The Economics of IPR for Traditional Knowledge - the Importance of Property Rights

Mare Sarr and Tim Swanson*

Very Preliminary Version

Abstract

This article investigates the issue of intellectual property rights in relation to traditional knowledge and bio-prospecting in the biological sector (pharmaceutical and biotechnology industry). We examine the case for protecting traditional knowledge with some form of property right and shed light on the importance of the placement of such right in the R&D industry, for both distributional and efficiency reasons.

1 Introduction

The R&D industry in the biological sector is structured as a non integrated vertical industry that has two stages. In the primary stage, a flow of information originating within the natural environment and requiring a diverse stock of natural capital (namely land) is captured by virtue of investment in traditional human capital - in settings where human populations persistently interact with the natural environment through observation and selection. The combination of the two factors results in a primary R&D output. At the other end of the vertical industry, the secondary stage biological R&D process collects the information stocks made available by the primary R&D stage, and invests in physical and human capital (laboratory equipment and scientists) to produce new R&D and new solutions designed to consumers. Appendix 1 depicts the structure of such industry.

*Department of Economics, University College London

The characteristic of this industry is that research is cumulative, i.e. the outcome from prior (or basic) research is used as an input factor in later research to make innovation. The industrial organisation literature has analysed at length the implications of the cumulative nature of innovation on the design of intellectual property rights policy. The importance of giving first innovators enough incentive to invest and innovate is particularly emphasised because no inventions or discovery would be possible without their contribution. It is therefore argued that first innovators should be protected namely via patents while the second innovator could possibly be denied a patent protection whenever licensing can be relied upon.

However, it is striking that, in practice in the biological sector, only the secondary modern stage of the research process is granted property rights protection to reward its innovation effort while the primary traditional stage is left unrewarded despite its crucial contribution to innovation. This raises two problems: because traditional knowledge is not protected, it may first remain unknown and even may be lost at some point, which would lead to a relatively lower rate of innovation and therefore lower social welfare; secondly traditional knowledge can be misappropriated by R&D firms that can then patent it for their own profit.

Bio-prospecting is a route chosen by pharmaceutical or biotechnology firms to find and collect natural compounds necessary for the development of new drugs. It requires the cooperation between the bio-prospector and the community owning genetic resources or traditional knowledge. This interaction fits into the cumulative research framework described earlier. We assume that the R&D firm comes from the North; that it has technological capability as well as financial resources but lack the basic inputs necessary to develop new products. In contrast, the South is assumed to be rich in genetic resources and has accumulated traditional knowledge (know-how, remedies, practices), however it has little capability to develop for the North market.

Because the patent system exclusively rewards the North for its innovation despite the South undeniable contribution, concern about a fair division of benefits has led some observers to make the case for protecting genetic resource owners or traditional knowledge owners with intellectual property rights. In this paper, we set out to explore the questions of the number and placement of patents within the entire vertical industry (i.e. the suppliers of genetic resources as well as the manufacturers). These questions are crucial because they concern themselves with both distributional and efficiency issues. Essential to efficiency is the possibility of cooperation that only takes place in absence of large transaction costs.

2 Economic Analysis of cumulative innovation

2.1 Economic Rationale for intellectual property rights

The economic rationale for granting property rights to innovations was first explained by Nelson (1959) and Arrow (1962). Their argument proceeds as follows. Because innovation or knowledge is a public good (non rival and non-excludable), it is likely to be under-supplied as its social value exceeds its private value. A mechanism ensuring that positive externalities are internalised is therefore necessary. The implementation of intellectual property rights regime is one such mechanism. By granting a temporary monopoly over the use and exploitation of his innovation, intellectual property regimes give the innovator the incentive to invest by ensuring he captures part of the social value he has generated. Therefore, there is a trade off between giving firms the incentive to invest and conceding a monopoly power to innovative firms that creates a distortion in the economy.

2.2 Innovation as the result of a cumulative or sequential research process

Earlier economic analysis considered R&D innovations as a stand alone process, i.e. innovations are not based on existing research or do not use earlier research as input factors to make improvement. However, it is not uncommon to have firms or institutions specialised in basic research while others focus on the development of products based on the prior knowledge supplied by the former. Thus, the end product results from the accumulation of both innovation stages in the R&D industry. As a consequence, regarding research as a stand alone process fails to capture the specialization of research activities between firms carrying out basic research and those developing commercial products using the technology made available by the former. Hence research activities are better analysed in the framework of sequential or cumulative innovations in which the division of labour and expertise often does not allow for vertical integration.

However, when innovation is sequential, early innovators in an non-integrated vertical industry may lack the incentive to invent. Indeed, they may not be sufficiently rewarded for the social value they have contributed to create. The distribution of the profit between innovators is therefore a key issue as all innovators should be able to cover their research costs if they are to invest in innovation at all. The question of the distribution of the rent has been studied at length in the

industrial organization literature and some of the key findings will be summarised below.

Another important issue relates to the question of efficiency when intellectual property rights are granted. If both innovators are granted a patent then the double monopoly distortion within the vertical industry induces a welfare loss.

2.3 Information disclosure in cumulative research

The issue of information diffusion is paramount in cumulative research because it has important impact on both research costs and the rate of discovery. Scotchmer and Green (1990) discuss the trade-off between the protection of the innovators' profit and the benefits from the disclosure of information. These two goals are served by different patent requirements. The profit from an innovation is higher if the patent has a long effective life before being replaced by a different technology. In this sense, a strong novelty requirement may be better as it increases innovators' profit and encourages R&D. However, disclosing information in the public domain is socially beneficial because it accelerates the rate of discovery and reduces the aggregate cost of research by shortening the investment period. A weak novelty requirement encourages inventors to patent every small technological advance. Information becomes common knowledge and can be used to develop new products (there is a positive externality).

