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Abstract

The extinction of genetic resources as a consequence of land development, especially in 'biodiversity hot spots' like rain forests in South America or South East Asia, is becoming a serious problem - not only for local communities but also for international firms in the pharmaceutical industry. These firms are to some degree interested in genetic sequences or active ingredients of endemic species which serve as important input materials for innovative pharmaceutical products. Thus, there is a conflict between different interest groups. During recent years there have been a number of publications on the so called benefit-sharing (BS) as stipulated by the United Nations Convention on Biological Diversity (CBD). This convention was passed in 1992 and attempts to establish 'benefit-sharing' as a means to fairly and equitably share the benefits accruing from the commercial use of biodiversity. Although widely discussed in the political sciences, sociology and ethnology and subject to intense anecdotal case-study research there still is some lack of economic analysis of BS-agreements.

In this paper we propose economic criteria for the evaluation of benefit-sharing and discuss different forms of benefit-sharing that derive from the practical implementation of the instrument. We find that from an economic point of view benefit-sharing is often far less conducive to the attainment of the CBD's goals than often asserted in the literature.

Keywords: Access and benefit-sharing; developing countries; Convention on Biological Diversity; genetic resource preservation

JEL-classification: Q 13, Q 23, Q 32

For whose benefit? Benefit-sharing within Contractual ABS-Agreements from an Economic Perspective – the Example of Pharmaceutical Bioprospection –

1. Introduction

The Convention on Biological Diversity (CBD)[i] was negotiated in 1992. Its objective is to maintain and protect biological diversity, to support the development of supplier countries, and to achieve a fair and equitable sharing of benefits accruing from the use of genetic resources. As far as contractual or institutional access and benefit-sharing (ABS)-agreements[ii] are concerned, these intentions appear too ill-defined to become subject to precise economic analysis. Thus, a transfer into economic terms is necessary. From an economic point of view it must be asked, whether the given allocative and distributive situation without benefit-sharing arrangements produces unacceptable results, meaning that the given situation is allocatively inefficient or regarded as 'unfair' according to normative criteria. If a given situation is considered as unsatisfactory, it remains to be examined whether benefit-sharing (BS-) agreements pursuant to the CBD provide better alternatives compared to hypothetical market solutions implying a minimum of intervention, which are usually expected to be more efficient. In the following, we will focus exclusively on the different forms of benefit-sharing within ABS-agreements.

We should add here that the notion of 'benefit-sharing' is somewhat misleading, because also 'pure' forms of market transactions beyond the CBD's view of benefits and benefit-sharing are, strictly speaking, based on agreements to share benefits, for example, if owners of biological resources in host countries receive a share of the returns the purchaser extracts from the use of these resources in the form of the final product.

2. The CBD's goals from an economic viewpoint

Prior to the implementation of the CBD there had been no generally accepted rules for the sharing of benefits accruing from the commercial use of genetic resources. Before, the distribution of these benefits had resulted solely from the distribution of negotiation powers of suppliers of genetic resources rather than compared to private firms seeking after genetic information to be used for pharmaceutical and chemical products. For centuries, biodiversity has been destroyed and indigenous knowledge has been exploited in the course of searching for their commercial potentials or the simple need for land. Because there was no precise definition of property rights and asymmetric distributions of knowledge about the technological and market potentials of genetic information, suppliers of genetic resources achieved, if at all, only low prices for their goods.[iii]

The economic question is whether this is inefficient in terms of allocative efficiency and whether it is conducive to a satisfying distributive solution. Since certain conditions for market failure exist (insufficient definition of property rights; information asymmetries), one might argue that the current state is undesirable even from an economic standpoint. Nevertheless, 'CBD'-solutions may be far more favourable than 'market solutions', even if existing market failures can be removed.

Is the current situation allocatively inefficient? We see the problem of the procurement of biological resources by private firms from 'owners' of those resources mainly as a problem of input pricing or factor procurement. The private firms' interest is to acquire biological resources for the lowest achievable price. The price will be lower, the more intense the competition is between owners of biological resources. Incentives for preservation will be lower, the lower the prices paid are for genetic resources, as low prices are unlikely to offset the opportunity costs a landowner may have to incur in order to preserve genetic resources.

It is important to emphasize that the development in situations of uncertainty and irreversibility may not only be inefficient in many instances, as was shown as early as in 1974 by Arrow and Fisher. Furthermore one has to consider that development decisions driven by the demand for ingredients (not for plants) will regularly be excessive as they ignore plants' other positive qualities.

Although observers may sometimes find the distributional outcomes in markets for genetic resources undesirable, especially in the case of random search, allocation may be efficient if markets do not fail, that is if property rights are well-defined and if information asymmetries are not too large. In addition, one may even argue that information asymmetries between suppliers in host countries and firms tend to be smaller, if firms randomly seek for biological resources. Even if market failures such as information asymmetries and ill-defined property rights are absent, the market outcome may be inefficient if suppliers in a situation of excessive competition face insufficient incentives to conserve biological resources. As prices in this situation decrease, it will become attractive for land-owners to use their property for alternative ends, especially for agricultural production, mining, etc. Consider, for instance, the rainforest that originally covered a piece of land. If it is removed to make the area usable for agriculture, not only biological resources that firms are searching for in the present situation will be destroyed, but also resources will be removed that could meet unknown future needs. Thus, it may be desirable as a condition of efficient inter-temporal resource allocation to maintain the piece of land for bioprospection and to refrain from agricultural use. In the following section we attempt to specify this problem by highlighting the importance of different market structures.

2.1 The importance of a market structure for 'fair and equitable' benefit-sharing

2.1.1 The problem

Converting natural or near natural habitats into more intensive forms of land use is one of the strongest drivers of species extinction. Endemic species are especially threatened by conversion, because their range is more restricted (i.e. regularly also smaller) than non-endemic species. Unfortunately, some of the highest rates of land use change are reported from biodiversity hotspot areas in non-industrialized countries. As a consequence, the development of land leads to an irreversible destruction of plant genetic resources, some of them unknown to the industry and the scientific community.

Although a large share of the current pharmaceutical compounds are based on biological material, i.e. on genetic resources, and although spectacular cases of 'blockbuster'-drugs are documented[iv], uncertainty prevails on the future demand for natural genetic resources as a source of ingredients for next generation pharmaceuticals. This uncertainty of future demand reduces the present values of preserved plant species or genetically distinct populations.

The following analysis applies to the one-nation-case with competition among domestic suppliers as well as to the international case with suppliers from different nations competing in the international bioprospecting market.

The question to be addressed now is about the implications of different spatial arrangements of (endemic) plant species populations vis-à-vis the underlying structure of land-ownership, and incentives for alternative land uses.

Several reasons contribute to the low price for access contracts to or samples of genetic resources. Even if property rights are granted and enforceable, providers may compete in homogenous oligopolies for selling genetic resources. Thus, market structures are relevant for preservation/development-decisions as well. The problem of competition may aggravate, if one considers the fact that demand is not for specific plants but for certain active compounds. In several instances these active compounds can be found in several plants being more or less perfect substitutes for the demand. If a potential supplier of genetic material anticipates that he will find himself in a situation with a competitive market structure, this will further reduce his incentives for preservation. Thus, uncertainty is caused by imperfect information about the future demand for ingredients, many of them still being unknown, and by imperfect information about future market structures. Yet, given the situation that demand focuses on ingredients, not on plants, one *a priori* information exists for a landowner about the likelihood of finding himself in a competitive situation: the greater the share of cross-border plant populations in different parcels of land, the greater is the probability of supply competition. Nevertheless, overlapping populations do not exclude that monopolistic situations will emerge in the future. Another reason for low prices is insufficient negotiation power of providers of genetic resources.

