UNIVERSITY OF
CAMBRIDGE

Department of Land Economy

Environmental Economy and Policy Research

Discussion Paper Series

Biodiscovery and Intellectual Property Rights: A Dynamic Approach to Economic Efficiency

by

Tom Dedeurwaerdere, Vijesh Krishna and Unai Pascual

2005

Number: 13.2005

Biodiscovery and Intellectual Property Rights: A Dynamic Approach to Economic Efficiency

Tom Dedeurwaerdere[a], Vijesh Krishna[b] and Unai Pascual[c]

[a]Centre de Philosophie du Droit (CPDR), Université Catholique de Louvain, Belgium
[b]Faculty of Agricultural Sciences, University of Hohenheim, Germany
[c]Department of Land Economy, University of Cambridge, UK.

Abstract

This paper examines the use the use of economic incentives for knowledge generation through biodiscovery, in the particular case of the use of a highly valuable biogenetic resource stock from the South for industrial/research input. The focus is on a dynamic approach to contracting and property rights building upon insights from institutional and ecological economics. Two important conclusions come out of this analysis. First, it highlights the necessity to go beyond standard market approaches to economic valuation in order to address the issues of future possibilities of use and innovation and the integration of the different stages in the process of value creation. Second, it shows the necessity of developing alternatives to the current intellectual property rights regime, including systems for appropriate protection of the traditional knowledge of local communities

Keywords: Bioprospection, genetic resources, traditional knowledge, Kani model, benefit sharing

Address for correspondence

Dr. Unai Pascual
University of Cambridge
Department of Land Economy
19 Silver Street, Cambridge CB3 9EP
United Kingdom
Tel: + 44 (0) 1223 337151
Fax: + 44 (0) 1223 337130
e-mail: up211@cam.ac.uk

1. Introduction

There is a significant strategic interest by ‘Northern’ industries of accessing and using genetic resources (GR) and associated traditional knowledge (TK) from the South as repository of a highly valuable bioresource stock that co-evolves through the development of TK and the continuous GR refinement adaptations in natural and managed ecosystems. The debate over ownership, intellectual property rights, and of and access to GR and associated TK that shape biodiversity were crystallized in the negotiations of the United Nations’ Convention on Biological Diversity (CBD) which entered into force in 1993. The Convention establishes a legal framework for the reciprocal transfer of biological resources between countries (Bhat, 1999).

The Convention regulates bioprospecting activities by northern firms and it now stands as the only major international negotiated instrument that makes explicit provisions for the special link between TK, biodiversity and local and indigenous communities by granting rights to protect TK to the latter (Bodeker, 2000).[1] It assigns a formal protocol for sharing the benefits from GR and in so doing asserts the property of the bioresources to the source country. In addition, the standard recommended protocol is the access and benefit sharing (ABS) agreement to GR (and TK when applicable) between the parties in bioprospecting activities. It also calls for a *free prior informed consent* to be obtained from the holders of GR and TK before bioprospecting activities take place.

In order to evaluate the potential contribution of benefit sharing systems to the welfare of local communities and others, a number of studies have focused on estimating the value of bioprospecting using a wide array of approaches (Principe, 1989; Pearce and Purushothaman, 1992; Simpson *et al*, 1996; Rausser and Small, 2000; Craft and Simpson, 2001). Broadly speaking, these studies assess the value of bioprospecting using a standard cost-benefit analysis framework, in which the opportunity cost of land conservation, among others, is weighted to assess the expected benefits related to the discovery of a new useful property (net of the associated R&D costs such as biological material screenings). However, one can ask whether such a framework is appropriate for the economic valuation of the complex biogenetic-TK system.

The CBD acknowledges that when effective access and benefit sharing systems are removed, it creates desincentives for in-situ conservation of such bioresources. In many instances the rights of GR and TK holders, including the source country governments and indigenous communities are being erased and replaced by those who have exploited their biogenetic resources and TK prospecting endeavours. Such cases of *biopiracy* are being reported more frequently (Sheldon and Balick, 1995; Shiva *et al*, 1997; Drahos, 2000;

[1] The rather recently ratified UN Convention on Desertification (UNCCD) also makes explicit such provisions. Interestingly such provisions are included directly in the UNCCD text, while the CBD itself becomes more detailed in the later, and still non-binding, Bonn guidelines. The FAO International Treaty on Plant Genetic Resources for Food and Agriculture, adopted in 2001, also makes explicit this link. However it covers only the plant genetic resources for food and agriculture and the Treaty only attributes to the local communities the right to “participate to the decision making processes on the national level”. Moreover the access and benefit sharing provisions become only legally binding if transited into national legislation.

Dutfield, 2002; Verma, 2002). Against this backdrop, the debate on the conflicting approaches to intellectual property rights (IPR) with regard to domesticated and wild bioresources and TK is re-emerging in order to devise ways of defensive protection against the misappropriation by developers and bio-prospectors of biogenetic resources and the TK that 'holds' them and to design innovative means for positive protection (Dutfield, 2002). In particular, new insights to the debate are coming from contemporary economic analyses of contracts and property rights. These analyses are typically interdisciplinary in character, using tools from evolutionary and institutional economics to ecological economics and economic ethnobotany. The challenge is to build concepts that are better adapted to the specific character of the biological resources, and hence to take into account their evolving nature and the collective character of the associated knowledge of the behavioural properties.

A common point in such analyses is the added difficulty due to the diffuse character of the values, both monetary and non-monetary, created by biodiversity within evolutionary socio-ecological systems. Swanson (2000) argues that added value of biological resources is created at each step of the innovation process – from the ecosystem itself creating the natural diversity, through the contributions of the local communities and research laboratories to industrial applications, and not only at the final stage of the innovation process. The existing intellectual property mechanisms only address the top of the iceberg – the property associated to the final stage of this mechanism – and remains insufficient as a mechanism for rewarding and valorising the other stages (Goeschl and Swanson, 2002; Laird, 2002). Furthermore, it is also claimed that the current IPR mechanism remains insufficient for addressing other social values associated with the flow of resources and information generated by biodiversity (Brush, 1996). For instance, in the case of TK, IPRs may conflict with the collective nature of indigenous knowledge and the importance of cultural and religious values towards nature. This problem calls for a more differentiated approach towards institutional mechanisms for promoting conservation and sustainable use of bioresources. For instance, in the case of biodiscovery they include the financing of biogenetic resource conservation by research institutions such as the International Plant Genetic Resources Institute (IPGRI) and community management of risk in agrarian societies based on a system of reciprocity allowing for the preservation of a high level of agrobiodiversity (Brush, 1998).

