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Discussion Paper

Bringing Light to Dark Spots: The Case of Cross-border Bioprospecting

April 2021

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Discussion Paper Number:
JHD-2021-03

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Bringing Light to Dark Spots: The Case of Cross-border Bioprospecting

Abstract

Innovation-oriented cross-border collaborations are a means through which developing countries can upgrade technologically. However, the benefits accruing from cross-border collaborations can be asymmetric: while they may possess crucial resources, the developing country may gain little from the collaboration. We examine the context of bioprospecting, defined as the search for biodiversity aimed at commercial exploitation of its biochemical or genetic elements. The well-documented exploitation of developing countries' natural resources by international partners has made bioprospecting a 'dark spot' in the cross-border collaboration space. We adopt an abductive configurational approach to investigate the sets of conditions that allow cross-border agreements to include knowledge transfer and innovation, through crisp-set qualitative comparative analysis. Based on our empirical analysis of 59 cases, we provide some policy recommendations about the need for international collaborations and investments to include greater respect for local communities' fundamental rights and ecosystems.

Keywords

Bioprospecting, cross-border innovation, knowledge transfer, mutual sharing agreements

Acknowledgements

This is an extended draft of a chapter that has been accepted for publication by Oxford University Press in the forthcoming book "Cross-border Innovation in a Changing World. Players, Places and Policies" edited by D. Castellani, A. Perri, V. Scalera and A. Zanfei due for publication in 2022. We are indebted to the Editors, to Rajneesh Narula, and participants in the online workshop organised for the development of this book on 10-12 June, 2020, for helpful comments on an earlier draft.

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1. Introduction

The link between innovation, economic performance, and growth is now widely accepted in both academia and policy-making circles (OECD, 2015). Developing countries are benefiting from technology transfer, enabled by innovation-oriented cross-border collaborations, which is allowing these countries to reduce the gap with the technology frontier (see in Chapter 8 in Castellani et al., (2022) the discussion on Research and Development [R&D] offshoring by Nieto and Rodríguez, 2022). International collaborations that involve intensive sharing of knowledge and face-to-face interactions among the collaborating partners, are considered particularly valuable knowledge transfer means. They allow the sharing of diverse experience and mutual learning and can spark creativity and innovation (Alnuaimi, Singh, and George, 2012; Fleming, King, and Juda, 2007; Montobbio and Sterzi, 2013). However, the transfer of knowledge to developing countries is accompanied by problems related to the presence of an informal economy, regulatory uncertainty, limited Intellectual Property Rights (IPR) protection, and weak respect for contractual conditions (see Mukherjee, Makarius, and Gaur, 2022). This is resulting in pressure on developing country governments to ensure stricter enforcement of IPR legislation, to allow inventing entities to benefit from their R&D efforts and encourage location of innovation activities in these countries (Arora, Fosfuri, and Gambardella, 2001; Arrow, 1962; Nelson, 1959; see also Papageorgiadis and McDonald (2022), on IPR protection and cross-border collaborations).

However, worldwide IPR enforcement can have significant negative side-effects for particular groups, such as employees, consumers, and communities. For instance, the results of Kyle and McGahan's (2012) study of the impact of IPR protection on pharmaceutical R&D suggest that IPR can discriminate against illnesses that are prevalent in the most vulnerable and poor countries. Also, in the context of the agro-food industry, when Monsanto introduced genetically modified seeds to Argentina and other Latin American countries, this boosted the profitability of large-scale farms, but damaged the livelihoods of small farmers who were unable to use the seeds produced by the previous year's crops (Campi and Nuvolari, 2015). These are two examples of a broader problem. They show that there are 'dark spots' in the innovative and IPR protection spaces, that is, there are industries and contexts where innovation brings unequal benefits or where IPR protection benefits some social groups, but is undoubtedly detrimental to others. We argue that these dark spots tend to be overlooked by the innovation literature and, particularly, work on cross-border innovation. This results in a poor understanding of these negative externalities and absence of government and corporate initiatives aimed at reducing them.

To address these gaps, in this chapter, we consider cross-border collaborations or Benefit Sharing Agreements (BSA), in the context of bioprospecting, that is, in the context of the search for biodiversity aimed at commercial exploitation of biochemical or genetic elements (Robinson, 2012). The specialized literature considers bioprospecting a dark spot, because of its seeming devastating impact on biodiversity and the livelihoods of local communities (Robinson, 2010a; Shiva, 2007; Wynberg and Laird, 2009). The local communities affected include indigenous and other social groups, which often are repositories of knowledge about the properties of bio-resources (living species, plants, biological materials) and which, also, are the most negatively affected by the exploitation of indigenous resources via bioprospecting. The detrimental effects of bioprospecting for communities have been widely documented (e.g., Shiva, 2007). Our objective is to increase understanding of the conditions that would allow communities to benefit from bioprospecting activities and how public policy could support knowledge transfer to and empowerment of local communities.

We consider a sample of 52 bioprospecting cross-border agreements and use crisp-set Qualitative Comparative Analysis (csQCA) and an abductive, configurational approach, to investigate the contract conditions that include knowledge transfer. We seek to identify the contract conditions (available from public sources) that make the agreements more beneficial for local partners. We focus on knowledge transfer from the foreign partner because this augments the developing country's learning, capability building, and development by fostering innovation-related projects. We investigate the combinations of local and foreign signatories and the local institutional conditions that trigger knowledge transfer. Our goal is to shed some light on the dark spots in cross-border innovation activities. We identify five knowledge transfer conditions configurations. In two, the foreign partner is a research organization (university or research institute) and in three, the foreign leader of the BSA is a firm. Foreign universities collaborate with local organizations either in countries with a strong bio-conservation regulatory environment or in countries with weak regulation if the project is supported by a third-party donor – an international organization, a national development agency, an international development agency, or a development bank. The configurations that include foreign companies are, mostly, those including a recipient country with a weak regulatory environment. In many cases, they transfer knowledge to local organizations and in a few cases, manage to collaborate successfully with indigenous communities. We show, also, that in overly-complex configurations, that is, multiple partners involved in the contract agreement, likelihood of BSA failure increases. We contribute to the literature and to policy debates on bioprospecting, by highlighting the risks to vulnerable local communities and the natural environment involved in BSAs. More generally, we highlight the need for more careful consideration of the negative impacts of cross-border collaborations on local social groups or communities' rights, even when such collaborations are aimed at innovation.

2. Bioprospecting-oriented cross-border collaborations

2.1 The good and bad of bioprospecting

The search for and collection of plants is a centuries-old practice (Crosby, 1993). Bioprospecting related to use of plants and their genetic material for medicinal purposes is also a well-established practice (Cragg, Newman, and Yang, 1998). Many commercial pharmaceutical, food, cosmetic, and biotech products are founded on bio-resources (see, e.g., Abdulhameed, Pradeep, and Sugathan, 2017 for a detailed account). There are certain elements, which are described below, that make bioprospecting an interesting context for a study of cross-border collaborations.

The potential rewards from bioprospecting (e.g., new firm products, scientific discoveries) attract foreign investors and other organizations (Artuso, 2002; Fukushima et al., 2020; Habel et al., 2014). Some bio-resource-based products have been extremely lucrative for firms. For instance, it is estimated that, since 1990, Bayer has earned over €4 billion from sales of acarbose-based Glucobay – an anti-diabetic drug (Al-Janabi and Drews, 2010). Over the years, bio-resources have become an established source of innovation in some industries and the number of biodiversity-related patents has escalated (Oldham, 2007). Oldham (2007) shows that, between 1990 and 2005, some 51,765 patents included the European Patent Office Espacenet world-wide database refer to traditional medicines, while 37,227 patents are related to plants (see also Oldham, Hal, and Forero, 2013).

The interest of international actors in bio-resources can be seen as an opportunity for the countries where these resources are located and, in principle, should promote collaborations with international companies and universities with advanced knowledge about how to transform these resources into valuable products. Since most bio-resources are located in developing countries (Macilwain, 1998), this would, potentially, allow intensive, natural resources-based, knowledge sharing, and allow the host country to accumulate capabilities and knowledge in the natural resources in which they have comparative advantage. These increased capabilities and knowledge could help these developing countries to shift from being pure suppliers of raw materials to being innovators (Andersen and Marin, 2020), which would allow them to negotiate more beneficial terms of trade and increase their development.