It is necessary to distinguish between two different demand scenarios, the specific and the non-specific demand scenario, which may cause very different effects (see Simpson, Sedjo, and Reid, 1996 and Rausser and Small, 2000). First, in a random search scenario (which we will name 'non-specific demand'), i.e. the sequential testing of large numbers of leads in no particular order, firms will seek for more or less unspecified resources (genetic resources, bioactive compounds) worldwide. Thus, potential suppliers will be competitors worldwide (or perhaps in a larger geographical region, say South America or parts of it, like the Amazon basin). In this case, competition between suppliers will tend to reduce prices. Non-specific search (also called 'brute-force'-search, Rausser and Small, 2000) will, however, be the exceptional case, because it is a nearly cost-maximizing approach to discovery. It will be deployed as a 'backstop technology' only when all possibilities of more directed search have been exhausted (Rausser and Small, 2000: 175). Although the difference between specific and unspecific demand is sometimes compared to oil drilling where knowledge about 'promising' sites may command significant information rents (Rausser and Small 2000: 175), the case of bioprospecting is different: If economically feasible, oil companies are interested in the exploitation of the resource wherever it is found. As a consequence, discovery of a promising drilling site will potentially affect the sequence of sites exploited but not the *exploitability* of other sites. The situation in the case of genetic resource discovery is different. Once a firm has obtained the information incorporated in a certain species, there is no reason for it to ask for the same species from another site, as they are redundant now. Thus, owners of land parcels will regularly find themselves in a situation of 'winner-takes-all'-competition.

If firms search more specifically ('specific demand'-scenario) for certain compounds or genetic information, it is more likely that they will have to focus on a small geographic region which is expected to contain plants with desired qualities. Especially if this region does not include borders, there will probably be only a few negotiation partners for the firm. If the firm deals only with one partner (say, if the state owns property rights and there are no political borders in the region), suppliers of biological resources will find themselves in a monopoly situation or in a situation of monopolistic competition. In this case, prices obviously tend to be higher than in the random-search case.[v]

2.1.2 Some basic economic distinctions

In the following we consider a two-period situation with irreversible destruction of genetic resources when land is developed and uncertainty about future benefits, as already modelled by Arrow and Fisher (1974) or by Fisher, Krutilla, and Ciccetti (1974). Unlike the aforementioned authors we introduce different market forms. Here we make the following distinctions/assumptions:

1. In a given situation all agents know about substitutive species, all of them being suitable to meet demand by providing the active ingredient.

2. First of all one has to consider a case in which an ingredient a user asks for can be found in one or more parcels of land. Given the first case, the supplier is a monopolist. The determined price only competes with e.g. the costs of a firm's in-house research or its costs to acquire a (distant) substitute. The higher the costs of in-house R&D or the worse the substitutes, the higher the price will be.

3. If the active ingredient can be found in more than one parcel of land, suppliers from different parcels of land (a, b, … n) will compete. The simplest (and most unrealistic) case is the occurrence of identical species (A, B, … N) in all parcels of land, i.e. a situation with a(A), b(A), c(A), etc.

4. In addition we distinguish between 'monocultures' in which only one plant species can be found on a parcel of land and areas with biological diversity. This is, admittedly, very simplistic. To make assumptions more realistic, one could also as-

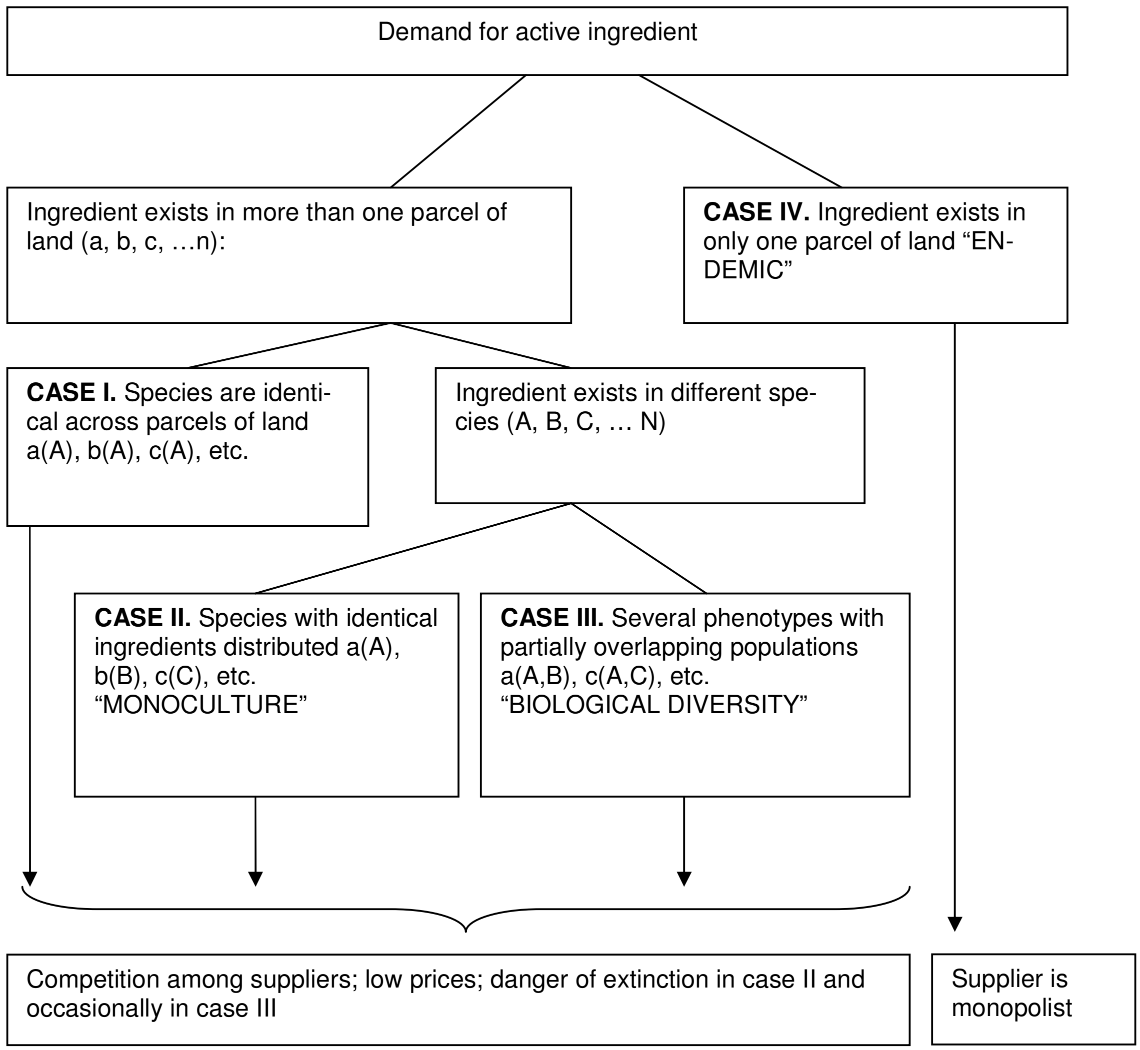
sume a very small variety of plants with almost identical ingredients or a situation in which other plants growing on a parcel of land are not expected to bear valuable ingredients. Let a(A) denote a parcel a containing only one single plant species A and a(A, B, … N) with a great variety of species.

5. Of course, the degree of overlap differs between any two parcels. We have to distinguish between overlap in phenotypes and overlap in active ingredients. Overlap in phenotypes includes overlap in ingredients. Obviously, a perfect overlap exists between allotments with identical natural cover. The overlap is confined to active ingredients if there are no identical phenotypes to be found in more than one allotment (see figure 1 for an overview).

6. Development causes (reversible) *in situ* extinction of species in cases of plants with known active compounds growing on only one particular parcel of land (endemic plants). In this case, extinction *in situ* may be reversible because plants harvested on the parcel of land will be cultivated and may in principle be replanted on their place of origin. More realistically, if a parcel of land is developed, extinction may also emerge if endemic plants without a compound asked for in a given moment of time are removed. Thus, a kind of 'collateral damage' emerges.

In addition to Arrow and Fisher, development decisions, i.e. benefit expectations, depend on market structures and expected market structures as well. In the following we again distinguish between non-random ('specific') demand for certain active ingredients and random ('non-specific') demand. The former will usually create a situation in which landowners' plant resources can command higher prices than in the 'non-specific' case (Rausser and Small 2000).