Assuming reverse engineering is possible, the case for a weak novelty requirement must be balanced against the fact that first innovators may well prefer secrecy over disclosure to protect their profit as opposed to what happens with a strong novelty requirement. Besides, it is argued (Eswaran and Gallini, 1996) that a strong novelty requirement makes firms concentrate on the most socially valuable projects.

2.4 The role of ex ante licensing in the division of profit

2.4.1 Desirable outcome with ex ante licensing

One of the major issue addressed in the literature of cumulative research is the question of the division of the rents between the first generation innovator and the subsequent ones (cf. Scotchmer 1991, Green and Scotchmer 1995, Gallini and Scotchmer 2002). In fact, cumulativeness introduces complexity in intellectual property rights regimes because it makes it more difficult to incentivise firms to invest in research. This is because each firm in the vertical industry must

receive sufficient incentive to invest at each stage. However, if the first innovator's profit shrinks due to the competition of the second generation product, or if the first innovator does not receive a share of the net social value (created by the second generation product), he may not find it worthwhile to invest.

The patent policy about the breadth of the patent (interpreted as the minimum improvement required to avoid infringement on the first generation product) is a key determinant of the division of the profit as well as the length of the patent (which in turn determines the size of the joint industry profit). In this regard, when the value and the costs of the project are certain a broad patent is particularly efficient to protect the first innovator. Indeed, with a broad patent the second innovator is more likely to infringe the earlier technology and therefore will sign an *ex ante* licensing contract (the license is signed before the second innovator decides to sunk costs) to be able to develop an improved product. In principle, *ex post* licensing (the license is signed after the second innovator decides to sunk costs and the new product infringes the first generation product) can also be used. However, it does not emerge in the equilibrium because the second innovator may lack the incentive to invest when it bear the full research costs while sharing his revenue with the licensor. In fact *ex post* licensing along with the breadth of the patent serve to set "threat points" for the bargaining of an *ex ante* license. Provided the second innovator adds to the joint profit, the first innovator will have incentive to invest.

2.4.2 Patentability of the second innovation

Scotchmer (1996) investigates how granting of a second patent impacts upon profitability of a first patent. Based on the assumption that the second generation product always infringes the original patent (i.e. the patent is assumed to be very broad), the author analyses how the division of profits is affected by the patentability of the second product. Restricting the study to the case where the entire commercial value of a base technology is contained in the application it facilitates, she shows that the patent system must ensure an adequate division of profit between both inventors so that each of them covers its costs. Provided *ex ante* licensing is feasible, there is sufficient incentives for the second innovator to invest, for an *ex ante* agreement allows firms to share profits in a way that avoids *ex post* hold up problem. So, denying patentability to the second generation product is a means to transfer profit to the first innovator.

The critical assumption here is that there is no impediment to *ex ante* licensing and such agreement induces no significant transaction costs. Given this assumption, granting a patent only to

the first innovator combined with *ex ante* licensing is sufficient to provide the right incentives. The decision to place the patent in the hands of the first innovator is due to the fact that without his investment and innovation, no second generation product can be developed. In addition, the first innovator may not be able to capture a share of the profit generated by the end product.

The possibility of contracting as well as the transaction costs will determine the extent to which firms will be involved in an agreement. If *ex ante* licensing is feasible then, the breadth of the patent will determine the extent of infringement and thereby the division of profits (Green and Scotchmer 1995).

2.5 Conclusion on IPR in sequential innovation

This discussion makes clear that, assuming reasonable transaction costs, the first best outcome in a vertical industry with sequential innovation is some form of vertical integration. This integration must provide the means for the unrestricted flow of information through the industry, while also providing the incentives for the ongoing investment in innovations at all levels. It is the tension between these two objectives that creates an interesting institutional problem. How do we provide for the free flow of information while still compensating each of the providers?

3 Economics of cumulative research applied to Traditional Knowledge

3.1 Rationale for granting intellectual property right to traditional knowledge holder: Traditional Knowledge as Tacit Information

Gehl Sampath (2003) argues that information can be seen as a continuum from highly uncodified (or tacit information) to highly codified (tangible information). The codified information represents information processed by the biological sector with the view to develop a marketable end product. Biotechnology or pharmaceutical companies commonly use basic information as an input for further research. For example, it is not uncommon that small and medium sized biotechnology firms act as suppliers of information to larger firms that process the final product. The supply of traditional knowledge to these R&D firms may play a similar role in the provision of tacit information. Biotechnology and pharmaceutical companies through bio-prospection try

to find new active principles to cure existing diseases. Traditional knowledge accumulated over the centuries may be particularly useful in the screening process of potential inputs and may help decrease substantially research costs while increasing the rate of discovery. There is evidence that traditional knowledge makes significant contribution and acts as *"complementary assets"* in the innovation process. Gehl Sampath argues that traditional knowledge should be protected via intellectual property rights on this ground. Indeed because the diffusion of information accumulated by traditional knowledge holders has an important social value but may be costly to collect (requires *"collaborative activity by scientists, ethnobotanists and national agencies to be able to document such knowledge and map it on a one-to-one basis to modern medicinal theories"*), granting a property right on traditional knowledge would ensure its disclosure. Such right would also ensure traditional knowledge holders more control over their knowledge to avoid its misappropriation.

