts from the premise that all countries have the same right to use the atmosphere as a receptacle of emissions. It respects the sovereignty of nation states and applies a similar practice that has been used in the extension of territorial waters and economic zones in coastal waters. It is similar to claim staking with respect to the property of land as experienced when man settled new territories. It can be interpreted as an expression of *Realpolitik.* When agreement on the total quantity of emissions has been reached, in a given situation a price per unit of emissions will evolve. This price reflects environmental scarcity in the actual situation. It corresponds to the polluter pays principle when only the flow of emissions, for instance per year, is taken into consideration.

This method can easily be used if all countries have similar economic conditions. Diverging previous successful efforts of countries to reduce emissions can be accommodated in this approach. This has been applied in the EU's emission trading arrangement. The approach is, however, unlikely to be implemented on a global scale because developing countries, latecomers in the use of the environment due to their economic development, feel disadvantaged.

Another version of the historical approach consists in looking at accumulated emissions of a country, i.e. at the stock of pollutants, instead of annual emission flows. After all, the industrialized countries have created the existing actual stock of pollutants, for instance the carbon stock, in the environmental system. The stock of pollutants is calculated as accumulated emissions over time, minus the normal diminution of pollutants in the natural system, i.e. it relates to the net anthropogenic increase of the stock of pollutants. This approach corresponds to the polluter pays principle with respect to the accumulated stock of pollutants, appealing to the responsibility of countries for the global environment. Accordingly, the countries responsible for the largest accumulated pollutants would have to

pay the highest price. Industrial countries would therefore bear the largest burden of emission reduction.

Whereas these approaches are very much influenced by interpreting the use of global media as an allocation problem, the capability to pay approach addresses the issue of global environmental use from the point of view of income distribution. Then countries with a higher income per capita carry a larger burden. Traditionally, the capability to pay criterion is used to justify progressive income taxation within a nation state. Consequently, this principle is at the heart of national sovereignty, requiring a democratic legitimacy of national governments ("no taxation without representation"). Under these conditions, the government of a high-income country, while being democratically legitimized to negotiate the burden of that specific country, does not have an unlimited authority to apply the "capability to pay approach" internationally and to cede sovereignty accordingly. Even in the European Union where a sizable part of sovereignty has shifted to the European level, the power to tax remains with the nation state. Accordingly, the preparedness to apply a taxation-underpinned capability to pay approach is limited internationally. This does not mean that some type of income transfer or technology diffusion cannot be agreed upon as is the case for instance in international aid.

Another proposal is that emission rights are allocated per head of the population. The motivation for this egalitarian approach is to consider the endowment of the earth with a given climate as an entitlement for mankind. It is considered to be a global public good. From this statement one can come to the conclusion that the capacity to absorb $CO_2$-emissions is also an entitlement for mankind. Then, each country would receive emissions rights according to the size of its population, and population-rich countries as China, India and countries in Africa would have an excess supply of emission rights which they could sell to the developed world. Such an allocation of emission rights per head of the population represents an immense transfer of rents in favor of the developing countries and to the disadvantage of developed countries. Its effect is comparable to the shift of property rights for crude oil in the 1970s.

The problem with this approach is the dual nature of the environment. Whereas the world's atmosphere represents a global good, this property does not refer to the capacity to absorb $CO_2$-emissions since this aspect can be organized as a private good and since markets have already been introduced in the last forty years in the industrial countries to signal environmental scarcity. Therefore, the world is not in a position as if it introduced property

rights as a completely new institutional arrangement for an issue that will only become relevant in the future. Consequently, it can be argued that the new institutional arrangement has to be developed starting from the given situation. Along these lines, the world's absorptive capacity of $CO_2$ would be interpreted as an input to production processes, i.e. as a factor of production, and to human activity in general, such as housing and transportation. A possible criterion then is $CO_2$-emissions per unit of GDP. Admittedly, this argument is very much in line with the given economic and political realities. Moreover, care must be taken that a new global institutional arrangement does not reduce the incentives to avoid and reduce emissions. This can indeed happen if the developing countries have an excess supply of emission rights. This can lead them not to be diligent in preventing $CO_2$-emissions.

*New technology.* In light of the difficulties in reaching an agreement, new abatement technology and technology transfer appear to have to play a major role. An example is the search for technologies for $CO_2$ capture and storage. Another important issue is to reduce the dependency on fossil fuels. Apparently, new technology would increase the willingness of countries to accept emission reduction as an important goal and to enter a new global institutional arrangement to prevent climate change. However, under the Alternative Policy Scenario of the International Energy Agency (2006) all currently installed and planned capture and storage capacity will only be able to save up to 0.2 percent of coal-fired power generation emissions in 2015. A problem is that companies will only invest in research and development if they believe in the increasing demand for solutions for reducing $CO_2$-emissions or substitutes with lower $CO_2$-emissions. In order to avoid risky research and development costs, industry might even discourage government from reducing $CO_2$-emissions.

*A global uniform emission tax.* An alternative to the cap and trade approach with the allocation of emission rights is to use a uniform carbon tax, i.e. a tax per unit of $CO_2$ (Nordhaus 2006). Such a tax would generate tax income for the states and therefore might be acceptable more easily than emission rights. However, it would be extremely difficult to agree on a uniform world wide emission tax. Besides, a uniform emission tax does not guarantee $CO_2$ reductions as it does not constrain the volume of emissions. In a long run global solution, all countries would have to pay the same tax per unit of $CO_2$. Consequently, a tax also influences the distribution of reduction costs and rents. In order to entice the developing countries to join such a system, side payments would be needed. Countries would have to

cede their sovereignty of taxation to a multilateral arrangement. This might be more difficult to do than joining a cap and trade system. In principle, it is possible to find a uniform global tax under static conditions with identical situations in all countries such that the tax corresponds to the results of a cap and trade approach. This, however, would only hold under very specific conditions. Thus, the equivalence no longer applies when economic conditions are different in countries and when they change over time (Petersohn and Klepper 2007).

