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Abstract

Major pharmaceutical companies such as SmithKline Beecham, Merck, Glaxo and Lilly, and a score of smaller ones, are developing profitable business opportunities in the world's forests while preserving biodiversity and producing incentives for leaving the forests intact. This case study covers the business relationships between Merck and Co. and In Bio in Costa Rica, and the activities of Shaman Pharmaceuticals in Latin America and Africa. It provides the details, discusses what each party expects from these deals, and explores the connections with securitization and with issues of corporate responsibility towards the environment. The study explains the properties of externalities,

which are typical of markets involving environmental assets, and the use of property rights in inducing efficient market solutions and corporate social responsibility.

1 An Overview

This case study reviews issues of external effects, which are typically found in markets involving environmental assets. *External effects* occur when private consumption and production by some traders has an effect (positive or negative) on other traders.¹ The environmental asset considered here is the biomass of a forest, which has positive external effects. A forest's biomass serves as an important purifier of noxious gases in the earth's atmosphere², and its *biodiversity* acts a source of genetic information used by pharmaceutical companies worldwide. This biodiversity is a valuable source of frequently used medical compounds such as aspirin, curare, digitalis, quinine, morphine, penicillin, reserpine, rosy periwinkle³ and taxol, which are used in the treatment of such diverse conditions as cancer, heart disease, malaria, pain, hypertension, and muscle spasms. A forest's biodiversity is perhaps its main economic value.⁴

Biodiversity is an environmental asset which produces positive external effects or *externalities* because the information it encodes, once known, can be used to produce medically valuable drugs at no extra cost to others. All industries whose activities involve the production of information for use as an input, such as for example the software industry, have the characteristic of producing external effects. Some times the effects can be captured by one producer, for example through the use of patents, but such institutional arrangements are typically limited in time and in scope. Eventually the information can be replicated at no extra cost to the benefit of many users worldwide.

The pharmaceutical industry is idiosyncratic in that the time involved in bringing a new discovery to market can be as long as 20-30 years, and the fixed costs of research and of marketing to compress this time scale into a commercially viable venture are very large indeed. Substantial amounts of capital and a well established marketing network are needed to realize the gains from discoveries. Thus the activity of discovery of the medical values of biodiversity generates information which has positive external effects, but these cannot generally be captured without large amounts of capital and without established marketing networks. When such resources are not available, external effects are present because the social benefits exceed available private gains.⁵

¹For a discussion of differences between private and social costs see Pindyke and Rubinfeld [15].

²Such as carbon dioxide (CO₂), often implicated in the warming of the earth's atmosphere, see Victor [21].

³A plant of Madagascar used by Eli Lilly to treat leukemia and Hodgkin's disease.

⁴Eisner [7], Lyons [14], Riggle [16].

⁵The purifying activity of the forests' biomass in recycling carbon in the earth's atmosphere also produces external effects. This is a second source of social benefits independent of the medical value

Most of the world's remaining forests are in developing countries, because industrial countries destroyed their own forests in the process of industrialization.⁶ However one of the main values of forests, the medical value of their biodiversity, is not captured by the developing countries themselves because they do not have the resources to research, produce and market pharmaceutical products. The main economic benefits of their forests' biodiversity are therefore captured by the industrial countries' firms which control the pharmaceutical market.

Under these current conditions developing countries do not have the resources nor the incentives to preserve an environmental asset which could be of large value to them in the future, but which today benefits the industrial countries more. This is a classical problem associated with external effects. It leads to inefficient market allocations which are environmentally harmful.

Inefficient allocations are typical of markets with external effects. This is because the full economic value of the asset which is the source of externalities is not well represented by its market prices; market prices are best suited to represent the value of private consumption or production by the traders, and not the value of the external effects such as the value which their consumption or production produces indirectly to others. In practical terms, this means that the medical value of a forests's biodiversity is not properly accounted for by market prices. The forest as a source of biodiversity will be typically undervalued.⁷ An example presented below is the undervaluation of the biodiversity of the Korup National Park in Nigeria, the oldest forest in Africa and the richest in terms of biological diversity.

