Traditional Knowledge as Private Information

Mare Sarr† Tim Swanson‡

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Abstract

Bioprospecting is the purposeful search for natural compounds undertaken by pharmaceutical or biotechnology firms to find leads necessary for the development of new drugs. It requires cooperation between the bio-prospecting firm—the North—and the country hosting the genetic resources (GR) and/or traditional knowledge (TK)—the South. The host country provides basic or pure information on potential solution concepts, while the R&D firm supplies the practical capabilities for developing these solution concepts into marketable compounds and products. In this manner primary biological information is generated and channelled through a secondary R&D sector to become commercial products capable of addressing consumer needs. An important issue concerns the nature of the incentive mechanism that should govern the production of innovation within this R&D sector. The current arrangement in this industry usually provides for a single property right at the secondary stage of R&D. This raises two problems, one of efficiency and one of equity. The key question asked here is whether it is necessary to institute a distinct and separate system of IPR for TK if a fully functional system of property right for GR has been established. We demonstrate that in world in which TK and GR are complements in the production of R&D, a resolution of the property rights failure in GR also resolves the allocation failure in TK even in the absence of a distinct property rights system. The reason is that TK is akin to a private good, with the comparison of TK with a trade secret being a suitable parallel. The key aspect in the analysis is the degree to which the outside option of the South changes with courts in the North upholding a property right.

Keywords: Biodiversity Prospecting; Traditional Knowledge; Genetic Resources; Intellectual Property Rights; Sequential R&D

JEL Classification: Q56; O34; L24

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†School of Economics and Environmental Policy Research Unit, University of Cape Town, Private Bag, Rondebosch 7701, South Africa. Email: mare.sarr@uct.ac.za

‡Department of Economics, University College London, London WC1E 6BT, United Kingdom. Email: tim.swanson@ucl.ac.uk
1 Introduction

Bioprospecting is the purposeful search for natural compounds undertaken by pharmaceutical or biotechnology firms to find leads necessary for the development of new drugs. It requires cooperation between the bio-prospecting firm—the North—and the country hosting the genetic resources and/or traditional knowledge—the South. The host country provides basic or pure information on potential solution concepts, while the R&D firm supplies the practical capabilities for developing these solution concepts into marketable compounds and products. In this manner primary biological information is generated and channelled through a secondary R&D sector to become commercial products capable of addressing consumer needs.

Despite the South’s contribution in providing necessary primary information as inputs in the R&D process, genetic information and traditional knowledge generally do not meet patentability requirements—novelty and non-obviousness—and receive little or no compensation. The failure to protect these contributions may result in a lack of investment in genetic diversity and traditional human capital, and in inefficient flow of information across the sector. This sub-optimal situation may end up in a permanent loss of both genetic diversity and traditional knowledge and therefore a loss of valuable source of improvement of human health. Thus, to address this problem, Gehl Sampath (2005) suggests that the South’s information should be protected in a similar way as the basic information provided by small and medium sized biotechnology firms to larger firms which use these inputs to process a final product. It is thought that in the face of this incentive problem, the creation of ‘informational property rights’ (Swanson, 1995) could provide the South enough incentive to maintain genetic diversity and traditional knowledge, and grant access to her genetic resources. However, unless the property rights assigned domestically in the South are recognised across jurisdictions, the hold-up problem analysed in Sarr and Swanson (2008) is likely to persist. The real challenge is for North and South to coordinate their legal systems in a way that allows the South to be properly compensated for investing in genetic diversity and associated human capital, and in supplying genetic material.

Our purpose in this paper is to analyse North/South interaction when such coordination is achieved. In particular, our aim is to determine the number of property rights necessary to induce an efficient flow of information within this vertical industry, as well as their placement—in addition to the patent assigned to the North. Should these rights solely protect the genetic resource-based information, or should traditional knowledge also be protected? To investigate whether both types of contributions should warrant property rights protection, or whether a single right is sufficient, we propose a clear delineation between genetic resources and traditional knowledge. Throughout this paper, we define traditional knowledge as the information that allows the North to truncate the search, i.e. to search over a smaller number of species. (Costello and Ward, 2006) This information is assumed to be the South’s private information. The value of this private information lies in its efficacy in guiding the North towards the genetic resources that are most promising and useful for R&D. We explore the implications of the presence of traditional knowledge as private information both from an efficiency and a distribution perspectives.

We assume that cooperation takes place via a contract in which the proposer has the ability to make a take-it or leave-it offer. We will analyse the cases where each party in turn has this ability and is therefore given all the bargaining power. In the presence of traditional knowledge (i.e. private information) this
assumption amounts to the North solving a screening problem—when he is the proposer—and the South solving a signalling problem—when she makes the offer. We find that, under complete information—absent traditional knowledge—a property right in the genetic information creates the basis for efficient contracting. When traditional knowledge is present, the emergence of an efficient outcome depends on the magnitude of the South’s outside option induced by the existence of an enforceable property right in the genetic resources—in the screening case. The division of profits improves in favour of the South even without assigning a particular property right in TK. This result is obtained with a distribution assumption that is least favourable to the South since the North is given the right to make a take-it or leave-it offer. This suggests that despite the extremely unfavourable distribution, the South may capture some of the cooperative surplus even without a formal right in TK, so long as her knowledge is kept secret. In the signalling case, the South as the proposer is the residual claimant of the cooperative surplus and has therefore the proper incentive for efficient information trade with the North. Efficiency in this case hinges upon the assumption of risk neutrality and the possibility for the South to offer an ex ante contract, i.e. before learning her private information.

This paper is structured as follows: Section 2 provides a detailed presentation of the model. In section 3, we solve the contracting problem under symmetric information when genetic information is afforded property right protection and derive the efficient solution. In section 4, we investigate how the contractual outcomes are altered in the presence of traditional knowledge defined as the South’s private information about the usefulness of the genetic resources. Finally section 5 concludes the analysis.

2 The Model

2.1 Stylised Facts

Agents. North (N) and South (S) refer to two distinct regions comprised of: (i) distinct consumer groups \( CG_N \) and \( CG_S \); (ii) distinct firms \( F_N \) and \( F_S \); and (iii) distinct legal institutions or courts \( Ct_N \) and \( Ct_S \). The two regions could realise joint benefits by cooperating in the production of R&D for health services, but must coordinate their individual legal systems to generate these incentives toward cooperation. There are four crucial dimensions within which North and South interact.

Separate R&D Contributions. Firms from the North and the South, \( F_N \) and \( F_S \), can cooperate for mutual benefit through coordination in the supply of inputs within a process of sequential R&D. If they cooperate successfully, then a higher quality of health services is available to consumers. The South is gene rich and technology poor. The firms in the South \( F_S \) are specialised in the provision of genetic material \( g \) and traditional knowledge (TK). The North is technology rich and biodiversity poor. The firms in the North \( F_N \) use information contained in the genetic resources \( g \) and may combine them with traditional knowledge and technology in the North to search for new leads and develop new drugs \( d \).
Separate Markets. North and South have distinct consumer groups $CG_N$ and $CG_S$, and therefore separate markets for medicinal products. Consumers in the South $CG_S$ have low income and a low willingness to pay for medicines. By contrast, consumers in the North $CG_N$ have high income and are willing to pay high prices for drugs developed by the pharmaceutical industry.

Separate Property Rights Systems. In each region, there exists a property rights system that attempts to generate incentives for innovation by ensuring appropriation of the returns on investments in that region. Genetic resources $g$ and traditional knowledge are conferred property rights in the South. Likewise, the drug $d$ developed by $F_N$ in the North has a property right declared in it. Property rights conferred by a given region exist automatically only within that region’s boundaries, and must be adopted and implemented by the other region to be given effect there.