*Phasing in the introduction of new emission entitlements.* Global warming due to androgenic causes can be seen as a relatively new phenomenon in the earth's history. Consequently, it is unrealistic that an abrupt solution can be implemented. The introduction of new property rights for $CO_2$ emissions is more acceptable if it is phased in. However, according to scientists the world does not have too much time for such a gradual adjustment. Moreover, the accumulation of a carbon stock in the earth's system has long-lasting effects; similarly a reduction of $CO_2$-emissions takes time.

As an additional issue, the coming decades will experience an enormous geographical shift in industrial production and an increase in the developing countries' share of global emissions to more than 50 percent by 2030. In order to include these countries into a global emission reduction scheme, a redistribution of costs and benefits of emission reductions will play an important role. In the contraction and convergence proposal of the Global Commons Institute (1996) all countries have to agree on a safe level of greenhouse gases, for instance not more than 450 parts per million by volume (ppmv) by 2100, and on a convergence date when per capita emissions of all countries converge to a common level, for instance 2050 or 2100. This approach leads to welfare redistribution from industrialized countries to developing countries, particularly to China, India and Sub-Saharan Africa (Peterson and Klepper 2007).

The multi-stage approach, which was first developed by Gupta (1998) and adapted by Den Elzen (2002), includes a gradual increase in the number of countries that are part of binding agreements to reduce $CO_2$ emissions. More specifically, countries with diverse economic and environmental contexts are clustered into different groups with diverse levels and types of emission reduction commitments. In the first stage, countries do not have any commitments for $CO_2$ emissions reduction. In the second stage, countries have to limit emissions and in the third stage they have to absolutely reduce emissions. The countries agree on mechanisms for the transition from one stage to the next. For the participation in stages two and three, Den

Elzen uses an index of capability, measured in real GDP per capita, and responsibility, measured in the level of emissions per capita.

## *Institutional failure*

Two major issues have to be recognized with respect to environmental treatisies, free rider behavior and reneging on a contract.

*The free rider problem.* After an agreement has been reached, the issue arises whether and to what extent such an agreement will be upheld. Countries only have an indirect benefit from an improved world climate, except in special circumstances, for instance for countries at low sea level. Much depends on whether the country is prepared to impute its indirect net national benefit from the global improvement. Although countries can improve their indirect benefit relative to the non-cooperative solution, a country may be tempted to behave as a free rider, i.e., enjoying the benefits of a better global environmental quality without carrying the costs for it by simply disregarding the agreement. Countries have different economic and environmental conditions with respect to their stage of development and they have different preferences vis-à-vis environmental degradation, diverging willingness to pay and different attitudes and commitments to multilateral approaches. Consequently, countries might be tempted to play the game of enjoying the public good without carrying the cost for it. Then the countries are characterized by non-cooperative behavior and they have difficulty to find a cooperative solution similarly as in a prisoner's dilemma that we know from international trade. Only when the free rider is not essential for the solution or if a coalition of countries is willing to prepare the road for a solution in the future, as in the Kyoto Protocol without the US, can a solution be implemented. One may take some consolation from the experience, that quite often a country may not want to be stigmatized as an environmental polluter in an environment where other states care about the world's heritage. In terms of reputation, most probably a country does not like to be called the "dirty man of the world".

*Reneging on a contract.* Another issue is that a country may walk away from an international agreement later on. An important condition to prevent countries from reneging on an international environmental contract is that they have a net benefit from the arrangement. Unlike in international trade where the benefits are likely to increase over time with the

expansion of trade and world growth, this condition is difficult to be satisfied in the case of environmental protection. Again, we can look at China's huge coal reserves (see above). Assume constellations are such that energy becomes a limiting factor in China's growth. Then it becomes tempting to walk away from the contract if the coal deposits cannot be used. Apparently, the contract must have sufficient incentives to prevent such an outcome.

A positive case is that the instrument used, for instance in reducing $CO_2$-emissions, allows the country to also improve its national environment. Again we can take China as an example where reaching the national goal of a better air quality contributes to helping the world climate. Another case is side payments (see below). In all other instances, the benefits accrue to the world and the costs are borne by the country. The country not only has solely an indirect benefit from an improved world climate. In addition, this benefit is unlikely to increase in time. Prevention costs tend to rise progressively with the quantity abated, assuming a given technology; it becomes more costly to prevent $CO_2$-emissions. It is therefore unlikely to satisfy the condition that a country enjoys increasing benefits as is the case in international trade, unless a country conceives the reduced risk of climate change as an improved benefit. Nevertheless some conditions can be established. One is that prevention should be phased in so that impact of costs is felt less with an increase in economic development. Another is that the allocation of costs does not shift asymmetrically between countries over time, turning to the disfavor of a country.

## *Institutional mechanisms stabilizing a $CO_2$-agreement*

A set of institutional mechanisms can help to find and stabilize rules for the global environment. A review of these institutional mechanisms shows how different they are compared to procedures already established in the WTO.