If the value of a forest's biodiversity is underestimated, in economic terms its use will be inefficient. There will be a tendency to overuse the forest as a source of other forest products such as wood, trappings, and for its soil which is cleared to cultivate cash crops [2]. This will lead to overproduction of environmentally intensive products, such as wood pulp, plank and cash crops. This overproduction, which results from incorrect accounting of economic value, can be mistakenly considered the exercise of "comparative advantages" by developing countries. It can lead to international trade in these products at prices which are below real costs and to over consumption of environmental resources worldwide, in short, to inefficient patterns of international trade.⁸ It can lead eventually to extensive clearing of forests' biomass which can destroy its biodiversity irreversibly.

of the biodiversity of forests. The quality of the atmosphere is a public good which is common to all inhabitants of the planet. The preservation of a forest has positive effects for the country where it is located and also for the rest of the world. In the case of a small country consisting mainly of forests, such as many Central American nations, the international benefits of its forests exceed the benefits to the local populations many times over. External effects of preservation can exceed local gains.

⁶See Chichilnisky and Heal [4].

⁷Proper accounting techniques to record the value of environmental assets, also called "environmental accounting", are reviewed in [20].

⁸Chichilnisky [2], [3].

A textbook solution to this problem is to “internalize” the externalities, by which it is meant to find an institutional arrangement which allows the traders in a market to “capture” the value which they produce to others. This case study examines two business ventures which follow the textbook solution: they allocate property rights to the asset which generates the externality in such a way as to induce business incentives for its conservation. By assigning new property rights to the externalities produced by the environmental assets, their value can be realized in business terms. In this case, the property rights which must be assigned are over the biodiversity encoded in the forests’ biomass.

Two innovative business relationships are explored here: Merck and Co. in Costa Rica and Shaman Pharmaceuticals in Latin America and Africa. These are designed to make forests pay for themselves while the countries who own them acquire the technology and resources needed to screen and market natural compounds in their own institutions.⁹

We provide the details, discuss what each party expects from these deals, and explore the connection with securitization and with issues of corporate responsibility towards the environment.

2 The Medical Value of Forests: Chemical Prospecting in Business Terms

Forests are an important source of medical compounds. Although drug discovery is always risky, scientific evidence documents that there is a good chance of finding valuable medicinal compounds in nature, especially in the species-rich tropical rain forests. Plants and other forms of life have historically been an important source of medicines. Morphine is derived from opium, and penicillin is a fungal metabolite. Aspirin, curare, quinine, reserpine, and the rosy periwinkle which treats children’s leukemia are all forest discoveries.¹⁰

In simple terms, *chemical prospecting* is the search for new medicines, agrochemicals and other substances of use from animal, plant and microbial sources. There is worldwide agreement among scientists that only the smallest fraction of natural products has so far been characterized.¹¹

Today new techniques borrowed from biotechnology allow firms to screen thousands of chemical compounds for activity against human cancers and other diseases in a short period.¹² This has boosted interest in pharmaceutical products derived from forests. Taxol is a promising oncogen (anti cancer) compound derived from the bark of the Pacific yew, a conifer found in the 1960’s in the remaining virgin forests

⁹Joyce [12].

¹⁰Joyce [12], Hamilton [9], Killian [13].

¹¹Eisner [6].

¹²Business Week [1].

of the US Pacific Northwest. Taxol is being tested today against ovarian and breast cancer.

The US National Cancer Institute is currently screening thousand of plants and microorganisms for activity against human cancers.¹³ Such current Merck products as "Mexofin", "Primaxin" "Ivonec" and "Mevacor" were all derived from natural sources. Shaman Pharmaceuticals of California has three forest drugs in clinical trials which it found in Ecuador and Peru.¹⁴ One is an anti-viral drug for the treatment of herpes simplex, and another is a broad-spectrum anti fungal agent derived from a plant used by native tribes in North America and Africa for the treatment of infections.¹⁵

SmithKline Beecham is now clinically testing a plant-derived drug called topotecan as a treatment for ovarian cancer. The drug is an analog of campotothecin, a compound extracted from trees in China and India, discovered originally by the US National Cancer Institute in the 1960's. A water soluble analog was only recently created. Glaxo too has a commercial interest in campototechin, and it studying analogs of the compound. Glaxo is also testing artemisin, an anti malarial drug derived from a plant discovered in China and south east Asia, which is effective for drug-resistant malaria and for cerebral malaria, a serious form of the disease.