Separate Court Systems. Court systems exist in each region ($Ct_S$ and $Ct_N$) for enforcement of property rights. Any right conferred in a given jurisdiction will be recognised and enforced by courts in the other region. As a consequence, the only issue that courts in the North have to resolve in case of litigation is whether the drug $d$ has enough distinctiveness relative to $F_S$’s genetic resources or traditional knowledge, to warrant property right protection.

| Table 1: Stylised Facts: North/South interaction in the presence of TK |
|-------------------------------------------------|-----------------|
| Vertical Industry | South | North |
| Separate R&D Contributions | $F_S$: Upstream | $F_N$: Downstream |
| Separate Markets | $F_S$ has property right in $g$ and TK | $F_N$ has property right in $d$ |
| Separate Property Rights Systems | $Ct_S$ enforce rights in $g$ and TK | $Ct_N$ enforce rights in $d$, $g$ and in TK |

2.2 Description of the sequential innovation

We model the R&D industry (in the biological sector) as a non-integrated vertical industry of two stages as described in Appendix A.1. In the primary stage of the process, the firms from the South $F_S$ generate a
flow of information originating from nature and accumulated human capital. This information is collected by firms from the North $F_N$ to produce some innovation designed to meet consumers needs in the North.

Through observation of natural diversity, $F_S$ may identify some biological activity in a plant variety and then use this knowledge to produce and market herbal medicines. Thus, by application of her traditional human capital $h_S$ to the genetic capital endowment $g$, $F_S$ identifies essential information embodied within herbal medicines $H$. The genetic material $g$ is assumed to be present only in the South and, for purposes of this analysis, we assume that all innovations in this industry are derived from the capital stock $g$. $F_N$, as the second innovator in this industry, is endowed with scientific capital $h_N$ which he is able to combine with $g$ (and $h_S$) to produce a flow of innovations $d$ (disembodied information, e.g. identification and isolation of active principles). This innovation $d$ is then embodied within a pharmaceutical drug, which is then amenable to IPR. This industry is depicted in Figure 2 and Figure 3.

2.3 The Fundamentals of the Model

We assume that $F_N$ and $F_S$ are two risk neutral agents that bargain over the access to genetic resources $g$. In this paper, we assume that courts in the North $Ct_N$ recognise any property right granted in the South to protect genetic information and traditional knowledge.

Assume now that $F_N$ offers $F_S$ a contract to be granted access to $g$ in return for a transfer payment $t$. If successful negotiation is achieved, then the two parties form a joint venture within which $F_N$ can freely use the genetic information to develop a patentable product. The two parties receive the following payoffs:

$$\Pi_S = t - c^S_S(g)$$

$$\Pi_N = \pi_S(g) + \pi_N(g,d) - c_N(d) - t$$

where the benefits $\pi_S$ and $\pi_N$ are continuous, increasing and concave in their arguments; $d$ is $F_N$’s investment in drug development; $c^S_S(g)$ and $c_N(d)$ are respectively $F_S$’s supply cost and $F_N$’s development cost. These costs are increasing and convex in $g$ and $d$.

If no agreement is reached, $F_S$ considers placing derivatives of her herbal medicines directly onto the market in the North. In response, $F_N$ might develop a new drug built around the information contained in the herbal medicine. If $F_N$ does not invest in development, $F_S$ receives a profit of $\pi_S(g) - c_S(g)$—where $c_S(g)$ is the cost of developing the herbal medicine—and $F_N$ gets nothing. On the other hand, if $F_N$ decides to invest in drug development, then a court in the North decides whether it has infringed $F_S$’s right, in which case an ex post license is required. Infringement happens with probability $\xi$. If $F_N$ does not infringe then his innovation is patented and marketed in the Northern market. In this case, the newly patented drug will compete—competition in differentiated products—in the Northern market with the herbal medicine. The profits are then $\pi^*_S(g) - c_S(g)$ and $\pi^*_N(g,d) - c_N(d)$. We will assume that the drug produced by $F_N$ based on $F_S$’s information may or may not involve additional functions (due to value added by $F_N$). Hence, the court’s ruling hinges on how distinctive $F_N$’s innovation is relative to the $F_S$’s.

The noncooperative expected payoffs are therefore:
where $\beta$ is the share of $F_N$'s profit captured by $F_S$ through \textit{ex post} licensing or equivalently the damage paid by $F_N$ for infringement; and $\hat{g}$ and $\hat{d}$ result from the first order conditions—which are omitted here.

The sequence of the decisions is summarised as follows:

1. $F_S$ devotes resources to find genetic materials (e.g. plants) $g$ containing useful information protected by a property right.
2. $F_N$ offers $F_S$ to grant her access to $g$ and develop a new pharmaceutical in return for a transfer payment $t$.
3. $F_S$ accepts or rejects the offer.
4. In case of rejection, $F_N$ may (or may not) decide to develop a new drug based on $g$.
5. If a drug is developed, the Court in the North decides whether $F_S$’s exclusive right has been violated.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{decision_tree.png}
\caption{Decision tree}
\end{figure}
2.4 Efficiency condition

We assume again that efficiency is framed in terms of the industry’s outcome. By cooperating, $F_N$ and $F_S$ maximise the industry joint profit:

$$\max_{g,d} \Pi_S + \Pi_N = \pi_S(g) + \pi_N(g,d) - c^g_S(g) - c_N(d) \quad (5)$$

In equilibrium, the level of genetic resources $g^*$ and investment in drug development $d^*$ to balance marginal revenues and marginal costs of both parts of the R&D industry:

$$\pi'_S(g^*) + \frac{\partial \pi_N}{\partial g}(g^*, d^*) = c^g_S(g^*) \quad (6)$$

$$\frac{\partial \pi_N}{\partial d}(g^*, d^*) = c'_N(d^*) \quad (7)$$

In equation (6), the genetic resource level satisfies Bowen-Lindahl-Samuelson condition of optimal public good provision. Drug development is also undertaken optimally by $F_N$ at marginal cost.

We now establish the means by which the establishment of a property right protecting genetic information and/or associated traditional knowledge together with a procedure for its enforcement determines the prospects for efficient contracting. The main idea is that affording a property right in the information produced by $F_S$—unlike the current IPR regime—may trigger cooperation and lead to an efficient outcome.\(^1\) Paradoxically, the property right may not be used by $F_S$, but may serve to determine her outside option when an agreement is being discussed. The very existence of the property right ensures $F_S$ a stream of income that will be accounted for in any negotiation.

3 Contracting genetic resources in the absence of traditional knowledge

In this section, we commence with an R&D sector, depending solely upon genetic resources and scientific method. In the following section, we discuss the relevance of an R&D sector, in which $F_S$ has both genetic resources and traditional knowledge.

\(^1\) Unlike in Sarr and Swanson (2008) where $F_N$ and $F_S$ must rely on the court’s decision and renegotiation to reach an efficient allocation of $g$, here the existence of an enforceable property right in the genetic resource-based information enables the parties to reach efficiency without the court’s intervention. As we will discuss below, the court sole contribution in this paper is to shape the division of profits.
3.1 Contract offered by $F_N$

We assume that $F_N$ has the ability to make a take-it or leave-it offer. This implies that $F_S$ has no bargaining power. The problem faced by $F_N$ is to offer contractual terms to $F_S$ that will cause her to accept the offer to grant access to $g$. We first characterise the contract offered by $F_N$ when the usefulness of $g$ for R&D purposes is common knowledge. Later in section 4, we analyse how asymmetric information about the usefulness of $g$—interpreted as traditional knowledge—will affect the contractual outcome.

Under symmetric information, $F_N$ proposes to $F_S$ a contract $(g, t)$—access to $F_S$’s resources $g$ in return for a transfer payment $t$—that maximises his own profit subject to $F_S$’s participation constraint, that is:

$$\max_{g,d,t} \pi_S(g) + \pi_N(g, d) - c_N(d) - t$$

s.t. $t - c_S^d(g) \geq \xi(\pi_S(\hat{g}) + \beta\pi_N(\hat{g}, \hat{d})) + (1 - \xi)\pi_S^c(\hat{g}) - c_S(\hat{g})$

**Proposition 1:** In an industry where firms $F_N$ and $F_S$ possess important information for the production of successive innovations,

1) If the usefulness of $g$ is common knowledge, then there is a unique (sub-game perfect) equilibrium contract $(g^*, t^*)$ offered by $F_N$. This contract is characterised by the efficient allocation of genetic resources $g^*$ and a transfer payment $t^*$ as defined in (6) and (8).