Under such conditions, it seems more appropriate to adopt a dynamic approach to assess the economic value of biodiversity (Dedeurwaerdere, 2004). Such an approach incorporates the idea of bounded rationality and a broader vision of economic rationality (Driesden, 2003), alongside the dynamics of economic and cultural change outside the view of a static equilibrium situation (North, 1990). Accordingly, in this approach, the focus shifts away from a narrow concern about the optimal allocation of existing resources, to a concern about issues of adaptive efficiency, such as knowledge acquisition throughout the entire process of value creation and incentives for the preservation of future possibilities of innovation and use under conditions of uncertainty. By arguing in favour of such an approach, a new set of questions are introduced into the debate, which have to be solved in the implementation of any governance mechanism that is adopted, be it of a market, a community or public nature. That is, the question regarding the creation of institutions for coordinating the diversity of social values associated with biodiversity and the enabling of collective learning processes in a situation of intrinsic uncertainty is crucial for any mechanism that aims at valuing the diversity of GR and associated TK through biodiscovery. In order to elaborate such a framework for biodiscovery, an analysis of the full chain of innovation playing a role is necessary. This makes it possible to address the role of the ecosystem, the cultural role of local communities, the research community and of private companies in a comprehensive manner. This chapter attempts to analyse the shortfalls of the static approach to the issue of benefit sharing agreements (or monetary compensation through current IPR approach) to the holders of valuable GR sought by bioprospectors.

In order to discuss how to approximate the idea of the monetary value of bioresources in the context of a biodiversity–TK system from the TK holders' perspective, a case study of a unique biodiversity contract in South India is employed. This allows to point towards the gaps in the existing benefit sharing contract system from an evolutionary perspective. With approximately eight percent of the world's biodiversity, tropical India is a veritable emporium of medicinal herbs. Coupled with the therapeutic knowledge of the local indigenous communities it poses an ideal background for bioprospecting endeavours. A widely acclaimed benefit-sharing scheme evolved in one of the two biodiversity 'hotspots' of India, the Western Ghats, and is now famously known as the Kani model of benefit-sharing (KMBS) (Anuradha, 1998; Moran, 2000). This model of benefit sharing is the first instance in which payments have been made to the TK holders for a successfully developed pharmaceutical product with therapeutic properties.[2] This is based on *Trichopus zeylanicus*, a small perennial herb that is distributed in Southern India, Sri Lanka and Malaysia with the subspecies *Travancoricus* only being found at an altitude of around 1000m in India (Anuradha, 1998). After the incidental 'discovery' by a group of scientists of the therapeutic properties of the herb, the local Botanical Garden formulated a herbal tonic to bolster the immune system and provide energy known as *Jeevani*. Then the production technology was transferred to an Indian pharmaceutical company for its commercialisation and the company agreed to compensate the Kani community through the intermediation of a locally established Trust.

In this chapter the KMBS is evaluated from the point of view of a dynamic approach to economic efficiency. We use both qualitative and quantitative data, coming from field interviews and a contingent valuation survey, to show the necessity of an institutional design that can address the integration of the plurality of social values that play a role in the different stages of any biodiscovery endeavour. By addressing the gaps of the static framework, we draw some implications from the adoption of a dynamic framework regarding the valuation of TK and related GR through biodiscovery.

2. The Kani model of benefit sharing (KMBS)

The Kani community comprises around 18,000 people spread across 30 settlements and villages in the forests of the Agasthiyar Hills of the Western Ghats in Kerala. This area is

[2] The Kani Model of Benefit Sharing (KMBS) received the Equator Initiative award from the UNDP for developing a novel benefit-sharing model, during the World Summit on Sustainable Development at Johannesburg in 2002.

designated as a reserved forest, rich in biodiversity and strictly regulated by the Forest Department of the State Government. Traditionally, the Kanis have consumed a dry fruit from *T. zeylanicus* to reduce fatigue (Pushpangadan *et al*, 1988). [3] The ‘discovery’ of the therapeutic properties of the herb, *Trichopus zeylanicus* ssp. *Travencoricus* (locally known as *Sathan Kalanja* or *Arogyappacha*), by a team of Indian scientists visiting the reserve in 1987, laid the foundation for the KMBS. On the basis of this discovery, the Tropical Botanical Garden and Research Institute (TBGRI) in Kerala standardized a herbal as tonic to bolster the immune system and provide energy known as *Jeevani* (’*provider of life*’) and formulated with *T. zeylanicus* in combination with three other medicinal plants. In 1996 the production technology was transferred to an Indian pharmaceutical company, Arya Vaidya Pharmacy Coimbatore Ltd (AVP). The TBGRI licensed *Jeevani* to AVP, while it agreed to share the licence fee and royalty with the Kani community on a 1:1 basis.[4] This was then followed by the creation of a local Trust Fund for the Kanis known as the ‘Kerala Kani Community Welfare Trust’, first registered with members from the Kani tribe. The amount due to the Kanis was transferred to the Trust with the understanding that the share of the licence fee and the accrued interest and royalty would be in the form of a fixed asset of the Trust used for welfare enhancing activities of the Kanis (Sahai, 2000).

The proliferation of domestic and international markets for *Jeevani* necessitated regular supply of fresh leaves of *T. zeylanicus*. Since the wild collection was both inadequate to meet the market requirements and could create ecological overexploitation due to being habitat-specific (the therapeutically active compounds are produced only when the herb is cultivated in and around its natural habitat), AVP proposed a plan for the cultivation of *T. zeylanicus* to the Kerala Forest Department and the Tribal Welfare Department. According to this plan, the AVP would pay the Kanis initial seed money for the cultivation of the plant and enter into a buy-back arrangement with the Kanis to buy the leaves harvested from the cultivated plants. The firm was prepared to buy five tonnes of leaves per month and in 1996 the TBGRI trained 50 Kani households for a pilot level cultivation season by availing a subsidy of Rs 1,000 (about $US 22.25) per household.

Due to the lucrative nature of *T. zeylanicus* leaf sale, the local community started collecting the whole plant from its natural forest habitat, ultimately the Forest Department, part of the State Government, proscribing the cultivation fearing the extinction of the species.[5] After six years of negotiation, in 2003 the Forest Department issued consent to cultivate the herb and the Kanis were in a position to bargain for a better price for their produce. However, the contract with the pharmaceutical firm lasting only for another six months, made AVP unwilling to negotiate a new price contract for the produce.[6] The monetary benefit flow from the KMBS is illustrated in Figure 1.

[3] The phytochemical and pharmacological studies of *T. zeylanicus* revealed the presence of certain rare glycolipids and non-steroidal polysaccharides with profound adaptogenic, immuno-enhancing, antifatigue properties, and subsequently five process patents were filed on behalf of the Regional Research Laboratory (RRL).

[4] The conditions for the technology transfer agreement specify a total licence fee of Rs 1 million (about US$ 23,000) and a royalty of 2 % on ex-factory sale of the product.

[5] TBGRI tried with only limited success to develop a propagation technique through tissue culture seedlings.

[6] Francis (2004) examines the recent developments the Jeevani case, which is described as "the blatant infringement of an Indian patent by the US-based company". It has been noted after 2001 that Nutriscience

[FIGURE 1]

Despite the universal acclamation of the KMBS, it has not yet achieved its full potential due to various institutional impediments. Whereas the TBGRI as a part of the State Government licensed AVP to manufacture the drug, the Forest Department did not facilitate the manufacturing process (Anuradha, 1998). Hence, improper coordination amidst various governmental bodies made the execution of the scheme to be partial and the Kanis unable to benefit out of their GR and TK wealth.