3 The Market Value of Biodiversity

Natural products generate substantial revenue. In Europe, a product from the ginko tree, one of the oldest living trees, called ginkolyte, is used extensively to promote blood flow. The compound is estimated to generate \$300 million a year in sales in Europe. Fully one third of medical prescriptions given out annually in the United States are based on substances derived from nature, or synthesized in imitation of natural substances. Examples are common medicines such as digitalis, quinine, morphine, reserpine, and curare, used in the treatment of such diverse conditions such as heart disease, malaria, pain, hypertension and muscle spasms. Prescriptions drugs derived from forest products alone bring upward of \$100 billion annually in worldwide sales, according to Professor T. Eisner of Cornell University, former elected Chairman of the Section of Biology of the American Association for the Advancement of Sciences, the largest scientific organization of the United States.¹⁶

In sum: the biodiversity of tropical forests is emerging as the forests' most valuable economic asset and a very important source of revenue for the pharmaceutical industry worldwide. It is a source of products generating incomes in the region of tens of billions of dollars annually.

¹³Eisner [7].

¹⁴Killian [13].

¹⁵Hodgin [10].

¹⁶Eisner [7].

4 Biodiversity and the Destruction of Forests

Isolating specific plant compounds can be a technically difficult task. New biotechnology procedures are however changing the attractiveness of searching forest products for medicinal uses.¹⁷ They are making this a less haphazard and more cost effective process. The problem now is that the plants are disappearing, victims of tropical deforestation, faster than they can be investigated for their medicinal value.

Biodiversity counts the number of species present in a forest. The concentration depends on the age of the forest, with older forests exhibiting much more diversity of species. This age-induced richness makes biodiversity difficult to duplicate: the Korup National Park in Cameroon is 60 millions years old and one of the richest of the world's rain forests in terms of biodiversity.¹⁸

More types of species inhabit tropical forests than any other habitat. The discrepancy in biodiversity can be very large indeed. An American biologist Edward Wilson found 43 species of ant in one tree in the Amazon, about the same as found in the whole of the British isles. Costa Rica is said to have as many as 500,000 species of plants, insects and microorganisms of which only about a fifth have been described.¹⁹ Tropical plants and insects are particularly well-endowed with chemical defenses of interest to the pharmaceutical industry since they must repel so many predators. This includes alkaloids, such as morphine, and nicotine, phenolics and tannins, found in tropical trees like cecropia and mangrove.

However, most of the world's remaining forests are being used mainly as a source of forest products such as wood, hunting, fishing and trapping, and their cover is destroyed for the cultivation of cash crops such as palm oil, soya beans, coffee and sugar, largely sold to the international market. Indeed, 90% of the deforestation of tropical forests today is for agricultural use, principally for cash crops for the international market²⁰.

Standard valuations of forests for debt-for nature deals underestimate the value of the forests's biodiversity. A typical approach is that presented in Ruitenbeck [17], who develops a valuation of the Korup's National Park between Nigeria and Cameroon, the oldest forest in Africa and the richest in biodiversity, without mentioning its biodiversity in any of its computations.²¹

Commercialization of the natural pharmaceutical products based on the biodiversity of these forests is now being undertaken primarily by the industrial nations. The funds engendered revert in only small measure to developing countries. This is ironic since it is mostly the natural holdings of developing nations, and in particular rain forests, that harbor species from which the new chemicals are derived. Tropi-

¹⁷Hamilton [9] and Business Week [1].

¹⁸Ruitenbeck [17].

¹⁹Joyce [12].

²⁰Chichilnisky [2]

²¹Also omit any mention of its value as an absorber of CO_2 and source of oxygen through photosynthesis and thus as a buttress against global warming.

cal habitats, in fact, contain the vast majority of species which remain to be studied chemically, yet it is these very habitats that are disappearing. Local economies simply lack the funds and incentives for conservation.²²

Efforts that are now being pioneered will need to be intensified in the coming decade to address this paradox, and to capture the business opportunities that it implies.

5 Property Rights and International Partnerships

In essence what is needed is the establishment of property rights which capture the externalities, and business links which allow the realization of the value implicit in those rights. This is the textbook approach to the internalization of externalities via property rights — see for example Coase [5].

In our case the internalization of external effects must involve financial links, multinational in scope, between chemical prospecting, pharmaceutical marketing and conservation. Partnerships need to be brokered between forest areas in developing nations and pharmaceutical firms, partnerships committed to joint exploration for natural products, with an eye towards profit-sharing and return of revenue to conservation programs. The idea is rather simple: to exploit *gains from trade*. The developing countries have the biodiversity of their forests, but do not have the know-how or the resources to prospect it chemically, or to produce or market the medical products. The industrial countries, on the other hand, have the resources to prospect, produce and market the pharmaceutical products, but not the information needed — neither the genetic codes nor the knowledge of traditional medicines. In short the industrial and the developing countries have different, complementary endowments. With such complementarity in endowments there are always possibilities for gains from trade, provided the property rights are well established, Chichilnisky [2], [3]. How to achieve these in practice?