2) The equilibrium payment $t^*$ increases in the likelihood of infringement and with the supply of genetic material.

**Proof:** In the equilibrium, the participation constraint is binding. If that was not the case then $F_N$ could slightly decrease $t$, satisfy the constraint while increasing its profit. This would contradict the fact that we are in the equilibrium. $F_N$ therefore receives the value of her reservation profit so that: $t = \xi(\pi_S(\hat{g}) + \beta\pi_N(\hat{g}, \hat{d})) + (1 - \xi)\pi_S^c(\hat{g}) - c_S(\hat{g}) + c_S^d(g)$

Plugging $t$ into the objective function and deriving the first order conditions yields the efficient outcomes obtained in (6) and (7).

So the optimal transfer payment is given by:

$$t^* = \xi(\pi_S(\hat{g}) + \beta\pi_N(\hat{g}, \hat{d})) + (1 - \xi)\pi_S^c(\hat{g}) - c_S(\hat{g}) + c_S^d(g^*)$$  (8)

Moreover it is straightforward to derive the comparative statics:

$$\frac{dt^*}{d\xi} = \pi_S(\hat{g}) + \beta\pi_N(\hat{g}, \hat{d}) - \pi_S^c(\hat{g}) > 0$$

$$\frac{dt^*}{dg} = \xi \left( \pi_S(\hat{g}) + \beta \frac{\partial \pi_N}{\partial g}(\hat{g}, \hat{d}) \right) + (1 - \xi)\pi_S^c(\hat{g}) - c_S(\hat{g}) + c_S^d(g^*) > 0$$

When the quality of the information held by $F_S$ is common knowledge, $F_N$ enjoys an efficient access to $g$. Because of the uniqueness of this equilibrium, $F_S$’s informational rights can be substantially protected.
without inducing any loss of efficiency. Therefore, the maximum share received by $F_S$ in this framework is when the probability of infringement $\xi = 1$. However, given our assumption that $F_N$ holds all the bargaining power, a property right in $g$ addresses the distributional issues only to an extent since $F_S$ does not share in the cooperative surplus.

The courts in the North play an important role in the determination of the magnitude of the transfer because they make decisions regarding infringement. It is their ruling that determines the terms of the contract between the successive innovators. If $F_N$ makes minor amendments to $F_S$’s innovation, and the courts refuse to award a distinct property right, then $F_S$ is the sole owner of all innovations in that stream. On the other hand, if the courts award rights to $F_N$, then $F_S$ will have to compete in the Northern market.

### 3.2 Contract offered by $F_S$

We now reverse the ordering of the firm making the offer. We assume that $F_S$ proposes to $F_N$ a contract $(g, t)$ that maximises her own profit subject to $F_N$’s participation constraint, that is:

$$\max_{g,t} \quad t - c_S^q(g)$$

s.t. $$\pi_S(g) + \pi_N(g, d) - c_N(d) - t \geq \xi(1 - \beta)\pi_N(\hat{g}, \hat{d}) + (1 - \xi)\pi_N^c(\hat{g}, \hat{d}) - c_N(\hat{d})$$

For the same reason invoked above, the participation constraint must be binding so that:

$$t = \pi_S(g) + \pi_N(g, d) - c_N(d) - \xi(1 - \beta)\pi_N(\hat{g}, \hat{d}) - (1 - \xi)\pi_N^c(\hat{g}, \hat{d}) + c_N(\hat{d})$$

Replacing $t$ into $F_S$’s objective function and deriving the first order conditions, we obtain the same results as in section 3.1. In addition, the optimal transfer becomes:

$$t^* = \pi_S(g^*) + \pi_N(g^*, d^*) - c_N(d^*) - \xi(1 - \beta)\pi_N(\hat{g}, \hat{d}) - (1 - \xi)\pi_N^c(\hat{g}, \hat{d}) + c_N(\hat{d}) \quad (9)$$

The results obtained here are an application of the Coase theorem. Efficiency is attained independently of the identity of the proposer. Only distribution changes via different transfer payments: compare Equation (8) to Equation (9).

### 4 Contracting genetic resources in the presence of traditional knowledge

We now examine how the presence of traditional knowledge (TK) might influence the contractual terms between the parties. We assume that TK has the effect of informing $F_N$ about the most promising genetic resources for purposes of R&D. In this way, the quality of $F_S$’s traditional knowledge lies in her ability to truncate the search, i.e. to target the most promising genetic resources, thus reducing considerably the number of resources to be searched. (Costello and Ward, 2006) We investigate here the possibility of assigning a property right in TK, where the knowledge about the genetic resources that are most useful for R&D, is $F_S$’s private information and can only be acquired by $F_N$ via contracting. We continue to assume
that there is a property right in genetic information. At this point we make no assumption regarding the need for property rights in TK itself, and only examine how its existence impacts upon the contracts described within the previous section.

We say that $F_S$ holds traditional knowledge when she possesses information on the prospects of heterogeneous genetic resources in regard to their usefulness for R&D. For purposes of exposition, suppose $F_S$ has two types of information on the prospect that the genetic resources deliver a promising lead. There is a "high prospect" type $\theta$ with probability $p$ and a "low prospect" type $\theta$ with probability $1 - p$. High types are of higher value for two reasons: 1) they have a higher average value for producing information within the R&D process; and 2) they have a lower average cost when supplying information within the R&D process. Thus, the usefulness of the genetic resources for purposes of information generation is $F_S$'s private information. Together these assumptions constitute our definition of the economic meaning of TK.

As we did in section 3, we first analyse the case where $F_N$ makes the offer and then proceed to the case where $F_S$ has this ability.

4.1 TK as Private Information: The case of Screening by $F_N$

We now specify the ways in which the existence of this private information will impact upon the contracting process examined in section 3.1. $F_N$ specifies the offered contract enabling direct access to $F_S$'s genetic resources. A contract consists of access to $F_S$'s resource $g$ in return for monetary payment $t$. It is specified in terms of the different types of genetic resources available. A direct revelation mechanism is a menu of two contracts $\{(g, \bar{t}), (\tilde{g}, \tilde{t})\}$, one for each type of resource.

An agreement will be signed if transaction costs are small enough, and the participation and incentive compatible constraints are satisfied for each type of resource. The participation constraints (or individual rationality constraints $TR$ and $IR$) ensure that each type receives at least her expected reservation profit.

$$V = \bar{t} - c_S(\bar{g}) \geq \Pi^{nc}_S$$
$$V = \tilde{t} - c_S(\tilde{g}) \geq \Pi^{nc}_S$$

This is equivalent to

$$V \geq \Pi^{nc}_S + V_0$$
$$V \geq \Pi^{dc}_S$$

where $\Pi^{nc}_S = \xi (\pi_S(\bar{g}) + \beta \pi_N(\bar{g}, \bar{d})) + (1 - \xi) \pi_S(\bar{g}) - c_S(\bar{g})$; $\Pi^{nc}_S = \xi (\pi_S(\tilde{g}) + \beta \pi_N(\tilde{g}, \tilde{d})) + (1 - \xi) \pi_S(\tilde{g}) - c_S(\tilde{g})$; $\Pi^{dc}_S = \Pi^{nc}_S + (\Pi^{nc}_S - \Pi^{nc}_S) = \Pi^{dc}_S + V_0$. The term $V_0 = \Pi^{nc}_S - \Pi^{nc}_S$ represents the profit differential between the high and low type (i.e. the differential value of her outside option within the non-cooperative setting).

\footnote{For example, the knowledge that these are high prospect genetic resources might both contribute to a better targeting of the resource-based information onto a specific problem (higher value of information) and also do so in a much reduced search process (lower cost of information).}
Note that the participation constraints $\mathcal{TR}$ and $\mathcal{IR}$ are type dependent implying that the high type has better opportunities outside the proposed contract (larger expected reservation profit) than the low type. This specificity will lead to non-standard results.