3.2 Industrial structure of the economy

The current property rights regime regarding bio-prospection rewards innovations from the North and fails to protect the traditional knowledge from the South. The status quo IPR regime fails clearly to deliver an equitable benefit sharing. The present paper addresses both distribution and efficiency concerns and suggests a possible way to allow the South to be rewarded for its contribution within the vertical industry. In particular we wish to examine the extent to which assigning a property right in the first stage of the industry is necessary for efficiency and equity, given protection is already granted to innovations in the second stage. Note that efficiency here is considered from the producer point of view.

3.2.1 Definitions

Consider an economy populated by two agents South and North specialized in two different sectors.

A. South: Endowed with genetic capital G and has a comparative advantage in the production of pure information R. The South produces a product d_1 in which information R is embodied. South also contains consumers and their demand for products of this industry.

B. North: Endowed with human capital H and produces information I which it combines with R to produce a flow of innovation D. This innovation D is embodied in a pharmaceutical d_2. North also contains consumers and their demand for products of this industry.

C. R&D industry: This is a vertical industry where North and South have complementary activities: South produces information R necessary to North's innovation D. This industry is depicted in the appendix. Each sector of this industry holds power in its own market.

D. Rights structure: A property right is afforded to information R. Courts in South will enforce access and exclusive rights to d_1 in South's market. Innovation D may be patented by the North. Similarly, Courts in North will enforce access and exclusive rights to d_2 in North's market.

For example, we can think of an industry where, after recognising some biological activity from a plant, the South produces a herb (d_1) that has natural curative properties. In such industry, the information encapsulated within the herbal medicine can be identified, extracted and used by the pharmaceutical or biotechnology firms from the North to develop new drugs as d_2. The issues we address here relate to how well North and South cooperate in this R&D industry, and how they share the benefits. The North might or might not compensate the South for the information used to develop D. The South might compete with the North by marketing the herb in the North.

3.2.2 Efficiency requirements

We now wish to define the efficiency objective for an industry of this nature.

Proposition 1: *From the perspective of the producers North and South, the first best solution requires a single property right, complete specialization and a joint venture.*

Proof: In a vertical industry, it is well-known that integration brings efficiency from the producer's point of view since the joint profit is maximized. By forming a joint venture North and South integrate into a single entity able to develop new products using the comparative expertise of both partners. A single property right is then sufficient to protect the innovations made by this entity. Besides, given the complementarity of the two partners, comparative advantage will dictate full specialization within the joint venture.□

Any departure from the conditions stated in proposition 1 results in loss of efficiency. The allocation of two property rights in the vertical industry leads to the problem of multiple distortionary IPR regimes, and possibly to double marginalization which decreases the joint profit. In addition, competition erodes the profit of each party. An all out competition at both stages of the industry is even more wasteful from the producers' perspective: not only does it reduce each player's profit, it also causes a large loss of specialization since North and South invest in the sector where they have no comparative advantage. The opportunity cost of such behaviour is therefore particularly high. This case represents the worst possible outcome for the producers.

3.3 A model of the impact of a second property right in the R&D industry

In this section we now establish the means by which the establishment of a *property right in R* together with a *procedure for its enforcement* determines the prospects for efficient integration. Our main idea is that affording a property right in the information produced by the South (unlike the current IPR regime) may trigger cooperation and lead to an efficient outcome. Paradoxically, the property right might not be used by the South, but it serves to determine her outside option when an agreement for integration into a joint venture is being discussed. The very existence of the property right ensures the South a stream of income that will be accounted for in any negotiation.

3.3.1 The game

The game has three players, North, South and a Court in North. This is a sequential game where the North is the first mover.

1. The North offers the South to integrate and offers a share α of the joint profit.
2. The South decides a) to accept (A) the offer to form a joint venture; or b) to reject (NA) the offer and decides to develop a herb d_1 encapsulating the information using the protection granted the property right.
3. The North decides a) not to invest (NIn) and the game is over; or b) to invest (In) in which case the Court has to intervene.

4. The Court makes an enforceable decision upon infringement: a) in case of infringement or violation (V), the North needs a license (L) to market the new product d_2; b) if there is no infringement or no violation (NV) North and South compete (C) in the North market.

3.3.2 Specification of the payoffs

Suppose the South is granted a property right protecting its traditional knowledge, and suppose that the North has an idea to develop a new product using this information. Here, we assume that the IPR takes the form of trade secrecy. Since the North needs the knowledge from the South, it offers the South to integrate by forming a joint venture, against the payment of a royalty α on the joint profit.

If the negotiation succeeds then a joint venture is formed and will develop a new product d_2 that can be patented. The South will reveal some of its traditional knowledge, which results in faster and more cost effective development. South and North respectively receive payoff amounting to:

$$\Pi_S^i = \alpha(\pi_{N+S}^i - c_N^l)$$

$$\Pi_N^i = (1-\alpha)(\pi_{N+S}^i - c_N^l)$$

where π_{N+S}^i is the integrated monopoly revenue earned by the joint venture; α is the share of profit offered by the North; and c_N^l is the relatively low development costs incurred by the North given the South has exclusively revealed her secret information.