6 Example: the Merck-Costa Rica Initiative In-Bio

Costa Rica has set aside a quarter of its land holdings, some 12,000 km², for conservation. The area is one of biotic richness, estimated to contain about 500,000 species and about 5% of the world's biodiversity.²³ To inventory this biodiversity Costa Rica has set up a private corporation the *Instituto de Biodiversidad* or InBio for short, an organization in which professionals and scientists, such as biologists, collaborate

²²Eisner [7].

²³Joyce [12].

to determine what organisms Costa Rica harbors, how these organisms are associated and distributed in nature, and how they behave and survive. This information, aside from scientific value, has value to industry. To have access to a giant natural “greenhouse” library, neatly indexed, containing samples reliably labelled and ready for studying, is of worth to pharmaceutical companies intent on prospecting for chemicals. In exchange for limited non-exclusive rights to explore Costa Rica’s biodiversity for medicinal products, Merck, Sharpe and Dohme (Merck and Co.) provides InBio \$1 million up-front and in addition, will provide InBio a substantial royalty from products developed over time. Royalty returns are insufficient in such agreements because it may take one to three decades for a product to be developed and marketed from a natural source. Developing nations need funds for conservation now. The \$1 million offered InBio by Merck and Co. is slated for investment in Costa Rica’s conservation programs.

The agreement provides a model applicable worldwide to partnerships between industry and developing nations. To draw industries into such partnerships developing countries need to set aside land for conservation as did Costa Rica, and to establish institutes comparable to InBio dedicated to the indexing of biodiversity.

7 The Terms of the Merck- Costa Rica Deal

What are the terms of the agreement between Merck and InBio? ²⁴ Merck will provide approximately US\$1 million and necessary equipment over the first two years of the agreement. In exchange for the funding, Merck will receive a minimum number of samples and the exclusive right to evaluate samples for pharmaceutical and agricultural applications for a defined term. The contract provides that InBio will receive a royalty of a percentage of net sales on any product which Merck & Co. Inc. develops from an InBio sample.

7.1 Samples

The percentage of the samples that result in a marketable product is highly unpredictable. The samples will become part of the Natural Products Program at Merck, which has had several other great successes in the past such as Mexofin, Primaxin, Ivomec, and Mevacor.

7.2 Royalties

The royalty to be paid to InBio is a percentage which reflects the presumed level of contribution in the overall development by InBio. The royalty structure is consistent with that in other similar agreements.

²⁴News release, Merck and Co., see also Stevens [18], [19], and Joyce [12].

Merck will pay a royalty to InBio on the sales of any product that is developed by Merck's Research Laboratory Division from an InBio sample. InBio has indicated that royalty will support efforts to conserve Costa Rica's biological diversity. Sublicensing of the product will fall under the same terms as agreed in the contract.

7.3 InBio

The Instituto Nacional de Biodiversidad (InBio) de Costa Rica is a non-profit, private organization created by a recommendation from the Costa Rica government in 1989 to study the biodiversity and socioeconomic value of Costa Rica Rain Forest. InBio's mission is to preserve the Costa Rican's biodiversity by demonstrating the economic benefits of preservation. By putting to work the resources within the conserved lands of Costa Rica, InBio is working towards conservation in collaboration with private industry.

InBio selected a single major partner for their demonstration project, Merck, which is the world's largest manufacturer of pharmaceuticals with an annual research budget in excess of US\$1 billion, and a commitment to the environment. The Agreement allows Merck to access the InBio data base for selection purposes. Merck will neither have control over the InBio database, nor be able to restrict publication of information from that database. InBio's relationship with Merck is independent of other functions of InBio.

Prior to this agreement InBio had obtained US\$5 million in donations for a ten year project that will create an inventory of all organisms local to Costa Rica. As a result, InBio has grown to a staff of about 22 full-time employees with 31 para taxonomists in the field.

7.4 Costa Rica

Because of its location between North America and South America, Costa Rica has a broad range of organisms. It has been estimated that it contains about 5% of the world's biological diversity. Furthermore, a serious effort has been made to preserve this biodiversity, as 25% of Costa Rica is national park land.²⁵

8 How do the business partners benefit from the agreements?

Costa Rica will benefit from the agreement in several ways. Economically the agreement offers Costa Rica the opportunity of sustainable development of the rain forest. It gives Costa Rica a new property right: the right to the "intellectual" property encoded in the samples extracted from its rain forest. This is similar to the "intellectual

²⁵Joyce [12].

property rights" embodied for example in a piece of software. These property rights internalize the benefits of the externalities produced by the genetic information, because they produce a stream of profits - the royalties - which continues over time as the drugs based on this information are sold across the world.