Figure 1: Market forms



Given that the active ingredients A, … N are substitutes, suppliers will, ceteris paribus, value benefits the following way (let $B_{t,p}$ denote the expected benefits from preservation in period t):

$$B_{t,p}(CASE\ I) \leq B_{t,p}(CASE\ II) \leq B_{t,p}(CASE\ III) \leq B_{t,p}(CASE\ IV)$$

The landowner maximises expected discounted benefits with discount rate r until his 'discount horizon' K, a period in the future beyond which he does not plan:

$$\int_{t=1}^{K} B_{t,p}{}^{-rt}\, dt = \max!$$

If s denotes the share of cultivated land in a period, and if θ stands for the degree of overlap of active ingredients,

$$\frac{\delta s}{\delta B} > 0 \text{ and } \frac{\delta B}{\delta \theta} < 0\text{, thus } \frac{\delta s}{\delta \theta} < 0 \text{ applies.}$$

The landowner himself decides about *s* given his information about existing species and their ingredients and given his information about the degree of species overlap with the other parcels of land. If his information is imprecise, he may assume that a greater biological diversity in a specific region implies a greater overlap.

Specific demand:

Given this situation, owners of parcels with overlapping populations or with populations containing identical ingredients across parcels find themselves in a situation of a homogeneous oligopoly and will enter a situation of fierce price competition leading to prices at marginal cost level. In this situation, preservation is not an attractive option for land-owners. The likelihood of preservation increases, however, with an increasing number of endemic species, because a high number of endemic species induces higher expectations on the side of the land-owner that he will find himself in a monopoly-situation in the future. Owners of parcels with endemic populations containing ingredients the firm searches for specifically will not cultivate, but preserve land. However, this does not exclude the cultivation of land with endemic populations, if the species' active compounds are not demanded by the firm at a certain time - especially if the landowner only has limited expectations that his endemic species' ingredients will be demanded in a foreseeable future and that – as an outcome of the specific compensation arrangement (see below) - his discounted profits from cultivation will be smaller than in the preservation case. The same holds true for owners of land with endemic species in the case of

non-specific demand:

The greater biological diversity on a parcel of land, the greater is its owner's expectation that future demand for active compounds could also be met by suppliers from other locations, if a greater biological diversity implies a higher probability of overlap in active compounds/genotypes. As a consequence, if a competitive situation is anticipated, owners will be inclined to cultivate in the first period. This may not be critical insofar as 'redundant', i.e. overlapping species which also exist on other parcels, will not go extinct, but it may cause extinctions of endemic, non-overlapping species for which there is no demand by the firm as 'collateral damages'. This situation may not be efficient if species extinction causes a loss of positive externalities.

2.2 Some first conclusions

At this point we may conclude that:

- Transfer agreements may be allocatively efficient even if they produce outcomes that observers may find undesirable ("unfair") on distributional grounds.

- 'Pure' market solutions may be inefficient, if market failures prevail, but this does not necessarily mean that (state-driven) interventions using normative criteria may create superior outcomes.

- 'Pure' market solutions may be inefficient if species extinction causes a loss of positive externalities.

- High biological diversity may turn out to be a driving force of species extinction as it increases the likelihood of competitive supply structures, reducing expected benefits for the supplier.

- The existence of endemic species increases the likelihood of preservation only in cases of specific search. In cases of unspecific search, biological diversity increases the likelihood of non-extinction of endemic species only if other species are endemic as well.

In addition, a BS-contract is unlikely to lead to satisfying allocative or distributive results if it is not operational, that is if it is difficult to administrate under the prevailing conditions or if it is not robust, for example, if it loses enforceability under changing economic or political circumstances.

3. Economic criteria for the evaluation of BS-contracts

In economic terms the CBD's goal of a 'fair and equitable' sharing of benefits predominantly deals with the problem of input pricing, as the genetic resources in question are used as informational inputs[vi] in pharmaceutical production processes. The CBD's intentions were concretised by the Bonn Guidelines, which provide an overview on possible forms of benefit-sharing as part of ABS-agreements that are expected to fulfil the objectives of the CBD. In the following section we focus on a selection of these suggested forms, namely royalty payments, salaries, technology transfer, information transfer, and training.[vii]

In a first step we develop a set of criteria for the evaluation of different forms of benefit-sharing. We refer to types of agreements that are agreed upon within the CBD framework. We do not discuss other forms of contracts, which may also fulfil some of these criteria, as mentioned above.

CBD-conformity: By this 'meta-criterion' an arrangement complies with the CBD, if it fulfils the demands of the CBD, especially with regard to its distributive requirements, its aim to maintain biological diversity and its contribution to a host country's development. This criterion is a meta-criterion in the sense that it will not be fulfilled in cases in which an agreement's contribution to the fulfilment of other criteria is insufficient, for example if an agreement is not robust or if it is hard to implement. In those cases its contribution to the achievement of the development goal will remain limited, even if it is desirable from the allocative view. The reader may find it surprising that we examine the CBD-conformity of contracts that are agreed upon under a CBD-framework. The answer is that in economic terms it is by no means self-evident that an agreement that is usually thought to fit into the CBD-framework in reality creates incentives that are conducive to a CBD-compliance in a given situation.

Allocative effects: Secondly, we examine whether a type of BS-agreement is likely to be allocatively efficient. We expect pharmaceutical firms' decentralised decisions to allocate their resources for the procurement of biological resources to be allocatively efficient under given conditions. In theory, firms will employ factors of production in accordance with their relative scarcity until marginal costs meet marginal revenues.[viii] This means that additional bioprospectors, R&D-resources etc. will only be employed if their marginal costs meet their expected marginal contribution to the firm's revenue. It will be more difficult for the firm to generate valid expectations in the case of random search for genetic resources. In addition, experience has shown that it is difficult to establish accurate expectations about likelihoods of commercial values of final products even at stages at which a plant or an active compound is considered to be commercially interesting.[ix] Thus, firms will normally use rules of thumb for their decisions to employ additional factors of production. Restrictions to allocative efficiency will emerge especially when a firm's decision produces negative externalities, for example, when mono-cultures are built up or when the process of bioprospection causes environmental damages (which, albeit, is not likely).[x] Further restrictions to allocative efficiency may be observed, if the firm's decision causes irrevocable damages to existing resources and infringes possibilities of their future uses. Allocative efficiency can also be affected by informational asymmetries, which can occur on both sides, the firm and the supplier of genetic resources. Depending on the individual design of an ABS-contract, firms or suppliers may have incentives to behave opportunistically and to cheat on the other side, thus causing agency costs.

Social benefit will in general exceed private benefit accruing from a parcel of land. A piece of uncultivated land with genetic resources may also generate certain kinds of benefit which are entirely social, that is the landowner produces positive externalities, for example, if the plant population contributes to the stability of ecosystems of neighboured parcels, has positive effect on the climate etc. Especially in the latter case the land-owner will not receive any private compensation for the benefits that accrue for society in case he does not cultivate his land. If externalities cannot be internalised through negotiations between landowners (that is in a 'Coasean' way), the state comes into play. From the allocative viewpoint, it may be efficiency-enhancing, if the state decides to subsidise landowners to produce positive externalities. If these externalities cross state borders (for example if they have positive climate effects), even the state will have an insufficient incentive to compensate landowners. Yet, if the state decides to force firms searching for genetic information to make an extra payment to landowners in addition to the outcome of independent negotiations, this may be efficiency-enhancing and bear distributive effects as called for in the CBD. But a regulation like this may not measurably alter the outcome of efficient markets. The reason is that the sum of the compulsory payment and the payment that would have been made to the provider in any case must not exceed the firm's willingness to pay (WTP), which is determined by its profit expectations. Thus, if under free market conditions the provider can make the firm pay its entire WTP, compulsory additional payments would either allow the firm to negotiate concessions, or the firm would refrain from the contract. Only if under free market conditions the WTP is not reached (perhaps due to ill-defined property rights or asymmetric negotiation power), compulsory payments may yield some distributive effects.