3. From a static to a dynamic framework in biodiscovery

Under the CBD, biodiscovery is regulated through bilateral contractual arrangements for bioprospecting between private corporations and ecologically-rich states or communities, known as *Access and Benefit Sharing* (ABS) agreements. Such agreements ought to be based on the principles of *Free Prior Informed Consent* to be obtained from the holders of GR and TK and equitable sharing of the benefits arising from the development of commercial applications. Numerous benefit sharing agreements have already been signed (see: Mulligan, 1999; Svarstad and Dhillion, 2000; Peña-Neira *et al*., 2002). The existing mechanisms of regulation of bioprospecting contracts proceed on the two poles of the contractual relationship, the users in the North (mainly the seed and pharmaceutical companies) and the providers of the biogenetic resources in the South (mainly local communities, botanical gardens and government administrations). On the one hand, the contracts aim at providing an incentive for innovation through the IPR on the finished product at the end of the production line. On the other hand, they aim at protecting the providers' rights through the insertion of prior informed consent and access and benefit sharing clauses in the contract.

The 'success' of the KMBS is examined from the point of view of a dynamic approach to the economic institutions of contracts and property rights. This allows to point to some insufficiencies of general approaches to ABS and to identify proposals for their amelioration. The dynamic approach is characterized by first seeking to create incentives for innovation along the entire chain of production, and not only at the end of the line, and secondly aims at realizing the objective of maximizing the future options of development, beyond the question of allocating existing resources. In the broader field of biodiversity governance, there is already an increasing recourse to tools aiming to implement such

Innovations, a US company based in New York, has registered Jeevani under the US Trademark Rules and the product is being freely sold in the US market without the knowledge of TBGRI. It has been pointed out that Nutriscience has been sourcing Jeevani in bulk quantities from Arya Vaidya Pharmacy until 2000. One lapse on the part of proponents of KMBS was that they failed to register Jeevani as a trademark in the US and European markets. Gene Campaign, the New Delhi based NGO which came out openly against this 'piracy' by describing the Nutriscience's act as a deliberate act of theft and misappropriation. On the other hand, it has been pointed out as technically correct "third party trademark protection", which would have generated a much higher share of funds to be shared with the Kani tribe and also to fund future research (Gupta, 2002). The exposure this drug is getting internationally demonstrates the potential that lies ahead. At the same time, this incident might have created a negative attitude in the mind of Kani tribes against the possible bioprospecting endeavours in the region.

dynamic approach. One can think for example of certification schemes monitoring the flow of resources along the process of value creation (Gulbrandsen, 2004; Barber et al., 2003 or of the creation of trust funds dedicated to the conservation of biological diversity

The debate on the necessity to move beyond the ABS provisions of the CBD joins discussions in the social sciences, which have analyzed the insufficiency of new forms of governance that emerged in the 1990s as being linked to an overly simplified conception of the path of application of the norms of regulation, both in economic theory and in the theory of legal regulation. In particular, following an evolutionary economics approach (Nelson and Winter, 1982; Dosi, 1988), the conception of efficiency at work in the emerging regime of ABS can be criticized (Driesden, 2003). Expanding on the theoretical insights of new institutional economics, evolutionary theories propose a broader vision of the economic rationality governing the decisions of both government agencies and businesses, by showing how institutional objectives have to cope with behavioural routines and partial information.

In the context of this debate one can oppose the dynamic conception of efficiency to a static one. The latter conception characterizes the classical economic analysis **of law,** and it is linked to the idea of optimal allocation of existing resources under ideal conditions of perfect rationality. Moreover, it has characterized environmental policy during the last two decades resulting in an intensive application of benefit-cost analysis in the determination of the objectives of environmental regulation and the recourse to economic incentives as the means to achieve these objectives, increasingly through the creation of markets for environmental goods or environmental titles (Pearce, *this volume*; Driesden, 2003). A dynamic conception of efficiency, on the other hand, focuses on the acquisition of new knowledge and new competences allowing to maximize the range of future choices of development processes. Applying the dynamic approach to the case of ABS, one can point to a double limit of the static model of economic incentives.

First, with regard to the process of biodiscovery related to products that are *currently* interesting, the bilateral contract mechanisms considered in the ABS regime remain inadequate. The current mechanism of benefit sharing cannot address the entire innovation chain and the contracts mainly regulate the case where an effective marketable product is developed, which is rather the exception than the rule in most existing contracts, or a specific sector where such a development can seriously be anticipated, as for example in cancer research. By contrast, the reality is that all of those involved in the initial stages of the innovation process are in a period of intense experimentation, knowledge gathering, exchange of materials and information, etc. that is at the heart of biodiscorvery processes with outcomes that are difficult to predict. Innovative biotechnological applications only reach so far because they are standing on the shoulders of giants, e.g., the scientific merits of researchers, the cultural heritage of so many years of traditional seed and other bioresource improvements and the social networks of exchange of knowledge and resources on which so much biodiscovery is based. The point is that biodiscovery depends on initiatives at different stages of the innovation chain that guaranty a permanent flow of creation and regeneration of valuable biogenetic resources.

Solving the problem of the uncertainty on the potential value of these contributions through compensating only the few lucky cases of biological resources that make it to the marketplace is a poor strategy from an economic perspective. Figure (2) represents this problem of uncertainty in the context of the KMBS by adapting the scheme proposed for analysing a four-step industry (Swanson, 2000) to the case of knowledge generation for research / industry input through biodiscovery. Biodiscovery depends on an investment in the resource at the level of (1) ecosystems that produce diversity; (2) communities of local users (traditional farmers, healers, etc.) that co-evolve and manage the bioresource stock; (3) the scientific community doing research into new properties; and (4) product development. At each of these steps, the outcome of the investment is uncertain and, moreover, the investment at each stage is motivated by a broader set of social values than only potential market valorisation.

A second reason for the sub-optimal character of investment in biogenetic resources in the ABS regime is related to the inadequacy of the IPR mechanism with regard to a resource that is itself evolutive (Swanson & Goesch, 1999). In the agricultural field, for instance, the introduction of a productive, competitive seed (i.e. resistant) with regard to pathogens induces an adaptation in the population of pathogens in a way to make them more "aggressive" (Swanson and Goeschl, 1998:7), enhancing the relative fitness of successful mutants adapted to "intensely cultivated crops" (Swanson and Goeschl, 1998:5) or by increasing resistance of the pathogens to pest control technologies (Goeschl and Swanson, 2002:100-103). As a result, the resistance of these newly introduced productive seeds decreases with time and its latent competitive disadvantage needs to be taken care off permanently by adapting the seeds and/or the means of production in reaction to the adaptation of the population of pathogens in the environment. Similar mechanisms operate in the pharmacological field, where one observes for example a decrease in the effectiveness of antibiotics and anti-malarial products (*Ibid.*). Further, the associated traditional knowledge and know-how also co-evolves with the biological resources (Brush, 1996), adding another layer of complexity to the path of generation and use of biological diversity. Yet, the IPR mechanism creates an artificial monopoly for example on a productive seed or an effective drug, in the present, but it does not stimulate the investment with regard to potentially-useful biological resources able to cope with new populations of pathogens in the future. In order to maintain the innovation process over the long term, an incentive for the maintenance of a population of biogenetic resources that are potentially productive in the future needs to be established, thus satisfying the constant need for new innovations which can thwart the dynamics of natural evolution of pathogens.