The incentive compatible constraints respectively $\mathcal{IC}$ and $\mathcal{IC}$ ensure that each type is always better off revealing truthfully herself.

\[ \bar{t} - e_s^A(g, \theta) \geq t - e_s^A(g, \theta) \quad \text{(14)} \]
\[ t - e_s^S(g, \theta) \geq \bar{t} - e_s^S(g, \theta) \quad \text{(15)} \]

**Assumption A1:** \( \frac{\partial e_s^A}{\partial g} > 0, \quad \frac{\partial^2 e_s^A}{\partial g^2} > 0 \) and \( \frac{\partial e_s^A}{\partial \theta} < 0 \)

**Assumption A2 (Spence-Mirrlees condition):** \( \frac{\partial^2 e_s^A}{\partial \theta \partial g} < 0 \)

Assumption A1 says that the cost of supply is increasing and convex in the level of genetic resources provided but decreasing in the type. The latter implies that the high quality type can make transactions for access at a lower cost. This is because less search is required with high type information. Assumption A2 conveys the idea that the marginal cost decreases in type: the high type enjoys a lower marginal cost of supply.

The provider of information of low quality may misrepresent her type and obtain a payoff: \( \bar{t} - e_s^S(g, \theta) = V - \Phi(g) \). In addition, if the high type wants to mimic the low type, she would receive: \( t - e_s^S(g, \theta) = V + \Phi(g) \); where \( \Phi(g) \equiv e_s^S(g, \theta) - e_s^S(g, \bar{\theta}) \) with \( \Phi > 0 \) and \( \Phi' > 0 \) from assumptions A1 and A2. The term \( \Phi \) refers to the supply cost differential of the two types for a given level of supply \( g \).

The incentive compatibility constraints respectively $\mathcal{IC}$ and $\mathcal{IC}$ can then be re-written as:

\[ V \geq V + \Phi(g) \quad \text{(16)} \]
\[ V \geq V - \Phi(g) \quad \text{(17)} \]

\( F_N \)'s problem is then:

\[
\max_{((g, \theta), (\bar{g}, \bar{\theta}))} \quad p \left( \pi_s(g) + \pi_N(g, \bar{\theta}) - c_N(\bar{\theta}) - \bar{t} \right) + (1 - p) \left( \pi_s(g) + \pi_N(g, \bar{\theta}) - c_N(\bar{\theta}) - \bar{t} \right) \\
\text{subject to } (10), (11), (14), (15) \\
\]

The problem can be re-written as follows:

\[
\max_{((g, \theta), (\bar{g}, \bar{\theta}))} \quad p \left( \pi_s(g) + \pi_N(g, \bar{\theta}) - e_s^S(g) - c_N(\bar{\theta}) - \bar{t} \right) + (1 - p) \left( \pi_s(g) + \pi_N(g, \bar{\theta}) - e_s^S(g) - c_N(\bar{\theta}) \right) \\
- [pV + (1 - p)V] \\
\text{(18)}
\]
This analysis leads directly to the following proposition, detailing the effects on contracting that result from the existence of private information. Proposition 2 establishes once again that the factor most important in determining the payoff to \( F_S \) is the impact, if any, of any endowment (genetic resources or traditional knowledge) upon her outside options.

**Proposition 2:**

When \( F_S \) has private information about the most promising genetic resources for R&D purposes, \( F_N \) may seek cooperation by offering a menu of self-selecting contracts \( \{(\bar{\gamma}, \bar{t}), (\bar{\gamma}, \bar{t})\} \) to screen among the types of genetic resources. These contracts are characterised by:

1. \( \bar{\gamma} \geq \bar{\gamma} \) (Monotonicity condition)

2. For \( V_0 < \Phi(\bar{\gamma}^{SB}), IR \) and \( TC \) are binding. The supply of genetic resources required by \( F_N \) is efficient for the high type \( \bar{\gamma}^{SB} = \bar{\gamma}^{*} \) and distorted downwards for the low type \( \bar{\gamma}^{SB} < \bar{\gamma}^{*} \). The level of \( \bar{\gamma}^{SB} \) and the transfer payments \( \bar{t}^{SB} \) and \( \bar{\ell}^{SB} \) are given by:

\[
\pi'_{S}(\bar{\gamma}^{SB}) + \frac{\partial \pi'_{N}}{\partial \bar{\gamma}}(\bar{\gamma}^{SB}, \bar{\gamma}^{SB}) = c_{S}^{B}(\bar{\gamma}^{SB}) + \frac{p}{1-p} \Phi'(\bar{\gamma}^{SB})
\]

\[
\bar{t}^{SB} = \xi(\pi_{S}(\bar{\gamma}) + \beta \pi_{N}(\bar{\gamma}, \bar{t})) + (1 - \xi)(\pi_{S}'(\bar{\gamma}) - c_{S}(\bar{\gamma}) + c_{S}^{B}(\bar{\gamma}^{*})) + \Phi(\bar{\gamma}^{SB})
\]

\[
\bar{\ell}^{SB} = \xi(\pi_{S}(\bar{\gamma}) + \beta \pi_{N}(\bar{\gamma}, \bar{\ell})) + (1 - \xi)(\pi_{S}'(\bar{\gamma}) - c_{S}(\bar{\gamma}) + c_{S}^{B}(\bar{\gamma}^{*}))
\]

3. For \( \Phi(\bar{\gamma}^{SB}) \leq V_0 \leq \Phi(\bar{\gamma}^{*}) \), \( TR \) and \( IR \) are binding so that no information rent is given up to any type. The supply of genetic resources is efficient for both types, i.e. \( \bar{\gamma}^{SB} = \bar{\gamma}^{*} \) and \( \bar{\gamma}^{SB} = \bar{\gamma}^{*} \). The optimal transfer payments \( \bar{t}^{SB} \) and \( \bar{\ell}^{SB} \) are given by:

\[
\bar{t}^{SB} = \xi(\pi_{S}(\bar{\gamma}) + \beta \pi_{N}(\bar{\gamma}, \bar{t})) + (1 - \xi)(\pi_{S}'(\bar{\gamma}) - c_{S}(\bar{\gamma}) + c_{S}^{B}(\bar{\gamma}^{*})) = \bar{t}^{*}
\]

\[
\bar{\ell}^{SB} = \xi(\pi_{S}(\bar{\gamma}) + \beta \pi_{N}(\bar{\gamma}, \bar{\ell})) + (1 - \xi)(\pi_{S}'(\bar{\gamma}) - c_{S}(\bar{\gamma}) + c_{S}^{B}(\bar{\gamma}^{*})) = \bar{\ell}^{*}
\]

4. For \( V_0 > \Phi(\bar{\gamma}^{*}) \), there are countervailing incentives and \( TR \) and \( IC \) are binding. The supply of genetic resources required by \( F_N \) is distorted upwards for the high type \( \bar{\gamma}^{CI} > \bar{\gamma}^{*} \) and efficient for the low type \( \bar{\gamma}^{CI} = \bar{\gamma}^{*} \). The level of \( \bar{\gamma}^{CI} \) and the transfer payments \( \bar{t}^{CI} \) and \( \bar{\ell}^{CI} \) are given by:

\[
\pi'_{S}(\bar{\gamma}^{CI}) + \frac{\partial \pi'_{N}}{\partial \bar{\gamma}}(\bar{\gamma}^{CI}, \bar{d}^{CI}) = c_{S}^{B}(\bar{\gamma}^{CI}) - \frac{1-p}{p} \Phi'(\bar{\gamma}^{CI})
\]

\[
\bar{t}^{CI} = \xi(\pi_{S}(\bar{\gamma}) + \beta \pi_{N}(\bar{\gamma}, \bar{t})) + (1 - \xi)(\pi_{S}'(\bar{\gamma}) - c_{S}(\bar{\gamma}) + c_{S}^{B}(\bar{\gamma}^{CI}))
\]

\[
\bar{\ell}^{CI} = \xi(\pi_{S}(\bar{\gamma}) + \beta \pi_{N}(\bar{\gamma}, \bar{\ell})) + (1 - \xi)(\pi_{S}'(\bar{\gamma}) - c_{S}(\bar{\gamma}) + c_{S}^{B}(\bar{\gamma}^{CI}) - \Phi(\bar{\gamma}^{CI}))
\]
Proof 2: See Appendix A.1.

