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by

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1. Introduction

At least since the Earth Summit in Rio, global environmental problems are on the international policy agenda. The main problems which obviously require international policy coordination are the risks of global warming, the loss of biological diversity and the destruction of the ozone shelter. Although all these problems call for different actions to cope with, they are closely interconnected. For example, the burning or clearing of tropical forests does not only add to greenhouse gas accumulation which is responsible for the risks of global warming. Additionally, tropical forests host an unknown reserve of genetic codes the size of which is assumed to depend on the diversity of species.

As an answer to all the challenges associated with managing global environmental problems, ecologists have demanded that any resource use should be sustainable. The concept of sustainability has, therefore, become a keyword in international and national environmental policies. It seems that this keyword has entered almost every environmental policy objective by now. However, concrete definitions as to which resource use is sustainable and which one is not are hard to find. Hence, one may suspect that sustainability is often used as a catchword without any concrete definition in mind, hence old wine in a new bottle.

In this paper, we will discuss some of the rather rare concrete definitions of sustainability which have entered at least the academic discussion. We will focus on the international aspects of sustainability policies because we feel that the repercussions of international trade have not yet received enough attention. Neglecting international repercussions may be appropriate for problems which are local in the sense that they affect only local markets and local environmental problems. In a lot of cases, however, markets as well as environmental resource uses are embedded in an international setting which makes international repercussions likely.

This paper is organised as follows. Section 2 gives a classification for environmental problems which may call for a sustainability concept. Section 3 introduces into the relevant parts of standard international trade theory in order to be able to evaluate the impact of international trade repercussions. Section 4 discusses the role of resource mobility for sustainability policies. Section 5 evaluates the need for and the problems with international policy coordination. Section 6 concludes this paper by some policy implications.

2. A classification of potential environmental problems

Before going into some details of international trade issues, it is worthwhile to structure the potential problems under consideration. Table 1 gives a classification of possible factors which shape the environmental problems.

Table 1: A classification of possible factors

Concept of Sustainability	resource-based capital- and resource-based
Type of exhaustible resource	non-renewable renewable
Resource Use	solely as a production factor solely as a consumption good both as a production factor and a consumption good
Type of Country	small country large country
Factor Mobility	only intersectorally mobile intersectorally and internationally mobile
Factor Endowment	given for all periods determined by investments
Market structure	perfect competition imperfect competition
International coordination	unilateral introduction international introduction

The first entry of Table 1 classifies two different *concepts of sustainability*. A resource-based concept of sustainability considers only a single resource by requiring that its stock should remain constant, or at least, that its reproductive capacity should not be destroyed by harvesting so much of the resource that it can not reproduce itself. Therefore, this concept does not allow to balance resource extractions through other beneficial economic activities which are not strictly connected with the resource under consideration. For example, a resource-based concept for a sustainable forest management in a region does not allow to compensate forest clearing by improving regional water quality. A resource-based concept is also called a concept of *strong sustainability*. A capital- and resource-based concept allows these compensations in general and employs a certain rule which specifies which kind and which degree of investment may compensate for resource extractions. Two rules of this concept will be discussed in detail below. A capital and resource-based concept is also called a concept of *weak sustainability*.

The selection of the concept is not only a matter of taste or an indicator for the stringency of environmental policies but depends also on the *type of the resource*. Typically, environmental resources are in principle exhaustible because they cannot be reproduced after extinction. Exhaustible resources may either renew themselves (if they are not extincted completely) or regeneration is impossible. Capital and resource-based concepts may be applied to both renewable and non-renewable resources. When resource use is essential, however, resource-based concepts make sense only for renewable resources. An essential use is given if the economy cannot produce or consume without strictly positive resource extractions. If the resource is not renewable, fixing the stock means prohibiting resource use, and prohibiting resource use meant prohibiting production in general. The exploitation of fossil fuels is an example. Hence, we find that resource-based concepts may apply in the relevant cases only to renewable resources.