This double inadequacy of the current incentive mechanism leads to sub-optimal investment in biodiversity as a source of innovation. Following Goeschl and Swanson (2002), one can underline three kinds of insufficiencies that result from BSA regimes, based on incentives relying on the existing IPR mechanisms: First, the IPR mechanism is insufficient for investment in products with a short life span. It creates an underinvestment in GRs with high adaptability. Second, the IPR mechanism creates a trend of monopolisation and is therefore not compatible with the requirements of an innovation process based on diversity. Third, the IPR mechanism acts at the level of individual companies and does not create an incentive to invest in the other levels of value creation whose benefits are diffuse. It produces an underinvestment in the other levels of value creation, particularly at the level of the ecosystem and its local or indigenous users. The interest of demonstrating this triple insufficiency from the point of view of a dynamic approach is to show the necessity of abandoning a conception of efficiency based on a static allocation of resources, in order to progress towards a conception that better accounts for the collective character of the innovation process and the relationship between economic growth and the autonomous dynamics of the natural evolution of genetic resources.

4. Gaps in the Kani model of benefit sharing

The Kani ABS agreement took effect in 1997 under the establishment of the Trust, with the due amount of Rs 519,000 transferred to the account of the Trust (Rs 500,000 as the 50% of the licence fee and the rest was the first instalment of royalty from the sale of the drug, which up to 2003 generated Rs 100,000). The inadequate supply of the leaves of the herb being the reason for the relatively low amount of royalty accrued during this period. Subsequently, the pharmaceutical firm, AVP, began to use a limited quantity of raw drug collected from a another Western Ghat region of the nearby State of Tamil Nadu.

The mode of expenditure of the Trust was decided by majority voting in the Trust, employing the service of two lawyers to help in legal matters. Out of the total interest accrued, Rs 50,000 was awarded to the Kanis under the ABS. Although the major source of income from the ABS would have come from the supply of *T. zeylanicus* leaves for drug manufacturing, the Kanis could only harvest two crops (in 1996, before the Forest Department banned the cultivation due to fear of its over-exploitation). The 50 households who first cultivated the herb witnessed a significant increase in income given the low opportunity cost of family labour. As a result more households began to cultivate in the second season. The price offered by AVP increased from Rs 25/kg of fresh leaves to 75/kg through effective bargaining by the Kanis during the second harvest. The average size of area for cultivation was 0.1 ha which allowed households to generate a net revenue of Rs 1,123 and Rs 849, respectively during the two harvests in 1996 (the Rs 1000 subsidy given by the ITDP being primarily responsible for the higher figure for the first crop).

Had the scheme been implemented according to the proposal by the pharmaceutical firm (in which a monthly demand of 5 tonnes of fresh leaves was anticipated), the community could have earned a minimum of Rs 4.5 million annually at a fresh leaf price of Rs 75/kg. Thus, even without taking into account the associated increase in royalty (due to the increased raw drug supply and resulting higher level of production and sale), the income forgone by the Kanis is significantly greater than what they had achieved. Another question is whether the cultivation in the forest reserve is ecologically sustainable. Moran (2000) has expressed concern over the present system of sourcing *T. zeylanicus*, since there is no information on sustainability studies connected to methods of managing and harvesting the herb. Mere market creation for biodiversity resource need not always facilitate conservation. In fact, in this case unregulated biodiversity prospecting and drug development could speed up the destruction of the resource. The incident of overexploitation of wild *T. zeylanicus* can be noted as an example for this when in 1996 the raw drug price rose from Rs. 25 to Rs. 75 and the subsequent over-harvesting forced the Forest Department to ban the cultivation.[7]

However, the question of the facilitation of biodiversity conservation is not only a matter of methods for managing and harvesting. It points out also to the question of the control and sanction mechanisms for dealing with overexploitation of the wild variety and illegal trade. The ABS agreement with the Kani was established on a voluntary basis and not on a broader legal framework for regulation of bioprospecting, specifying the rights and the duties of the Botanical garden and private companies. In this situation, even with a clear incentive for the tribe members involved in the contract to adopt sustainable management practices, there could be no guarante that other groups would not free ride on the contract through exploitation of the wild variety or, alternatively, that the company would not look for other providers of the same plant under less restrictive conditions.

Moreover, the appropriate protection of the rights of the indigenous community over its traditional knowledge also depends on the existence of such guarantees. In the case of the Kanis, the disclosure of their ethnobotanical knowledge to the Indian scientists was entirely based on trust and good faith. It was based on the belief that they would honour their promise of benefit sharing in case of the development of a new product. Hence, it is not possible to replicate the contract automatically to other situations, where these relationships of trust do not exist. Under these conditions, the incentive to disclosure traditional knowledge for other communities remains limited to situations where personal relations, informal guarantees that their property rights will be protected and that the contract will lead to appropriate benefit sharing exist.[8]

One could also ask if the focus on the issue of intellectual property and the associated benefit sharing has not shifted the attention away from the question of the involvement of other actors in the negotiation of the contract. The contract is the outcome of an agreement negotiated between the TBGRI scientists and AVP, which in turn was initially based on a confidential agreement between the scientists and the Kanis. The property right holders of the physical asset, the forest administration and the members of the tribal community, seem to have been involved only marginally in the drafting of the terms of the contract and the legitimacy of the agreement is not recognized with the same intensity by all the actors. In particular, different perceptions subsist between the younger and the older tribal members, the latter caring more about the loss of cultural identity.[9] This lack of legitimacy may be due to the fact that the focus of the TBGRI has been on the bilateral contractual relationships between the private company and the Kani guides as the original providers of the genetic resource, without paying sufficient attention to the roles of the other community members and the demands of the forest department, which also play an important role in the valorisation to the biological resource, contributing thus indirectly to any possible biodiscovery endeavour.

---

[7] It bears a resemblance to the harvest of entire adult population of *Maytenus buchananni* (a source of anticancer compound Maytansine) by US National Cancer Institute in Kenya for testing its drug development programme (Oldfield, 1984; Reid *et al*, 1993).

[8] In other cases, such as the Costa Rican InBio-Merck agreement, an ABS agreement is signed already at this stage.

[9] Concerns have been raised by the elder tribe members that the expected welfare benefits could be outweighed by the loss of traditional medicinal practices (Ramani, 2001).

5. The market value of the bioresource from the Kanis' perspective

The classic static model of biodiscovery in the case of a biodiversity – TK system involves three main actors – the natural resource base, the indigenous community acting as stewards of the GR and TK base, and the commercial firm interested in the search of new chemicals from nature. In this framework, a contingent valuation study is presented, that allows to approximate an estimate of the level of compensation that representative members of the Kani tribe request for their involvement in the biodiscovery endeavour.