As indicated above, the basic result is that the impact of TK (on contracting) depends primarily on its impact on the value of the outside option. In parts 2.2 through 2.4 of Proposition 2, we see that the determining factor is whether the incremental rent appropriable by the high type ($V_0$) — by selling her herbal medicine in the Northern market, i.e. under non-cooperation — is less than or greater than the cost advantage appropriable via contracting, $\Phi$.

4.2 Discussion: TK and Information Rents

The importance of private information is that it might confer an information rent upon its holder. Our model departs from the standard prediction (that informational advantage confers a rent upon the promising type only) because the participation constraints are type-dependent. Whether $F_N$ gives up information rent and to which type depends instead upon the value of $V_0$, i.e. the difference between the outside option of the high type and that of the low type. When the high type enjoys a highly profitable outside opportunity relative to the low type, the contract must offer her a large transfer. This contract must also reward the low type to prevent her from misrepresenting the quality of her information since the additional cost she incurs by lying, i.e. $\Phi(g)$ is smaller than the profit differential $V_0$. To ensure that incentive compatibility is satisfied, $F_N$ will give her an information rent $V = V_0 - \Phi(g)$.

In this case $F_S$’s informational advantage works more effectively in competition with $F_N$ than it does in cooperation, and therefore her threat not to cooperate is credible (as in case 2.4). Thus, $F_S$’s private information creates a bargaining advantage: the existence of TK confers a clear-cut increase in $F_S$’s share of the production surplus.

If $F_S$’s primary informational advantage lies in her supply costs rather than in her outside option — that is, the differential in reservation profit $V_0$ does not exceed the cost differential between the high type and the low type — then the benefit conferred by private information comes from the high type’s ability to mimic the low type, taking advantage of the supply costs differential (as in case 2.2). In this case, the high type is able to appropriate some informational rent by reason of the asymmetric information whereas the low type is excluded from the sharing of the surplus.

If, however, $F_S$’s informational advantage lies above the cost advantage for the high type resources but below the cost of lying for the low type, then $F_N$ is able to screen effectively between the two types and eliminate all informational advantages (as in case 2.3). Indeed, the cost differentials are sufficiently different to enable screening between them. For intermediate values of $V_0$, $F_N$ can impose incentive compatible contracts where both types of genetic resources receive their expected reservation profit. This is because no agent has an incentive to misrepresent her type so that the symmetric information outcome (see section 3.1) can be implemented.

In sum, the fact that there exists private information on the genetic resources that are most promising may or may not alter the contractual terms offered to $F_S$. So long as the private information does not impact the

---

$^3$This informational rent is decreasing in $\bar{g}$. Thus an upward distortion in the supply of high quality genetic material would allow $F_N$ to minimise this informational rent.

$^4$It is important to recognise that the rent given up to the high type increases in $\bar{g}$, implying that a reduction in $\bar{g}$ will help minimise this rent. Thus, there is an incentive for $F_N$ to distort its demand for low type downwards away from the efficient level $g^*$ in order to minimise rent-sharing.
outside option in a substantial manner (as defined above in Proposition 2), the contract can replicate the complete information outcome. Then there are no informational rents to be appropriated by $F_S$. On the other hand, if the outside option is significantly affected by the private information, the contractual terms will be altered in one of the ways described above, and this may result in additional rents for $F_S$ accruing to either the low type or the high type information provider. These informational rents would create additional incentives for investment in the provision of these resources to the R&D process, enhancing the efficiency of the R&D process.\(^5\)

Given that $F_S$ uses her private information to extract some informational rent, it is important to know whether this private information provides incentives to invest optimally in traditional knowledge. The answer will depend on the source of the high type advantage, i.e., the access cost advantage and the outside opportunity advantage.

When the high type’s advantage derives from the cost of access, then she has strong incentive to invest in human capital to keep her edge and continue to capture informational rent. At the same time, if the low type wants to improve her position by narrowing her cost disadvantage, she too has to invest in TK. By contrast, if the high type’s advantage stems from the outside opportunity differential, whether she has incentive to invest in traditional knowledge, depends on the source of the differential. If the advantage in the reservation profit comes from the quality of the information, then this will certainly induce human capital investment. However, if this differential is only vaguely related to the quality of the information that enables to truncate the search then the production of TK is unlikely to be incentivised. This would be the case if for example the advantage in the reservation profit lies in the high type’s marketing ability to target effectively consumers in the North.

### 4.3 TK as private information: the case of Signalling by $F_S$

We now assume that $F_S$, the informed agent, has the ability to make an offer to $F_N$, the uninformed agent. Both high and low types would like to be seen as possessing valuable information. To be convincing, the high type should signal herself to induce $F_N$ to accept the offer granting him access to the genetic resources and traditional knowledge against a sizable payment. We assume that $F_S$ offers an *ex ante* contract (Laffont and Martimort, 2002). In such a contract, $F_S$ is uncertain about the prospect of her genetic resources to be useful for the purpose of $F_N$’s specific R&D, when she makes an offer. She only knows the probability distribution $p$ that her information is useful to truncate the search (high type). With probability $1 - p$, her information is of little use to $F_N$ (low type). There are two reasons for the assumption of *ex ante* contracting. First, $F_S$ may simply be unfamiliar with some diseases common in the North, when the contract is offered, so that there is no certainty about how useful her information is. Second, this assumption simplifies the treatment of the signalling problem by yielding only a separating equilibrium—i.e., no pooling equilibrium will result from this contract. The timing is described as follows:

\(^5\)Informational rents may contribute to their own types of inefficiencies, however, as efficiency is lost whenever $F_S$ has an incentive to misrepresent herself to capture some information rent and appropriate some of the cooperative surplus. This places $F_N$ in the situation in which he will move away from productive efficiency in order to minimise rent-sharing. That is, to minimise rent-sharing, $F_N$ has to decrease $g$ (in case of low $V_0$), and increase $\bar{g}$ (in case of large $V_0$) away from the productively efficient levels, respectively $g^*$ and $\bar{g}^*$.  

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The problem faced by $F_S$ is to offer an incentive compatible contract in which $F_N$ is willing to participate. By the revelation principle, $F_S$ can restrict, without loss of generality, to a direct revelation mechanism of the form $\{(\tilde{g}, \tilde{d})(\tilde{q}, \tilde{l})\}$ contingent on the usefulness $(\tilde{\theta}, \tilde{\theta})$ of her information. An incentive compatible contract is one in which $F_S$ has always the incentive to signal her true type.

Given such a contract, $F_S$ maximises her \textit{ex ante} profit subject to her incentive constraints and $F_N$'s \textit{ex ante} participation constraint. We will neglect $F_S$'s \textit{ex ante} participation constraint since she would not offer the contract if she were worse off by doing so.

The incentive constraints require that whatever her type, $F_S$ is always better off revealing her type after she learns it. Formally this translates into: $\tilde{t} - c_S^a(\tilde{g}, \tilde{\theta}) \geq \tilde{t} - c_S^a(\tilde{g}, \tilde{\theta})$ and $\tilde{t} - c_S^a(\tilde{g}, \tilde{\theta}) \geq \tilde{t} - c_S^a(\tilde{g}, \tilde{\theta})$. This can be re-written as in (16) and (17). Note that Assumptions A1 and A2 still hold. Because participation is voluntary, the contract must induce $F_N$ to participate. In other words, the payoff earned by accepting the offer should be greater than or equal to his reservation profit. By rejecting the offer, $F_N$ will receive the following expected reservation payoff:

$$\Pi_0^N = p\Pi_N^a + (1 - p)\Pi_N^c$$

where $\Pi_N^a = \xi(1 - \beta)\pi_N(\tilde{g}, \tilde{d}) + (1 - \xi)\pi_N(\tilde{g}, \tilde{d}) - c_N(\tilde{d})$ and $\Pi_N^c = (1 - \xi)\pi_N(\tilde{g}, \tilde{d}) + (1 - \xi)\pi_N(\tilde{g}, \tilde{d}) - c_N(\tilde{d})$.