However, developing countries are often characterized by poor state capacity and weak rule of law. This can result in international actors exploiting their bio-resources while not offering fair compensation and benefiting from poor monitoring by the national authorities of the conditions for extraction and use of these resources. This argument is consistent with the more general academic discussion on institutional arbitrage, according to which firms try to minimize any regulatory burden attached to their activities, by targeting countries where they can exploit rich local resources and accommodating local institutional conditions (Carruthers and Lamoreaux, 2016). Knowledge about the beneficial properties of plants and other living organisms belongs to the local or indigenous community. These communities have engaged in lengthy processes of inter-generational communal or collective invention (Landon, 2007), *de facto,* developing tacit (or traditional) knowledge about these substances' use and properties. For generations, use of these specific biological substances by the local (indigenous) community, was allowed by 'indigenous customary law.' However, in a property rights context, these communities cannot claim ownership of these resources (see WIPO, 2018, for a discussion), which increases the risk for these groups and for this reason, bioprospecting is considered as an intrusive and disruptive practice (Neimark, 2012).

The appropriability of traditional knowledge (and its related biological materials), and the rise of IPR appropriation by international actors of these materials and their underlying knowledge, have produced a wealth of undesirable effects that have been well documented in the specialized literature. One effect is the intensive harvesting of bio-resources to allow their commercialization in global markets, which, has reduced the biodiversity and altered the natural environment of local communities (see Amarasinghe, 2018, on bioprospecting of freshwater fish species, and Zenobia and Fakir, 2004, on the Kava and Maytenus Buchananni anti-cancer drug). Another problem is the change in the conditions of use of certain bio-resources by indigenous communities as a consequence of their IPR appropriation by international actors (see e.g., the appropriation and genetic modification of native seeds by agro-food companies in Colombia, documented by Goyes and South, 2016). In addition, Mackey and Liang (2012) argue that bioprospecting has adverse effects on the health of indigenous groups, because the owners of IPR protection often prevent these communities from using traditional treatments and patented medicines are too costly.

Since the economic returns of IPR appropriation of bio-resources are rarely shared equally or fairly between the IPR (patent or trademark) owner and the indigenous group that owns the traditional knowledge, the damage to the local community is even more severe. While on the one hand, patents have been granted to international actors even in the case of patents not covering truly novel discoveries (Box 11.1 for an overview of revoked patents); on the other hand, indigenous communities have generally not been duly compensated for their contribution to the discovery and for preserving the precious natural resource. For these reasons, starting in the 1990s, the indigenous groups and farmers, along with Non-Governmental Organizations (NGOs) and activists, have started to express discontent over bioprospecting, considered a form of resource and knowledge depredation or –also referred to as ‘‘biopiracy’ (Robinson, 2010b; Shiva, 2007).

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Box 11.1 Biopiracy: Examples of revoked patents for lack of originality

Numerous patents have been revoked following appeals or advocacy campaigns by NGOs and other civil society groups, claiming that the patenting entity has not invented anything new or that the patent concerns natural features of edible substances (typically vegetables and fruits) already found in nature. Cases of patents revoked on the grounds of lack of originality include:

- Monsanto's European patent (granted in 2011) on conventionally-bred **melons**, revoked by the European Patent Office (EPO) in 2016 after the opposition by several organizations in 2012;[1]
- the Indian wheat variety called **Nap Hal** for which Monsanto filed a patent in 1991, awarded in 2003 and subsequently revoked in 2011;
- the **Neem tree seeds** patent; the seeds were used for their pest repellent function, patented in 1994 by W.R. Grace, but then revoked by the EPO in 2000;
- the **Pudina** (mint) and **Kalamegha** (andrographis) used as ingredients for the treatment of H5N1 avian influenza or bird flu, for which the Chinese company M/s Livzon Pharmaceutical Group Inc. was granted a patent in 2007, was cancelled by EPO the same year;
- **Basmati** rice was patented in 1997 by the US company RiceTec, Inc. The patent has been highly contested by activists who brought the case against the Supreme Court of India, leading the USPTO struck down most sections of the basmati patent in 2001;
- Other cases concern substances like **Ashwagandha** (patent denied by EPO in 2010); Pergolarium (patent revoked by EPO in 2010); **Turmeric, cumin, ginger** and **onion** (patent withdrew in 2009); **Aloeaceae** (Aloe vera) (patent withdrawn in 2010) and even cow milk (patent withdrawn in 2010).

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To address the concerns and conflicts related to biopiracy, the international community has worked to construct a stronger framework to regulate relationships between local communities/governments and international actors. Rather than being oriented towards the

[1] Since June, 2017, products (animals or plants) obtained exclusively from essentially biological processes are excluded from patentability by the EPO.

avoidance of natural resources' exploitation, the existing regulation is oriented towards strengthening IPR regimes and ensuring that local populations have given informed consent and benefit fairly (in both financial and knowledge transfer terms) from the exploitation of the bio-resources. The Nagoya Protocol, a milestone international legal framework to regulate the conservation of biological diversity and sustainable use of its components (see Box 11.2 for an overview), was ratified in 2014. It is aimed at ensuring fair and equitable sharing of the benefits from genetic resources, based on BSAs between the providers and users of genetic resources. The Nagoya Protocol (Art. 23) focuses explicitly on promoting technical cooperation and knowledge transfer to developing countries. Its ratification is too recent to allow systematic assessment of its impact.[2] However, many countries had already adopted BSAs and we can learn from their experience. We explore a set of BSAs (mostly prior to, but some after the signing of the Nagoya Protocol) to investigate the contract conditions that allow for knowledge transfer.[3]

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Box 11.2 On the regulation of appropriation of natural resources and traditional knowledge

The first important step to regulate biopiracy was the Convention on Biological Diversity (CBD). It opened for signatures at the Earth Summit held in Rio de Janeiro in 1992 and came into force in December 1993. The CBD is an international treaty on conservation of

[2] Despite its recent application, some have raised concern about the effectiveness of the Nagoya Protocol and some argue that it will perpetuate existing imbalances. It has been argued that, first, there will be even greater enforcement of IPR protection on bio-resources, which will privatize the biological resource rather than maintaining it as a public good and, second, that the digital sequencing of genetic resources dematerializes the bio-resources and de-territorializes the BSA, resulting in little hope that the local community will benefit from future agreements (Bond and Scott, 2020; Laird et al., 2020).

[3] Data limitations prevent a policy assessment exercises; therefore, we do not try to measure whether the Nagoya Protocol has affected knowledge transfer to local communities.

biodiversity, sustainable use of the components of biodiversity, and equitable sharing of the benefits derived from the use of genetic resources. At the time of writing this chapter, 196 parties (195 states plus the European) had signed the CBD, and all United Nations member states except the US, have ratified the treaty. The CBD seeks to address all threats to biodiversity and ecosystem services, including threats from climate change, to scientific assessments, development of tools, incentives and processes, transfer of technologies and good practice, and full and active involvement of relevant stakeholders including indigenous and local communities, youth, NGOs, women and the business community. To meet the CBD goals, countries reserve their sovereign right to exploit their own resources. Thus, exploitation of genetic resources is possible only after the competent authorities in a CBD Contracting Party give prior informed consent to exploit these resources. At the same time, the CBD encourages the Contracting Parties to provide a mechanism for the protection of 'traditional knowledge' associated with genetic resources. The commitments of the Parties under the CBD were translated into national laws by several of the Contracting Parties to the Convention. To ensure more stringent enforcement across countries, two further protocols were added to the 1993 CBD.

The first was the *Cartagena Protocol on Biosafety to the Convention on Biological Diversity* (or the Cartagena Protocol) which seeks to protect biological diversity from the potential risks posed by living modified organisms resulting from modern biotechnology. It regulates the safe handling, transport, and use of living modified organisms, resulting from modern biotechnology, that might have adverse effects on biological diversity, taking account, also, of the risks to human health. The Cartagena Protocol was adopted on January 29, 2000 and came into force on September 11, 2003.