The monetary benefits realized from the current Kani BSA scheme reach the community in the form of cash payments to the Trust. Since the rights to the service under consideration (the use of TK) are held by the local community, willingness to accept (WTA) compensation for participating in the biodiscovery process by disclosing their traditional ethnobotanical knowledge would be the appropriate format for value elicitation (Shyamasundar and Kramer, 1996). One difficulty of using the WTA elicitation format is the indirect payments through the provision of public goods to the community by the Trust, making direct elicitation of WTA less precise in reflecting households' preferences. Hence, the question posed to the Kani community members is based on the maximum willingness to pay (WTP) to protect their traditional knowledge from outside illegal appropriation.[10]

The population sample for this study is 68 households randomly selected from ten tribal settlements of the Kanis in the Western Ghats. This sample is stratified into cultivators (50%) and non-cultivators of *T. zeylanicus*. Using the local language (Malayalam) household heads were asked to report on households' socio-economic characteristics, the economics of *T. zeylanicus* cultivation, knowledge and attitude on implementation of the bioprospecting contract and protection of their traditional knowledge. Surveyed households' average annual per capita income is Rs 7,727 (about US$172 at 2004 prices) with 68% of income arising from homestead farming in about one hectare of land that includes crops such as coconut, tapioca, banana, betel nut, black pepper and rubber. 20% of income accrues from wage labour and 12% from selling various permitted non timber forest products such as wild gooseberry, asparagus, honey and nutmeg.

The interest is in sheeding light on the Kanis' WTP value for protecting their TK with regard to the external appropriation of bioresources and the various household socio-demographic and economic characteristics that affect their implict valuation, including family size, age, education, income and activities as potential cultivators of the herb). A dichotomous choice (DC) model is used.[11] The results from the CV analysis appear in Table 1 together with a description of the explanatory variables of the model.

---

[10] It is sensible to think that the estimated Kanis' WTP value for protecting their TK through the CV study is a lower bound of the true compensation required by them as suggested by most studies comparing WTP and WTA values (e.g., Adamowicz *et al*, 1993; Shogren *et al*, 1994; Morrison, 1997).

[11] The hypothetical situation presented and question posed to the households is as follows: *"Suppose a pharmaceutical firm markets a herbal medicine using the traditional knowledge of Kanis without asking for your prior concern. In this regard, the Trust or any other NGO (dealing with Kani welfare) has decided to bring this particular firm to court. If the TRUST/NGO wins the case, the right on the use of this particular traditional knowledge will rest within the community only, or alternatively the community may get a fair amount of compensation for sharing the knowledge (as in the case of Arogyappacha). The Trust/NGO decides to collect money from Kani tribes to meet the court expenses. In this regard,*

[TABLE 1]

As expected, Kanis' likelihood to accept the proposed bid for protection of their TK base decreases when the proposed bid increases, as the negative coefficient of the 'BID' variable suggests. In addition, the variable INCOME that controls for households' *ability to pay* is positive, implying that poorer households are less able to afford a payment for the community's Fund to protect TK. Interestingly, the expectation that older tribe members would be more likely to donate for TK conservation as are assumed to be more attached to traditional community values is not met (albeit its positive sign) given the low statistical significance of the AGE variable. The data suggests that those Kani households with more family members are less willing to donate to the fund. It has been observed that the larger family size is mostly associated with an increased number dependants (children and the aged) in the family. One explanation of the lower likelihood to donate by larger families may come households turning more cautious and risk averse in spending and the tendency to save income for these dependants. The same phenomena could be attributed to the insignificant influence of 'age' on probability to donate, as the aged have lesser control over the management of family income earned by the younger generation.

The data also indicates that the Kani households who cultivate the herb are more likely to donate than non-cultivators possibly influenced by the direct experience by the former with respect to deriving a tangible use value from trading with the herb. The level of education by the Kani members through formal schooling, while low in general, is associated with a higher likelihood to agreeing to donate to the fund the elicited amount, possibly indicating a higher level of awareness about exploitation by the more educated.

Using the coefficients from Table 1, the restricted mean WTP is Rs 358.4 (about US$8) per household (with a 95% confidence interval of Rs 276.9-660.9). This implies that the mean household WTP is about 3% of their annual per capita income. Notwithstanding the lower bound of the true WTA value, the aggregate community WTP to protect the marginal TK component from outside illegal appropriation is Rs. 1.4 million (US$ 31,111), significantly larger than the total monetary benefit realised under the benefit sharing scheme. The aggregate WTP can be seen as a lower bound supply price for disclosure of TK expressed by the community. Once revealed, the traditional knowledge on indigenous healthcare can be accessed openly. Thus, given the public nature of TK from the point of view of the indigenous community, the aggregated lower bound WTP should be a more appropriate value for the licence fee regarding the TK transfer, compared to the Rs. 0.5 million that the Kani community obtained as fee from the AVT pharmaceutical.

Due to the sensitivity of the CV analyis to interval-censored data, a monotonicity restriction on the distribution free estimator (Turnbull distribution) is also imposed (Turnbull, 1976; Cosslett, 1982) following Carson et al (1998) and Haab and McConnell (1997) to obtain a conservative lower bound on WTP, independent of the true underlying distribution. Table 2 presents the results of the application of the Turnbull estimator to the

---

would you be willing to donate Rs __ to the fund?" The bids ranged from Rs 50 to Rs 400 with a constant interval of Rs 50. The amount was specified as one time payment. The bids were fixed based on a previous WTP study in the Western Ghat region of Kerala by Babu (2002).

data on the WTP of the Kanis to protect their TK. The mean WTP value is estimated as Rs 260.26 with Rs 234.9- 285.6 with a 95% confidence interval. This non-parametric value could be regarded as a lower bound to the true WTP value. In aggregate, this amounts to one million Rupees, the figure that AVP offered, and which was shared in a 1:1 basis between the community (through the Trust) and the tropical botanical garden. Thus the community shared only half of the minimum benefit that thought it deserved from engaging in the bioprospecting contract.

[TABLE 2]

The results derived from the parametric and non-parametric models indicate that an important gap exists between the market value that the company is prepared to pay the Kani community for the TK through the licence fee and the level of compensation for the shared GR and TK by the local community. The WTP to pay for keeping full property rights over TK is an aggregate value, covering all the Kani tribe members, and these can have very different attitudes towards the Trust fund and the biodiscovery endeavour. Indeed, for some members, it covers the compensation for licensing the property rights on the TK, but for others it consists also in the anticipated monetary return from engaging in cultivation and selling of T. zeylanicus or even the WTP for preserving the traditional culture values attached to indigenous healthcare.[12]

The contingent valuation is attached to a static view to the biodiversity – TK system. Indeed, it focuses on the evaluation of the actual value of the resource within the existing market and focuses on two players involved in a bilateral contractual agreement, the private company and the providers' community. So it does not fully address the stake of preserving future possibilities of use and innovation and the contributions of the other actors involved in the entire innovation chain. For instance, the danger of the disappearance of the resource altogether is not addressed in the bilateral relationship, and it is the conservation policy of the forestry department that takes into account this preservation of the ecosystems value. In addition, the value of the GR and related TK for scientific research into taxonomy and plant related medicine is not accounted for in the valuation, even though public actors are investing in it through government or international cooperation.[13] However, in the actual institutional setting, there is no real integration of these different players throughout the

[12] The importance of the preservation of culture value in *in situ* conservation is also confirmed by an interesting case study of Dyer et al. (2000) on local seed markets in Mexico. The introduction of new crop varieties caused a diversification of the farmers' activities. Nevertheless, because of local traditions and culture, they still continue to grow the classical varieties, despite the fact that from an economic point of view one can show that they have no reason to do so (Dyer et al., 2000).