$F_N$'s participation constraint is therefore given by:

$$p \left( \pi_S(\tilde{g}) + \pi_N(\tilde{g}, \tilde{d}) - c_N(\tilde{d}) - \tilde{t} \right) + (1 - p) \left( \pi_S(\tilde{g}) + \pi_N(\tilde{g}, \tilde{d}) - c_N(\tilde{d}) - \tilde{t} \right) \geq \Pi_0^N$$

Or equivalently:

$$p \left( \pi_S(\tilde{g}) + \pi_N(\tilde{g}, \tilde{d}) - c_S^a(\tilde{g}) - c_N(\tilde{d}) - \tilde{V} \right) + (1 - p) \left( \pi_S(\tilde{g}) + \pi_N(\tilde{g}, \tilde{d}) - c_S^a(\tilde{g}) - c_N(\tilde{d}) - \tilde{V} \right) \geq \Pi_0^N$$

(27)

$F_S$'s problem is then written as:

$$\max_{(\tilde{g}, \tilde{d})} p\tilde{V} + (1 - p)\tilde{V}$$

subject to (16), (17), (27)

**Proposition 3:**
Given that $F_N$ is risk neutral, $F_S$ can offer an efficient ex ante contract that signals her type. The contract is characterised by:

1) Monotonicity: $\overline{g} \geq \underline{g}$

2) Efficiency: $\overline{g} = \overline{g}^*$ and $\underline{g} = \underline{g}^*$

3) Transfer payment: $t^* > t^*$ where $t^*$ and $t^*$ are defined as:

$$
t^* = p \left( \pi_S(g^*) + \pi_N(g^*, \overline{d}) - c_S^*(g^*) - c_N(d^*) \right) + (1 - p) \left( \pi_S(g^*) + \pi_N(g^*, \overline{d}) - c_S^*(g^*) - c_N(d^*) \right) - \Pi_N^0
+ (1 - p) \phi(g^*) + c_S^*(g^*)
$$

$$
t^* = p \left( \pi_S(g^*) + \pi_N(g^*, \overline{d}) - c_S^*(g^*) - c_N(d^*) \right) + (1 - p) \left( \pi_S(g^*) + \pi_N(g^*, \overline{d}) - c_S^*(g^*) - c_N(d^*) \right) - \Pi_N^0
- p \phi(g^*) + c_S^*(g^*)
$$

4) $F_N$’s ex ante participation constraint is binding. Moreover the contract induces $F_N$ to invest efficiently in drug development.

Proof: See Appendix A.2. ■

$F_S$’s ability to make a take-it or leave-it offer makes her the residual claimant of the cooperative surplus. Therefore, she has the proper incentive to engage in efficient information trade with $F_N$, which results in efficient drug development. The main issue for the high type is to convince $F_N$ of the usefulness of her information so that she can claim a large compensation. She can convincingly signal her type by exploiting her supply cost advantage relative to the low type. By offering a large level of access to the resources, the high type can differentiate herself because the high supply cost incurred by the low type in such case will act as a deterrent and prevent the low type to imitate her.

It is important to note that the efficient and separating equilibrium results from the combination of the risk neutrality of $F_N$ and ex ante contracting. In the context of the signalling problem, an ex ante contract will circumvent the emergence of potentially inefficient equilibria such as the pooling equilibria, where the same contractual terms are offered whatever the usefulness of $F_S$’s information.

4.4 Role of Property Rights in TK

No property right in TK was necessary to achieve the results described in this section. The fact that TK is private information is sufficient to confer advantages upon $F_S$, and alter the bargaining environment which determines the level of $F_S$’s share of the surplus. The existence of a property right in genetic resource-based information retains its importance as the value of the outside option remains dependent upon the enforcement of the right in the Northern market. If the court holds that $F_N$ has not infringed $F_S$’s right—i.e. if the drug is distinctive enough from the herbal medicine marketed in the Northern market—then $F_S$ will
receive little compensation under cooperation. If however, the court rules that \( F_N \) has infringed the right, then \( F_S \) will receive a substantial payoff based on her ability to license her right after the court’s decision.\(^6\)

In this way, the role of TK is likely to enhance the value of \( F_S \)’s underlying genetic resources, but only if there is a potentially recognisable claim in those genetic resources to begin with. This indicates that it is not necessary for a property right to be conferred in everything of value which \( F_S \) contributes to. It is only important to create such a right in an output which \( F_S \) is able to market independent of cooperation (i.e. in competition with \( F_N \)). Once that right is recognised, \( F_S \)’s other contributions may be able to be channelled through the existing right in terms of its impacts upon the outside option.

\( F_S \) will be compensated according to the marginal contribution of \( g \) on the total benefit at the industry level, i.e. \( \pi'_S(g) + \frac{\partial \pi_N}{\partial g}(g, d) \). This marginal contribution increases as valuable traditional knowledge is used to improve \( F_N \)’s success rate. Thus, \( F_S \)’s private information acts as a trade secret which is revealed to \( F_N \) only against due compensation and the willingness to pay for this secret increases with the usefulness of the information to \( F_N \).

Finally, private information provides incentives for efficient investment in TK when the high type’s advantage comes from the cost of access. In such case, the high type has the incentive to invest in generating potential useful traditional human capital in order to capture information rent. However, when the high type’s advantage comes from the reservation profit and the advantage is not directly related to the quality of the traditional knowledge, then private information may not induce efficient investment in traditional human capital.

5 Conclusion

This paper has analysed a simple model of the interaction between North and South in relation to the establishment of property rights to protect genetic resources and traditional knowledge. We have stylised the North as rich in human capital but in need of essential genetic resources and traditional knowledge only available in the South to make innovations in the life sciences industries. We examine the impacts upon the cumulative research setting of assigning a second property right to the resources held by the firms in South. In doing so, we investigate how this can achieve efficiency and discuss the implications for the division of the profit.

We find that under complete information (in the absence of TK), the creation of a second property in genetic resources is conducive to efficiency in the industry. Crucial to the division of the joint profit is the allowance to the firms in the South of an exclusive right recognised by courts in the North. This right allows them to market their products—derived from the protected genetic resources—in the North, which gives them an outside option. When such right exists, the division of the profit depends on whether the firms in the North infringe this right.

Traditional knowledge has been assumed to act as private information on the prospect of individual genetic resources to yield a successful search. In the presence of TK, the firms in the South have three possible means of generating an additional return. Either they can misrepresent the quality of their information—and

\(^6\)It is straightforward to show that \( F_S \)’s compensation increases with \( \xi \) both in the screening and the signalling cases.
hence attempt to generate an information rent—or they can hope that the existence of promising resources increases the perceived value of their outside option. Alternatively, they can actively signal the quality of their information to the firms in the North. Any factor that increases the value of their outside option—or reduces the value of the Northern firms’ outside option—increases the credibility of the threat to compete (rather than cooperate) and hence enhances their payoff under cooperation. It is not necessary to establish a separate property right in TK in order to appropriate this enhanced return. The granting of a single property right to the Southern firms is probably sufficient to establish a channel whereby they are able to appropriate the value of their different types of contributions to the industry.

In general, we show that the capacity of Southern firms to share in the rents from the R&D sector to which they contribute depends on the existence of an independent property right in the genetic resources. This independent right (gives an outside option) establishes the baseline upon which contracting occurs, and creates the basis upon which Southern firms may demand compensation in line with their contribution. Importantly, this right need not ever be exercised independently, it needs only to exist in order for cooperation to occur.