The second protocol is the *Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits arising from their Utilization to the Convention on*

Biological Diversity (or the Nagoya Protocol), which can be considered a move from mere declaration of intent to concrete measures. The Nagoya Protocol was adopted on October 29, 2010 and came into force on October 12, 2014, and to date has been ratified by 124 Parties. The US and Canada decided to neither sign nor ratify the protocol, while Australia and Italy only signed it. Many of the provisions of the Nagoya Protocol are taken from the *Bonn Guidelines on Access to Genetic Resources and Fair and Equitable Sharing of the Benefits Arising out of their Utilization*, a set of voluntary non-binding guidelines on access and benefit sharing endorsed by the CBD Conference of the Parties at its Sixth Session in 2002. The Nagoya Protocol has created greater legal certainty and transparency for both providers and users of genetic resources and traditional knowledge by:

- establishing more predictable conditions for access to genetic resources, in particular ensuring these communities' prior informed consent;
- helping to ensure benefit-sharing agreement (or mutually agreed terms) when genetic resources leave the country providing those genetic resources.

<End of Box>

2.2 Conceptual framework

Our analysis considers different explanatory conditions to explain when BSA are likely to be most beneficial for local communities, i.e., when the agreement includes provisions about cross-border transfer of knowledge which sets the condition for cross-border innovation processes. In our conceptualization, these conditions, that relate to the local conditions as well as the signatories, all come together in the form or agreements. Thus, we want to understand the relationships between them and their combined influence on knowledge transfer and on the development of cross-border collaborative efforts to innovate around bioprospecting projects. We start by discussing how the presence of each individual condition could relate to the inclusion of knowledge transfer in the agreements, when taken in isolation (see Table 11.1 for an overview of the conditions and their potential knowledge transfer mechanisms).

First, we look at the country level conditions, such as presence of a strong biodiversity regulatory environment and high levels of education. We expect these conditions to favour the inclusion of knowledge transfer in the BSA: a stronger biodiversity regulatory environment ensures a higher quality and better managed natural resources. Countries with these conditions in place may be better able to protect use of their bio-resources and ensure that they benefit fairly from their use by the other parties to the agreement. Countries with better regulation of biodiversity and its conservation are likely to have a longer-term orientation that might be reflected by a greater interest in building knowledge than in obtaining a short-term monetary reward. A higher level of education is likely to lead to a better understanding about the importance of protecting biological resources and some assurance that any collaborative agreement will include knowledge transfer. Also, countries with a higher level of literacy have stronger education systems which makes it easier for the international organization to identify bioprospecting partners (see Mukherjee et al., 2022, for a discussion of the enabling role of the knowledge infrastructure for knowledge transfer).

Second, we consider that the quality and characteristics of the local signatories to the BSA will affect the likelihood of knowledge transfer. We identify whether the local signatory is a local community, that is, a distinct and well-defined social group, often an indigenous or farmer community. On the one hand, research on farmers' rights and seed activism, shows that communities can demand substantial control over their bioresources (Peschard and Randeria, 2020; Torri, 2011). Therefore, we predict that direct involvement of the local community will equate with a stronger desire for a 'good' outcome and, therefore, assurance of knowledge transfer. On the other hand, if the community is financially constrained, it might rank economic value higher than long-term outcome such as capability building and learning. Also, some communities may lack the skills required to benefit from inward knowledge transfer. We posit that the inclusion of knowledge transfer in the agreement depends, also, on other conditions. We also consider whether a local university or research centre is involved in the collaborative agreement. We expect that a local university partner will maximize the probability of knowledge transfer in the agreement; universities and research centres have scientific skills which would allow understanding and mastery of knowledge inflows from international partners and also would allow greater exploitation of cross-collaborative innovation opportunities. University or research centre researchers can act as knowledge gatekeepers and transform the knowledge so that it is more easily understood by the local national audience (Giuliani and Arza, 2009). University researchers may consider BSAs to represent learning and knowledge accumulation opportunities, which will add to their CVs and enhance their career prospects.

Third, we consider the foreign signatories, that is, whether they include foreign firms or a foreign university/research institute, and whether they include a third-party donor as a key financier. We expect that, compared to foreign firm signatories, universities will be more inclined to favour knowledge transfer and local capability building, based on their more science-oriented rather than profit-oriented activities. Although universities will seek to benefit, both economically and in terms of academic prestige, from patenting a new discovery, their third-mission activities are part of their academic duties and, in many university systems, are included in regular academic evaluations. Hence, while companies may seek to minimize knowledge leakages, universities may favour them, generating an advantage to the local community. In addition, firms may prefer monetary compensations to the local community, whereas, universities, may prefer to establish linkages oriented at fostering research collaborations that involve transfers of knowledge. Finally, since in the context of BSAs, third party donors may have a specific mandate to promote development processes or enhance capability building, their presence may facilitate rather than hinder knowledge transfer. Donors are generally assessed on the basis of the impact of the focal project on the host country and host community; therefore, they may have a greater incentive to ensure knowledge transfer and longer-lasting impacts. Also, the presence of a donor may provide the developing country with financial support to pursue a more technologically sophisticated strategy (Weiss and Eisner, 1998).

Table 11.1 Conceptual framework: Conditions for knowledge transfer in BSA

Conditions favouring knowledge transfer in benefit sharing agreements	**Expectation on knowledge transfer**	**Mechanism**
Country:		
Biodiversity regulatory environment	Positive	Better protection of the country' bio-resources; more interest in favouring long term effects of benefit sharing agreements
Education	Positive	Greater interest and higher capacity of national communities and social groups in learning from benefit sharing agreements
Local signatories:		
Local community involvement	Positive or negative	Direct involvement of the local community may create the right conditions for knowledge sharing, but local communities may also prioritize economic interests or be less open to or capable of receiving/absorbing knowledge from an international partner.
Local university/research center involvement	Positive	The local university's researchers may have incentives for exploiting and learning from cross-border collaborations; they could become knowledge gatekeepers.
Global signatories:		
Foreign companies (vs. foreign universities)	Foreign universities: Positive	Universities are more science- than profit-oriented; knowledgedissemination and third mission activities are part of the universities' goals; companies may be more averse to knowledge leakages
Involvement of a third-party donor	Positive	Mandate to support development processes, capability building.

We identified six conditions which we propose could influence knowledge transfer and cross-border collaborations in BSAs: two country level conditions, two conditions related to the local signatories, and two conditions related to the foreign signatories. All these conditions likely influence innovation-related knowledge transfer. However, we do not expect any of these conditions, in isolation, to be either necessary or sufficient for knowledge transfer to occur. Rather, we suggest that there are certain combinations of conditions that ensure inclusion of knowledge transfer in the BSA. Section 3 describes our data collection and introduces the BSA cases.

3. Methodology

We consulted experts in this highly specialized field to make our decision about a workable number of cross-border BSAs. They confirmed that there were no existing databases of BSAs. We therefore proceeded as follows. First, we searched the Scopus database for published papers, and searched Google Scholar for grey literature and books. We used different combinations of search terms, including biodiversity, bioprospecting, access and benefit-sharing, benefit-sharing agreement, mutually agreed term, cooperation and collaboration. Second, we used the same search terms to search the NexisUni database (formerly LexisNexis), which is considered the world's largest electronic legal and public-records related information database. Third, we used these search terms to search for agreements on Google. Fourth, we consulted several other websites (see Appendix (A) for a full list of sources) and identified reports on biodiversity, bioprospecting, and benefit-sharing .

We scrutinized all the information and identified a set of cross-border BSAs, involving a developing country (where the biological material was located). We excluded BSAs involving parties from the same country and those involving only parties from advanced or high-income countries (see Appendix (B) for an overview of the cases). We scanned the resulting cases and selected only those BSAs that provided full information on the partners involved and the type of agreement. For each case we codified the relevant information and derived a dataset of 52 cases, 42 of which had explicit knowledge transfer arrangements.