[13] TBGRI benefits from several international projects for cooperation of research and value addition. In particular, a collaborative research project entitled 'Ethnopharmacology of Indian Medicinal Plants' is carried out between the TBGRI and the Department of Medical Chemistry at the Royal Danish School of Pharmacy, Copenhagen, Denmark, sponsored by the Danish International Development Agency. It is in the framework of this collaborative research that the components of *arogyapaacha* (the local name of *T. zeylanicus* ssp. *travencoricus*) were isolated, some of them having been sent to Copenhagen for characterization (Gupta, 2004).

innovation process and the ABS scheme was not able to live up to its full economic potential.

The dynamic approach depends on a more balanced assessment of the different biodiversity related values, hence addressing not only the market value of the final product of the innovation chain, but also other social values including the cultural values of the Kani community, the public good value of the preservation of a diverse genetic stock or the value for scientific research. This would imply going beyond the CV approach and combine the CV method with qualitative information on the motives and attitudes underlying the local people's statements on the value of bioresources (O'Conner, 2000); Spash 2000).

The CV analysis shows the insufficiency of the static approach, which considers only the point of view of the possible market value from the point of view of the product development at the end of the pipeline. In doing so, it brings into the foreground another biodiversity related value, which is its value from the point of view of the TK holders' community. However, the CV methodology itself should be further refined and combined with other methods in order to approximate the value of the biodiversity – TK system in a dynamic framework.

6. Conclusion

This chapter has focused on the economic incentives for in situ knowledge generation through biodiscovery from the point of view of a dynamic approach to the economic institutions of contracts and property rights. In a dynamic framework, the focus is not on the *ex ante* determination of the optimal allocation of resources under conditions of perfect rationality, but on issues of adaptive efficiency, such as knowledge acquisition and incentives for the preservation of future possibilities of use under conditions of uncertainty. Through applying this dynamic approach to the process of biodiscovery, we attempted to show the importance of analysing the full chain of innovation playing a role in innovation processes.

In this way, our analysis moves away from the position that only considers the difficulties posed by intellectual property rights on genetic resources as being a technical legal issue. At present, in the field of genetic resources, one sees a tendency to create new laws for each sector of activity. This results in the emergence of many specific legal regimes for the protection of genetic resources and related TK: patents for processes relying on genetic manipulation, plant breeder's rights for plant varieties resulting from genetic selection, farmers' rights for traditional farmers' varieties and national sovereignty governing the rights to access and use the natural resources from ecosystems producing biological diversity. Nonetheless, the multiplication of different sectorial laws still falls in a static conception of efficiency and does not really meet the need for an integrated approach to the process of value creation through the whole innovation chain.

Some new institutional mechanisms already tackle the need for a more dynamic approach to efficiency. In the case of the KMBS, the trust fund is already an example of an institution for coordinating the different social demands coming from the community. However, as we have seen, it largely remains insufficient, because no social learning is generated that allows to bridge the conservation interests of the forest department and the interests of (a part) of the community involved in the benefit sharing agreement. Further, within the community a great deal of uncertainty remained on the appropriate protection of the traditional knowledge. Other means for enhanced institutional coordination that are currently being considered in international *fora* are the creation of an international *system of* certificates of origin for monitoring the flow of genetic resources (Barber et al, 2003), the establishment of collection societies for traditional knowledge registries (Drahos, 2000) or the creation of partnerships between research institutions and community based breeding programs (Brush, 2002). In the field of IPR, Reichman (2000) proposes to evolve from a paradigm that functions by hybridization of existing tools, based essentially on patent and copyright, to a paradigm in terms of a liability regime, allowing the *ex post* compensation of the prior link in the innovation chain. These proposal all include mechanisms that aim at diffusing incentives through the whole production chain and maximizing the future choices of development. They consider the necessity of new legal tools and governance mechanisms, but also the importance of the associated institutional means for social learning and information sharing.

The *rationale* of the focus in this chapter on the full economic value is thus not so much on the necessity to replace the bilateral market approach to bioprospecting contracting with a different approach, based for instance on public involvement, or to do away with the voluntary mechanism of benefit sharing of the KMBS. Rather, it proposes to look for a more balanced view, where the bilateral market approach viewed in a dynamic and second best institutional-economic setting combines institutional means for coordination between the different actors involved in the innovation chain, ranging from informal norms for building trust between the actors through self-regulation to formal legal means allowing appropriate sanctioning of opportunistic behaviour and collective learning.

References:

Adamowicz, W.L., Bhardwaj, V., Macnab, B. 1993. Experiments on the difference between willingness to pay and willingness to accept. *Land Economics*, **69**: 416-427.

Anuradha, R.V. 1998. *Sharing with the Kanis: a case study from India*. Secretariat to the Convention on Biological Diversity, Fourth Meeting of the COP, Bratislava, Slovakia.

Barber Ch-V., Johnston S. & Tobin B. (2003), "User Measures", United Nations University Institute of Advanced Studies Report, UNU/IAS, Tokyo, 37pp.

Babu, A.T.S. (2002), Valuation of Athirappally tropical forest in westernghats of kerala, India; MSc thesis unpublished, University of Agricultural Sciences, Bangalore, India.

Bhat, M.G. 1999. On biodiversity access, intellectual property rights and conservation. *Ecological Economics*, 29:391-403.

Bodeker, G. 2000. *Indigenous medical knowledge: the law and politics of protection*. Oxford intellectual property research centre seminar, St. Peter's College, Oxford, 25th January, 2000.

Brush, S. B. 1996. "Is Common Heritage Outmoded?". In *Valuing Local Knowledge: Indigenous People and Intellectual Property Rights*. Washington, DC: Island Press.

Brush, S. B. 1998. Bio-cooperation and the benefits of crop genetic resources: the case of Mexican maize. *World Development* 26: 755-766.

Brush, S. B. 2002. "The Lighthousde and the Potato: Internalizing the Value of Crop Genetic Diversity". University of Massachussets at Amherst: Political Economy Research Institute Working Paper n° 37.

Carson, R.T., W.M. Hanemann, R., Kopp, J.A. Krosnick, R.C., Mitchell, S. Presser, P.A., Ruud, V.K. Smith, M. Conaway, and K. Martin (1998), Referendum design and contingent valuation: the NOAA panel's No-Vote referendum. *The Review of Economics and Statistics*, **80**, 484-7.

Cosslett, S.R., 1982, Distribution free maximum likelihood estimator of the binary choice model. *Econometrica*, **51**, 765-82.

Craft, A.B. and Simpson, R.D. 2001. The social value of biodiversity in new pharmaceutical product research. *Environmental and Resource Economics*, **18**(1): 1-17.

Dedeurwaerdere, Tom (2004), "Bioprospecting, intellectual property law and evolutionary economics: the stake of a theory of reflexive governance", in M. M. Watanabe et alii (eds.), *Innovative Roles of Biological Resources Centres,* World Federation for Culture Collections, Tsukuba, pp. 389-395.

Drahos, P. 2000. Traditional knowledge, intellectual property and biopiracy: is a global bio-collecting society the answer? *European Intellectual Property Review*, **6**: 245-250.

Driesden D. M. (2003), *The Economic Dynamics of Environmental Law*, MIT Press, Cambridge (MA).

Dosi G. (1988), "Sources, procedures and microeconomic effects of innovation", in *Journal of Economic Literature*, Vol. 26, No 3, pp. 1120-1171.