In order to determine the environmental problem, one must determine the *resource use* in detail. Resources may be used as production factors and/or consumption goods. Environmental problems arise if at least one resource use exists which is not marketable because this resource use defines a public good or a public bad. In this case, private resource use implies a positive or negative externality which is not taken into account by the decisions over the marketable resource use. Hence, resource uses differ from a private and a global perspective and make policy intervention necessary. For example, clearing a forest is beneficial for timber producers and timber consumers but may not take into account the benefits of biological diversity which are supposed to be substantial when forests are not cleared.

We are now able to give an example for a resource-based sustainability policy for a renewable resource. Suppose that a resource (e.g. a forest) is a private good and serves for production of a resource (e.g. timber). The regeneration of the stock depends on the stock size, and resource producers do not take a positive externality of holding a large stock into account. A stylised example is given in Figure 1.

Figure 1: Steady state stock and sustainability constraint for a renewable resource

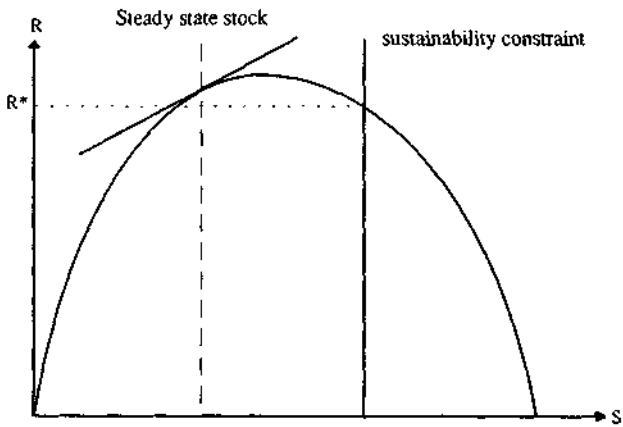

Figure 1 mirrors a simple regeneration function which has an interior maximum yield. When the stock of the resource is completely exploited, no regeneration is possible such that this resource is exhaustible as well. From the economic theory of renewable resource uses, it is well-known that unregulated resource exploitation leads to a steady state stock which equalises the marginal regeneration rate (see the depicted slope) and the interest rate. When there are positive externalities the size of which depends on the stock, the steady-state stock is too low from a social perspective. Hence, resource-based sustainability policies may set a sustainability constraint which regulates resource use such that the stock does never fall short of this limit. In Figure 1, this constraint specifies a limit which lies in the range of a negative marginal regeneration, a stock which would never be hold by private users voluntarily. Figure 1 shows that

regulated resource users are still able to exploit the resource as they may extract R* in every period.

Capital- and resource-based rules must be applied on essential, non-renewable resources. They require that resource extractions should be compensated by investment. There are two rules which specify different investment levels:

Table 2: Two different rules for weak sustainability

Rule (a) Hartwick Rule	**Invest your resource rent.** net investment = resource price × resource use
Rule (b) Rule of constant wealth	**Keep the value of the sum of all stocks constant.** capital price × net investment = resource price × resource use

The first rule is called the Hartwick Rule (Hartwick, 1977, 1978). The second rule ensures that the value of all stocks is not decreasing. It should be emphasized that these rules have different motivations. Hartwick's Rule originates from searching for the necessary investment level in a closed economy which would guarantee constant consumption for all future generations in an economy with a non-renewable resource. The second rule which we call a rule of constant wealth essentially consists of an intergenerational welfare judgement demanding that every generation should be endowed with the same total stock of natural and man-made resources. As there are in principle many stocks which determine the total stock, they must be weighted by their respective prices. We will take these rules as they stand and will not discuss their appropriateness. These rules are - to our knowledge - the only rules for weak sustainability which can be identified and formulated in a formal economic model.

When turning to the international dimension of sustainability policies, additional aspects need to be taken into consideration. The *type of a country* which engages in international trade determines the country's influence on the world market. According to the usual terminology, a country is called small if any change in this country can not influence world market prices. A country is called large if her policies affect world market prices. These effects may then no longer be neglected because environmental

policies in one country will have repercussions on the use of resources in the rest of the world.