Table 11.2 reports the descriptive statistics for the BSAs in our dataset: in 13% of the agreements the local signatory includes a local community; in 40%, a local university or a research centre is a signatory; the remaining 47%, the local signatory is an NGO or a national institution. Among international signatories, 75% involve at least one foreign company and 25% involve a university and/or a national research institution. Twenty-one per cent of the agreements included support from a third-party donor, such as the Inter-American Development Bank, the US National Institutes of Health, the Biodiversity Conservation Network, the German Agency for International Cooperation, or the International Cooperative Biodiversity Groups (ICBG) which are sponsored by the US National Institutes of Health, the US National Science Foundation, and the US Agency for International Development. Only two of the BSA in our dataset were signed after ratification of the Nagoya Protocol. Neither of these agreements includes planned knowledge transfer activities.

Table 11.2 Percentage of benefit sharing agreements, by type of transfer

	Knowledge transfer - %	Money transfer - %
Local signatory		
Local community (at least one)	12	20
University/research centres (at least one)	43	30
Others (NGOs, national institutions)	50	50
International signatory		
Company (at least one)	71	90
Others (university, national institutions)	29	10
Third party donor	24	10
Country of bioprospecting		
Africa	24	40
Asia	17	20
Eastern Europe	0	10
Latin America (+ Hawaii and Bermuda)	55	30
Oceania	4	0

Note that the local signatory classification is not exclusive, that is, there may be several local parties involved in the agreement (local community, university, etc.)

Given our QCA approach, we coded seven measures to separate membership in the condition (1) from non-membership in the condition (0). Consistent with our conceptual framework, we include *Knowledge transfer* (to capture the transfer of knowledge within the cross-border collaborative agreement) as the outcome condition and six explanatory conditions: two at country level (presence of a *Strong regulatory environment* and *High literacy);* two related to the local signatories (*Involvement of the local community* and *Involvement of a local university/research centre*), and two related to the foreign signatories (*Company signatory* and *Involvement of a third party donor*).

Five conditions were retrieved from the cases: *Knowledge transfer, Involvement of the local community, Involvement of a local university/research centre, Company signatory, Involvement of a third-party donor* are coded 1 if the data gathered for each condition mentioned their presence, and zero otherwise. Note that the absence of knowledge transfer (0) means that the BSA is based exclusively on monetary compensation. Note also that, given our two possible signatory types, the absence of a company signatory (0) means that a foreign university or research institute is involved. However, the presence of a company signatory does not mean that a university is not involved. We retrieved country-level conditions from secondary sources. We complemented these data with a measure of the strength of the country's regulatory environment, based on FAOLEX data and, to measure education, we considered literacy rates obtained from the World Bank's World Development Indicators. A country is considered to have a strong regulatory environment in a given year if it has in place at least 50 regulations on biodiversity, genetic resources, protected areas, and IPRs. We considered 50 as a relevant threshold because there is a gap in the distribution of the number of country regulations around 50, suggesting there are two different groups of country*years, one with below and one with above 50 regulations. Moreover, this distinction receives good face validity in the cases we investigate. A 90% literacy rate for those aged 15 and over in a given year is considered high. Around 90% literacy rate in our data and our cases provided satisfactory face validity.

We ran our analyses using fsQCA 3.0 (Ragin, Drass, and Davey, 2006). We conducted necessity analysis of all the conditions and their negation. We also conducted sufficiency analyses, which generated a a 'truth table,' which is a matrix that summarizes the property space (all possible combinations) determined by our conditions. We set a minimum frequency of one case per configuration and a consistency threshold of 0.80 (see, e.g., Bell, Filatotchev, and Aguilera, 2014; Fiss, 2011; Misangyi and Acharya, 2014).

4. Empirical Results

We applied the commonly accepted threshold of 0.90 consistency in the necessity analyses and found that none of our six explanatory conditions was necessary for the inclusion in the agreement of knowledge transfer and cross-border innovation (Greckhamer, 2016; Schneider and Wagemann, 2012). We found also that a signatory is necessary for absence of knowledge transfer, which means that all the agreements that involve a foreign university or research institute, result in knowledge transfer, which is consistent with our predictions. The absence of a third-party donor is another necessary condition for absence of knowledge transfer; in other words, all agreements supported by a third party involve knowledge transfer. This is also in line with our expectations since the primary role of the third-party donor is to mitigate the risks associated with cross-border innovation.

The sufficiency analysis produced four meta-configurations of conditions favouring knowledge transfer (Table 11.3). Overall, the solution consistently explains 29 out of 43 cases of knowledge transfer, that is, 69% coverage. Before discussing the configurations and corresponding cases, we comment briefly on the overall solution.

Table 11.3 Configurations for knowledge transfer in BSA

	1	2	3a	3b	4
Country context					
Strong regulatory environment	●	⊗	⊗	⊗	
High literacy				⊗	●
Local stakeholders					
Involvement of the local community	⊗	⊗	⊗	●	●
Involvement of a local university/research center				⊗	●
Global stakeholders					
Company signatory	⊗	⊗	●	●	●
Involvement of a third-party donor	⊗	●	⊗		●
Raw coverage	0.10	0.10	0.33	0.05	0.05
Unique coverage	0.07	0.05	0.21	0.05	0.05
Consistency	1.00	1.00	0.82	1.00	1.00
Number of cases	4	4	17	2	2
Overall solution coverage	0.71				
Overall solution consistency	0.93				
Total number of cases	29				

While configurations 1 and 2 involve foreign universities or research institutions, configurations 3a to 4 involve foreign firms as main international partners, as indicated by the absence and presence of *Company signatory*. In addition to allowing us to isolate those cases with foreign firm involvement, from the other conditions, we observe that, for both types of signatory, BSAs involve knowledge transfer in strikingly different situations for both types of signatories.

Comparing configurations 1 and 2, we observe that for foreign university-local organization collaborations to involve knowledge transfer, a strong institutional context or the support of a third-party donor are necessary conditions. Comparing configurations 1 and 3a, we observe that foreign companies and universities participate in similar agreements, but in different country types: in the former case, countries with weak regulatory institutions and in the latter case, countries with strong regulatory institutions. Also, in *Configuration 3a*, but not in *Configuration 2*, third-party donors are absent. We discuss the results and summarize the cases describing each configuration (Appendix (C) provides full summaries of each case).

Configuration 1. The first configuration includes collaborations between foreign universities (indicated by the absence of a *Company signatory*) and one among several local organizations rather than a local community (indicated by the absence of involvement of a local community). Third-party donors are not involved; this condition is absent. Depending on the case, a local university may or may not be among the signatories, so that this condition is not relevant to the configuration. In some cases, the local signatory is a university or a research centre. Also, in these cases, the agreements involve countries with strong biodiversity, genetic resources, and IPR regulations. In line with our predictions, the agreement entails knowledge transfer: universities work to generate knowledge and they collaborate with research partners. Also, in this configuration, universities tend to prefer to collaborate with countries with regulations on biodiversity and genetic resources. For example, the Chagas-Space Project, led by the University of Alabama and NASA, in a collaboration with the Instituto Nacional de Biodiversidad, Costa Rica, was aimed at finding a plant-based cure for Chagas disease, which is caused by the parasite Trypanosoma cruzi. In 1997, when the project started, Costa Rica had over 50 regulations on biodiversity. By 2001, when the second phase of the project was initiated, it had more than 150 regulations. The project was a research collaboration between the local and international parties and envisaged two space missions (see Appendix (C) *InBio Costa Rica and the University of Alabama* for more details).

Configuration 2. This configuration also includes research collaborations involving foreign universities and local organizations (absence of *Company signatory* and *Involvement of the local community*). Again, the local signatories may (or may not) involve a local university. However, in this configuration, the strong biodiversity regulatory environment is absent and core, i.e., the knowledge transfer takes place in a country with a comparatively weak regulatory environment in the biodiversity domain. This configuration also involves the participation of a third-party donor (present and core condition). Hence, knowledge transfer in countries with weak regulation seems to be facilitated by the involvement of a third-party donor, which may reduce project uncertainty for the international universities involved. For example, the collaboration between the University of Utah and the University of Minnesota, and the University of Papua New Guinea in the context of the Papua New Guinea ICBG. ICBGs aim at ensuring equitable sharing of biodiversity benefits from research collaborations related to drug developments. The agreement includes commitment to improving the education and science infrastructure in Papua New Guinea, contributing to the conservation and sustainable use of biodiversity, and the transfer of knowledge, expertise and technology related to the collection, storage bioassay-guided isolation and characterization of natural products and therapeutic agents. In 2002, when the project started, Papua New Guinea had only 10 biodiversity related regulations (see Online Appendix (C) for more details on *University of Papua New Guinea, University of Utah and University of Minnesota*).