Another important issue under allocative aspects is whether bioprospection and alternative forms of land use are mutually exclusive or not. If the latter is the case (for example single shot extraction for subsequent *ex situ* laboratory production), the landowner does not need compensation for his loss of income, but if both forms of utilisation mutually exclude each other (for example if the firm depends on ongoing re-supply of samples while land has to be deforested for agricultural use), compensation is needed. While in the non-exclusion case no decision has to be made between biodiversity maintenance and alternative forms of land use, compensation must be high enough to provide a sufficient incentive for long term biodiversity preservation, which is the CBD's intention (Day-Rubenstein and Frisvold, 2001: 206ff.).

Distributive Effects: It is one of the CBD's primary aims to 'correct' distributive effects of 'pure' market-BS agreements. As mentioned above, even efficient agreements may be found undesirable from a distributive point of view. In most cases it is – more or less convincingly – argued that suppliers of genetic resources benefit insufficiently from the profits the firms generate from genetic resources. Since this is primarily a normative criterion, it generally cannot be exactly specified in economic terms. We assume a contribution to the distributive aims of the CBD if, given an efficient market outcome, the supplier of genetic resources finds himself – perhaps even slightly – better off than in the (hypothetical) 'pure market solution'. In other words, we do not make any judgements about the 'fairness' of a contract. If the original situation is characterised by inefficiencies, for example because of weak property rights, one has to distinguish between two different effects of BS-contracts. On the one hand, the contract may be efficiency enhancing, if, for example, it allows an appropriation of property rights especially for the suppliers. On the other hand, the contract may also include distributive elements that favour suppliers of genetic resources.

More fundamentally, one may ask whether the CBD and the Bonn Guidelines yield any redistributive effect at all. The Bonn Guidelines state that 'benefits should be shared fairly and equitably with each person who has been identified as having contributed to the resource management, scientific and/or commercial process', and 'Benefits should be directed in such a way as to promote conservation and the sustainable use of biological diversity'. Despite the fact that this formulation is (inevitably) somewhat vague, it has to be said that these requirements do not necessarily mean a redistribution compared to the 'pure market'-result. Instead, several parties involved may find it 'fair' to improve their living compared to the initial situation or to obtain any income at all – even if it is low.

Feasibility: A contract is defined as more feasible than another contract, if its implementation costs, i.e. costs for information purchase, organisational efforts, overcoming resistances etc. are lower than those of alternative solutions.

Robustness: A contract is robust if its terms and outcomes remain unchanged in the case of alterations in political or economic framework conditions. For example, assuming that a contract assigns benefits to indigenous communities and therefore defines property rights for the genetic resource, a contract is found to be robust, if the indigenous community may profit from the agreement even in the case that the host country's authorities claim the genetic resources to belong to their national property. A further change of framework conditions might be caused by additional legal requirements imposed on the parties by the host country's government, for example if firms from abroad are forced to found subsidiaries for the employment of local staff etc.

Furthermore, robustness may also become an important criterion if parties consider renegotiations at a later stage of the bioprospecting activity. First steps of pharmaceutical bioprospecting are very risky investments for the industry. Only at the later stages of R&D, when the success of the final product becomes more probable, the firm's interest in the preservation of a certain area is likely to increase. To assure, for example, either the ongoing re-supply with raw materials or the continuation of prospecting measures, contracts may be renegotiated as the WTP for the conservation of the biodiversity by the firms rises. From the CBD viewpoint, such a decision for ongoing *in situ* extraction is not problematic. But a firm may also change its attitude towards originally intended *in situ* extraction and reduce its activities in this field, perhaps because of its misjudgement about the commercial potential of local genetic resources. If this is the case, the firm will have an incentive to renegotiate contracts. Under such circumstances advance payments are obviously more renegotiation-proof than salaries, for example.

4. Contractual Agreements on Access and Benefit-sharing

In the first years following the Convention on Biological Diversity there was a tremendous lack of information about the possibilities on how to translate the Convention's ideas of Access and Benefit-sharing into feasible terms of a contract. Therefore the Conference of the Parties III called for case studies on access and benefit-sharing.[xi] Until the year 1998, 15 case studies reached the Secretariat of the Convention. The majority of the cases dealt with pharmaceutical bioprospecting arrangements. Although these different case studies gave a first insight into possible forms of access and benefit-sharing, they left many questions unanswered. Even today only a few case studies are officially registered on the Convention's homepage, the number of international experts is also rather small, and there is quite a number of decisions concerning individual articles of the Convention that have not yet been transformed into feasible solutions. Aware of the situation, the 'Bonn Guidelines on Access to Genetic Resources and Fair and Equitable Sharing of the Benefits Arising out of their Utilization' were worked out and accepted by the Conference of the Parties (COP) VI in 2002. The Guidelines are a contribution to the implementation of the Convention's objectives. They are intended to help establish institutional frameworks and negotiating potential contractual arrangements for bioprospecting by giving an overview of possible forms of access and benefit-sharing solutions. Both, aspects of access as well as of benefit-sharing, are important when negotiating contracts for bioprospecting. In the following we will focus on some selected forms of benefit-sharing.

The forms of benefits mentioned in the Bonn Guidelines are monetary and non-monetary forms of 'private' benefits. Examples of monetary benefits are access fees/fee per sample, up-front payments, milestone payments, payment of royalties, licence fees in case of commercialisations, salaries, etc. 'Non-monetary' forms of benefit-sharing can deal with the sharing of results (from research and development), cooperation, contribution to scientific research and development programmes or participation in product development.[xii] In the following we will concentrate our investigation on a selection of very commonly applied forms of benefit-sharing agreements.

5. Selected forms of Benefit-sharing

Detailed information about the contents of contractual agreements on bioprospecting activities is hard to find. As the use of genetic resources is increasingly critical for a firm's success, information is usually kept secret for competition reasons. State-financed contracts, for example from the International Cooperative Biodiversity Group (ICBG) and the US National Cancer Institute (NCI) promise data, which is more reliable and easier accessible.

The selection we make is based on the 15 case studies handed to the COP as well as the interviews conducted by ten Kate and Laird with the ICBG.[xiii] From this information we infer the most commonly applied forms of benefits and develop a benefit-sharing 'profile' for bioprospecting contracts. All studies considered involved the use of genetic resources in 'mega diversity' eco systems, like the tropical rainforest or cloud forests. The only exception was a contract from the Yellowstone National Park in the USA. In addition, all contracts considered are long-term partnerships that follow the idea of sustainable use of biodiversity.

5.1 Royalties

Royalties are payments to the supplier of genetic information, usually on a per cent (normally ranging from 1 to 5 per cent)[xiv] basis of the net sales that firms yield by selling products based on the information. The amount of royalties paid is fixed in contracts, which are agreed upon at different stages of the firms' R&D-processes. Precise figures about the sums of royalties paid are rarely published. They depend on the category the genetic resource belongs to (plant, micro-organism, ground samples etc.), the extent to which the final product is based on the sample, the way the sample has been taken (ethno botanically or by chance), the value of biological and intellectual information of the supplier's country, the number of parties involved, the scarcity or 'newness' of the sample, the market shares that are likely achievable with the final product, the size of the firm (its negotiation power), and on overall market trends determining the royalty level in general.