References


6 Appendix

A.1 Sequential R&D

Figure 2: R&D stages in the biological sector (adapted from Goeschl and Swanson, 2002b).

```
Primary stage
Natural capital stock g + Traditional Human capital h_s

Secondary stage
Scientific human capital stock h_S

Output
New solutions

R & D Stages

Physical manifestation
Medicinal herbs for gene activity (H)
Pharmaceuticals for specific action (D)

Rights
CBD Sovereignty in South
Patents in North

“e” is the biological activity recognized by the South
“d” is the directed biological activity discovered by the North
```
A.2 Proof of Proposition 2

The combination of the two incentive constraints implies that $\Phi(\bar{g}) \geq \Phi(g)$. By Spence-Mirrless condition, $\Phi' > 0$ and hence $\bar{g} \geq g$ (Monotonicity condition).

Because the participation constraints are type dependent, the search for equilibrium requires to consider several cases. Let us first represent the four constraints (12), (13), (16), and (17) in the space $(V, \bar{V})$.

The analysis is restricted to the region delimited by the two participation constraints and located above the 45° line because the boundaries of the two incentive constraints $\bar{V} = V + \Phi(\bar{g})$ and $\bar{V} = \bar{V} - \Phi(\bar{g})$ have positive intercepts in the space $(V, \bar{V})$. Note that $IC$-line is always above $\bar{IC}$-line since $\Phi(g) \leq \Phi(\bar{g})$.

Let $E \left(\Pi_{S}^{nc}, \Pi_{S}^{nc}\right)$ be the intersection between the two participation constraints lines and let $D = \{(V, \bar{V})| \bar{V} = V + \Pi_{S}^{nc} - \Pi_{S}^{nc}\}$ be the line parallel to the two incentive constraints lines passing through $E$. $D$ represents the high type's reservation profit and shows the extent to which she has a better outside opportunity than the low type.

Case 1: $V_{0} < \Phi(g^{SB})$, i.e. $\bar{IC}$-line is above $D$
$F_N$ would like to compensate the high type vs the low type no more than the outside option differential $V_0$. However, because $V_0$ is so small, the high type can obtain a better compensation by lying to $F_N$. If this happens the high type can potentially generate a cost saving of $\Phi(g)$ which is greater than the outside opportunity $V_0$. So, the high type has an incentive to misrepresent herself and receive an information rent. It follows that $IR$ is slack while $IC$ must be binding: $V = V^* + \Phi(g)$.

Besides, by lying the low type would incur an extra cost of access of $\Phi(g)$ that is greater than $V_0$ (since $\Phi'>0$). Therefore, she has no incentive to lie, which implies that $IC$ is irrelevant and $IR$ is binding: $V = \Pi^{nc}_S$.

Plugging $\bar{V}$ and $V$ in (18) and deriving the first order conditions yields:

$$\max_{(g,\bar{V})} \left\{ \pi_S(\bar{g}) + \pi_N(\bar{g}, \bar{d}) - c_S^L(\bar{g}) - c_N(\bar{d}) + (1-p) \left( \pi_S(g) + \pi_N(g, d) - c_S^L(g) - c_N(d) \right) \right\}$$

$$- [p(\bar{V} + \Phi(g)) + (1-p)\Pi^{nc}_S] \quad (30)$$

$$\frac{\partial \pi_{N+S}}{\partial g} (\bar{g}^{SB}, \bar{d}^{SB}) = \pi'_S(\bar{g}^{SB}) + \frac{\partial \pi_N}{\partial g}(\bar{g}^{SB}, \bar{d}^{SB}) = c_S'(\bar{g}^{SB}) = \frac{\partial \pi_{N+S}}{\partial g} (\bar{g}, \bar{d}) \quad (31)$$

$$\frac{\partial \pi_{N+S}}{\partial g} (\tilde{g}^{SB}, \tilde{d}^{SB}) = \pi'_S(\tilde{g}^{SB}) + \frac{\partial \pi_N}{\partial g}(\tilde{g}^{SB}, \tilde{d}^{SB}) = c_S'(\tilde{g}^{SB}) + \frac{p}{1-p} \Phi'(\tilde{g}^{SB}) > \frac{\partial \pi_{N+S}}{\partial g} (\bar{g}^{*}, \bar{d}^{*}) \quad (32)$$

By continuity and concavity of $\pi_{N+S}()$ it follows that: $\bar{g}^{SB} = \bar{g}$, $\tilde{g}^{SB} < \bar{g}$, and $\bar{g}^{SB} < \tilde{g}^{SB}$. There is no allocative distortion for the high type, but there is a downward distortion for the low type: $F_N$ requires an
optimal access to the genetic resources from the high type and a sub-optimal access to the low type. These allocations give rise to the following transfer schemes:

$$t^{SB} = \xi (\pi_S(\tilde{g}) + \beta \pi_N(\tilde{g}, \tilde{d})) + (1 - \xi) \pi_S^c(\tilde{g}) - c_S(\tilde{g}) + c_a^{SB} > t^* \quad (33)$$

$$t^{SB} = \xi (\pi_S(\tilde{g}) + \beta \pi_N(\tilde{g}, \tilde{d})) + (1 - \xi) \pi_S^c(\tilde{g}) - c_S(\tilde{g}) + c_a^{SB} \quad (34)$$

From the diagram, the profit maximizing point for $F_N$ is $S_1$ at which both the low type participation constraint $IR$ and the high type incentive constraint $IC$ are binding.

**Case 2: $\Phi(g^{SB}) \leq V_0 \leq \Phi(g^*)$, i.e. $IC$-line is above $D$ while $IC$-line is below $D$**

![Figure 5: Case 2: Intermediate $V_0$](image)

We follow the same reasoning as in Case 1. The high type has no incentive to lie when $V_0$ (differential in outside option between the two types) is greater than the saving on access cost she would get by mimicking the low type. Truthful revelation of her type will guarantee her to receive $V_0$—that she would obtain by not cooperating. This implies that $IR$ is binding and $IC$ is always satisfied. The low type, on the other hand faces the same situation as in Case 1, so she has no incentive to lie. Again, her participation constraint $IR$ is binding and her incentive constraint $IC$ always hold.

In this case, $F_N$ achieves the complete information outcome: $V = \Pi^{nc}_S$ and $V = \Pi^{nc}_S$. Plugging $\bar{V}$ and $V$ in (18) and deriving the first order conditions yields:
\[
\frac{\partial \pi_{N+S}}{\partial \bar{g}} (g^{SB}, \bar{d}^{SB}) = \pi'_{S}(g^{SB}) + \frac{\partial \pi_{N}}{\partial \bar{g}} (g^{SB}, \bar{d}^{SB}) = c_{S}^{a}(g^{SB}) = \frac{\partial \pi_{N+S}}{\partial \bar{g}} (g^{*}, \bar{d}^{*}) \quad (35)
\]

\[
\frac{\partial \pi_{N+S}}{\partial \bar{g}} (g^{SB}, \bar{d}^{SB}) = \pi'_{S}(g^{SB}) + \frac{\partial \pi_{N}}{\partial \bar{g}} (g^{SB}, \bar{d}^{SB}) = c_{S}^{a}(g^{SB}) = \frac{\partial \pi_{N+S}}{\partial \bar{g}} (g^{*}, \bar{d}^{*}) \quad (36)
\]

By continuity of \( \pi_{N+S}(\cdot) \) it follows that: \( g^{SB} = g^{*} \), \( g^{SB} = g^{*} \), and monotonicity ensures that \( g^{*} \leq g^{*} \).