When the resource serves as a production factor, different assumption can be made with respect to *factor mobility*. In standard models, factors are assumed to be intersectorally but not internationally mobile. This feature holds for some resources as well. For example, water use is almost exclusively concentrated on domestic industries since water is almost never exported. However, international immobility may be no longer an appropriate assumption for other resources such as fossil fuels. A large share of fossil fuels like crude oil is not used in their country of production. In this case, one should treat resources as an internationally mobile factor.

One of the important factors in determining the pattern of international trade consists of the different relative *factor endowments* of countries. The notion of factor endowments includes not only land, labour, and capital, but natural and environmental resources as well since they also serve as inputs in production processes. It is therefore clear that sustainability policies will have an impact on resource endowments and these endowments will in turn influence the international division of labour. Two forces are at work in this case. First, sustainability usually requires a reduction in the use of resources, and secondly, it requires substitution of natural resources by man-made resources such as physical or human capital. These issues are discussed in the next two sections.

The world oil market as well as other markets for natural resources make evident how important *market structure* is for the allocation of resources. Substantial differences in the pricing of resources exist depending on the degree of competition in such markets. Consequently, policy interventions in such markets may produce quite different reactions of the participants.

Finally, the question whether sustainability policies should be subject to *international coordination* plays an important role in formulating the policy objectives within the political process. Unilateral policies in an open economy result in two different effects. First, a sustainability policy will change the price and cost structure within that economy and thus will affect the competitiveness of particular sectors. In our case, it is likely that industries which use environmentally intensive technologies will tend to loose competitiveness. This will change trade patterns and it will lower the income of industry-specific factors with obvious political repercussions. The second impact concerns environmental and natural resources which are inherently international such as the ozone layer, some water resources, fish stocks, and specific issues in biodiversity. In these cases, unilateral action is in general inefficient such that only international coordination can lead to an optimal pattern of policy intervention.

3. International Trade and Sustainability

The international division of labour constitutes an integral part of today's economic activities. The flow of goods between countries is influenced by factors such as comparative cost advantages e.g. due to different technologies or different factor endowments or due to different tastes. One of the fundamental differences between countries consists of the different composition of factors of production. Whereas traditionally attention was mainly paid to the endowment with land, labour, and capital as the determinants of the wealth of a nation, it is now clear that the environment, both as a source of raw materials and as a receptor of wastes generated in the course of economic activities, needs to be considered as an indispensable factor of production as well. The notion of sustainability takes account of this fact in an intertemporal setting by stressing the need for an economical use of the resource "environment". Of course, sustainability policies will then also have repercussions on international trade.

One of the basic results of the theory of international trade says that a country specializes in the production of those goods which use that factor of production most intensively with which the country is relatively well endowed. An extreme example can be found in Arabian countries being endowed with huge oil reserves compared to other factors such as labour, land, or capital. Sustainability policies aim at restricting the exploitation of the environment either for maintaining a constant stock of a renewable resource or for saving non-renewable resources for future generations. Therefore, such policies will restrict the availability of one factor of production, namely the environment, and thus changes the factor endowment of the country. This will then influence the comparative advantage of certain sectors of the economy with the result that the export and import structure of the economy changes.

Even in a simple trade model things become complicated quite quickly. The environment in its different forms can be either used as a factor of production inside the country endowed with that resource or it can be moved across borders and be used as a factor of production abroad. Both possibilities have different results as long as sustainability policies are not coordinated across countries.[1] We first discuss the case of environmental resources which are not tradable between countries, i.e. only goods which contain environmental resources as factors of production can be traded.

Sustainability policies commonly amount to a reduction in the availability and use of environmental resources over time. This is often supplemented - especially in the case of non-renewable resources - by a deliberate increase in the stock on man-made capital

[1] At least for local environmental resources which impose no transfrontier pollution problems there is no need to coordinate sustainability policies.

in order to compensate future generations for the irreversible loss in that resource stock and in order to maintain a desirable stream of consumption over time. The reduction in the supply of environmental resources as a factor of production will reduce the total amount of goods which can be produced - this loss is of course compensated by an increase in environmental quality - and it will change the trade structure of that country.