Allocative effects: Royalties are unlikely to produce economically efficient outcomes. As royalties depend on a large number of parties and factors, information asymmetries are highly probable. Especially in the early stages of the product's R&D, it is almost completely unknown both to the firm and to the supplier whether the biological information provided by the sample will become a contribution to a new product, let alone whether this product will become a commercial success. At later stages of the product development, firms obviously have better information about the genetic information's contribution to the product and about its success probability. Thus, as time passes, the information asymmetries favour the firm's interests. In both cases royalties will tend to be low. During early phases it is rational from the firm's standpoint not to pay high sums for an input good which is almost unknown with regards to its commercial relevance. Because both parties are almost systematically ignorant about the samples' 'real' values, the amount of royalties paid is not an outcome of a market failure due to information asymmetries. Instead, both sides will build their ideas about the adequacy of royalties based on their experiences and expectations. Still, market power may be a factor of significant importance here. At later stages, firms will deliberately underestimate the value of the input good provided by the host country, especially its contribution to the final product. Once the firm possesses the genetic information required, the host country is in a weak position for the enforcement of its property rights. The fact that many contracts stipulate room for renegotiations at later stages of R&D if the parties gain new information about the likelihood of a genetic information's future commercial applicability does not solve the general problem of information asymmetries. Furthermore, firms may even try to renegotiate if they can argue that the final product is such a distant prospect compared to the initial genetic information, that the supplier should no longer be entitled to receive the original share of the net sales. Rational providers thus have to calculate expectations about the periods in which the product that is based on their genetic information yield sales (denoted by *j* to *k*), about the likelihood that the genetic information can be successfully transformed into a marketable product (p_S), and about the amount of net sales in each period during which they are expected ($\mu_{NS,t}$). As potential royalty payments are promised for a possibly distant future, rational providers will discount them to their net present value. If they have personal expectations about acceptable net present values of royalties they may have received (*R*) when the product leaves the market one day, they can calculate their 'royalty factor' (*RF*) being the percentual share of the assigned net sales:

$$R = p_S \cdot RF\left(\frac{\mu_{NS,j}}{(1+i)^j} + \frac{\mu_{NS,j+1}}{(1+i)^{j+1}} + (\ldots) + \frac{\mu_{NS,k}}{(1+i)^k}\right), \qquad (1)$$

thus

$$R = p_S \cdot RF \sum_{t=j}^{k} \frac{\mu_{NS,t}}{(1+i)^t} \qquad (2)$$

If *R* is given, the royalty factor amounts to

$$RF = \frac{R}{p_S \sum_{t=j}^{k} \frac{\mu_{NS,t}}{(1+i)^t}} \qquad (3)$$

R may represent the income to be earned by the supplier of a genetic resource in order to be indifferent between alternative forms of land use. If *R* is smaller, the supplier may prefer to destroy plants on his piece of ground to harness it for agricultural cultivation, cattle breeding, mining, etc. In other words, if the firm wants to exploit the genetic resources, it has to offer at least *R*. In many instances, agricultural cultivation and the utilisation of the land as a source of genetic information are completely exclusive forms of land use, because the firm may have to secure its re-supply of genetic resources in later periods in the case that commercial utilisation becomes likely and the sample is not yet synthesizable. In these cases (for example, ten Kate and Laird, 1999: 72), the firm has to rely on ongoing *in situ*-extraction of samples at later stages of its R&D.[xv] As time preference rates will often be high (for example, if providers are poor), *R* will almost automatically be too low to sustain genetic resources on the allotment. As a consequence, royalty arrangements are often combined with other forms of monetary and non-monetary benefits, for example salaries for the supply of raw materials, which compensate time preference effects by assigning sources of immediate income to the provider (Rubin and Fish, 1994; Rosenthal, 1996). Let y denote any other form of benefit paid to the provider in addition to the royalty payment. If, in the simplest case, y is an up-front payment, equation (3) changes to

$$R = y + p_S \cdot RF \sum_{t=j}^{k} \frac{\mu_{NS,t}}{(1+i)^t}\,, \qquad (4)$$

thus, the royalty factor reduces to

$$RF = \frac{R - y}{p_S \sum_{t=j}^{k} \frac{\mu_{NS,t}}{(1+i)^t}}\,. \qquad (5)$$

With a higher time preference rate, the landowner must be offered a higher up-front payment (or analogously, higher - discounted - milestone payments or salaries) or must be assigned a higher royalty factor in order to provide him with a sufficient incentive to leave his parcel of land uncultivated. As a consequence, royalty payments will tend to be crowded out by other forms of 'benefit-sharing' among poor people, who often have a higher time preference rate than the rich.

Distributive effects: As it is difficult to assess the royalty agreement's free market result, distributive effects are also complicated to quantify, but because the instrument of royalties tends to bring about incentives for low sales shares, it can be assumed that agreements stipulating a significant share of the final product's revenues to be paid to the host country may contain a redistributive element. Yet, one may still ask whether such outcomes had to be expected under free market conditions as well. For example, a firm may find it rational to make generous payments to an owner of a biodiversity hot spot in order to guarantee first-rank access to the host's resources in future periods or the owner of specific resources is a monopolist in the sense that certain genetic resources are not to be found elsewhere. Thus, it may be difficult to distinguish between 'pure market'-outcomes and redistributive elements of a contract in the individual case in reality. With respect to the different urgencies of extracting an income from different forms of land use, it must be said that royalties are not agreements to be chosen by the poor. Instead, the rich, who can afford to bridge the time gap until the final product commences to yield revenues, may prefer royalty solutions.

Feasibility: In general, a royalty scheme will not be particularly costly to implement. Nevertheless, significant transaction costs will emerge, if it is difficult to determine which parties have to be integrated in the agreement. For example, a piece of ground may be under state ownership, but indigenous populations possess knowledge about different plants' qualities etc. In addition, it may be costly for suppliers to enforce claims from the contract. The problem that the supplier's contribution to the final product's commercial success will often be highly disputable can be evaded in a royalty agreement, if the supplier is assigned a payment independent of his effective contribution, but depending on an observable variable (for example net sales). Nevertheless, this leaves the risk with the firm so that the latter will try to keep royalties low in order to account for the risk equivalent. A qualitatively somewhat different situation emerges when the final product is based on derivates only distantly related to the original genetic resource. In this case, the firms may deny any significant contribution at all from the side of the source country (Masood, 1998: 540).

Robustness: Royalties are payments that depend on the success of the final product and are therefore paid only when the product reaches the market. In comparison to other forms of benefit-sharing, royalties are generally robust with respect to changing circumstances, especially host countries' attempts to alter frame conditions, as these do not affect the probability of the product becoming a commercial success. Unfortunately, in reality the amount of royalties paid to the provider does not only depend on the commercial success of the final product, but also on the degree the active agent found in the plant contributes to this success. In this field, the firm has better information and may attempt to urge the provider to abandon his original claim and agree to lower royalty factors. Empirically, firms tend to be in a good position for renegotiations with local communities because in their patent applications they normally do not ascribe any contributions to the drug discovery to local providers (Mulholland and Wilman, 2003: 431).

CBD-conformity: Contracts on bioprospecting and the subsequent use of biogenetic resources between local providers and private firms in literally every case contain royalty agreements, but these are often combined with other forms of benefit-sharing. As mentioned above, pure royalty solutions will rarely suffice to achieve the CBD's goals of preserving biodiversity and redistributing benefits to favour the poor. While the idea of royalties as agreements allowing providers from host countries to share the monetary profits accruing from products based on their inputs is in accordance with the CBD, royalties in reality often fail to attain this goal because specific characteristics of the pharmaceutical R&D process, especially its long term orientation, are widely ignored.

5.2 Salaries

Several steps in the pharmaceutical production process chain can take place in the source country of the genetic resources. The employment of staff for different assignments like the collection and processing of samples, the production of raw materials as well as first steps in laboratory research (for example for guaranteeing the constant quality of the compound) has become an increasingly popular form of non-monetary benefit-sharing. The main objective of this form of benefit is to assure the re-supply of raw materials. Depending on the grade of synthesis of the final product the need for raw material can mount up to several thousand kilograms cumulatively for the full extraction and development of the active compounds.[xvi]

Allocative effects: As briefly mentioned above, salaries will tend to bring about significant allocative effects, because they may prevent land users from cultivating their parcels of land, especially if they have a high time preference rate. Obviously, the payments a landowner gets from a firm will depend on its expectations concerning the commercial success of the final product. If payments are high enough and if the firms are interested in an ongoing extraction of genetic resources, salaries may contribute to a sustained conservation of biodiversity. If firms' discounted profits of products based on genetic information extracted from the land parcel are too low to compensate the landowner by paying him a salary, the land will be cultivated. The same will happen if salaries are too low for 'marginal' landowners, in case of supply competition between them. Here, only landowners with fertile land, that is with income expectations which exceed payments offered by firms, will cultivate. Thus, private information at a given moment leads to optimal land use. With its willingness to pay a salary, say, to a collector of samples, the firm expresses that it accepts the collector's right to sell the sample. Thus, even under ill-defined property rights, salaries may create 'surrogate' claims for providers, but if they compete with each other for supplying the firms with recourse to uncultivated land with an unclear ownership structure, salaries will tend to be low. Obviously, a common pool-situation prevails here. But even low payments may induce some, yet small, preservation effects, if investments into agricultural use are risky under these circumstances.