However, if they fail to agree, the South keeps her traditional knowledge as trade secret and develops a herb d_1 that can potentially target the market in the North. The North has to decide whether to invest or not in development given that the useful information is not disclosed due to trade secrecy. The North can access to the South's information via "reverse engineering" or the information might be misappropriated, which would breach the IPR protection. The cost of developing a new pharmaceutical in this case is relatively higher than if the South had cooperated to give the North direct access to her knowledge. We assume that the North will eventually develop successfully a useful drug if she decides to invest. A Court then decides whether it infringes the right. If there is infringement a license is required and the South is deemed the sole supplier, receiving royalty β[1] on sales by North. In such case North and South may agree

[1] In this part of the game the North would receive a share $(1-\beta)$ analogous to the share α offered to the South, i.e. its participation constraint (outside option profit)

to collude to avoid competition in the North's market. If the North does not infringe then its innovation is patented and competes with the South. Competition proves particularly harmful to the South because the North the market power combined with her superior marketing result in profit erosion for the South. The North infringes with probability q, and does not infringe with probability $1-q$. South and North receive respectively expected profits equal to:

$$\Pi_S^{ni} = q[\pi_S + \beta\pi_N] + (1-q)\pi_S^c - c_S$$

$$\Pi_N^{ni} = q(1-\beta)\pi_N + (1-q)\pi_N^c - c_N^h$$

In contrast, if the North decides not to invest in the research at all, the South receives a profit of $\pi_S - c_S$ and the North gets nothing.

This game can be interpreted as an entry game where the South is trying to enter the market of the North with its medicinal herb.

Further assumptions detailing relative payoffs:

1. The integrated joint revenue is larger than the non-integrated profit in the whole industry: $\pi_{N+S}^i \geq \pi_N + \pi_S = \pi_{N+S}^{ni}$.
2. Competition erodes the revenue of both parties: $\pi_S^c < \pi_S$ and $\pi_N^c < \pi_N$.
3. Investment increases the overall profit in the vertical industry, i.e. $\pi_S^c - c_S + \pi_N^c - c_N^h \geq \pi_S - c_S$, which implies that $\pi_N^c - c_N^h \geq \pi_S - \pi_S^c > 0$.
4. The North is better off when she does not infringe, i.e. $\pi_N^c - c_N^h \geq (1-\beta)\pi_N - c_N^h$ or equivalently $\beta \geq \dfrac{\pi_N - \pi_N^c}{\pi_N}$.

3.4 Equilibrium when the South provides information of uniform quality under complete information

Note that because assumption 3 that investment increases the industry profit implies that $\pi_N^c - c_N^h > 0$, there cannot be an equilibrium in which the North does not invest.

The North has the first move and proposes to the South a contract that maximises its own profit subject to the South participation constraint. The problem of the North is:

$$\begin{cases} \max\limits_{\alpha} & (1-\alpha)(\pi^i_{N+S} - c^l_N) \\ \text{s.t.} & \alpha(\pi^i_{N+S} - c^l_N) \geq q[\pi_S + \beta\pi_N] + (1-q)\pi^c_S - c_S \end{cases}$$

In equilibrium, the participation constraint is binding. If that was not the case then the North could slightly decrease α, satisfy the constraint while increasing its profit. The South therefore receives the value of its outside option. We then obtain:

$$\alpha^* = \frac{q[\pi_S + \beta\pi_N] + (1-q)\pi^c_S - c_S}{\pi^i_{N+S} - c^l_N} \tag{1}$$

The North chooses a profit share α^* that makes the South indifferent between accepting and rejecting the offer. As a result, the North captures all the surplus generated by the joint venture.

When the quality of the information held by the South is uniform, a joint venture is formed in the equilibrium with $\alpha = \alpha^*$. Within the joint venture the South reveals its information exclusively to its partner. Both North and South specialize according to their comparative advantage to produce a new product protected by a property right (patent in particular), which induces a single monopoly pricing. Hence, the integration into the joint venture achieves the first best outcome for the producers.

It is nevertheless important to note that such outcome can occur only if transaction costs are low enough, i.e if the benefits of information revelation from the first innovator exceed the costs of bargaining.

Proposition 3: *In an industry where the North and the South each possess important information for the production of successive innovations, if the South provides information of uniform quality and transaction costs are low, then there is a unique equilibrium involving profit sharing through a joint venture where the South obtains a share α^* of the joint profit. This equilibrium reaches the first best and requires the existence of a single property right allocated to the joint venture.*

3.5 Impact of the Court and Enforceability

The Court plays an important role in the determination of the magnitude of profit sharing because it makes decisions upon infringement. In other words the decision of the Court has implications

for the distribution of the profit. Expression (1) clearly shows a positive relationship between the share of profit offered to the South and the probability of infringement. Holding everything else constant, infringement increases the South's profit share through license fees payment.

As the probability of infringement q tends to 0, (the innovation from the South receives no protection) the share of the industry profit offered to the South tends to $\frac{\pi_S^c - c_S}{\pi_{N+S}^i - c_N^l}$. The South receives a low profit share eroded by competition.

When the Court does not enforce the South's property right (that is the innovation from the South is not protected in the North), the North can have access to the information of the South by paying a low price based on the eroded profit earned by South if there was competition. The more severe the competition, i.e. the lower π_S^c, the eroded the profit will be.

At the other end as the probability of infringement q tends to 1, the share of the industry profit offered to the South tends to $\tilde{\alpha}^* = \frac{\pi_S + \beta\pi_N - c_S}{\pi_{N+S}^i - c_N^l}$. The profit offered to the South is the profit she would receive if she ran the non-integrated industry.$\tilde{\alpha}^*$ is the ratio between that profit and the joint profit in the integrated industry run by the North.

This implies that the Court's commitment to the enforce the South's property right would result in a division of surplus based on South's returns if it ran the industry.