*Commitment.* An important prerequisite for multilateral arrangements is that countries commit themselves to the international contract (see Chapter III). Commitment is especially important in treaties in which, unlike the WTO, countries do not have direct and increasing benefits but where cost sharing is an essential aspect of providing a public good such as preventing global warming (Barrett 2005). Commitments can encompass a duty to contribute to financing an

agreement in order to make side payments possible, to emission reduction obligations and to rules that recognize emission reductions in other countries if undertaken by domestic firms.

*Reputation.* Free-rider behavior may be reduced if the agreement can be interpreted as a repeated game played over many periods. Then, a free rider will balance the benefit that he can reap from free riding in a specific period against potential costs that he will incur from the behavior of the other players in the future. Reputation matters and this may induce a potential free rider to adhere to the agreement. Reputation is especially relevant, if not only one layer of interdependencies exists (such as global environmental media) but other interdependencies are present as well. Then other fields may offer compensations against free-rider behavior in pollutants.

*Mutual affection.* Another reason why agreements to cooperate are kept is that people care about the others affected by the agreement. Dasgupta (2002) calls this "mutual affection" – a phenomenon we know from a family. A similar idea is expressed by Sen (1987) where an action can be understood to be "… better for the respective goals of all of us." My concept of a utility function, including argument variables in other countries, contains a similar idea.

*Self enforcing contracts*. In contrast to a national setting, where sanctions exist, sanctions are usually lacking internationally and international agreements can seldom be enforced or cannot be enforced at all. As a solution the idea of a self-enforcing contract has been developed (Barrett 1994a, b; 2005). According to this approach, the incentive structure of a multilateral arrangement must be such that it is in the interest of a country to behave as every country would like it to behave. Following Barrett (2005, p. 196) an equilibrium is self-enforcing if "no signatory can gain by withdrawing unilaterally from the IEA [international environmental agreement, added by author] and no non-signatory can gain by acceding to it, given the terms of the treaty and the participation decisions of other countries."

One approach is that countries agree to sanctions and bind themselves in this way in an international contract. For instance they create credible sanctions for the members of the group for the case that a member deviates. Barrett (1992) discusses a mechanism by which countries link their abatement activity to the other countries. If a country reduces its

abatement activity, not sticking to the agreement any more, other countries lower their emission reduction as well, thus inflicting damage on the deviating country. However this form of sanction does not make too much sense, taking into account the environmental goal. Chandler and Tulkens (1997) describe an agreement in which, if one or more countries deviate from the agreement, the other signatories discontinue the agreement (Barrett 2005, p. 213). This threat is thought to prevent deviating behavior. However, this may well be a destabilizing strategy from an environmental point of view.

Instead of such a negative mechanism of linking policy instruments in a destabilizing way, a positive mechanism can be introduced: A country will abate more if another country abates more. Or reducing emissions by a certain percentage when a new country joins an agreement represents a positive externality making a coalition attractive. Also, countries may agree on a minimum participation level. This may make it more attractive for countries to join the agreement. Furthermore, countries may agree on a fine system so that the polluter who deviates from agreed upon standards must pay a fine. The countries joining the agreement may commit themselves by an initial lump sum investment in the project similar to a club entrance fee. If they walk away from the club, they lose the initial lump sum payment. Alternatively, the funds provided can be used to finance side payments as an incentive to abate. All this should help in preventing the potential free rider from taking the free-rider position. Such commitments have some similarity to the commitment in the form of bound tariffs. They are self enforcing if it conceived as fair. Apparently, the more demanding an agreement is, the fewer willing participants it will find. A whole array of proposals to stabilize international environmental institutional arrangements can be found in Heister (1997).

*Changing the rules of the game.* A situation in which countries find themselves in a prisoners' dilemma can be transformed into a game with a different equilibrium if a different treaty is written, i.e. when the properties of the game are changed. Thus, the principal task of a treaty is to change the incentive structure for the participants: "…by changing the rules of the game – by writing a treaty that specifies how each signatory should behave, conditional on the number of signatories – the equilibrium of the underlying dilemma game can be transformed." (Barrett 2005, p.205)

*Conditions to sustain a treaty*. Several conditions make a treaty more likely: common preferences of the members, for instance a similar esteem of the environment, increasing benefits for members or reducing costs over time, flexibility in the rules if new scientific evidence arises, supporting mechanisms such as compliance and participation enforcement, a low number of participants with the advantage of depth of the arrangement, but admittedly at the costs of broadness of the approach (see below) and a commons problem that is limited in space, for instance affecting only some countries.

*Strategic choices.* Several aspects of a treaty represent a strategic choice affecting the incentive structure of the treaty (Barrett 2005, p. 355-357). These include side payments, the choice of instruments by which a treaty tries to change behavior, the linkage of instruments, the minimum participation level and the depth of the agreement (see below).

*Depth versus breadth of arrangements.* A trade-off exists between the depth and the breadth of an institutional arrangement. Different outcomes are conceivable. A deep and narrow treaty attempts to reach ambitious goals. Such an approach may be successful in reaching an ambitious goal and it usually includes specific instruments to be applied. However, deepness (goal achievement and intensity of instruments) comes at the cost of broadness (participation). If succesful, such an approach may attract other participants over time. But it may also prove to be interpreted as an exclusive and elitist club which in turn reduces its attractiveness; the exclusive character may perpetuate and the deep treaty may end up in not succeeding to extend to a larger group. A broad but shallow treaty has the advantage of large participation, but the goals to be reached are not high-powered and the instruments to be applied are far from intense. Broad but shallow agreements may make it easier for countries to join since the costs of joining are low. The treaty may succeed to become deeper over time changing its objectives and intensifying the instruments to be used. However, in both scenarios it is conceivable that the treaties remain stuck in their initial concepts with a rather specific path dependency.