Yet, the problem of irreversibility can hardly be circumvented with private salaries: From a global perspective, one regularly has to expect that a piece of uncultivated land bears undiscovered genetic resources that are not yet part of firms' private R&D- and production plans, and consequently are not integrated into their profit expectations. As by definition the number and potential of all plants will always exceed that of the discovered plants and their active ingredients, firms' WTP for salaries (that is: its private incentives) will be systematically too low to allow for optimal prevention.

If private salary payments are combined with payments from third parties (the state, NGOs etc.), other problems will emerge. Obviously, salary payments of this kind may help to make salary-based incomes converge to the optimal preservation level, but firms may be incited to free-ride on the third parties' WTP and reduce their own salary payments. Theoretically, salary payments from third parties may even lead to a super-optimal engagement in bioprospecting and too little cultivation of land, because third parties also lack information about the 'true' value of the genetic resources that can be extracted from a piece of land.

In general, paying salaries to local providers of samples or services is nothing but factor procurement. Usually, factors will be paid wages determined by their scarcity and negotiation power. If local suppliers have comparative advantages compared to others, for example if their knowledge about active ingredients or laboratory services are less costly to acquire than analogous information generated by in-house-R&D, it is rational from the firms' perspective to procure these inputs locally anyway. Thus, salary agreements are likely to occur even outside conventions like the CBD, which can only make a difference if it makes firms pay salaries higher than 'pure market'-salaries. In this case, however, firms will be provided incentives to return to in-house activities or procurement of factors not made expensive by CBD rules. In other words, an increase in prices for the procurement of local factors of production tends to partially deprive them of their comparative advantage.

Distributive effects: As mentioned above, primarily the poor would cultivate the land if they did not receive any immediate compensation for their income losses. Thus, if a firm pays salaries for simple bioprospecting activities, they may often address people with low qualification levels and thus low incomes (for example collectors). Consequently, salaries may be found desirable under the goals of the CBD. If a firm is interested in ongoing long-term bioprospecting, salary payments (to the poor) will also be paid under 'free market'-conditions nonetheless. It might be useful to distinguish between salary payments made to procure low qualified labour and payments for more complex services when employing skilled labour, like laboratory research and raw material production. Again, the fact that these payments are made allows no conclusions about their distributive character compared to a 'pure market'-outcome, especially since local providers of skilled labour, like laboratories, producers of raw materials etc. may simply make use of their comparative advantages, like lower labour costs.

A discussion about distributive effects of salaries must not ignore potential side effects typically caused by tenurial regimes (Barrett and Lybbert, 2000: 297-298). First, the ability to gain advantages from salary payments offered by firms to landowners or persons having access to genetic resources may be unequally distributed among local populations, that is the powerful will normally find ways to crowd out the poor in order to extract windfall profits from salary payments (Platteau, 1996). In addition, growing demand of the biotech industry for some factors of production will increase their prices while other (local) producers who also have to rely on the same factor inputs (for example local light manufacturing) will incur disadvantages due to the price increases. Changes in prices induced by industrial demands from abroad will of course alter the distribution of incomes in the host country in favour of those who have access to the desired resources. As a consequence, disparities in income distribution may even aggravate and worsen (perhaps even in absolute terms) the position of the 'asset poor' (Carter and Barham, 1996), potentially even while the host country's economy as a whole enters a growth path.

Feasibility: Normally, salaries can be implemented easily. Employment of local staff is and has always been common practice for firms, which intended to make use of biological resources in Third World countries. Complications may only occur if local authorities impose additional conditions to the employment, like minimum wages, requirements to found subsidiaries etc. Again, it might be helpful to distinguish between skilled and unskilled labour force. If skilled labour is needed, salaries will regularly have to be combined with training activities.

Robustness: Compared to other forms of BS-agreements, salaries are robust with respect to changes in the economic situation and structure in host countries, because they solely depend on the firms' commercial interests that are regularly intertwined with local economic developments. Since salaries are paid immediately, there is no room for renegotiating once they are paid. Only if contracts stipulate long-term employment, firms may try to change agreements in the case of unsuccessful prospecting. An example of this kind of firm behaviour is the National Cancer Institute's (NCI's) engagement in Cameroon (Ten Kate and Laird, 1999: 72). NCI had invested in employment, infrastructure and training in Cameroon for the cultivation of *ancistrocladus korupensis* for the re-supply of plant material in order to extract *michellamine B*. This substance finally proved to be toxic which lead to a stall in NCI's R&D. As a consequence, NCI stopped its local activities in this field (Laird and Lisinge, 1998).

CBD-conformity: With regard to CBD's conservation objectives, salaries can be a good solution for the creation of alternative sources of income for landowners, who are provided incentives to refrain from destroying habitats of biodiversity. As salaries are paid immediately, even the poor may profit under certain conditions. But salaries may also evoke tendencies to create monocultures or to over-harvest (sub-)tropical ecosystems in order to secure the re-supply of raw materials. Another negative aspect might be the growing dependence of local communities on the employment by a single firm which is in a monopsonistic position on local labour markets, as was the case with Merck's engagement in Brazil for the collection of the *Jaborandi* leaf. Because salary solutions would also be implemented in 'pure market'-situations, the mere fact that they exist allows no conclusion about their CBD-conformity in the sense that they bring forth 'fair and equitable' sharing of benefits. As far as the CBD's third objective, the building of capacities in host countries is concerned, salaries are an appropriate tool given that they are combined with other forms of benefit-sharing, such as information and technology transfer and training.

5.3 Information exchange

Information exchange is a common form of benefit-sharing applied by the parties involved in bioprospecting activities. It includes the provision of research results among the contracting partners. The information being shared can have different forms. Information can include scientific data about the source country's biodiversity, for example for biodiversity inventories, research results or other information on the research topic, and the provision of technical or scientific literature.

Allocative effects: Obviously, allocative effects of information exchange differ depending on its form, that is allocative effects depend on the host countries' abilities to make use of information provided to them.

If the host country is given edited data to complete its inventories, or information about effects of active agents existing in plants, it might be relatively easy for it to commercialise the information received. For example, knowledge about active compounds found in an initial research project may be sold to third parties. In this case, the firm that participated in the initial research project ('incumbent') possibly creates positive externalities with respect to firms ('entrants'), which are willing to 'buy' information from the completed inventory. From the allocative viewpoint, this is a desirable effect, because information diffuses at a cost that is lower than that an entrant would have to expect if it did bioprospecting by itself. Still, even in this case, an incumbent may involuntarily cause cost reductions for other firms, for example by facilitating search processes. Possibly undesirable externalities are created if critical information from incumbents diffuses through host countries to *competitors*, that is, if incumbent and entrant are both interested in the same genetic information. If firms have to fear that critical information leaks out to competitors, they will be reluctant to give valuable information to host countries in information exchange agreements. This is usually agreed upon in detail ex ante in the framework of BS contracts.

Host countries in several cases will need a sufficient 'absorptive potential' to be able to extract profits from the information. As resources in host countries are usually scarce, directing them towards investments (for example research laboratories, qualification of scientists and highly skilled workers etc.) that are complementary to the information received will regularly not be an option to them and will require support from abroad.

Distributive Effects: Depending on the kind of information exchange, distributive effects will differ significantly. In many instances, information exchange will have a regressive rather than a neutral or progressive influence on distribution. Of course, if, say, poor or indigenous people are provided with knowledge that can be harnessed for medical treatments with local plants or for agricultural uses etc. in most cases, it will be governments or firms in the host country who will benefit from the information transferred. Information transfer solutions may also be agreed upon in 'pure market' situations, as parties will regard information exchange as a simple market compensation for resources extracted in host countries. Because information, for example in the form of taxonomic classifications, is inevitably generated as a by-product in R&D-processes, it could be particularly attractive for firms to offer this information to their partners in host countries.

Feasibility: Theoretically, it may be complicated for the contracting parties to specify *ex ante*, which information has to be transferred in the end, because the discovery of information is the purpose of the project. Thus, contracts on information transfer will always be incomplete. Therefore, the parties may choose to classify different types of information to be transferred or the forms of transfer. For example, the parties may agree not to transfer information, which is critical for competition. Or the parties may covenant to convey only aggregated information, which is difficult to decompose for third parties.