Besides, note that α^* decreases with the South's development costs c_S since the expected profit received by the South if she decides not to integrate is lower the larger the costs.

Proposition 4: *The share of profit offered to the South a) increases in the likelihood of the Court enforcement of the IPR; b) decreases with the intensity of competition in the North's market; and c) decreases with the relative cost of development (North vs. South).*

3.6 Discussion

4 A model of the impact of a second property right in the R&D industry when the quality of TK is not uniform

4.1 Complete Information contract

Suppose the North faces two types of traditional knowledge holder from the South: a highquality type and a low quality type. The type is a *common knowledge*. We assume that with probability

p the South provides information of high quality and with probability $1-p$ it provides information of low quality. Assume further that North offers a menu of contract $\{(\bar{\alpha}, \bar{f}), (\underline{\alpha}, \underline{f})\}$ where α and f represent respectively the royalty and the upfront payment to the South; and the upper and lower bars represent respectively the high quality and low quality types.

The ex ante agreement will be signed if transaction costs are small enough, and the participation constraints are satisfied for each type. The participation constraints ensure that each type receives at least her outside option.

The problem of the North is then:

$$\begin{cases} \max\limits_{\{(\bar{\alpha},\bar{f}),(\underline{\alpha},\underline{f})\}} & p[(1-\bar{\alpha})(\bar{\pi}^i_{N+S} - \bar{c}^l_N) + \bar{f}] + (1-p)[(1-\underline{\alpha})(\underline{\pi}^i_{N+S} - \underline{c}^l_N) + \underline{f}] \\ \text{s.t.} & \bar{\alpha}(\bar{\pi}^i_{N+S} - \bar{c}^l_N) + \bar{f} \geq q[\bar{\pi}_S + \beta\pi_N] + (1-q)\bar{\pi}^c_S - \bar{c}_S \qquad \overline{IR} \\ & \underline{\alpha}(\underline{\pi}^i_{N+S} - \underline{c}^l_N) + \underline{f} \geq q[\underline{\pi}_S + \beta\pi_N] + (1-q)\underline{\pi}^c_S - \underline{c}_S \qquad \underline{\text{IR}} \end{cases}$$

Now define $\bar{V} = \bar{\alpha}(\bar{\pi}^i_{N+S} - \bar{c}^l_N) + \bar{f}$ and $\underline{\text{V}} = \underline{\alpha}(\underline{\pi}^i_{N+S} - \underline{c}^l_N) + \underline{f}$.

The problem can be re-written as follows:

$$\begin{cases} \max\limits_{\{\bar{V},\underline{\text{V}}\}} & p(\bar{\pi}^i_{N+S} - \bar{c}^l_N) + (1-p)(\underline{\pi}^i_{N+S} - \underline{c}^l_N) - [p\bar{V} + (1-p)\underline{\text{V}}] \\ \text{s.t.} & \bar{V} \geq q[\bar{\pi}_S + \beta\pi_N] + (1-q)\bar{\pi}^c_S - \bar{c}_S \qquad \overline{IR} \\ & \underline{\text{V}} \geq q[\underline{\pi}_S + \beta\pi_N] + (1-q)\underline{\pi}^c_S - \underline{\text{c}}_S \qquad \underline{\text{IR}} \end{cases}$$

In the equilibrium, the two participation constraints are binding and therefore:

$\bar{V}^* = \bar{\alpha}^*(\bar{\pi}^i_{N+S} - \bar{c}^l_N) + \bar{f}^* = q[\bar{\pi}_S + \beta\pi_N] + (1-q)\bar{\pi}^c_S - \bar{c}_S$

$\underline{\text{V}}^* = \underline{\alpha}^*(\underline{\pi}^i_{N+S} - \underline{c}^l_N) + \underline{f}^* = q[\underline{\pi}_S + \beta\pi_N] + (1-q)\underline{\pi}^c_S - \underline{\text{c}}_S$

No information rent is given to the South whatever her type because the North can observe the true type and design a contract that pays the South's outside option. As we found previously, the profit offered to the South depends positively on the enforcement of the property right by the Court, so that her decision will be have important equity implications.

The critical condition for the choice of $\{(\bar{\alpha}, \bar{f}), (\underline{\alpha}, \underline{f})\}$ is that:

$\bar{V}^* = \bar{\alpha}^*(\bar{\pi}^i_{N+S} - \bar{c}^l_N) + \bar{f}^* \geq \underline{\text{V}}^* = \underline{\alpha}^*(\underline{\pi}^i_{N+S} - \underline{c}^l_N) + \underline{f}^*$

Moreover the North will implement the joint venture so long as her expected payoff with the ex ante agreement is greater than without:

$$p(\bar{\pi}^i_{N+S} - \bar{c}^l_N) + (1-p)(\underline{\pi}^i_{N+S} - \underline{c}^l_N) - [p\bar{V}^* + (1-p)\underline{\text{V}}^*] \geq q(1-\beta)\pi_N + (1-q)\pi^c_N - c^h_N$$

We assume this condition holds.