*Coalitions.* In contrast to a wide multilateral agreement with many states, countries with a special interest in environmental problems may form a coalition. Then the issue arises whether an agreement can be made attractive for potential members, who are still outside, i. e. whether each potential member enjoys a benefit if he joins. Alternatively, the question is

under which conditions a country may develop an interest in joining. Under ideal conditions eventually a small coalition may extend to a comprehensive international agreement. An example is the Montreal Protocol, originally starting out with 26 members and now extending to 181. An example from a completely different field is the European Union which over fifty years succeeded in attracting new members. A major question in this context is whether the abatement level should be chosen subject to the number of signatories and to what extent the abatement level of the coalition can increase over time.

Thus, conditions can exist which make it interesting for a potential member to opt into the agreement instead of remaining outside (Heal 1992). Several reasons can be put forward: First, consider the case where abatement functions are characterized by fixed costs. If a country reduces pollutants unilaterally, it is likely that the costs of abatement are larger than the benefit for this country, unless the country is very large and fixed costs are less of a problem. Thus, a country may be able to reduce the role of its fixed costs, if it joins the club. Second, other complementarities between the abatement functions, i.e., positive externalities, also are an incentive to become part of a group. Positive spillovers may exist for instance through technology transfer where the technology of the coalition is offered to the newcomer. Especially, if no hegemon exists, countries of more or less equal size may form a coalition in order to exploit complementarities. Third, the interdependencies of countries may prevail in other fields as well influencing the reputation in the long run. Fourth, countries may introduce a mechanism which effectively creates a sanction. Heal (1992) defines a minimum critical coalition as the smallest coalition with the property that all members will gain from an abatement agreement. Without side payments, indirect benefits must at least be equal to costs for each country taken separately. With side payments, indirect benefits plus side payments must be equal to costs.

*Management Associations.* Even though completely local, the Water Associations in the Ruhr Area, the first one being established in the first decade of 19$^{th}$ century (Kneese and Bower 1968; Siebert 2008), contain mechanisms that possibly can be used in international treaties. The water associations of the Ruhr area (Ruhr, Emscher, Lippe, Wupper, Niers, Erft, Left Lower Rhine, and Ruhr Water Dam Association) represent organizations in which membership is mandatory for every polluter. The general assembly of the association determines the water quality to be attained. When the required environmental-quality level is specified, the association can determine the amount of capital equipment and investment to be

put in place and the operating costs it has to spend to attain these standards. Thus, the total costs of abatement are specified. The problem then consists of allocating these costs to the individual polluters. Costs are attributed in such a way that the costs to the individual polluter are related to his quantity (and quality) of pollution. This creates an incentive to abate pollutants. The water associations can be interpreted as an institutional arrangements for cost sharing in which a quality target is transformed into individual behavior through a mechanism which share the costs of reaching the targets and simultaneously develops an incentive system.

There are some interesting institutional features of the water associations. Voting rights vary with the volume of effluent charges paid and consequently with the volume of pollution produced; thus, the largest polluter has the greatest number of votes. In spite of this rule, analysis shows that the decisions of the associations seem to have been reasonable. Klevorick and Kramer (1973) have researched this problem and have shown that most environmental concerns have been taken care of by the associations. One reason for this success is that institutional safeguards have been introduced. For instance, in the Niers Association, the downstream polluters receive 75 votes before the remaining 225 votes are distributed according to the paid effluent charges. In the Lippe Association, coal mines cannot have more than 40 percent of the votes. Moreover, municipalities – also present in the associations – were interested in the quality of drinking water. Admittedly, this approach was local, but similar concepts can be used in multilateral solutions.

*Compliance*. A precondition for the effectiveness of international treaties is compliance. This requires commitment, for instance due to some homogeneity of preferences. Arbitration and dispute settlement mechanisms are helpful. In contrast to rules for trade, enforcement of environmental treaties is difficult since they deal with a public good (Yang 2006). An important aspect therefore is the transformation of identity and interest.

*Sanctions.* Unlike in other international institutional arrangements such as the WTO, sanctions in the international environmental area are not yet very developed. One reason is that in the last fifty years, introducing environmental scarcity into institutional arrangements has first of all been a concern of national policy. Another aspect is that the US, as the hegemon of the post War era, had no interest in international environmental matters.

Environmental sanctions therefore have to rely on international law, for instance on countermeasures that are allowed by international law such as retorsions, i.e. unfriendly acts, but being lawful (Yang 2006). Where environmental treaties exist, treaty-based individual or collective sanctions can be applied, including reciprocal action and reprisals and even membership sanction.

*Credibility of sanctions*. Threats must be credible. If a threat, for instance the threat of a sanction, is not backed by facts, such a threat is not likely to influence the behavior of other countries. This is also the case if a threat is simply infeasible in the eyes of agents or if it hurts the nation announcing the threat. A threat is also hard to believe if it contradicts a pattern of behavior in the past and if a political economy analysis reveals that the threat is unlikely to be implemented. Experience with threats is sketchy; unilateral US sanctions with respect to whaling against Japan and Norway have been ineffective (Yang 2006, p. 7). Economic embargos often have been ineffective (Hufbauer, Schott and Elliott 1990).