Robustness: The mere transfer of information gained from R&D projects is robust with regard to economic shifts in host countries. Only individual abilities to make use of information may alter with shifts of the economic situation.

Because the contract is inevitably (highly) incomplete and stipulates the conveyance of information still to be discovered, and because the R&D-process leaves the delivering side better informed, it is infeasible to limit the space for opportunistic behaviour by contract penalties. Only if the discovered information and its classification (for example competitively critical/not critical) are agreed common knowledge there will be no ex post bargaining.

CBD-conformity: Information exchange may be an appropriate means to support the building of local capacities like research and development institutions or biodiversity inventories. This obviously would be in accordance with the CBD. Yet, the exchange of information does not necessarily favour the poor and may even bring about regressive effects. Contracts stipulating information exchange do not tend to be particularly renegotiation proof and may invite opportunistic behaviour. However, the conveyance of competitively uncritical information is probable. As information exchange may reduce costs for biodiversity inventories it also makes their utilisations less costly. For instance, the definition of nature reserves may be facilitated, if biodiversity sources and their localisation are known from inventories. In addition, the host country may learn about the economic potential of biogenetic resources and can make decisions based on better information about the preservation of genetic resources in light of reduced uncertainty. As a consequence, information exchange may contribute to biodiversity preservation – again, under advantageous circumstances.

5.4 Technology Transfer

Technology transfer includes the transfer of specific equipment needed for field collection as well as for laboratory works and office duties. The equipment can include almost everything needed for the production process in the source country (like for example lamps, nets, cooling boxes, milling machines, freeze dryers, computer software etc.). In addition, special equipment for inventories or collections (for example plant presses, solvents etc.) can be transferred to the host country. It is advisable to differentiate between sophisticated and simple technologies and to ask for the ownership structure and for the distribution of the rights of disposal of technologies transferred.

Allocative effects: Compared to other forms of benefit-sharing, allocative effects of technology transfer may be particularly pronounced as they offer the best opportunities for the establishment of capacities in the host country. The time lag here is not as problematic as it is with other forms of benefit-sharing, because technology is normally transferred in an initial phase of the collaboration.

In any case of technology transfer the supplier of genetic resources is enabled to work with the technology transferred, but this does not necessarily mean that he controls or even owns it. The way technology is transferred can take different forms. Especially if it is highly sensitive or costly, firms will be reluctant to pass equipment to unskilled local staff. In cases like this, technology is likely to be withdrawn from the host country after the termination of the project. Thus, especially when highly sophisticated equipment is employed, local providers will have only very limited access to recent technology. As a consequence, local diffusion effects are likely to remain confined to rather simple technologies.

Of course, the application of recent technology enhances efficiency in the supply phase. If firms decide to transfer (recent) technologies to host countries, they obviously try to profits from comparative advantages of these countries, that is, they want to exploit local resources more efficiently or use opportunities to employ inexpensive local labour force. But again, the transfer is nothing but an activity to enhance the productivity of a preliminary stage in the value added chain (if providers are handed over technologies) or even an extension of the vertical range of manufacture (if firms keep property of and control over technologies). Thus, only under limited conditions technology transfer can be classified as a form of benefit-sharing.

Distributive effects: Especially in the case of sophisticated and expensive technology usually only a small part of the value added created by the new technologies will accrue in host countries. Here, local factors of production will only profit from technology transfer if their skills are complementary to the technologies transferred. As it is unlikely that the poor will have the skills complementary to sophisticated technologies, their transfer will probably yield regressive distributive effects. If low-tech solutions are transferred and if equipment is not withdrawn after project termination, locals may profit from the transfer. If the transferred technologies are characterised by high asset specificity it probably does not pay for firms to withdraw equipment from host countries due to high sunk costs, even before the depreciation period has ended. Thus, it may be hard to distinguish between a benevolent transfer of technologies to host countries beyond the immediate necessities of the project and technologies remaining in host countries due to an economic calculus that would have been made anyway.

Feasibility: In general, feasibility is not a significant problem with technology transfer, because it does not require much organisation and the implementation is rather simple, esp. in contrast to information exchange.

Robustness: Technology transfer is robust with regard to political changes, as technological knowledge will not disappear when circumstances change. But in many instances a successful technology transfer will depend on the technology remaining installed in place for some time. If technological installations and qualified staff can be withdrawn easily in times of political turmoil the transfer process will be interrupted. The same may occur if projects prove to yield disappointing results. But withdrawal is costly if equipment is characterised by asset specificity, that is firms have to face substantial sunk costs in case of political instability, exposing themselves to hold-up situations. Consequently, irreversible forms of technology transfer will only be carried out if the technology transferred is expected to remain untouched. If control over transferred technologies remains in the hands of firms, there is almost no room for unwanted technology diffusion, which will remain limited anyway. Cheating to the detriment of firms is almost excluded in such situations. If locals can have the right to dispose technologies and facilities, firms may lose the ability to restrict unwanted forms of technology use.

CBD-conformity: In general, technology transfer allows the building of capacities in host countries for activities like the development of high-quality extracts, the use and development of new screens, the replication of hit extracts, identification and isolation of lead compounds or even the setup of medical chemistry and drug development capacities. The extent to which technology transfer contributes to the preservation of biological diversity cannot be delineated a priori, because it depends on the concrete terms of an agreement. If improved technology allows a host country to reap a larger share of value added from bioprospection and subsequent pharmaceutical production, it will of course create incentives to preserve genetic resources. As in most instances technology transfer agreements will be rather efficient forms to enhance productivity of upstream 'industries' (that is providers from host countries) or even to expand the vertical range of manufacture, it is likely that higher shares of the value added will accrue in the host countries, especially in the segment of skilled labour, while the poor may hardly be able to benefit from transfer arrangements. As technology transfers are likely to occur also in 'pure market'-situations and as distribution results are difficult to attribute to technology transfer, the specific effect of the CBD in technology transfer agreements is hard to identify for the poor in the country, although the income of the country as a whole may rise. This implies that there may be some factors of production which gain superproportional profits, for example if they are equipped with complementary skills.

5.5 Training

Training in the sense of research collaborations between pharmaceutical firms and suppliers of genetic resources can take different forms, like short- or long-term training programmes. The staff of the source country can be trained in scientific disciplines relevant for all steps of the development of a new drug. From rather simple skills like collecting techniques up to complete trainings on specific aspects of biochemistry or microbiology, pharmaceutical companies can offer a broad variety of possibilities to integrate local staff into the production process. Other needful disciplines can be resource management[xvii] and information management, for example in the sense of establishing biodiversity inventories or the management of herbariums.

Allocative effects: In general, training will be efficient, as given investments in human capital in host countries will usually yield strong increases in labour productivity. If the knowledge acquired is generic, that is if it is not firm specific and not losing (parts of) its value when applied elsewhere, it may diffuse easily through the host country. If suppliers have a high time preference rate or are risk averse, they will often like to choose training measures, especially if they can acquire knowledge and skills they can use elsewhere, thus raising the prices their labour force can command on labour markets. Individuals who have been qualified by training measures will have no particular interest in the maintenance of a specific piece of land, because they do not have to fear that their human capital will depreciate if the piece of land is cultivated, but they are not interested in cultivation if the value of their labour force depends on the availability of land that is suitable for bioprospecting. Again, the implementation of training measures is self-enforcing and would occur independently of the CBD, because it is advisable for firms to invest in the productivity of factors of production procured if they possess comparative advantages.

Distributive effects: Empirically, most of bioprospecting-related training measures aim at improving the productivity of low-level activities requiring low qualification levels, like for example sample collection or first steps in materials processing. As these activities are usually carried out by people with low incomes, training measures will regularly yield desired distributive outcomes. In the field of highly qualifying training, firms will tend to rely on their own staff because of secrecy and competition reasons. In addition, comparative advantages of local populations tend to be less pronounced here, as they will often lack appropriate educational backgrounds. Highly qualifying training measures are more likely to be observed in cases of long-term trustful co-operations.