Configuration 3. Configurations 3a and 3b are linked by their core conditions, according to the standard QCA. Both configurations correspond to agreements with a foreign firm signatory from a country with fairly weak biodiversity and property rights regulations. However, they vary significantly in terms of their contributing conditions and local signatory types.

Configuration 3a includes 33% of the cases, that is, 17 cases, are consistent with this configuration and 21%, that is, 9 cases, are not consistent with any other configuration. In addition to presence of a foreign company signatory and absence of a strict regulatory context, this configuration includes absence of direct community involvement and absence of a third-party donor. Thus, these agreements are led and financed primarily the foreign firms that collaborate with the local organizations in countries with weak regulation. An example of configuration 3a is the partnership between the Kenya Wildlife Service (KWS) and the Danish biotechnology company, Novozymes, to collect, identify, and characterize microorganisms from Kenya's national parks. One of Novozymes commercial products was based on samples collected in Kenya. Therefore, it initiated the project and identified a local partner. The regulatory regime was weak: in 2007, Kenya had only 29 regulations related to biodiversity, roughly six times fewer than that the average of the countries involved in our cases. The collaboration and transfer of knowledge took the form of Novozymes training Kenyan students in taxonomy, isolation, and identification of microorganisms. The company also established a microbial discovery laboratory in KWS and transferred advanced technology to KWS, including knowledge about how to collect and isolate micro-organisms and how to characterize microbial diversity.

Another example is the San Francisco-based Shaman Pharmaceuticals Company which signed a partnership with Bioresources Development and Conservation Programme (BDCP), a multi-ethnic international NGO based in Nigeria. Shaman planned to use its ethnobotany and isolation and natural products chemistry to discover and develop novel pharmaceuticals based on plants identified in Nigeria. In 1990, when the collaboration started, there were no specific biodiversity preservation or IPR regulations related to natural resources in Nigeria, making the role of the partner NGO particularly crucial for the success of the agreement. Local healers were involved in the collaboration and local communities benefited from transfer of knowledge in several ways; however, Shaman Pharmaceuticals main point of contact was predominantly BDCP (see Online Appendix (C) *Kenya Wildlife Service and Novozymes* and *Bioresources Development and Conservation Programme- BDCP Nigeria and Shaman Pharmaceuticals, Inc*).

Configuration 3b includes only 2 of the 29 cases. This small coverage likely reflects the problems related to BSAs with indigenous communities as opposed to national organizations, NGOs, or local universities. This configuration includes agreements involving some kind of knowledge transfer from the foreign company to a country with limited biodiversity regulation. We observe, also, that these agreements are linked to countries with low literacy rates, and local signatories that include local communities, but not local universities. For example, Aveda Corporation concluded an agreement with the Yawanawa tribe in Brazil to access Bixa, a plant whose seed is used as a red colorant for cosmetic products. The agreement was signed in 1992, when Brazil had only between 30 and 40 regulations related to biodiversity, compared to over 400 in 2020. Also, literacy rates were well below 90% (the World Bank estimates that they had reached 86% in 2000), suggesting that indigenous communities may have had limited access to education. Creating an organization to represent the rights of the members of the Yawanawa community, was a precondition for signing the agreement and ensuring knowledge transfer. Aveda provided the Yawanawa community with technical and administrative support to start the project, including processing and packaging machinery and quality control standards. (see Online Appendix (C) *The Brazilian Yawanawa tribe and Aveda Corporation* for further details),

Configuration 4. This may appear to be ideal for knowledge transfer. The cases include a large number of local and global signatories, and a high literacy rate. In particular, at the local level, there is participation of both indigenous communities and local universities, highlighted by the presence of these two conditions (as core). They also include participation of both foreign companies and third-party donors. We observe, also, that foreign universities contribute to the projects. However, this configuration includes only two cases of knowledge transfer. This scenario seems quite rare and may be because it requires implementation and management of complex contractual arrangements among a set of very diverse parties. Both projects suffered from contractual and political problems, which hindered their implementation (see Appendix (C) *Fiji Verata community, University of South Pacific, Smith Kline Beecham and the SIDR* and *Mexican Maya communities, ECOSUR, Molecular Nature Limited and the University of Georgia*). In the first case (Fiji Verata), the company disengaged after six months over contractual issues; in the second case (the Maya communities in Mexico), local and international opposition precipitated the ending of the project. The first case corresponds to a research agreement with Fiji from 1995 to 1999. According to the World Bank, Fiji had a 93% literacy rate in 1996. The local signatories included the Fijian University of the South Pacific and the Verata community, and the international partners included the British Smith Kline Beecham (now Glaxo Smith Kline) and the Scottish Strathclyde Institute of Drug Research (SIDR). Funding was provided by the Biodiversity Conservation Network, a grant-awarding and applied research programme, which operated from 1993 to 1999 and a prominent third-party signatory in the context of biodiversity projects. The second case corresponds to an ICBG bioprospecting project, which ran from 1998 to 2000 in Mexico which had a literacy rate of 91% in 2000 according to the World Bank. ICBGs typically entail large scale cooperation. In this particular case, the local participants included a group of Mayan communities in the Chiapas highlands and El Colegio de la Frontera del Sur (ECOSUR), a Mexican public research institution. International partners include Molecular Nature Ltd, a small UK-based biotechnology company, and the University of Georgia (US). Promaya, an organization dedicated to representing the rights of the 28 Maya groups and co-ownership of the intellectual property generated by the project, was created. The non- monetary benefits included establishment of a laboratory on the ECOSUR campus, to process natural products. Technicians were trained in modern laboratory techniques and methods to enable accurate recording and presentation of data. Eventually, disagreements at both the local and international levels and accusations of biopiracy led to the project being terminated in 2001 and the withdrawal of ECOSUR.

5. Concluding remarks

This chapter has shed light on the dark spots in the innovation and IPR spaces, that is, industries or contexts where innovation brings unequal benefits or where protection of innovative outputs is beneficial for some social groups, but detrimental to others. We considered the context of cross-border bioprospecting agreements because of their well-documented potential negative impacts on local communities' livelihoods and biodiversity conservation. We apply a csQCA methodology to a unique sample of bioprospecting cross-border agreements involving developing countries, to understand the conditions that allow the transfer of knowledge to developing countries' communities and organizations. We argued that knowledge transfer and technological or scientific collaborations are more likely than monetary compensation to have lasting effects on recipient countries.

We identified configurations of cross-border agreements that included knowledge transfer. We found that collaborations between foreign universities and local organizations (universities or research centres) and a strong bio-conservation regulatory environment favour knowledge transfer, but that in the case of weak regulatory environments, the presence of a third-party donor is required for knowledge transfer to occur. We found, also, that cross-border agreements involving a foreign firm may result in knowledge transfer. Although foreign companies are usually partners with countries with weak regulatory environments, we observed cases where transfer of knowledge to local organizations was specified, for example, the case of Danish Novozymes and KWS. Two cases show that foreign companies can collaborate successfully (i.e., be involved in knowledge transfer) with indigenous communities (e.g., the Brazilian Yawanawa tribe collaboration with the US company Aveda). We found that the involvement of too many partners was linked to project failure.

Our study has implications for research and policy related to bioprospecting contracts and contributes, also, to the stream of work on cross-border collaboration and innovation. We have added to the understanding of collaboration and the risks for local communities and their natural environment. However, our findings related to whether BSAs are effective for local communities and their country's development processes are mixed. We provide some evidence of what configurations might prove more successful for achieving knowledge transfer and innovation, in the context of bioprospecting projects. Our findings suggest that agreements should not include too many partners since this adds complexity to individual interests and incentives and threatens the chances of learning by the local partners. We found also that in the context of countries with weak regulation of biological resources, the inclusion of a third-party donor can compensate for this weakness. Finally, the biopiracy literature considers foreign firms to be predators of natural resources. Our findings call for a more fine-grained examination of the role foreign companies, since some may also foster accumulation of capabilities and facilitate knowledge transfer to the developing country. However, local communities and organizations need to ensure that the agreement will benefit them, which requires policies to empower vulnerable communities and strengthen their awareness of their fundamental rights.