*The Kyoto Protocol and its possible successor*

In the context of the United Nation's Framework Convention on Climate Change, the Kyoto Protocol - basically a cap and trade system - came into force in February 2005, after it was ratified by Russia in 2004. As of January 2008, the Kyoto Protocol has been ratified by 176 countries plus the European Union, accounting for 61.6 percent of 1990 $CO_2$-emissions. The US, which was responsible for 17.4 per cent of global 1990 carbon dioxide emissions, has not ratified the Protocol; it withdrew from it in 2001. In getting the Kyoto process started, a particular procedure was chosen to set the Protocol into force. It was considered as being ratified if at least 55 countries, responsible for at least 55 per cent of 1990 $CO_2$-emissions of the industrialized countries, the Annex I countries, had ratified the Protocol.

The total global volume of $CO_2$ emissions amounted to 28 billion tons in 2004 (Table 2). The US accounted for 21.6 percent, the European Union (EU-27) for 15.3 percent, the OECD countries for 49.1 percent and China for 18.2 percent. The issue is how these emissions can be reduced.

**Table 2**: World $CO_2$- emissions in million tons, 2004 [a, b]

| | Emissions | In percent |
|---|---|---|
| EU-27 | 4,237 | 15.3 |
| France | 417 | 1.5 |
| Germany | 886 | 3.2 |
| Italy | 490 | 1.8 |
| UK | 562 | 2.0 |
| | | |
| Australia | 382 | 1.4 |
| Canada | 593 | 2.1 |
| Japan | 1,286 | 4.6 |
| Russia | 1,618 | 5.9 |
| S. Korea | 466 | 1.7 |
| US | 5,987 | 21.6 |
| | | |
| Brazil | 332 | 1.2 |
| China (incl. Hong Kong) | 5,050 | 18.2 |
| India | 1,343 | 4.9 |
| Asia [c] | 1,343 | 8.1 |
| | | |
| Mexico | 438 | 1.6 |
| S. Africa | 437 | 1.6 |
| Others | 5,538 | 20.0 |
| | | |
| World | 27,667 | 100 |

[a] Excluding Taiwan. [b] For non-Annex I countries data are from estimates of $CO_2$ emissions made by the Carbon Dioxide Information Analysis Center (CDIAC). – [c] Ex China, Japan, India, South Korea and Russia.

Source: United Nations Statistics Division, Millennium Development Goals Indicator database 2007.

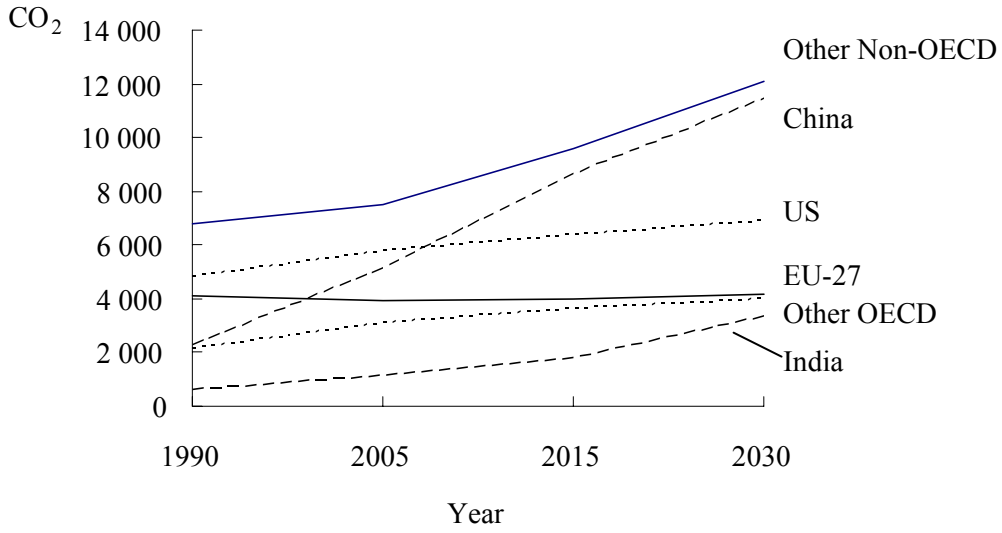
The reference scenario of the International Energy Agency (2007) indicates that China, whose emission of greenhouse gases surpassed those of the US in 2006, will be the largest emitter of $CO_2$ in 2030 with 11.5 billion tons, more than the US with 6.9 billion tons and the EU-27 with 4.2 billion tons. Note that "Other OECD" is slightly understated since it was calculated by subtracting the $CO_2$-emissions of the US and the EU-27 from the total OECD emissions. Note that some smaller countries such as the Baltic States, though part of the EU-25, were not part of the OECD at the time of the IEA report in 2007.

**Table 3**: IEA Reference Scenario, in million tons of $CO_2$-emissions

| | 1990 | 2005 | 2015 | 2030 |
|---|---|---|---|---|
| US | 4832 | 5789 | 6392 | 6891 |
| EU-27 | 4084 | 3944 | 4011 | 4176 |
| China | 2244 | 5101 | 8632 | 11448 |
| India | 587 | 1147 | 1804 | 3314 |
| Other OECD[1] | 2137 | 3105 | 3651 | 4000 |
| Other Non-OECD | 6804 | 7534 | 9581 | 12076 |

Source: International Energy Agency (2007).