Dutfield, G. (2002), “Protecting traditional knowledge and folklore: A review of progress in diplomacy and policy formulation”. In *UNCTAD/ICTSD Capacity Building Project on Intellectual Property Rights and Sustainable Development.*

Dutfield, G. 2002. *Literature survey on intellectual property rights and sustainable human development*, UNCTAD, Geneva. www.iprsonline.org/unctadictsd/docs/bioblipr.pdf

Dyer G.A., Taylor J.E. and Yúnez A. 2000. Who pays the cost of in situ conservation?, Paper presented at the Symposium “Scientific basis of participatory plant breeding and conservation of genetic resources”, Oaxtepec, Mexico.

Francis, P.A. 2004. Stealing of Jeevani patent. PHARMABIZ.COM. www.pharmabiz.com/article/detnews.asp?articleid=20367&sectionid=47

Goeschl T. & Swanson T. (2002), “On the Economic Limits of Technological Potential: Will Industry Resolve the Resistance Problem?”, in T. Swanson (ed.), *The Economics of Managing Biotechnologies*, Kluwer Academic Publishers, Dordrecht/London/Boston, pp. 99-128.

Gulbrandsen, L.H. (2004), “Overlapping Public and Private Governance: Can Forest Certification Fill the Gaps in the Global Forest Regime?”, in *Global Environmental Politics*, 4(2), pp. 75-99.

Gupta, A.K. 2002. Value Addition to Local Kani Tribal Knowledge: Patenting, Licensing and Benefit-Sharing. *IIMA Working Paper No.* 2002-08-02. Indian Institute of Management, Ahmedabad, India.

Gupta A.K., 2004. WIPO-UNEP study on the role of intellectual property rights in the sharing of benefits arising from the use of biological resources and associated traditional knowledge, WIPO publications n° 769 (E).

Haab, T., and K.E. McConnell, 1997, Referendum models and negative willingness to pay: alternative solutions. *Journal of Environmental Economics and Management*, **32**: 251-70.

Haab, T., and K.E. McConnell, 2002, *Valuing environmental and natural resources: The econometrics of non-market valuation*. Chelternham: Edward Edgar Publishing Limited.

Laird, S. A. 2002 (ed). *Biodiversity and Traditional Knowledge. Equitable Partnership in Practice*. London, Sterling (VA): Earthscan Publications Ltd.

Moran, K. 2000. Bioprospecting: lessons from benefit-sharing experiences. *International Journal of Biotechnology*, **2**(1/2/3): 132-144.

Morrison, G.C. 1997. Willingness to pay and willingness to accept: some evidence of an endowment effect. *Applied. Economics.* **29**: 411-417.

Mulligan S. P. (1999), “For Whose Benefit? Limits to the Sharing in the Bioprospecting Regime”, in *Environmental Politics*, Vol. 8, No 4, pp. 35-65.

Nelson R. R. & Winter S. G. 1982, *An Evolutionary Theory of Economic Change*, Belknap, Cambridge (MA).

NOAA, 1993, Report of the National Oceanic and Atmospheric Administration Panel on Contingent Valuation. *Federal Register*, **58**: 4601-4614.

North, D. C. (1990), *Institutions, Institutional Change and Economic Performance.* Cambridge: Cambridge University Press.

O’Connor, M. 2000. “Pathways for environmental evaluation: a walk in the (Hanging) Gardens of Babylon”, *Ecological economics*, **34**, 175-193.

Oldfield, M.L. 1984. *The value of conserving genetic resources*. US Department of Interior, National Park Service, Washington DC.
Pearce D.W. 2005. Do we really care about biodiversity? In Kontoleon, A., Pascual, U., and Swanson, T: *Frontiers in Biodiversity Economics*, 14(4), 84-100.
Pearce, D.W. and Purushothaman, S. 1992. Preserving biological diversity: the economic value of pharmaceutical plants. *Discussion Paper: 92-27*, CSERGE, London.
Pena-Neira S., Dieperink C. & Addink H. (2002), *Equitability sharing benefits from the utilization of natural genetic resources: The Brazilian Interpretation of the Convention on Biological Diversity*, presented at the 6th conference of the parties of the CBD. The Hague. The Netherlands..
Principe, P. 1989. *The economic value of biodiversity among medicinal plants*. Paris, OECD.
Pushpangadan, P. 2000. Pushpangadan model of benefit-sharing. National Botanical Research Institute, Lucknow (India). http://www.nbri-lko.org
Pushpangadan, P., Rajasekharan, S., Ratheesh Kumar, P.K., Jawahar, C.R., Velayudhan Nair, V., Lakshmi, N., and Saradamma, L., 1988. "Arogyappacha (*Trichopus zeylanicus*): The Ginseng of Kani tribes of Agasthyar Hills (Kerala) for evergreen health and vitality". *Ancient Sciences of Life*, **7**: 13-16.
RAFI. 2002. *Bioprospecting/biopiracy and indigenous people*. Rural Advancement Foundation International, US. http://www.latinsynergy.org/bioprospecting.htm
Ramani, R., 2001. "Note and comment: market realities versus indigenous equities", *Brooklyn Journal of International Law*, 26: 1147-1175.
Reichman J.H. (2000), "Of Green Tulips and Legal Kudzu: Repackaging Rights in Subpatentable Innovation", *Vanderbilt Law Review*, 53, 1743.
Reid, W.V., Laird, S.A., Gamez, R., Sittenfeld, A., Hanzen, D.H., Gollin, M.A. and Juma C. 1993. A new lease of life. *Biodiversity prospecting: Using genetic resources for sustainable development*. World Resource Institute, Washington D.C.
Rausser, G.C. and Small, A.A. 2000. Valuing research leads: bioprospecting and the conservation of genetic resources, *Journal of Political Economy*, **108**(1): 173-206.
Sahai, S. 2000. Commercialisation of Indigenous Knowledge and Benefit Sharing. UNCTAD Expert Meeting on Systems and National Experiences for Protecting Traditional Knowledge, Innovations and Practices. Geneva.
Schulze, W.D., G. McClelland, D. Waldman and J.Lazo, 1996. Sources of bias in contingent valuation, In D. Bjornstad and J. Kahn (eds), *The contingent valuation of environmental resources: methodological issues and research needs*, Chapter 6. Chelternham, U.K: Edward Elgar Publishing Ltd.
Sheldon, J.W. and Balick, M.J. 1995. Ethnobotany and the search for balance between use and conservation. In Swanson, T. (ed), *Intellectual property rights and biodiversity conservation: an interdisciplinary analysis of the values of medicinal plants*. Cambridge, Cambridge University Press.
Shiva, V., Jafri, A., Bedi, G., and Holla-Bhanu, R. 1997. *The enclosure and recovery of the Commons*. Research Foundation for Science, Technology and Ecology. New Delhi.

Shogren, J.F., Shin, S.Y., Hayes, D.J., and Kliebenstein, J.B. 1994. Resolving differences in willingness to pay and willingness to accept. *American Economic Review*, **84**: 255-270.

Shyamasundar, P. and R.A. Kramer. 1996. Tropical forest protection: an empirical analysis of the costs borne by local people. *Journal of Environmental Economics and Management*, **31**: 129-144.