A typical industrial country being well-endowed with man-made and human capital but comparatively poor in environmental and natural resources which moves towards a sustainable resource use will tend to produce less of those goods which use the environment most intensively. Since demand has not changed, this reduction in domestic output of the environment-intensive commodity will be compensated by increased imports of that commodity. In turn, it will produce more of the capital-intensive commodity, mainly for financing the increased imports through exports. As a consequence, the sustainability policy will reduce the domestic use of the environment but this is partly or fully compensated by the import of goods which contain foreign environmental resources as factors of production. Thus, the unilateral sustainability policy leads to an indirect import of sustainability.

If the country is large enough to influence world market prices through its policies the price of the environment-intensive good will rise. This is equivalent to a terms-of-trade loss of this typical industrial country. Therefore, the sustainability policy will be accompanied by welfare losses from the international division of labour. The opposite, of course, happens in the foreign countries which possess a comparative advantage in the production of the environment-intensive commodities. They will experience terms-of-trade gains through higher world market prices of their export good (Klepper 1994). But this comes at the danger of a deterioration of environmental quality within these countries.

The weak sustainability version is mainly concerned with environmental resources which are nonrenewable or which exhibit regeneration rates so low that the resource use at a constant stock is not possible. In such cases it is advocated that the decrease in the environmental stock should be compensated by increases in other stocks, namely the physical and human capital stock (Pearce, Atkinson 1993). Such a policy of weak sustainability presupposes that capital and the environment can be substituted in the production of commodities. This policy of capital accumulation has repercussions on the international division of labour as well.

Sustainability induced investment in the man-made capital stock beyond the investment which is determined by the autonomous decisions of investors will also change the relative endowment of the country relative to its trading partners abroad. Again

taking a capital-intensive industrial country, this investment will increase that country's comparative advantage in the production and export of commodities which are produced capital-intensively even more than before. As a result, exports of the capital-intensive good increase and imports of the environment-intensive good increase as well. In addition, the industrial country experiences a terms-of-trade gain. In summary, the unilateral sustainability induced investment will also be partially financed by increased imports of environmentally intensive commodities and welfare gains due to the improved comparative advantage. Hence, unilateral sustainability policies by a country which is already less endowed with the environment will further improve its comparative advantage in the capital/labour-intensive goods.

Of course, the opposite will happen if a country well-endowed with - or currently strongly overusing - the environment will change course. It will lose some of its comparative advantage in environment-intensive goods. Since this comparative advantage was based on an unsustainable resource use this policy change will increase welfare in terms of environmental amenities and in terms of intergenerational welfare but not in terms of income. The loss in the terms of trade will impose some additional costs on the relatively resource-rich country which the capital-rich country can avoid.

Since in the long-run weak sustainability rules increase capital-accumulation and resource extraction, sustainability policies if performed unilaterally will make the country's capital stock ever larger and will enable it to eventually finance some of its costs of sustainability through trade. Especially, if its sustainability rule is only defined over domestic resource extraction, it will make the rest of the world less sustainable.

These results are derived under the assumption that environmental resources can only be traded indirectly when they are enclosed in produced commodities. In the next section, the impact of unilateral sustainability policies is investigated for the case in which environmental resources can be traded directly.

4. The effect of sustainable domestic resource use on international resource trade

Conventional trade models do not assume that any production factor like labor, capital or resources is tradable but is only mobile between sectors within an economy. When only commodities are tradable, commodity trade is a substitute for factor trade because it tends to equalize factor prices as well. This is a fundamental result of trade theory which was developed in times in which factor immobility was a quite reasonable assumption. From the perspective of today's environmental policies, however, it makes a

substantial difference whether resources are tradable or not. When resources are tradable, sustainability policies are likely to influence trade in resources. Of course, the impact on resource trade is different when sustainability policies are introduced unilaterally compared to an international policy coordination. Hence, resource mobility deserves special attention when designing environmental policies for a sustainable resource management.