Proposition 4: *When the quality of information provided by the South is not uniform and is common knowledge, the North proposes a menu of contracts* $\{(\bar{\alpha}, \bar{f}), (\underline{\alpha}, \underline{f})\}$ *such that:*

$$\bar{V}^* = \bar{\alpha}^*(\bar{\pi}^i_{N+S} - \bar{c}^l_N) + \bar{f}^* = q[\bar{\pi}_S + \beta\pi_N] + (1-q)\bar{\pi}^c_S - \bar{c}_S$$

and

$$\underline{V}^* = \underline{\alpha}^*(\underline{\pi}^i_{N+S} - \underline{c}^l_N) + \underline{f}^* = q[\underline{\pi}_S + \beta\pi_N] + (1-q)\underline{\pi}^c_S - \underline{c}_S$$

and

$$\bar{V}^* \geq \underline{V}^*$$

Discussion: In this case, efficiency is reached. Because of complete information, the North finds itself in the same situation as described earlier: the contracts offered are the same as in the case of uniform quality.

4.2 Incomplete information contract

Suppose now that the type is a *private information* for the South. Assume further that North offers a menu of contracts able to separate the two types $\{(\bar{\alpha}, \bar{f}), (\underline{\alpha}, \underline{f})\}$.

An agreement will be signed if transaction costs are small enough, and the participation and incentive compatible constraints are satisfied for each type. The participation constraints ensure that each type receives at least her outside option. The incentive compatible constraints ensure that each type is always better off telling the truth.

The problem of the North is then:

$$\begin{cases} \max\limits_{\{(\bar{\alpha},\bar{f}),(\underline{\alpha},\underline{f})\}} & p[(1-\bar{\alpha})(\bar{\pi}^i_{N+S} - \bar{c}^l_N) + \bar{f}] + (1-p)[(1-\underline{\alpha})(\underline{\pi}^i_{N+S} - \underline{c}^l_N) + \underline{f}] \\ \text{s.t.} & \bar{\alpha}(\bar{\pi}^i_{N+S} - \bar{c}^l_N) + \bar{f} \geq q[\bar{\pi}_S + \beta\pi_N] + (1-q)\bar{\pi}^c_S - \bar{c}_S & \overline{IR} \\ & \bar{\alpha}(\bar{\pi}^i_{N+S} - \bar{c}^l_N) + \bar{f} \geq \underline{\alpha}(\bar{\pi}^i_{N+S} - \bar{c}^l_N) + \underline{f} & \overline{IC} \\ & \underline{\alpha}(\underline{\pi}^i_{N+S} - \underline{c}^l_N) + \underline{f} \geq q[\underline{\pi}_S + \beta\pi_N] + (1-q)\underline{\pi}^c_S - \underline{c}_S & \underline{\text{IR}} \\ & \underline{\alpha}(\underline{\pi}^i_{N+S} - \underline{c}^l_N) + \underline{f} \geq \bar{\alpha}(\underline{\pi}^i_{N+S} - \underline{c}^l_N) + \bar{f} & \underline{\text{IC}} \end{cases}$$

In this economy, the low quality traditional knowledge holder may want to misrepresent his type to obtain a higher payoff: $\bar{\alpha}(\underline{\pi}^i_{N+S} - \underline{c}^l_N) + \bar{f} = \bar{V} - \bar{\alpha}\Delta[\pi^i_{N+S} - c^l_N]$. In addition, if the high type wants to mimic the low type, he would receive: $\underline{\alpha}(\bar{\pi}^i_{N+S} - \bar{c}^l_N) + \underline{f} = \underline{\mathrm{V}} + \underline{\alpha}\Delta[\pi^i_{N+S} - c^l_N]$; where $\Delta[\pi^i_{N+S} - c^l_N] = (\bar{\pi}^i_{N+S} - \bar{c}^l_N) - (\underline{\pi}^i_{N+S} - \underline{c}^l_N)$.

The problem can be re-written as follows:

$$\begin{cases} \max\limits_{\{\bar{V},\underline{\mathrm{V}}\}} & p(\bar{\pi}^i_{N+S} - \bar{c}^l_N) + (1-p)(\underline{\pi}^i_{N+S} - \underline{\mathrm{c}}^l_N) - [p\bar{V} + (1-p)\underline{\mathrm{V}}] & \\ \text{s.t.} & \bar{V} \geq q[\bar{\pi}_S + \beta\pi_N] + (1-q)\bar{\pi}^c_S - \bar{c}_S & \overline{IR} \\ & \bar{V} \geq \underline{\mathrm{V}} + \underline{\alpha}\Delta[\pi^i_{N+S} - c^l_N] & \overline{IC} \\ & \underline{\mathrm{V}} \geq q[\underline{\pi}_S + \beta\pi_N] + (1-q)\underline{\pi}^c_S - \underline{\mathrm{c}}_S & \underline{\mathrm{IR}} \\ & \underline{\mathrm{V}} \geq \bar{V} - \bar{\alpha}\Delta[\pi^i_{N+S} - c^l_N] & \underline{\mathrm{IC}} \end{cases}$$

The combination of the two incentive constraints implies that $\bar{\alpha} \geq \underline{\alpha}$, i.e. the high quality type should be offered a higher royalty than the low type.

In addition, $\overline{IC}$ can be disregarded because the high type has always incentive to tell the truth. The problem here is rather to make the low quality type reveal its true type. Furthermore, the ability of the low type to imitate the high type implies that he will be offered a payoff strictly higher than her outside option. $\underline{IR}$ is therefore strictly satisfied. Thus, only two constraints are relevant: $\overline{IR}$ and $\underline{IC}$. At the optimum of the North's problem, both constraints are binding. If that was not the case the North could slightly reduce $\bar{V}$ and $\underline{\mathrm{V}}$ by ε, still satisfy the constraints and increase her payoff, leading to a contradiction.