Simpson, R.D., Sedjo, R.A., and Reid, J.W. 1996. Valuing biodiversity for use in pharmaceutical research. *Journal of Political Economy*, **104**:163-185

Spash, C. 2000. "Ecosystems, contingent valuation and ethics: the case of wetland recreation", *Ecological economics*, **34**, 195-215.

Svarstad H. & Dhillion S. 2000, *Responding to bioprospecting: From Biodiversity in the South to Medicines in the North*, Spartacus Vorlag, Oslo.

Swanson T. (1997), *Global Action for Biodiversity*, Earthscan.

Swanson T. (2000), "Property Rights Involving Plant Genetic Resources: Implications of Ownership for Economic Efficiency" in *Ecological Economics*, 23 (1), 75-92.

Swanson, T. and Goeschl, T. (1998), "The management of genetic resources for agriculture: ecology and information, externalities and policies". Centre for Social and Economic Research on the Global Environment, CSERGE Working Paper, University College London

Swanson T. and Goeschl T. (1999), "The Management of Genetic Resources for Agriculture: Ecology and Information, Externalities and Policies", in G.H. Peters & J. von Brown (eds.), *Food Security*.

Verma, I.M. (2002), Biopiracy: distrust widens the rich-poor divide. *Molecular therapy*, **5**(2): 95.

Turnbull, B., 1976, The empirical distribution function with arbitrarily grouped, censored, and truncated data. *Journal of the Royal Statistical Society*, 38B: 290-95.

Figure 1: The monetary benefit flow from the KMBS

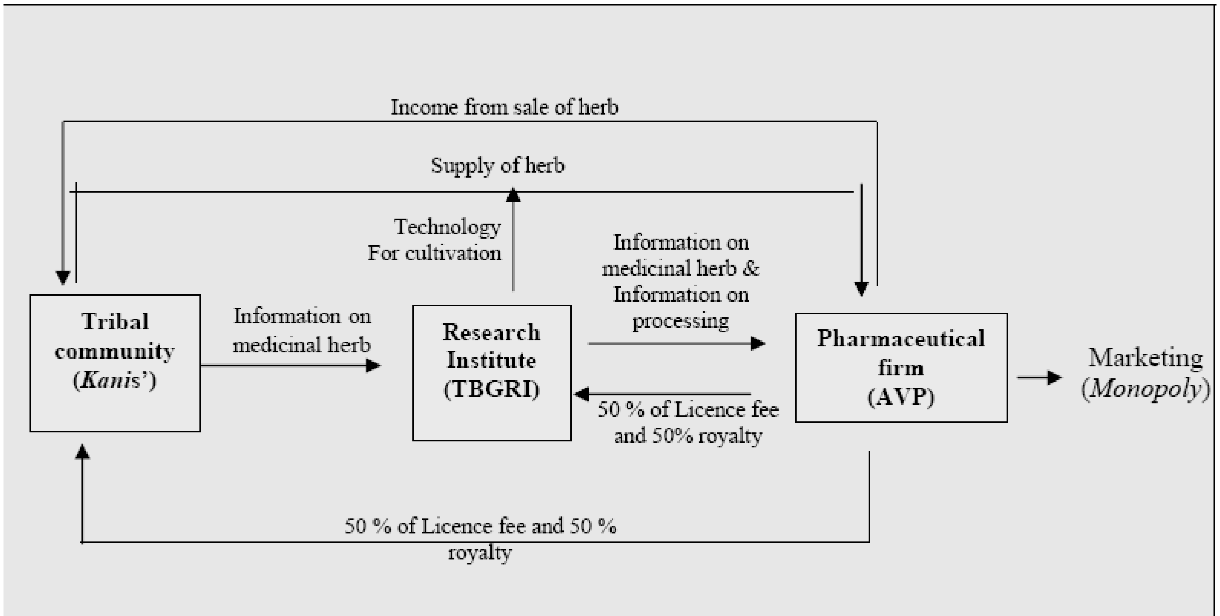

Figure 2. Biodiscovery Chain

Biodiscovery Chain

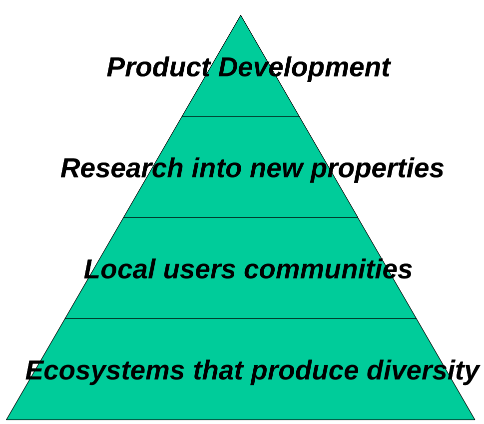

Table 1: WTP to protect GR and TK from illegal appropriation – results of the logit single bounded dichotomous choice model

Variable	Description	Sample Mean (Std dev)	Marginal Coefficients (Std error)
Dependent variable			
1	Willing to pay the bid amount	65%	
0	Not willing to pay the bid amount	35%	
Independent variables			
Constant			0.40 (2.12)
BID	Amount about which the household was asked to elicit preference (Rs x 10)	22.42 (11.31)	-0.10*** (0.04)
INCOME	Household annual per capita income (Rs x 100)	77.27 (65.88)	0.02* (0.01)
FSIZE	Family size (number of family members)	4.03 (1.45)	-0.45* (0.25)
AGE	Average age of household (years)	33.31 (12.88)	0.05 (0.04)
SCHOOL	Average schooling (years)	4.00 (4.14)	0.24** (0.12)
CULTIVATOR	Dummy:1 for Cultivators; 0 for Non-cultivators	50%	2.17*** (0.81)
Log-Likelihood			-26.74
χ^2 for significance of regression			34.82
Restricted WTP point estimate (Rs)			358.39
95 % Krinsky – Robb confidence interval using 1000 repetitions (Rs)			276.9- 660.9

5 N: 68 households. ***, **, *: Statistically significant at 1%, 5% and 10% levels, respectively.

Table 2: Turnbull estimation of WTP to protect TK from illegal Appropriation

Upper bound for bid intervals (Rs)	T_j	N_j	N_j/T_j	**Turnbull estimates** F_j^*	f_j^*
50	7	0	0.000	0.000	0.000
100	9	1	0.111	0.111	0.111
150	10	3	0.300	0.300	0.189
200	9	4	0.444	0.444	0.144
250	10	6	0.600	0.485	0.040
300	6	3	0.500		
350	8	3	0.375	Pooled back	Pooled back
400	9	4	0.444		
Infinity	N/A	N/A	1.000	1.000	0.515

T_j: Number of observations for the bid B_j; N_j : Number of NOs' on the bid value; F_j***:** Frequency of N_j after pooling back; f_j*: Change in frequency.

Estimated mean willingness to pay, $E_{LB}(WTP) = \sum B_j . f^*_{j+1}$ = Rs. 260.26

$$V[E_{LB}(WTP)] = \sum \frac{F_j^*(1 - F_j^*)}{T_j^*}(t_j - t_{j-1}) \quad V[E_{LB}(WTP)] = \sum \frac{F_j^*(1 - F_j^*)}{T_j^*}(t_j - t_{j-1})$$

95 % Confidence Interval for $E_{LB}(WTP)$ = Rs. 234.88 to 285.61