When environmental resources are internationally mobile, national resource markets become interdependent. Integration of resource markets means that the supply and demand for resources are cleared on a world market and not on separated domestic markets. Unless some countries erect trade barriers, integration implies that the same market forces operate in all countries. This effect may restrict the policy options of a single country significantly. If a country is small, its policy does not vary the world market prices for resources. Hence, a country has significantly less influence on supply and demand conditions in an open trading system than in a closed economy.

Another feature of integrated resource markets is that reduced domestic extraction policies can be substituted by resource imports. This feature raises the question whether domestic resource use or domestic resource extraction should define the objective of sustainability policies. The difference between resource use and resource extraction are resource imports. When domestic resource extraction should be lowered to a sustainable level, one may expect that the decrease in resource extraction is at least partially compensated by an increase in resource imports. When domestic resource use is lowered, domestic resource extraction may by and large remain unaffected. Hence, it is a basic question whether sustainability policies intend to tackle a local resource problem or a resource problem which can only be solved on a global scale.

As long as a resource possesses a purely local nature in that the jurisdiction of a country can completely control that resource, there are no direct repercussions through trade on the sustainability in another country. Of course, the reduction in the availability of that resource or other investments in order to achieve sustainability may indirectly change trade flows because the relative resource endowments have changed. This change in comparative advantage may have a negative impact on other environmental resources in a foreign country because the demand for those substitutes of the protected resource may increase.

The more complex case is that in which the stock of an (environmental) resource is distributed over several countries. A unilateral sustainability policy will then directly affect trade flows of that resource, resource extraction, and resource use in those countries not pursuing sustainability policies. This raises the question what the appro-

priate sustainability rule should be. Should domestic resource extraction or domestic resource consumption be the reference to which the weak sustainability rule is applied? As this is a normative question, both approaches will be discussed.

In order to illustrate the basic relationship between different sustainability policies and trade in natural resources the results of a dynamic general equilibrium trade model with a non-renewable resource will be presented (Klepper, Stähler 1996). The basic intertemporal aspects of sustainability rules in an open economy come from the intertemporal resource extraction decisions of resource owners and the investment decisions based on the sustainability rules. Both will change the size and structure of the economies which are engaged in trade of resources and commodities. In addition, it will turn out that both decisions are interdependent.

The calculus of a resource owner for determining the amount of resources which he supplies depends on the price of the resource at a point in time and the expected price change in the future. In an open economy these prices are not any more determined domestically but by the world market. For an individual resource owner who feels unable to influence world market prices his extraction decision can be derived from the resource price path over time. If he expects resource price to increase at a rate faster than the rate of interest he will reduce extraction — in the most simple but also unrealistic case to zero. The reason is that the resource is worth more if extracted in the future than the return from extraction today, even when the returns are invested and pay interest. Conversely, if the resource price increase at less than the interest rate — or even decreases — it is profitable to increase extraction since the revenues from extraction will yield a higher interest than the alternative option of leaving the resource in the ground. Finally, a resource owner will be just indifferent between extracting and waiting if the resource price is expected to increase at a rate which is just equal to the interest rate. This is the famous Hotelling-rule for resource extraction. Although resource prices in reality do not exactly follow such a price path, it is still the most plausible theory so far.

We are now able to discuss sustainability policies for a tradable, non-renewable resource. Suppose that public action is necessary in order to restrict an excessive resource use. An excessive use may result from significant externalities which are not taken into account by resource users. For example, fossil fuels cause environmental damages which make restriction of their use necessary. Another example would be the extraction of resource stocks below some critical level at which they can not reproduce themselves. When non-renewable resources are subject to sustainability policies, it depends also on the type of production technology whether weak or strong sustainability concepts should be applied.