**Figure 3**: Reference scenario for $CO_2$-emssions, 1990- 2030




Source: International Energy Agency (2007)

The Kyoto Protocol lies out legally binding limits on greenhouse gas emissions in industrialized countries, the Annex I countries. It takes 1990 emissions as a starting point. The "commitment period" for the reductions is between 2008 and 2012, allowing for fluctuations to be averaged out. Commitments are 5.2 per cent on average for industrialized countries relative to their 1990 $CO_2$-emissions. They vary between countries, with minus 12.5 per cent for instance for the United Kingdom and minus 8 per cent for the European Union. As of 2007, the signatories have not succeeded to reach their committed targets. For 2010, the European Environment Agency (2007, Figure 4.4) estimates that the EU-15 will meet its Kyoto targets if member states make use of carbon sinks and implement additional measures quickly and fully. The EU-15 is projected to reduce greenhouse gas emissions by 4.0 percent

instead of 8 percent compared to 1990.) China, India and Brazil have approved the Kyoto Protocol, but they are non-Annex I countries.

The Kyoto approach contains several flexible mechanisms. According to the Joint Implementation Mechanism, emissions can be traded among Annex I countries. Countries that reduce more emissions than agreed upon can sell the emissions credits to other countries. Emission reductions can also be banked. The Clean Development Mechanism applies to projects in developing countries that have no targets under the Kyoto Protocol. Firms in the developed countries can treat abatement activities in developing countries as if they were undertaken in the developed countries; possibly this may apply only for a certain percentage of abatement. The reasoning is that since the earth's atmosphere is a global environmental medium, specific emissions reduction sites are inconsequential. It is also hoped that joint implementation will encourage the transfer of environmentally sound technology to developing countries. In the Kyoto framework, non-compliance is administered by a 20-member Compliance Committee. A critical point is which sanctions will be sufficient to change behavior (Yang 2006, p. 40).

The first stage of the Kyoto Protocol including the reduction commitments expires in 2012; subsequent arrangements are being discussed. Negotiations will take place in the Climate Change Dialogue among the G8 plus 5 (United States, United Kingdom Canada, France, Germany, Italy, Japan, Russia as the G8 plus Brazil, China, India, Mexico and South Africa as the "5") in 2009. An agreement for such negotiations to take place was reached in Washington in 2007. The participants acknowledged the effects of greenhouse gas emissions on climate change and the responsibility of both developed and developing countries to reduce these emissions. It is intended to establish a global carbon market for $CO_2$ emissions. In Bali, representatives of 180 countries, including the USA, agreed on the Bali Roadmap, also in 2007, to complete negotiations for a post-Kyoto treaty until 2009 in order to have sufficient time to ratify and implement the treaty before the Kyoto commitment period ends in 2012.

Meanwhile, the US has launched a counter agreement to the Kyoto Protocol in 2006, the "Asia-Pacific Partnership on Clean Development and Climate", including Australia, China, India, Japan, South Korea and the United States, of which only Australia, Canada and Japan have legal obligations under the Kyoto Protocol. The member countries account for around 50

percent of the world's greenhouse gas emissions. The US does not want to commit itself to Kyoto, since it claims scientific ambiguity about climate change and expects strains on its economy, given that its main future rival, China, does not participate. The American idea is to have a looser institutional arrangement does not include a mandatory enforcement mechanism. Emission reduction targets are set individually for the member countries. The intent to reduce greenhouse gases is described in general terms, i.e. to develop, deploy and transfer existing and emerging clean technology, meet increased energy needs and explore ways to reduce greenhouse gases without hurting the economies and seek ways to engage the private sector. Such a voluntary approach should not be ruled out right away. We have seen examples of "highly motivated partnerships" (Schelling 2002) such as NATO where burden-sharing was a central and crucial mechanism. This presupposes that the major countries of the world agree on the goal of reducing greenhouse gas emissions. In such an approach, technology transfers and income transfers to developing countries to introduce emission preventing technologies would have to play a large role.

At this stage, it is difficult to see which solution will come out of the Post-Bali negotiations. A baseline below which countries are unlikely to go back is that all Annex I countries of the Kyoto Protocol will continue to avid and abate emissions, in a similar agreement as the Kyoto Protocol. Most likely this group of countries will intensify its efforts to reduce $CO_2$ emissions. Unfortunately, this alone would not represent a major progress. A much better solution consists in a rule system in which all the signatories of the Kyoto Protocol and all OECD countries, including the US, agree to reduce emissions relative to a base year. The new US administration most likely is open to such a solution, independently of party affiliation. However, for a new agreement to be successful, it is necessary to make major emerging countries such as Brazil, India and China part of the agreement, with commitments accepted to reduce emissions. Such commitments could be phased in for these countries, for instance with increasing emission reductions over time, let us say over two decades. They would be instrumental in improving air quality, for instance in China, and thus would be in the countries' own interest. A major issue in such an arrangement consists in determining the relative emission reduction obligations of emerging countries. For instance, emission reduction could be specified in terms of $CO_2$-emissions per unit of GDP. For 2005, the coefficients are 0.2904 kilo $CO_2$ per $1 GDP of the EU-27, 0.4662 kilo per $1 GDP of the US and 2.2830 kilos per $ 1 GDP of China. Apparently, the US could produce less $CO_2$ per unit of GDP if it would use European technology. China could improve its situation if it would

apply US technology. Such a method allows applying a best practice approach for the long-run solution. In this approach, the phasing in could take a longer time period for emerging countries, say fifty years. Incentives for technology transfer such as the Development Mechanism should play a major role.