The findings from our analysis suggest the need for careful consideration of the negative impacts of cross-border collaborations, even if they are innovation oriented. Compared to other types of cross-border ventures, such as those involving the extractive industries, production, or mega-infrastructural projects, innovation may be seen as a high value and noble activity and, thus, not involving harm to the environment, societies, or human rights (Giuliani and Macchi, 2014). As innovation scholars begin to question this assumption (e.g., Biggi and Giuliani, 2021; Coad et al., 2021), future research on cross-border innovation should focus more on the dark spots of innovation. Such an investigation would be timely in view of the growing international attention on the monitoring and regulation of international businesses and the impact of their operations on human rights and the environment. Our examination of the content of international investment agreements develops in parallel with the increasing awareness about the need to introduce the principle that environmental rights and more broadly local communities' rights are non-tradable. Cross-border investors and collaborators can no longer ignore the need to respect fundamental human rights and the environment of host countries, an idea that is in line with the current supra-national discussions on business and human rights (see, e.g., the 2011 UN Guiding Principles on Business and Human Rights and the OECD Guidelines for Multinational Enterprises, 2011, Chapter IV). Incorporating elements of soft-law regulation that are meant to discipline business conduct in international cross-border agreements will be a future challenge for policy makers.

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Online Appendix

A. List of sources consulted to identify cross-border BSA

Our list of scrutinized sources includes the following: ABS Initiative, ABS Clearing House, Bioresources Development and Conservation Programme, CBD and Nagoya protocols official website, Bio-Economy, Biodiversity International, Bioresources Development and Conservation Programme, CONABIO, CONADIBIO, CONAGEBIO, EarthOrg, EU-funded BENELEX project, Ethiopian Institute of Agricultural Research, Forestry Commission of Ghana, Instituto Nacional de Biodiversidad – InBio, Grain, M S Swaminathan Research Foundation, National Biodiversity Authority, Papua New Guinea Institute of Biological Research, The Access Initiative, The Dutch Research Council, The Food and Agriculture Organization of the United Nation, The Indo-German Biodiversity Programme, The South African National Biodiversity Institute, The World Intellectual Property Organization, The Economics of Ecosystems & Biodiversity, The Federal Ministry for Economic Cooperation and Development, Union for Ethical Biotrade.

B. List of Benefit Sharing Agreements

Topic	Scope	Local signatory	Country	Date	Global signatory
Arid land plants	Technology and knowledge transfer	Insituto de Recursos Biologicos de Argentina Universidad Nacional de la Patagonia	Argentina	1993-2004	University of Arizona Wyeth-Ayerst/American Cyanamid Purdue University Hansen's Disease Center ICBG
Marine bioprospecting	Technology and knowledge transfer	Bermuda Biological Station for Research	Bermuda	1999-2002	Diversa
Amazon bioprosecting	Technology and knowledge transfer	Brazilian Extracta	Brazil	1999-2002	GlaxoSmithKline
Bixa	Technology and knowledge transfer	Yawanawa tribe	Brazil	1992-n.a.	Aveda Corporation
Natural genetic resources	Technology and knowledge transfer	Bioamazonia	Brazil	2000-2003	Novartis
Ancistrocladus korupensis	Money transfer	Government of Cameroon	Cameroon	1993-n.a.	National Cancer Institute
Arid land plants	Technology and knowledge transfer	Pontifica Univ. Catolica de Chile	Chile	1993-2004	University of Arizona Wyeth-Ayerst/American Cyanamid Purdue University Hansen's Disease Center

					ICBG
Microbial genetic resources	Technology and knowledge transfer	HUBEI Academy of Agricultural Sciences	China	1997-2004	Syngenta Crop Protection AG
Seeds and plants	Money transfer	Nanjing Botanical Garden	China	1992-n.a.	Piroche Plants
Tropical insects and other invertebrates	Technology and knowledge transfer	InBio University of Costa Rica	Costa Rica	1993-1999	Cornell University Bristol Myers Squibb ICBG
Aromas and fragrances	Technology and knowledge transfer	InBio	Costa Rica	1995-1998	Givaudan Roure
Tree in the dry tropical forest	Technology and knowledge transfer	InBio	Costa Rica	1992-2004(ongoing)	British Technological Group Ecos La Pacífica Corporation
Aquatic and terrestrial microorganisms	Technology and knowledge transfer	InBio	Costa Rica	1995-2007	Diversa
Plants, animals, and soil	Technology and knowledge transfer	InBio	Costa Rica	1991-2001	Merck & Co.
Antimicrobial and antiviral components	Technology and knowledge transfer	InBio	Costa Rica	1996-2002	INDENA
Extracts from leaves, roots and other parts of the plants	n.a.	InBio	Costa Rica	1998-2000	Phytera Inc
Botanical compounds	Technology and knowledge transfer	InBio	Costa Rica	1999-2000	Eli Lilly Agreement
Plants and animals	n.a.	InBio	Costa Rica	1999-2001	Akkadix Corporation
Extracts from plants	n.a.	InBio	Costa Rica	1997-2001	University of Strathclyde Japanese private sector (no details)
Compounds with insecticide activity	Technology and knowledge transfer	InBio	Costa Rica	1995-1998	University of Massachusett National Health Institutes
Medicinal plant species	Technology and knowledge transfer	InBio	Costa Rica	2000-2003	University of Guelph
Medicinal plant species	Technology and knowledge transfer	InBio Escuela de Agricultura de la Región Tropical Húmeda Universidad Nacional	Costa Rica	1997-2004(ongoing)	University of Alabama National Aeronautics and Space Administration Universidad Católica del Norte Universidad de Santiago de Chile Universidad de la República in Uruguay Instituto Nacional de Parasitología in Argentina
Teff	Technology and knowledge transfer	Institute of Biodiversity Conservation Ethiopian Agricultural Research Organisation	Ethiopia	2005-2009	Health and Performance Food International

Aquatic and terrestrial organisms	Technology and knowledge transfer	Department of Chemistry University of South Pacific Verata community	Fiji	1995-1999	Smith Kline Beecham (for the first 6 months) Strathclyde Institute of Drug Research (once the company left the agreement) Biodiversity Conservation Network
Environmental samples	Technology and knowledge transfer	University of Ghana	Ghana	2001-n.a.	Diversa
Cohune nuts	Money transfer	Industria Petenera de Corozo Ecomaya	Guatemala	1992-2002	Croda Inc Conservation International
Environmental samples	Money transfer	Marine Bioproducts Engineering Center University of Hawaii	Hawaii	2002-n.a.	Diversa
Indonesia bioprosecting	Money transfer	Bogor Agricultural University	Indonesia	1997-1999	Diversa
Aquatic and terrestrial microorganisms	Technology and knowledge transfer	International Centre for Insect Physiology and Ecology	Kenya	2001-2007 (est.)	Diversa
Aquatic and terrestrial microorganisms	Technology and knowledge transfer	Kenya Wildlife Service	Kenya	2007-2012	Novozymes
Seeds	Technology and knowledge transfer	National Museums of Kenya Kenya Agricultural Research Institute Kenya Forestry Research Institute Kenya Forest Department Kenya Wildlife Service	Kenya	2000-2020	Royal Botanical Garden Kew
Seeds	Technology and knowledge transfer	Lebanese Agricultural Research Institute	Lebanon	2000-2005	Royal Botanical Garden, Kew
Calophyllum lanigerum	Technology and knowledge transfer	Government of the State of Sarawak	Malaysia	1994-n.a.	Medichem Research The National Cancer Institute University of Illinois
Biological samples	Technology and knowledge transfer	Biotechnology Institute of the National Autonomous University of Mexico	Mexico	1998-2001	Diversa
Microbiotic mushroom samples	Technology and knowledge transfer	The Union de Comunidades Zapoteco Chinanteca UZACHI	Mexico	1995-1998	Sandoz
Medicinal plant species	Technology and knowledge transfer	28 municipalities of Tzeltal and Tzotzil-speaking communities El Colegio de la Frontera del Sur	Mexico	1998-2000	University of Georgia Molecular Nature Limited ICBG
Biological samples	Technology and knowledge transfer	National Autonomous University of Mexico	Mexico	1998-n.a.	Diversa
Arid land plants	Technology and knowledge transfer	Universidad Nacional de Mexico	Mexico	1993-2004	University of Arizona Wyeth-Ayerst/American Cyanamid Purdue University Hansen's Disease Center