Therefore we have:

$$\bar{V}^{**} = q[\bar{\pi}_S + \beta\pi_N] + (1-q)\bar{\pi}^c_S - \bar{c}_S$$

and

$$\underline{\mathrm{V}}^{**} = \bar{V}^{**} - \bar{\alpha}^{**}\Delta[\pi^i_{N+S} - c^l_N]$$

Or equivalently:

$$\bar{\alpha}^{**}(\bar{\pi}^i_{N+S} - \bar{c}^l_N) + \bar{f}^{**} = q[\bar{\pi}_S + \beta\pi_N] + (1-q)\bar{\pi}^c_S - \bar{c}_S$$

and

$$\underline{\alpha}^{**}(\underline{\pi}^i_{N+S} - \underline{c}^l_N) + \underline{f}^{**} = \bar{\alpha}^{**}(\underline{\pi}^i_{N+S} - \underline{c}^l_N) + \bar{f}^{**}$$

Re-arranging the latter equation, we obtain:

$$(\underline{\alpha}^{**} - \bar{\alpha}^{**})(\underline{\pi}^{i}_{N+S} - \underline{c}^{l}_{N}) = \bar{f}^{**} - \underline{f}^{**}$$

Since we have established that $\bar{\alpha} \geq \underline{\alpha}$ and thereby $\bar{\alpha}^{**} \geq \underline{\alpha}^{**}$, it follows that $\bar{f}^{**} \leq \underline{f}^{**}$. In words, the high type will be offered a higher royalty but a lower upfront payment than the low type.

Note that $\bar{V}^{**} = \bar{V}^{*}$ and $\underline{V}^{**} > \underline{V}^{*}$ (because of the information rent received by the low type)

The information rent given up to the low type is:

$R = \underline{V}^{**} - (q[\underline{\pi}_S + \beta\pi_N] + (1-q)\underline{\pi}^c_S - \underline{c}_S)$

$R = \Delta\left(q[\pi_S + \beta\pi_N] + (1-q)\pi^c_S - c_S\right) - \bar{\alpha}^{**}\Delta[\pi^i_{N+S} - c^l_N] > 0$

$\bar{\alpha}^{**} < \dfrac{\Delta\left(q[\pi_S + \beta\pi_N] + (1-q)\pi^c_S - c_S\right)}{\Delta[\pi^i_{N+S} - c^l_N]}$

Proposition 6: *When the quality of information provided by the South is not uniform and is private information, the North proposes a menu of self-selecting contracts* $\{(\bar{\alpha}, \bar{f}), (\underline{\alpha}, \underline{f})\}$ *to screen among the types. There is a single separating equilibrium in which* $\bar{\alpha}^{**} \geq \underline{\alpha}^{**}$ *and* $\bar{f}^{**} \leq \underline{f}^{**}$ *such that:*

$$\bar{V}^{**} = \bar{\alpha}^{**}(\bar{\pi}^{i}_{N+S} - \bar{c}^{l}_{N}) + \bar{f}^{**} = q[\bar{\pi}_S + \beta\pi_N] + (1-q)\bar{\pi}^c_S - \bar{c}_S$$

and

$$\underline{V}^{**} = \underline{\alpha}^{**}(\underline{\pi}^{i}_{N+S} - \underline{c}^{l}_{N}) + \underline{f}^{**} = \bar{\alpha}^{**}(\underline{\pi}^{i}_{N+S} - \underline{c}^{l}_{N}) + \bar{f}^{**}$$

4.3 Discussion

In the equilibrium the North offers the high quality type a lower upfront payment and higher royalty than the low type. Such a scheme is more conducive to identify the high quality type: Indeed this type is more willing to earn little today in the prospect of higher future payoffs. So this scheme allows the North to identify those who have a credible commitment to provide information of high quality.

The payoff offered to the high type is positively related to the enforcement the South property right as found previously. As for the low quality, its ability to imitate the high type implies that her payoff is positively related to the royalty and upfront payment offered to the high type.

This contract is less efficient: because the low type ends up receiving more than she should do due to her ability to mimic the high type, the North may be less willing to bargain. In comparison to the complete information case, the North expected payoff is reduced by the amount of information rent conceded to the low type. Because of this, the prospect of an agreement may be more limited because the North is less likely to satisfy her own participation condition, i.e. her expected payoff with the ex ante agreement is greater than without:

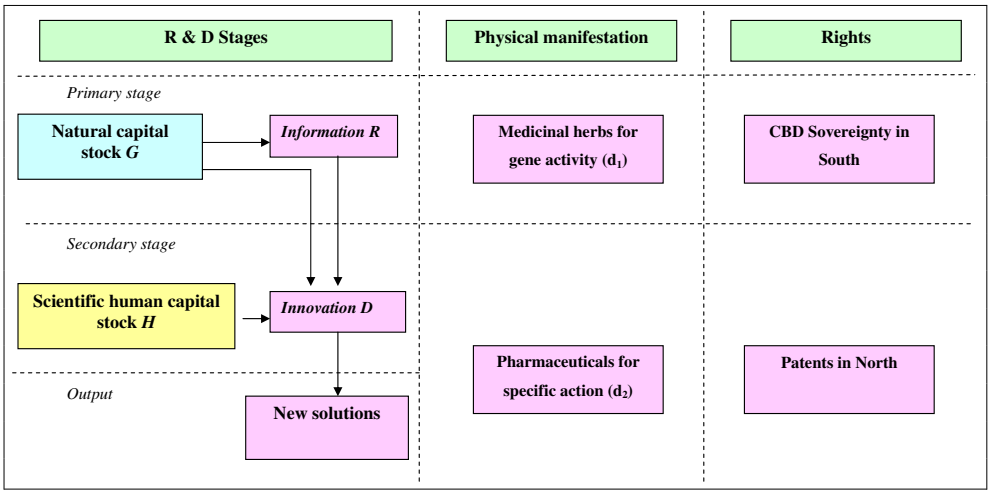
$$p(\bar{\pi}^i_{N+S} - \bar{c}^l_N) + (1-p)(\underline{\pi}^i_{N+S} - \underline{c}^l_N) - [p\bar{V}^{**} + (1-p)\underline{V}^{**}] \geq q(1-\beta)\pi_N + (1-q)\pi^c_N - c^h_N.$$