Allocative efficiency is reached for both types: \( F_{N} \) will have an optimal access to the genetic resources from both types. These allocations give rise to the following transfer schemes where no rent will be given up:

\[
\tilde{t}^{SB} = \xi(\pi_{S}(\tilde{g}) + \beta \pi_{N}(\tilde{g}, \tilde{d})) + (1 - \xi) \pi_{S}(\tilde{g}) - c(\tilde{g}) + c_{S}^{a}(g^{*}) = \tilde{t}^{*} \quad (37)
\]

\[
\tilde{\xi}^{SB} = \xi(\pi_{S}(\tilde{g}) + \beta \pi_{N}(\tilde{g}, \tilde{d})) + (1 - \xi) \pi_{S}(\tilde{g}) - c(\tilde{g}) + c_{S}^{a}(g^{*}) = \tilde{\xi}^{*} \quad (38)
\]

Case 3: \( V_{0} > \Phi(g^{*}) \), i.e. \( IC \)-line is below \( D \)

Figure 6: Case 3: High \( V_{0} \)

The high type faces the same situation as in Case 2 as \( V_{0} > \Phi(g^{*}) > \Phi(g^{SB}) \), so that \( TR \) is binding and \( IC \) holds. On the contrary, the low type now has incentive to misrepresent herself. By doing so, she incurs an extra cost of access \( \Phi(g^{*}) \) that is smaller than the differential in reservation profit in favour of the high type, \( V_{0} \). As a consequence, \( TR \) and \( IC \) are binding: \( V = \Pi_{S}^{c} \) and \( V = \Pi_{S}^{c} - \Phi(\bar{g}) \). From a graphical point of view it is immediate to see that the optimal point that maximizes \( F_{N} \) profit or equivalently minimizes the expected rent given to the South \( [pV + (1 - p)V] \) is \( S_{S} \) where \( TR \) and \( IC \) bind. The low type receives an information rent (this is a case of countervailing incentives \( CI \)) whereas the high is offered her expected reservation profit.
Plugging $\bar{V}$ and $\underline{V}$ in (18) and deriving the first order conditions yields:

$$\frac{\partial \pi_{N+S}}{\partial \bar{g}} (\bar{g}^{CI}, \bar{d}^{CI}) = \pi'_S(\bar{g}^{CI}) + \frac{\partial \pi_N}{\partial \bar{g}} (\bar{g}^{CI}, \bar{d}^{CI}) = c'_S(\bar{g}^{CI}) - \frac{1-p}{p} \Phi'(\bar{g}^{CI}) < \frac{\partial \pi_{N+S}}{\partial \bar{g}} (\bar{g}, \bar{d}^*) \quad (39)$$

$$\frac{\partial \pi_{N+S}}{\partial \underline{g}} (\underline{g}^{CI}, \underline{d}^{CI}) = \pi'_S(\underline{g}^{CI}) + \frac{\partial \pi_N}{\partial \underline{g}} (\underline{g}^{CI}, \underline{d}^{CI}) = c'_S(\underline{g}^{CI}) = \frac{\partial \pi_{N+S}}{\partial \underline{g}} (\underline{g}^*, \underline{d}^*) \quad (40)$$

By continuity and concavity of $\pi_{N+S}(.)$ it follows that: $\bar{g}^{CI} > \bar{g}^*, \bar{g}^{CI} = \bar{g}^*$, and $\underline{g}^{CI} < \underline{g}^{CI}$ (Monotonicity). There is no allocative distortion for the low type, but there is an upward distortion for the high type: The low type will supply the genetic resources optimally whereas the high type will be required to supply an excessively high level of resources. These allocations give rise to the following transfer schemes:

$$T^{CI} = \xi(\pi_S(\bar{g}) + \beta \pi_N(\bar{g}, \bar{d})) + (1 - \xi)\pi'_S(\bar{g}) - c_S(\bar{g}) + c'_S(\bar{g}^{CI}) > \bar{T}^*$$

$$\underline{T}^{CI} = \xi(\pi_S(\underline{g}) + \beta \pi_N(\underline{g}, \underline{d})) + (1 - \xi)\pi'_S(\underline{g}) - c_S(\underline{g}) + c'_S(\underline{g}^{CI}) - \Phi(\underline{g}^{CI})$$

In all these cases, it is easy to show that given $g$, drug development $d$ is chosen optimally.\[\blacksquare\]

### A.3 Proof of Proposition 3

As in the case of screening, the combination of (16), (17) and $\Phi' > 0$ implies that $\bar{g} \geq \underline{g}$.

The Lagrangian of the programme is given by:

$$L = p\bar{V} + (1-p)\underline{V} + \lambda [\underline{V} - \bar{V} + \Phi(\underline{g})] + \mu [p(\pi_S(\bar{g}) + \pi_N(\bar{g}, \bar{d}) - c_S(\bar{g}) - c_N(\bar{d}) - \bar{V}) + (1-p)(\pi_S(\underline{g}) + \pi_N(\underline{g}, \underline{d}) - c_S(\underline{g}) - c_N(\underline{d}) - \underline{V}) - \Pi_N^0]$$

where $\lambda$ and $\mu$ are the Lagrange multipliers for (17), and (27). The first order conditions are:

$\bar{V}$: $\xi + \lambda - \mu - 0$  

$\underline{V}$: $(1 - \xi) - \lambda - \mu(1-\xi) = 0$

For any probability $p$, $\mu = 1$ and $\lambda = 0$ solve the system formed by the two first order conditions. It means that $F_N$’s participation constraint is binding and the low type’s incentive constraint need not be. It follows that the efficient outcome can be implemented by the informed $F_N$ by using an *ex ante* contracting. This is because the low type will tell the truth as $\underline{L}^C$ is slack, and $F_N$ receives exactly his outside option $\Pi_N^0$ so that $F_S$ becomes the residual claimant of the surplus. From the binding participation constraint, we obtain:

$$p\bar{V} + (1-p)\underline{V} = p(\pi_S(\bar{g}) + \pi_N(\bar{g}, \bar{d}) - c_S(\bar{g}) - c_N(\bar{d})) + (1-p)(\pi_S(\underline{g}) + \pi_N(\underline{g}, \underline{d}) - c_S(\underline{g}) - c_N(\underline{d})) - \Pi_N^0 \quad (41)$$

The first order conditions with respect to $\bar{g}$ and $g$ will yield an efficient outcome for both types $\bar{g} = \bar{g}^*$ and $\underline{g} = \underline{g}^*$. Given this efficient outcome, $F_N$ also chooses $d$ efficiently, i.e. $\bar{d} = \bar{d}^*$ and $\underline{d} = \underline{d}^*$.  

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Given that $\bar{V} > \underline{V}$ from the high type incentive constraint (16), $F_S$ can structure her payoff so that:

$$V^* = p (\pi_S(g^*) + \pi_N(g^*, d^*) - c^S_S(g^*) - c^N(g^*)) + (1 - p) (\pi_S(g^*) + \pi_N(g^*, d^*) - c^S_S(g^*) - c_N(g^*)) - \Pi_N^0 + (1 - p) \Phi(g^*)$$

(42)

$$V^* = p (\pi_S(g^*) + \pi_N(g^*, \bar{d}^*) - c^S_S(g^*) - c_N(\bar{d}^*)) + (1 - p) (\pi_S(g^*) + \pi_N(g^*, \bar{d}^*) - c^S_S(g^*) - c_N(\bar{d}^*)) - \Pi_N^0 - p \Phi(g^*)$$

(43)

It can be easily verified that $V^*$ and $\bar{V}^*$ satisfy the incentive compatibility constraints (16) and (17) as well as the ex ante participation constraint (27).

We can therefore determine the optimal transfer payments:

$$\bar{\tau}^* = V^* + c_S^S(g^*)$$

(44)

and

$$\bar{\xi}^* = V^* + c_S^S(\bar{g}^*)$$

(45)

By monotonicity we know that $\bar{g}^* \geq g^*$. Therefore, as $c^S_S$ is increasing, we have $c_S^S(\bar{g}^*) \geq c_S^S(g^*)$. It follows that $\bar{\tau}^* > \bar{\xi}^*$.

Subtracting (42) and (43) gives $\bar{V}^* - V^* = \Phi(g^*) \geq \Phi(g^*)$ which satisfies both incentive compatibility constraints (16) and (17). Subtracting (42) to $p\bar{V}^* + (1 - p)\bar{V}^* + (1 - p)\Phi(g^*)$ and combining it with $\bar{V}^* - V^* = \Phi(g^*)$, we show that the ex ante participation constraint (27) is also satisfied.