					ICBG
Nigeria bioprospecting and traditional knowledge	Technology and knowledge transfer	Bioresources Development and Conservation Programme	Nigeria	1990-1999	Shaman Pharmaceuticals, Inc
Flora	Technology and knowledge transfer	Pakistan Science Foundation Himalayan Wildlife Foundation	Pakistan	1998	Cambridge University Botanic Garden Centre for Plant Diversity and Systematics
Panama bioprospecting	Money transfer	National Association for the Conservation of Nature	Panama	2018-ongoing	Indigena Biodiversity German Agency for International Cooperation
Papua New Guinea bioprospecting	Technology and knowledge transfer	University of Papua New Guinea	Papua New Guinea	2002-2010 (est.)	University of Utah University of Minnesota ICBG
Extracts from plants	Technology and knowledge transfer	Conap (representing Aguaruna Peoples) Universidad Peruana Cayetano-Heredia Universidad San Marcos	Peru	1993-1998 (est.)	Washington University Searle Co Monsanto
Marine bioprospecting	Technology and knowledge transfer	Marine Science Institute of the University of the Philippines Philippine Department of Agriculture	Philippines	1998-2005	University of Utah Wyeth-Ayerst, formerly American Cyanamid
Wild rice species Oryza longistaminata	Technology and knowledge transfer	International Rice Research Institute	Philippines	1990-n.a.	University of California at Davis Stanford University Two, un-named agricultural biotechnology companies that have licensed the gene Xa21 from UC Davis
Russia bioprospecting	Money transfer	Bechtel Corp's Idaho National Engineering and Environmental Laboratory	Russia	2000-n.a.	Diversa
Hoodia	Money transfer	San community Council for Scientific and Industrial Research (CSIR)	South Africa	2003-2008 (est.)	Phytopharm plc Pfizer Inc Unilever
Rooibos	Money transfer	San and Khoi communities	South Africa	2014-ongoing	Nestle
Horti- and flori-culture	Technology and knowledge transfer	South African National Biodiversity Institute (SANBI)	South Africa	1999-2004	Ball Horticulture
Seeds	Technology and knowledge transfer	South African National Biodiversity Institute (SANBI)	South Africa	2000-2020	Royal Botanical Garden Kew
Fowering plant	n.a.	South African National Biodiversity Institute (SANBI)	South Africa	n.a.	Royal Botanical Garden Kew
Plants	n.a.	University of the Free State	South Africa	1998-2004	New York Botanical Garden Merck Research Laboratories

Marine bioprospecting	Technology and knowledge transfer	Rhodes University	South Africa	1998-2000	SmithKline Beecham plc National Cancer Institute Coral Reef Research Foundation
Environmental samples	Money transfer	Council for Scientific and Industrial Research	South Africa	2000-n.a.	Diversa
South Africa bioprosecting	Technology and knowledge transfer	Bioresources Development and Conservation Programme	South Africa	1993-n.a.	Walter Reed Army Institute of Research Smithsonian Tropical Research Institute International Centre for Ethnomedicine and Drug Development ICBG
Suriname bioprospecting	Technology and knowledge transfer	Suriname office of Conservation International/ Saramaka Maroons Bedrijf Geneesmiddelen Voorziening Suriname	Suriname	1994-2002 (est.)	Virginia Polytech Institute and State University Missouri Botanical Garden Bristol Myers-Squibb Pharmaceutical Research Institute ICBG
Aquatic and terrestrial organisms	Technology and knowledge transfer	Ministry of Lands of the Government of Vanuatu	Vanuatu	2006-n.a.	French National Museum of Natural History French Institute for Research for Development Pro-Natura International

C. Case focus: Detailed overview of the configurations

***Configuration 1:* InBio Costa Rica and the University of Alabama**[4]

INBio, together with EARTH, the National University of Costa Rica and other Latin American institutions in Argentina, Brazil, Chile, Mexico and Uruguay, and NASA in the USA, are part of the project Espacio Chagas, aimed at finding a plant-based cure for Chagas disease. The World Health Organization estimates that some 6 million to 7 million people worldwide are infected with Trypanosoma cruzi, the parasite that causes Chagas disease. The main areas affected are in rural parts of Latin America. The ChagaSpace Project, with started in 1997, was a collaborative effort between researchers and scientists from institutions and universities in the US and Latin America, to find potential extracts from the tropical forest that would inhibit specific enzymes in the parasite that carries Chagas. In two different space missions, Franklin Chang Díaz, the leader of the Chagas project, and a member of the EARTH University Board of Directors and a NASA astronaut, crystallized the proteins of the parasite, enabling researchers on the ground to conduct targeted experiments. In 2001, the USA Congress approved funding to refinance the project and the biological tests were resumed.

***Configuration 2:* University of Papua New Guinea, University of Utah and University of Minnesota**[5]

This research collaboration between the University of Papua New Guinea (UPNG), the University of Utah and the University of Minnesota focused on the conservation and sustainable use of biodiversity in Papua New Guinea (PNG), in the context of an ICBG, and lasted for eight years. The benefit sharing agreement took the form of a Memorandum of

[4] Sources : http://www2.ecolex.org/server2neu.php/libcat/docs/LI/MON-082436.pdf; https://www.cbd.int/financial/bensharing/g-abs-iucn.pdf; https://www.cbd.int/financial/bensharing/costarica-absinbio.pdf; .
[5] Source : http://www.abs-initiative.info/uploads/media/ABS_Best_Practice_Pacific_Case_Studies_Final_01.pdf

Understanding (MoU), signed in 2002 and renewed in 2008. The overarching goal of the ICBG project was to improve human health and well-being through a set of programmes dedicated to the description, assessment, utilization, and conservation of biodiversity in PNG, with a focus on HIV and tuberculosis. The agreement described commitments to improving the education and scientific infrastructure in PNG; contributions to the conservation and sustainable use of biodiversity; transfer of knowledge, expertise, and technology related to the collection, storage, bioassay-guided isolation, and characterization of natural products and therapeutic agents. The collaboration was conducted in two phases. The first phase dealt with initial collection activities and investigations. Phase two entailed the development of lead compounds and materials identified in phase one, to produce commercial products. The MoU specified that separate agreements would be made for each product entering phase two development and that, if indigenous knowledge was involved in the collection of samples or development of commercial agents, suitable recognition would be given to their intellectual property, including appropriate compensation and patent inventorship, if necessary. The most productive target of the project was tuberculosis, which resulted in two patent applications, two provisional patent applications, and three manuscripts. The MoU stated further that any licences granted to agents or companies on any patents resulting from this collaboration must abide by the terms of the agreement.

Configuration 3a: **Kenya Wildlife Service and Novozymes**[6]

The Kenya Wildlife Service (KWS) and Novozymes, in 2007, entered into a five-year partnership for the collection, identification, and characterization of microorganisms from Kenya's national parks. The agreement resulted from pre-CBD collections that Novozymes had received, and their subsequent efforts to address the absence of an agreement associated with these collections which led to the development of a commercial product, Pulpzyme.