## *EU Emission Trading*

The most significant efforts toward implementing the Kyoto Protocol have taken place in Europe. The EU has committed itself to an overall reduction of 8 per cent of 1990 emissions; this goal was ratified in May 2002 by the EU and all its member states. Additionally, the ten new member countries which have joined the EU in 2004 have all ratified the Protocol and have their own reduction targets between 6 and 8 per cent. In 2007, the EU has set a 20 percent target of reducing $CO_2$ emissions by 2020. It has offered a reduction of 30 percent if other countries would go along in spite of the fact that the EU has not reached its own targets.

Emission trading in the EU began in 2005 between member states, each of which has established a national allocation plan. In its first phase 2005 to 2007, the system covered only $CO_2$- emissions and initially included only certain industries: power, oil refining, cement production, iron and steel manufacture, glass, ceramics, paper and pulp. The second period 2008-2012 will address all greenhouse gases but it is yet not settled whether aviation emissions will be covered. In 2008 all relevant installations must be included (EU Commission web site (European Commission 2007). Emissions trading will use one ton $CO_2$ as the allowance currency, and fines per excess unit will be 40 euro until 2007 and 100 euro thereafter. It is estimated that between 12,000 and 15,000 installations will be covered by the emissions trading system.

The initial distribution of allowances, as envisioned in the national allocation plans, is one of the most significant determinants of the effects of emissions trading. The European Commission left it to the member states to allocate their emission rights to the different domestic sources and has offered three different approaches to allocate the rights: the historic approach with emissions of a base year, the forecasting approach and the least cost approach. In the historical emissions model, companies were given permits at a rate matching their

current emissions. The forecasting approach was similar, but corrected for expectations about which sectors will grow or contract in the economy. The least cost approach attempted to equalize abatement costs both within the emissions trading sectors (which will happen in any event) and abatement costs in other sectors, and consequently allocated fewer permits to the trading sectors. It was heavily debated, for instance in Germany, how past reduction efforts were to be integrated into this scheme and how the total amount of emissions of these sources related (and still relates) to other emission sources. The new EU member countries not only have lower abatement costs than Western Europe but also are in many cases already below their Kyoto targets, due to the economic restructuring following the collapse of Communist system. This enables them to sell excess permits. Progressively tightening caps are foreseen for each new period, forcing overall reductions in emissions.

With 764 million tons of $CO_2$ trade in the first three quarters of 2006, EU emission trading represented about 75 percent of the global carbon market in terms of volume traded (Table 4). Carbon exchanges have developed in different locations, for instance EEX in Germany, APX in the United Kingdom, Powernet in France and CXX in Chicago. Some of these exchanges also trade futures. Moreover, voluntary pools have emerged (e.g. North Pool for Scandinavia). The starting price per unit allowance was at about ten euro and it broke through the 30 euro benchmark in April 2006 but then dropped down to a below one euro. The reason was an excess supply of allowances from national allocation plans. Another reason was that the allowance expired at the end of 2007 and new permits were required for the next phase. In 2007, futures for 2008 demanded a higher price. In November 2007, the average future price for a 2008 European Emission Allowance (EUA) was 22.62 euro at the European Energy Exchange (EEX). In principle, one can rate the EU emission trading as successful.

**Table 4**: World Carbon Market 2006 [a]

| | Volume [b] | Value [c] |
|---|---|---|
| Allowances | | |
| EU Emission Trading Scheme | 763.9 | 18.8 |
| New South Wales Greenhouse Gas Abatement Scheme | 16.2 | 0.2 |
| Chicago Climate Exchange | 8.25 | 0.03 |
| UK Emissions Trading Scheme | 2.3 | 0.01 |
| Sub total | 790.65 | 19.04 |
| Project-based transactions | | |
| Clean Development Mechanism | 214.3 | 2.3 |
| Joint Implementation | 11.9 | 0.09 |
| Other compliance | 7.9 | 0.06 |
| Sub total | 234.1 | 2.45 |
| Total | 1,024.75 | 21.49 |

[a] First three quarters. - [b] In million tons. - [c] In billion US$.

Source: International Emissions Trading Association (IETA) (2006).

## *Multilateral arrangements to protect fauna and flora*

Biodiversity is the richness of species, of animals and plants in the ecosystem. It is a good or a resource with strong positive externalities: it enhances the productivity of the ecosystem; it represents insurance, for instance by having a pool of plants being resistant to a virus. It is a source of genetic knowledge and of "keystone species", crucial in defining the property of complex ecosystems and ecoservices. A case in point is the equatorial rain forest in Brazil and other countries having a positive value in absorbing $CO_2$, producing oxygen and allowing biodiversity. The valuation of biodiversity varies with the different functions assigned to it. Other more specific, but related value categories may be distinguished, such as genetic diversity and species diversity, natural area and landscape diversity, ecosystem functions and the existence value (Nunes and van den Bergh 2001). Conversely, cutting down the rain forest would reduce these values of having biodiversity. It would reduce the option value or existence value (Heal 2000; Deke 2007) and represent a negative externality to other countries (Barbier and Burgess 2001). Biodiversity loss has been measured through species extinctions and proxies such as loss of habitat. In recent years, environmental analysts have measured significant declines in biodiversity. According to the World Wildlife Foundation (2002), global biodiversity has decreased by one-third since 1970.