An example for the possible application of both concepts are endangered species which are protected by CITES. If strong sustainability policies are introduced for a certain species which is in danger of becoming extincted, any economic use of this species needs to be prohibited. However, prohibition does not imply that commodity production breaks down. These species are not essential for maintaining human consumption or production activities. The contrary holds for so-called necessary resources like energy resources. Energy resources are necessary because a certain input level is necessary to sustain any production. A strong sustainability would imply zero production levels. Therefore, only weak sustainability can make any economic sense.

Suppose now that a small country restricts the extraction of a resource on grounds of sustainability. In an open economy input and output prices are determined by the world market. Consequently, demand for the natural resource will not change and the reduced domestic supply will be substituted by resource imports. In order to finance these resource imports the country needs to export manufactured goods and thus experience a loss in real income. Hence, a restriction in domestic resource extraction will lead to resource imports and to a loss in real income.

Another strategy would be not to restrict the extraction of the resource but the consumption of the resource. This would require higher resource prices which could be achieved through a tax on resource consumption. This strategy would raise production costs for consumer goods and would in turn make commodity imports more competitive. At the same time, the balancing of trade would lead to a possible export of the natural resource. In summary, a restriction in the consumption of the natural resource would not lead to an equivalent reduction in extraction since some resources may now be exported.

If this small country follows a weak sustainability rule and induces investment in the capital stock in order to substitute for the reduction in the resource stock an additional effect on the use of natural resources is induced. The larger capital stock will, other things such as prices being equal, increase the demand for other factors of production notably natural resources. This increased demand will have no price effects and thus will not change the domestic extraction decision of resource owners. Hence, the additional input of natural resources in production will be met by imports. A policy of reducing resource extraction and increasing capital accumulation will thus lead to a combined increase in resource imports, hence an import of sustainability.

Now suppose that the country which imposes a sustainability rule is large enough to influence world market prices. A restriction in domestic resource extraction will then raise the world market price for the resource thus leading to a reduction in world demand and in the country following the sustainability policy. Therefore, the increase in

import demand for the natural resource will be less pronounced. The price policy of lowering demand domestically will lead to an excess supply of resources and a fall in the world market price such that the world demand for resources increases. As a consequence, exports of the natural resource may increase as well.

If that large country follows a policy of weak sustainability it will need to increase its capital stock if voluntary investment in the country is insufficient to compensate for the decrease in the resource stock. This increase in investment triggers two effects. Firstly, the increase in the capital stock will over time change the factor endowment of the country relative to the rest of the world. The consequences of this effect have been described in the previous section. An already capital-intensive industrial country would increase its comparative advantage in the production of capital-intensive goods and thus will experience a terms-of-trade again.

The second effect is induced by the changes in world market prices. The increased investment will increase the world capital stock which in turn changes the relative prices of the factors of production. I.e., the rate of return on capital will fall since a larger capital stock will have lower productivity. In addition, the world market for natural resources will react because the price path of resource prices depends on the interest rate on capital.

Irrespectively of the particular weak sustainability rule chosen the interplay of a unilateral sustainability policy on resource extraction, investment, trade flows and sustainability are as follows. The country which introduces a sustainability policy through investing in the man-made capital stock will increase the imports of natural resources. However, these imports do not grow without limits; in most cases the import ratios attain relatively low bounds, at least within a relatively simple dynamic model of international trade with mobile resources. The time profiles of output and consumption depend on the particular sustainability rule chosen. Whereas resource extraction remains equal within the country and abroad since world market prices determine the supply behavior, the resource use increases in the country trying to achieve sustainability when compared to a situation without such a policy.

The rest of the world reacts by specializing in the export of natural resource and importing consumer goods. This specialization leads to an increase in income when compared to a situation without the unilateral sustainability policy. Parallel to this foreign consumption is also higher. The impact on the sustainability of the rest of the world ambiguously depends on the particular sustainability rule chosen in the country mentioned above.