Feasibility: Especially in the field of training measures for low qualified workers, feasibility is very high. Otherwise, the situation is very similar to that of salaries. More than that, in many cases firms will prefer to qualify external staff because of lower costs rather than using their own capacities.

Robustness: The robustness of training measures is comparable to that of salaries. Once training measures are completed, there is no room for renegotiations as the trained individual cannot be deprived of his qualification. On the other hand, firms cannot be manoeuvred into hold-up positions because critical knowledge is almost never transferred and qualification measures can be carried out easily, especially, of course, in the field of activities requiring limited skills.

CBD-conformity: In economic terms, training is nothing but a measure to enhance the productivity of an upstream stage in the value added chain or a measure to increase the productivity of factors of production procured by firms. A priori it is by no means guaranteed that training will intensify incentives to maintain genetic resources, especially when qualifications built up by training are generic. Only if better skills allow landowners to extract a higher income from uncultivated land, incentives to maintain biodiversity may be intensified. Progressive distribution effects may occur if predominantly recipients of low incomes are subject to training measures. Again, training is regarded as a measure for the quality enhancement of largely unskilled labour force and effectuates high marginal productivity increases. It is highly self-enforcing under free-market conditions and does not require additional political backing in order to become implemented.

Table 1 gives an overview of different forms of agreements and their effects.

- TABLE 1 HERE -

6. Conclusions

The Bonn Guidelines envision some typical contractual forms said to be applicable for the achievement of the goals of the Convention on Biological Diversity (CBD). We ask whether these forms are indeed suitable. In addition, we discuss if outcomes achieved by the application of typical contractual forms of benefit-sharing differ from the self-enforcing results of decentralised decisions to contract by agents in free markets. That is, we ask whether the Bonn Guidelines create 'additionality' with respect to the goals of the CBD. If self-enforcing contracts attain the CBD's preservation and redistribution goals, the CBD is dispensable. We find that in some instances contractual BS-arrangements indeed contribute, at least partially, to the CBD's aims, however, all of them had already resulted from decentralised negotiations between market agents before the CBD was in power. Yet, many arrangements mentioned in the Bonn Guidelines create incentives which are not in line with the CBD because they hardly enhance agents' willingness to leave land untouched or do not bring about distributive outcomes as demanded by the CBD. Only if some typical contractual forms are combined (for example royalty payments and salaries), desired outcomes become more likely. In general, it must be said that the conditions for typical contractual agreements (as mentioned in the Bonn Guidelines) to bring about the results that are demanded in the CBD are very restricted. More than that, an application of the contractual forms mentioned hardly brings about additionality in the sense of going beyond 'free market'-solutions. This is not surprising if one keeps in mind that the Bonn Guidelines refer only to *existing* forms of 'benefit-sharing' having emerged on markets for genetic resources. Thus, in many instances what is called 'benefit-sharing' will hardly bring about more than efficient solutions to the firms' procurement problem of input factors. From an economic perspective it is difficult to delineate conceptions like 'fair' or 'equitable' sharing of benefits, but if observed contracts stipulate distributive outcomes that would not have emerged under 'free market'-conditions, one has to ask for the contract's efficiency. In our view, it is incorrect to characterise contracts *per se* as being in line with the CBD only if they are of a type mentioned in the Bonn Guidelines. The applicability of individual forms of benefit-sharing largely depends on institutional settings; their effectiveness and efficiency strongly differ.

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Criteria / Type of BS -arrangement	*CBD-conformity*	*Allocative effects*	*Distributive effects*	*Feasibility*	*Robustness*
Royalties	Often applied BS-instrument; CBD-conformity hard to achieve without complementary means	allocative efficiency unlikely	Difficult to observe, progressive results to be assumed in case of significant revenue shares to be paid to host countries	Substantial transaction costs possible as decisions must be made based on information being highly uncertain	Robust with regard to political circumstances, but strong incentives to re-negotiate
Salaries	Effective instrument, but may also lead to mono-cultures or excessive harvest of promising samples; instrument often implemented in 'pure market'-contracts as well	May induce immediate decisions on cultivation or use for bioprospection, depending on firms' WTP; problem of salaries being systematically too low for prevention due lack of information about undiscovered resources	Can induce desired distributive effects, but these might be brought about in 'pure market'-arrangements as well. Tenurial regime is important; firms often in monopsonistic position in local labour markets	Easy to implement	Once paid, they are obviously highly robust; in case of long term employment re-negotiation possible.
Information exchange	May support building of local capacities esp. in R&D, conveyance of critical information depends on framework conditions	Effects depend on kind of actors gaining profit from positive externalities (competitors or third parties) and incumbent firms' ability to control information diffusion	Effects depend on kind of exchange, but danger of regressive distribution effects	Contracting on information transfers complicated, contracts will be highly incomplete	The mere transfer is rather robust but the individual possibilities of using the information highly depend on economical and political circumstances
Technology transfer	Generally given	Depending on the degree of sophistication of technologies and local absorptive capacities; transfer of recent technology is generally efficiency enhancing	Mainly skilled local factors of production will profit, that is highly skilled labour force	Easy to implement	Robustness is not given when equipment and qualified staff can be easily withdrawn from host countries
Training	Esp. in case of generic skills the incentives for biodiversity maintenance are vague	Will in general be efficient due to strong increases in labour productivity	Depend on the labour market segments being subject to training measures, increasing wages of trained personal	Very high, situation similar to that of salaries	Very high as individuals can not be deprived of their qualifications

Table 1: Different effects of benefit-sharing: overview.

[i] United Nations, 1992.

[ii] The aspects of access to biodiversity and of benefit-sharing out of its utilisation are both usually dealt with within one contract, the so-called ABS-agreement. In this article we focus on the benefit-sharing aspect.

[iii] The well-known case of the *Catharensus roseus* of Madagascar is a classic example. The bioactive compounds of this plant were discovered by scientists of Eli Lilly Pharmaceuticals with support of a local indigenous healer in the early 1960s. Two blockbuster drugs, *Oncovin* and *Velban*, were invented which based on the genetic information of the plant. Neither the state of Madagascar nor the indigenous group involved in the discovery process have ever been compensated.

[iv] Ten Kate and Laird, 1999: 40-43.

[v] For example if a supplier can provide samples in combination with traditional or scientific knowledge or other cost-reducing information or services for the pharmaceutical firm (Artuso, 1997).

[vi] To be precise: there are also cases in which not only the information included in genetic resources of plants flows into the production process but also the bioactive compounds as tradable goods themselves.

[vii] As mentioned in Appendix II of the Bonn Guidelines for an overview of the suggested forms of benefit-sharing. See Rubin and Fish, 1994: 49 ff. for a more detailed description of the different forms of benefit-sharing.

[viii] In general, the demand curve for samples of genetic resources is downward sloping (Simpson, Sedjo and Reid, 1996).

[ix] It is said that there is only one potential hit among roughly 10.000 compounds tested (McChesney, 1996: 12).

[x] An example is the case of *Pilocarpus jaborandi* in north-east Brazil, where excessive harvesting of wild populations and the local community's dependence on commercial production were the negative consequences of a bio-prospection which at first had appeared to be successful (ten Kate and Laird, 1999: 73).

[xi] See Decision III/15 "Access to genetic resources" of COP III. (available at http://www.biodiv.org)

[xii] See Bonn Guidelines: Appendix II. (available at http://www.biodiv.org)

[xiii] See: 'Synthesis of case-studies on benefit-sharing' of the CBD's workgroup on access and benefit-sharing and ten Kate and Laird, 1999: 64.

[xiv] Very seldom and only applied at later stages of the R&D process, the royalty can mount up to 15 per cent of the net sales of the final product.

[xv] As there will hardly be any situations in which the entire potential of an allotment's plant population is known in advance, utilisation complementarities (extract samples first, then change to agricultural use) are unlikely to occur.

[xvi] For the preclinical and early clinical studies on Taxol about 7.000kg of raw material was required. For further clinical phases the annual quantities needed were as much as 27.000kg (ten Kate and Laird, 1999: 72).

[xvii] A form of training that is not often stipulated in bioprospecting contracts.