For some of the uses of biodiversity, private property rights can be established, for instance for the role of biodiversity to enhance the productivity of natural systems such as agricultural land. The price for a unit of land then would implicitly contain the value of the ecosystem that exists on this piece of land. Another example related to land (or water) are bioprospecting rights. In these cases, the competing use of land can be made explicit and the willingness to pay can be expressed by markets. New intellectual property rights are another recent development, for instance crop developers patenting genes or pharmaceutical firms patenting natural substances for biomedicine. Such rights establish incentives to preserve certain plants if they provide the necessary input a marketable product.

However, at a given moment of time, not all potential applications of genes and substances can be known. Thus, property rights and markets cannot be established for all potential future uses. There is simply no actual demand for some of these ecoservices. Consequently, biodiversity cannot be preserved by markets alone. An alternative approach becomes necessary. The task is to determine the option value or existence value for ecosystems and then to find institutional approaches to preserve them. A possible avenue is to define an ecosystem that is to be preserved in the hope that this system contains a sufficient number of species that may be of value in the future. This can be achieved through a policy of spatial separation. Countries that have such ecosystems as rain forests may be induce d to preserve them by international compensation. Similarly, as side payments are required in a solution to reduce transfrontier pollution, one can argue for side payments to the countries with a rain forest to encourage them not to destroy the rain forest. For the bargaining, however, one difference with the case of transfrontier pollution must be stressed. It might very well be that it is in the long-run interest of the rain forest country to maintain the forest for its own advantages including tourism in the future and that the country has not been aware of its own interests.

A major issue is monitoring and enforcement. An international agreement on the protection of the rain forest can be interpreted as a principal-agent problem where the international community is the principal and the rain forest country is the agent. It is difficult for the international community to monitor whether the rain forest country plays by the rules agreed upon, for instance when it receives transfers in order to protect the rain forest.

International agreements to save specific species such as the whale represent another approach. To date, there have been two major international agreements that attempt to deal with biodiversity loss, though both regulate the issue as a legal matter without recourse to economic instruments. The first is the Convention on International Trade in Endangered Species of Flora and Fauna (CITES), which was signed in 1973 and entered into force in 1975. CITES was conceived as an international agreement to prevent the over-exploitation of species, and 172 nations are signatory to it. It classifies species in three categories, allowing export permits for two types and regulating completely the trade in the most endangered type (Finus 2003). So far, no species listed on CITES has become extinct. The second treaty, the United Nations International Treaty on Plant Genetic Resources for Food and Agriculture, has entered into force on June 29, 2004. The Treaty institutes a multilateral system of facilitated access and benefit-sharing for the crops and forages most important for food security. Scientists, international research centers and plant breeders from public and private organizations benefit from enhanced access to genetic biodiversity. The multilateral system also ensures the fair sharing of benefits derived from the use of genetic resources, in particular for farmers in developing countries that have for centuries contributed to the conservation of genetic resources.

### *Existing multilateral Arrangements*

Table 5 summarizes the most important international environmental conventions in the fields of the atmosphere, biodiversity, hazardous wastes and regional seas. It indicates the date of final agreement, the date that the convention went into force, the number of members and the UN Secretariat in charge. 17 conventions exist extending to 140 countries which share common bodies of water and the associated environmental problems. For a more detailed list of conventions see Barrett (2005).

**Table 5**: Selected core multilateral environmental agreements

| Agreement type and name | Date of final agreement | Date of entry into force | Members | Secretariat |
|---|---|---|---|---|
| **Atmosphere Conventions:** | | | | |
| United Nations Framework Convention on Climate Change (UNFCCC) | 05/1992 | 03/1994 | 192 | UN |
| Kyoto Protocol to the United Nations Framework Convention on Climate Change | 12/1997 | 02/2005 | 176 | UN |
| Vienna Convention for the Protection of the Ozone Layer | 03/1985 | 09/1988 | 191 | UNEP |
| Montreal Protocol on Substances that Deplete the Ozone Layer | 09/1987 | 01/1989 | 191 | UNEP |
| Convention on Long-Range Transboundary Pollution | 11/1979 | 03/1983 | | UNECE |
| **Biodiversity-related Conventions:** | | | | |
| United Nations International Treaty on Plant Genetic Resources for Food and Agriculture | 2004<br>11/2001 | 06/2004 | 169 | UN |
| Convention on Biological Diversity | 06/1992 | 12/1993 | 190 | UNEP |
| Cartagena Protocol on Biosafety to the Convention on Biological Diversity | 01/2000 | 09/2003 | 143 | UNEP |
| Convention on International Trade in Endangered Species(CITES) | 1973<br>03/1973 | 07/1975 | 172 | UNEP |
| **Chemicals and Hazardous Wastes Conventions:** | | | | |
| Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal | | 05/1992 | 170 | UNEP |
| **Regional Seas Conventions and Related Agreements (Examples):** | | | | |
| The Convention for Cooperation in the Protection and Sustainable Development of the Marine and Coastal Environment of the Northeast Pacific (Antigua Convention) | 2002 | | 5 | UNEP |
| Convention on the Conservation and Management of Fishery Resources in the South-East Atlantic Ocean, | 04/2001 | 04/2003 | 4 | UNEP |
| Global Programme of Action for the Protection of the Marine Environment from Land-based Activities | 11/1995 | | 109 | UNEP |
| Convention for the Protection of the Mediterranean Sea against Pollution (Barcelona) | 02/1976 | 02/1978 | 22 | UNEP |

Source: UN Environment Programme (2007)

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