In section 2, two different rules for weak sustainability have been presented, the Hartwick-Rule — demanding to invest the resource rent in each period — and the rule of constant wealth — demanding to keep the value of all capital and resource stocks constant over time. These two rules become ambiguous in an open economy since resources extracted and resources consumed are not identical any more if trade in resources is possible. It is therefore necessary to decide whether the weak sustainability rule is defined over the resources extracted within a country or over the resources consumed.

There is no a-priori reason to prefer one rule over the other. An extraction based rule assigns the responsibility of maintaining sustainability to the country in which the resource stock is located, the consumption based rule assigns it to the consumer of the resource although the resource rent is appropriated in the country which extracts the resource. Since this is essentially a normative issue, Klepper and Stähler (1996) have investigated all four possible configurations, i.e. the Hartwick-Rule, extraction and consumption based, as well as the rule of constant wealth, extraction and consumption based.

The best weak sustainability rule when used unilaterally by one country in terms of sustainability for the rest of the world is the Hartwick-Rule compared to the rule of constant wealth irrespective of whether the consumption or the extraction based variant is used. Only the extraction based rule of constant wealth leads to a strongly deteriorating sustainability in the rest of the world. Under the other rules, the rest of the world remains unsustainable but this situation does not deteriorate. It may even improve slightly.

In terms of consumption, i.e. the utility of consumers, the consumption based sustainability rule is particularly bad for the country pursuing the sustainability policy and particularly advantageous for the rest of the world. This rule requires large investments which, firstly, reduce the amount of output available for consumption and, later on, they deteriorate the terms of trade of that country. Consequently, the rest of the world can increase its consumption which is mainly financed through the export of resources.

These illustrations show that even in a rather simple model of an open economy with trade in natural resources quite complex interactions can take place and the definition of a sustainability rule is not obvious anymore. However, the interactions described and the sustainability rules used so far belong to only one set of model assumptions, the most important being the requirement to invest in the physical capital stock. Since such a policy reduces the productivity of the capital stock and thus the interest rate, it also accelerates resource extraction although at a sustainable pace. An alternative would be to invest in other man-made capital stock such as human capital which

would increase interest rates and over time increase the rate of price increase of the natural resource.

There are quite a few examples which demonstrate the relevance of this distinction. Take again energy resources: If the use of energy resources is merely compensated by physical capital accumulation, one must expect that this additional capital will need energy resources to be employed. Instead, qualitative growth would substitute energy-intensive technologies by less intensive technologies like solar technologies or by energy saving programs. This measures may be able to increase the productivity of the existing capital stock, and they may be able to decrease the necessary energy input. Other measures include investment into human capital and promotion of research and development, especially for resource conservation.

5. International policy coordination

The last two sections have demonstrated that national sustainability policies imply international repercussions which should be taken into account carefully when designing national policies. The need for international policy coordination depends primarily on the type of the environmental resource in question. An environmental resource may predominantly provide local services, for example local ecosystems. Any policy which intends to make their use more sustainable does not need international policy coordination. The reason is that all environmental services associated with a local resource are under the complete control of the host country. If policies for preserving a local resource change trade patterns, changed trade patterns are the consequence of changed relative environmental scarcities. A country which restricts excessive exploitation of local resources thereby corrects its relative endowment with environmental resources into the right direction.

A lot of environmental resources, however, predominantly provide global services. These resources may be of benefit not only to one country but to other countries as well. If all other countries benefit from this resource, the resource is called a global resource. The crucial point is that the other countries cannot be excluded from the benefits of global resource conservation. In this case, every country benefits from the resource as a whole, and any action taken affects all countries. Examples include tropical forests, large-scale ecosystems like rivers and seas and the ozone shelter.