[6] Source : https://www.cbd.int/doc/meetings/abs/abswg-06/other/abswg-06-cs-02-en.pdf

Pulpzyme reduces the amount of chlorine needed to bleach wood pulp. Although the conditions under which the initial samples were collected are not clear, it was assumed that the collections took place in a protected area and, thus, were under the management of KWS. Novozymes approached KWS to develop a benefit-sharing agreement for the proceeds from this product, although commercial sales had been modest. A deal was negotiated to pay an accumulated royalty on past sales and running royalties on any future sales and to build a new partnership around microorganism collection, identification, and characterization. The transfer of knowledge took the form of Novozymes training Kenyan students in taxonomy, isolation, and identification of microorganisms. Novozymes also set up amicrobial discovery laboratory at KWS and transferred advanced technology to KWS, including knowledge of how to collect and isolate micro-organisms and how to characterize microbial diversity. The agreement also granted Novozymes the rights to commercial use of additional specific strains isolated in Kenya.

Configuration 3a: **Bioresources Development and Conservation Programme- BDCP Nigeria and Shaman Pharmaceuticals, Inc**[7]

The Bioresources Development and Conservation Programme (BDCP) was a multi-ethnic international NGO based in Nigeria that focused on building technical skills to improve health care and sustainable development through exploitation of bioresources. It targets therapeutic categories for tropical diseases suffered in Nigeria, such as malaria, leishmaniasis, and trypanosomiasis. In 1990, Shaman Pharmaceuticals Inc., a small San Francisco company that uses ethnobotany to discover and develop novel pharmaceuticals, established a research relationship with Nigerian scientific institutions, and the BDCP became the focal point for collaborative research. Four ethnobotanical field expeditions were conducted. In

[7] Sources : https://pdfs.semanticscholar.org/d2ba/aca2eb932ba5d967eb33ec4b3559932b8d35.pdf; https://www.cbd.int/financial/bensharing/nigeria-medicine.pdf; https://www.culturalsurvival.org/publications/cultural-survival-quarterly/lessons-bioprospecting-india-and-nigeria; https://www.etcgroup.org/fr/node/482

collaboration with BDCP, Shaman Pharmaceuticals offered workshops and training programmes in public health, botany, conservation, and ethnobotany; support for a medicinal plant reserve; supplies for village schools; botanical collection supplies for a herbarium; laboratory equipment for scientific research on plants that treat parasitic diseases prevalent in West Africa; and support for Nigerian scientists to apply modern analytical techniques. In 1997, BDCP launched the Fund for Integrated Rural Development and Traditional Medicine (FIRD-TM), a vehicle for receiving and channelling the benefits from several bioprospecting projects to indigenous communities. The FIRD-TM has an independent board composed of leaders of traditional healers' associations, senior government officials, multi-ethnic representatives of village councils, and technical experts from scientific institutions. The collaboration allowed the transfer of technology and knowledge in the context of the BDCP. However, results in terms of commercial drugs, have been disappointing. In 1999, Shaman Pharmaceuticals, which had signed a number of benefit sharing agreements centring on ethnobotany and had become a reference for bioprospecting, had not managed to get a single drug approved by the Food and Drug Administration. The company decided to withdraw from the pharmaceutical industry and focus on the development of botanical dietary supplements.

Configuration 3b: **The Brazilian Yawanawa tribe and Aveda Corporation**[8]

Bixa Orellana is an endemic plant used as a colourant for a range of industries such as food and cosmetics. The Brazilian Yawanawa tribe cultivates Bixa on 30 hectares of land. They process and sell the dye to Aveda (approx. 10 tons annually) and with other companies, mainly in the Sao Paulo region. Aveda agreed to pay US$2,40/kg for Bixa, which was almost the its market price. Aveda incorporates the dye in several of its products, including lipsticks

[8] Source: Waddington and Laird (1999) "The production and marketing of a species in the 'public domain': the Yawanawa and Aveda Corporation Bixa orellana Project, Brazil", in Kerry Ten Kate and Sarah A. Laird, The Commercial Use of Biodiversity: Access to genetic resources and benefit-sharing, London, Earthscan Publications Ltd., 398 pp.

and colour shampoos and conditioners. In 1994, Aveda's Bixa-based products represented approximately US$550,000 in sales. As part of the agreement, Aveda provided the Yawanawa with technical and administrative support to start the project, including processing and packaging machinery, and quality control standards. It constructed malaria treatment facilities and a warehouse. It also provided a solar electric system to service the Bixa processing facilities, which was extended to serve some homes in the village. The company provided a water pasteurization unit and some Yawanawa students received English language training in the US and marketing, law administration, and healthcare education. Thus, Aveda transferred extensive expertise and technology to the Yawanawa and supported business training alongside the project. It also provided a loan of US$ 50,000 to support the initial stages of the project's development. In return, the Yawanawa agreed that Aveda uses the community's image, conditional on getting their consent on its marketing campaigns. Thus agreement was enabled by the involvement of the Organizacao dos Agricultores e Extractivistas Yawanawa do Rio Gregorio, which is the community's legal representative in the agreement and handles the financial transactions.

Configuration 4: **Fiji Verata community, University of South Pacific, Smith Kline Beecham and the SIDR**[9]

This bioprospecting project involves the University of the South Pacific (USP), the Verata community in the Fijis, the UK based company Smith Kline Beecham (now GSK), and the Strathclyde Institute of Drug Research, which acts as a broker. The project, which received a grant from the Biodiversity Conservation Network, focused on marine bioprospection and community development and knowledge transfer. Initially, a direct contract between SB and

[9] Sources : https://www.cbd.int/doc/case-studies/abs/cs-abs-fj.pdf; http://www.feem-web.it/ess/ess07/files/ding_fp.pdf

the community was envisaged, but the legal problems involved and some general governance issues, prevented Smith Kline Beecham from finalizing the contract before it closed its natural products discovery division. This resulted in the company withdrawing from the project six months after it had begun. USP then partnered with the Strathclyde Institute of Drug Research , with Strathclyde University acting as the broker between the project and the companies interested in buying samples. Although it retained 40% of the amount of the deals, it managed to negotiate higher prices than the other signatories could have achieved. The remaining 60% was shared between USP, the Verata community, and the Fiji Government. However, compared to Smith Kline Beecham, although willing to contribute to the research effort alongside USP, The Strathclyde Institute of Drug Research was less keen to contribute to the Verata community's development and made prior informed consent mechanisms on commercial developments practically impossible. In contrast, as part of its contract with USP, the Verata community was informed about the research activities conducted and the future potential commercial uses. In addition, members of the community benefited from environmental conservation and monitoring workshops. As part of the agreement, six individuals from different villages in the county of Verata were trained in the collection and preparation of samples, six others were trained in biodiversity monitoring methods, and six more were given socioeconomic monitoring training. Six monthly community-wide workshops were held on resources management and community development. For USP, the non-monetary benefits came from the joint research with Strathclyde Institute of Drug Research, in the form of capacity building.

Configuration 4: **Mexican Maya communities, ECOSUR, Molecular Nature Limited and the University of Georgia**[10]

[10] Source : https://www.cbd.int/financial/bensharing/g-abs-iucn.pdf

In 1998, the International Cooperative Biodiversity Groups provided a grant for a partnership among three academic and private institutions, to carry out a research project in the Highlands of Chiapas, Mexico, on commonly shared traditional knowledge on bioprospecting of medicinal plants in that region. In terms of access to genetic resources, the Maya ICBG sought to implement SIC agreements with the communities, and the benefit-sharing provisions included co-ownership of patents, technology transfer, and dissemination of 'science-validated' traditional knowledge. The purpose of the project was 'to promote human health, economic development, and diversity conservation through sustainable development of medicinal plant resources and associated traditional knowledge'. The organization Promaya was created to represent the rights of the 28 Maya groups and co-own the intellectual property generated within the project. The non-monetary benefits of the agreement included the establishment of a state-of-the-art laboratory on the ECOSUR campus, to process natural products. Technicians were trained in modern laboratory techniques and methods to accurately record and present data. Eight graduate students from ECOSUR and Eight from UGA were involved in the project during the first six months. An exchange programme between the two academic institutions was established to allow student and faculty exchanges. Since ECOSUR was an active participant in the project, ten Maya collaborators were trained in field collection, processing, and surveying, recording of data, and ethics (including prior informed consent and intellectual property rights). Part of the Maya ICBG was dedicated to promoting traditional medicine. However, local and international opposition and accusations of biopiracy led to termination of the project in 2001 and the withdrawal of ECOSUR.