Education, a key activity of InBio, will benefit through the agreement's support of educational initiatives. The Costa Rican biological research community will benefit from the infusion of state of the art technology which Merck will transfer for the initial processing of samples. Of course a large element in the economic value is the know-how to produce and market the medicines, and a transfer of this element is not contemplated in the current agreement. It would be of interest to Costa Rica to produce and sell their own drugs in the future.

The collaboration with InBio will expand Merck's inventory of biological samples that are investigated by Merck's ongoing screening program. InBio also offers Merck the opportunity to work with a unique biological diversity located within the Costa Rican biosphere, a high level of government support and an established network of scholars, and the commitment to provide trained people to support the effort locally.

InBio will be responsible for the initial processing and extraction of plant and insect samples. Exploration of the properties of the samples will take place at the Merck facilities in Rathway N.J. and West Point, Pennsylvania. Environmental samples will be sent directly to the Merck Research Facility in Madrid Spain.

The samples will be collected by trained para taxonomists who were educated on proper selection procedures by foreign and Costa Rican taxonomists. The possibility of accidental or excessive collection of an endangered species is minimal, as InBio has compiled a database which catalogues endangered species status. If a desired species is endangered, Merck will request InBio to collect another similar species which is in greater availability or to collect a sample small enough not to affect the species. InBio has the right to restrict collection of a species based on availability.

9 Shaman Pharmaceuticals Inc.

Shaman Pharmaceuticals of San Carlos, California has entered in similar agreements with localities which contain medical knowledge of medical compounds in Latin America and Africa. The name "shaman" means "medical person". Their partnership is not with a government but with private groups and local cooperatives near the rain forest areas.

Founded in 1989, this company has so far developed three patent-pending drugs from plants used by tropical peoples, each with a potential market value of hundreds of millions of dollars. One is Provir, termed also SP-303, a drug which is used for respiratory viruses which entered human clinical trials in the Fall of 1991, made from a plant to treat colds in South America villages. Another is a topical herpes treatment derived from the same plant. The third is an anti fungal drug derived from a plant used in Africa to treat infections.

Total investment in the company is US\$13 million raised from investors that include Salomon Brothers and Sequoia Capital. Shaman has also equity capital from the Italian pharmaceutical firm Inverni della Beffa, the largest plant based pharmaceutical manufacturer in the world. This latter deal consists of equity investment in Shaman, non-exclusive comarketing rights in Italy of Shaman's SP 303, and a long term manufacturing agreement for the same product.

The main difference between the Shaman and Merck agreements is that while Merck uses standard testing techniques on the basis of InBio's samples, Shaman uses the medical knowledge of native healers as a short cut in drug discovery. The notion is that such a short cut, which is very substantial, may give the young company a competitive edge.

Shaman has a non-profit arm, Healing Forest Conservancy, and the company will distribute a share of profits to regional conservation efforts and will compensate local people for their ideas. And in the hope of creating industries which depend on conservation, not destruction, it has forged agreements with villagers to supply information and raw materials for drugs.

As of October 1992 the company's thirty three employees had stakes in the business but Shaman has still to make profits. This may take a while, as some drugs spend years caught in the regulatory maze of the Food and Drug Administration.

10 Financial Markets and Securitization

Several possibilities are already emerging for extending the examples of Merck and Co. and of Shaman Pharmaceuticals to other firms in the USA and in Europe.

International organizations such as the World Bank, or its financial arm the International Finance Corporation, could offer support to such partnerships in the form of preferential business oriented loans.

In addition, it seems possible to open up such partnerships to stock-market trading. For example, Merck and Co could "securitize" their deal with Costa Rica and sell shares in the world's markets. This would involve the creating of a tradeable instrument whose shares are shares in the profits of the joint Merck-InBio deal. Their business agreement can therefore become an asset which backs a security sold in the world's financial markets. This securitization could provide a wider public access to such financial partnerships and increase their competitiveness. In addition, it could provide a more liquid outlet for such business opportunities, making them more attractive as they are more readily traded and enable Costa Rica and InBio to anticipate revenues by selling shares in them.

In sum: biodiversity and multinational partnerships with the pharmaceutical industry could form the basis for a sound market-based, profit-oriented solution to the preservation of the world's rain forests and of the wealth of healing compounds which they offer humanity.

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