Suppose that a certain country considers to take actions which yield environmental benefits for all countries. For example, a single country may consider to promote the introduction of energy-efficient technologies or restrict energy consumption by intro-

ducing energy taxes in order to curb carbon dioxide emissions. Then, this country has to carry the costs of this program whereas its benefits are little compared to the benefits across all countries. If one country takes a certain action in order to make the use of a global resource more sustainable, all other countries will benefit from this policy. Without any policy coordination, we must expect that a single country has only minor incentives to pursue unilateral policies because it has to carry all costs but benefits only little. This incentive may even disappear if the national efforts are expected to be completely offset by other countries which react on national policies by increasing their resource use. Hence, it is evident that global environmental resource policy needs coordination in order to make sustainability on a global scale profitable for all countries.

International policy coordination, however, carries its own problems. These problems originate from the sovereignty status of all countries involved in international policy coordination. Sovereignty means that every country may in principle decide autonomously about its policy. Coordination requires that all involved countries agree upon a certain joint policy. Hence, sovereignty and policy coordination conflict with each other unless countries only agree upon what is also in their purely national interest.

However, only policy coordination leads to an efficient solution in the case of joint environmental policies for global resources and global commons. Although all countries are better off by coordinated actions, each country is even better off if all other countries coordinate their actions but itself does not. This incentive may lead into a dilemma because each country refrains from cooperation and hopes that all other countries will cooperate. This dilemma could be avoided if all countries could sign a binding contract which specifies coordinated actions. But the sovereignty status of every country makes any commitment to behave according to coordinated actions incredible if defection benefits this country.

In fact, there are two restrictions which are due to the sovereignty status. The first restriction is that no country can be forced into cooperation. Every country may opt for an outsider position because it hopes that other countries cooperate. This incentive explains why countries are so reluctant to sign environmental treaties which specify concrete obligations. Instead, such treaties often contain only imprecise declarations of intent. The declaration of countries to look for policy options to freeze carbon dioxide emissions is an example.

The second restriction originates from the non-enforceability of a signed treaty. If a country does not meet its obligations whereas the other countries do, it is obviously better off than meeting its obligations. As no supranational authority is able to enforce the treaty, other mechanisms must substitute for legal enforcement. The threat that a

country breaches an agreement is not hypothetical. The debt crisis has impressingly revealed that sovereign countries are in fact able to deviate from an international agreement. In this case, debts were repudiated by indebted countries, and in subsequent negotiations creditors accept to write off a part of debt services although they were laid down in a contract.

Hence, global sustainability policies may not be as effective as other policies because they need to cope with the significant problem of international policy stabilisation. The lack of a supranational authority and the sovereignty of countries are likely to make international policy coordination more complicated than national policies. Therefore, international policy stabilization requires that every country participating in coordinated actions has no long-run incentive to quit joint sustainability policies. Heister et al. (1995/6) demonstrate that institutional arrangements which guarantee compliance must build on repetition and use utility transfers, economic sanctions and treaty adjustments.

6. Policy implications

This paper has given a discussion of some of the problems which arise with sustainability policies in an international setting. It turned out that international repercussions may threaten the success of national sustainability policies. This threat is twofold: First, unilateral sustainability policies will change the international allocation of resources. In particular, the import of natural resources may make the rest of the world even more unsustainable. Secondly, in the case of transfrontier externalities of resource conservation there is also an incentive to free-ride on environmental preservation.

It is therefore more promising to coordinate national sustainability policies. The last section has demonstrated that international coordination is much more difficult to achieve than national environmental policies. However, for environmental problems which cross national borders, there is no alternative because uncoordinated actions will not guarantee sustainability in this case.

From all these considerations, we draw the following conclusions:

- Any sustainability policy which intends to compensate resource extractions through other beneficial economic activities should not accumulate physical capital. Physical capital accumulation may lead to increased resource exploitation in the long run, and this effect is the substantially stronger when resources are traded. Instead, such a policy should take actions which increase the productivity of the existing capital

stock, like investment into human capital and research and development which enhances resource conservation.

- Even for environmental resources which do not create transfrontier externalities, the question is open as to whether sustainability rules should be defined with respect to the consumption of an environmental or natural resource or with respect to its extraction.

- In the case of transfrontier externalities policy coordination is essential for reaching sustainability.

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