5 Conclusion

This paper analyzes in a simple model the interactions between North and South in relation to traditional knowledge and bio-prospecting. The North is rich in human capital but needs essential genetic resources and knowledge only available in the South to make innovations in the biological sector. We use the cumulative research setting developed in the industrial organization literature to examine the possibility of assigning a property right to the information R held by the South. In doing so, we investigate whether this can achieve efficiency and discuss the implications on the division of the profit. We find that such move is efficient from the producers' perspective because it is conducive to integration and therefore to the maximisation of the joint profit. However, although there may be improvement (compared to the current status quo) when the South is afforded a broad protection, the benefit sharing still largely remains in favour of the North. Indeed the latter captures all the surplus generated by the efficient outcome although the South has contributed to the emergence of the first best.

Appendix 1: Schematic overview of R&D stages in the biological sector (adapted from Goeschl and Swanson, 2002).

Schematic overview of sequential innovation in the biological sector (adapted from Goeschl and Swanson, 2002)



R is the biological activity recognized by the South

D is the directed biological activity discovered by the North

Appendix 2: Structure Model???

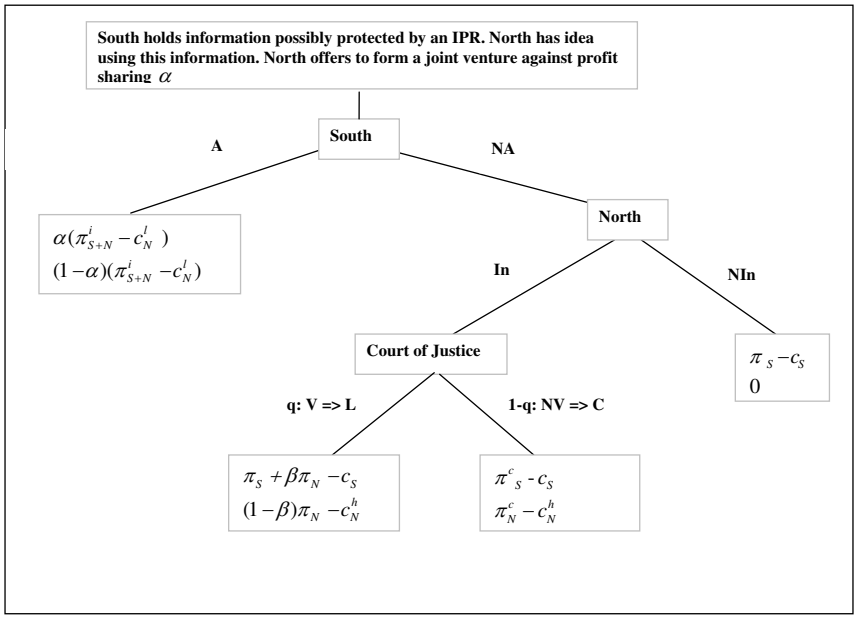
Structure of the Model???

	South	North
Capital	Natural capital stock *G*	Scientific human capital stock *H*
R & D Industry	Pure Information R	Innovation D
Consumers	South Consumers	North Consumers
Courts	Access to South Market	Access to North Market

R is the biological activity recognized by the South

D is the directed biological activity discovered by the North

Appendix 3: Description of the game tree



References

[1] Eswaran M. and N. Gallini (1996): Patent Policy and the Direction of Technological Change, The RAND Journal of Economics, 27: 722-746.

[2] Gallini N. and S. Scotchmer (2002): Intellectual Property: When is it the Best Incentive System?, in Jaffe A. et al. Eds., Innovation Policy and the Economy, MIT Press, 51-78.

[3] Gehl Sampath P. (2003): Defining an Intellectual Property Right on Traditional Medicinal Knowledge: A Process-Oriented Perspective, UNU/INTECH Discussion Paper Series # 2003-4.

[4] Gehl Sampath P. (2005): Regulating Bio-prospecting: Institutions for Drug Research, Access and Benefit-Sharing, United Nations University Press.

[5] Goeschl T. and T. Swanson (2002): The Economics of R&D within the Biological Sector and its Optimal Management, World Bank Working Paper.

[6] Green J. and S. Scotchmer (1995): On the Division of Profit in Sequential Innovation, The RAND Journal of Economics, 26: 20-33.

[7] Scotchmer S. and J. Green (1990): Novelty and Disclosure in Patent Law, The RAND Journal of Economics, 21: 131-146.

[8] Scotchmer S. (1991): Standing on the Shoulders of Giants: Cumulative Research and the Patent Law, The Journal of Economic Perspective, 5: 29-41.

[9] Scotchmer S. (1996): Protecting Early innovators: Should Second-Generation Products be Patentable?, The RAND Journal of Economics, 27: 322-331.

[10] Vieillefosse A. (2003): MSc. Dissertation, University College London.