Chapter 5
Property Rights and Government Involvement in Market-Like Biodiversity Conservation: An Empirical Analysis of Bioprospecting

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5.1 Introduction

Genetic resources (GR) and the traditional knowledge (TK) about their use, for example, for traditional medicinal purposes, hold multiple values for society. They also form valuable inputs into basic research and development activities in the life science industry. However, the sustained conservation of nature that hosts GR, and the access to them, requires governance structures which involve clear property rights. It is in this context that the Convention on Biological Diversity (CBD) addresses bioprospecting projects in developing countries by aiming to provide conservation incentives under favourable conditions to biodiversity holders while facilitating GR access to external users.

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Much of the economic analyses on bioprospecting tend to focus on GR valuation and on theoretical assessments of the effect of the current international patent legislation, which is often criticised for giving firms only short-term incentives to invest in biodiversity (e.g. Goeschl and Swanson 2000; Rausser and Small 2000). Other research (e.g. Mulholland and Wilman 2003) has explored theoretical aspects of the functionality of different benefit sharing modalities in bioprospecting projects. Other analyses have addressed the relationship between bioprospecting outcomes and the jurisdictional governance setting (e.g. OECD 2003; SCBD 2008; UNU-IAS 2008). However, as highlighted by Polski (2005), there is a lack of empirical evidence about the performance of bioprospecting contracts, especially on the governance factors that influence bioprospecting schemes as framed by the CBD. One such understudied governance aspect is the nature of the contractual hazard involved in bioprospecting projects (SCBD 2008).

In this chapter, contractual hazard refers to the conditions that make a contract be interrupted or finished before the respective rights and responsibilities of the project are fulfilled. This notion has a non-evaluative connotation; that is, it is not associated with a normative evaluation of whether bioprospecting contracts as such are positive or negative in terms of conserving biodiversity, nor if they are an effective means for promoting fair and equitable allocation of rights and responsibilities between stakeholders. In fact, bioprospecting contracts, as market-based legal mechanisms, vary substantively because it is up to the parties to decide the content of each individual contract.[1] Among the many normative interpretations of what is a successful bioprospecting project (see e.g. Shiva 1997; ten Kate and Laird 1999), here we define a successful bioprospecting project more simply as a project that proceeds without cancellations or interruptions.

In this chapter, we cast new light on the link between different institutional designs of bioprospecting projects and the project outcomes. We analyse the main institutional roles of governments in terms of clarifying and enforcing property rights of GR. This type of analysis is carried out using standard concepts from institutional economics (e.g. Oxley 1999; Williamson 1985, 1999, 2005). The main idea or hypothesis that we hold here is that transaction costs associated with public policies to regulate bioprospecting might cause contractual hazard in such projects, which may bear negative effects on their outcomes.

We specify a theoretical framework based on the idea that there is likely to be trade-offs between having clear and enforceable property rights for biodiversity holders and the level of transaction costs associated with setting those property rights. We also pose that governments might under certain circumstances ease contractual hazards. In order to understand the link between government intervention and concrete outcomes of bioprospecting contracts, it is necessary to understand the role of government intervention within the overall context of the contractual project.

[1] Interruption of a contract and its subsequent renegotiation or even its premature termination may not be a failure but a success in terms of agreeing a more equitable allocation of rights and duties over the use of GR and associated TK and/or in a better adequate way of conserving biodiversity.

In this chapter, we explore empirically the role that the two mentioned government functions have on the overall contractual context of the projects to shed light on whether and the extent that governments can aspire to have a significant role in affecting bioprospecting outcomes. Here, we refer to the contractual context as the institutional conditions under which the parties negotiate the content of bioprospecting projects and implement them.

5.2 The Nagoya Protocol's Influence on Sovereignty and Property Rights

The entering into force in 1993 of the CBD was a critical event for rights claims over GR because it spread the debate of whether sovereignty implies property rights over GR including access and benefit sharing rights and obligations over these resources and associated knowledge.[2] In 1992, the CBD was opened for signature, and it has been ratified by 193 countries to date.[3] The CBD recognises the sovereign rights of states over GR and mentions that national governments have the authority to determine the access to or exclusion from GR through national legislation (CBD 1992 Article 15.1). The CBD, in its Article 15, entitled "Access to Genetic Resources," states: "1. Recognizing the *sovereign rights of States* over their natural resources, the authority to determine access to genetic resources rests with the national governments and is subject to national legislation" (italics added).

It is important to note what the CBD explicitly expresses in terms of sovereignty and property rights. The relationship between sovereignty over GR and property (which is not explicitly mentioned in the CBD) is often politically and academically contested (see e.g. Coombe 1998; UNEP 2005; Elvin-Lewis 2007; Caneiro-da-Cunha 2008). Sovereignty does not necessarily equate to property. Johnston (interview 21 January 2009) considers that the relationship between sovereignty and property implies a political exercise.[4] It is up to the countries to shape their own interpretation concerning sovereignty rights to GR under Article 15 of the CBD.

Countries have opted for three main approaches: first, some countries have signed and ratified the CBD but have not related the term sovereignty to property. A second approach has been chosen by several of the so-called developing countries which have actively engaged in its interpretation and implementation. These countries emphasise the states' sovereignty over GR as being recognised under the CBD, with

[2] Property can be broadly understood as the social organisation of rights and entitlements over resources, both physical and intellectual, and may include the right to access biocultural resources or to exclude others from accessing these resources.

[3] For a list of the countries that are party to the CBD, see http://www.cbd.int/convention/parties/list.shtml.

[4] Sam Johnston, Senior Research Fellow, United Nations University-Institute of Advanced Studies TK initiative.

national legislation about access and benefit sharing, and property rights over GR. A third approach is followed especially by industrialised countries, which does not consciously refer to the CBD but use other international treaties to make the connection between GR and property. For example, the USA makes the connection between GR and property without referring to the interpretation of Article 15 of the CBD but relating GR to property under the intellectual property rights system. The intellectual property rights law has expanded in many ways, including into fields such as software, and biotechnological products and processes. In this context, the CBD has had a strong impact on the sociolegal dynamics associated with biocultural rights in national and international law.[5] Hence, the Convention on Biological Diversity, as an international legal instrument with a binding character, has changed the landscape of property rights claims over biocultural resources. In particular, the CBD has influenced the way in which bioculturally-rich countries reassert and interpret the legal principle of state sovereignty over plant forms.

In 2010, the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization (Nagoya Protocol) was agreed in the 10th Conference of the Parties of the CBD in order to advance in the implementation the CBD's third objective.[6] The Protocol is still ambiguous in parts, such as regarding products derived from genetic resources (Bille et al. 2010). However, in contrast to the text of the CBD, the Nagoya Protocol refers explicitly to intellectual property rights in relation to benefit sharing, prior informed consent and mutually agreed terms. In its Article 6, it mentions the need to "establish clear rules and procedures for requiring and establishing mutually agreed terms. Such terms shall be set out in writing and may include, inter alia: … (ii) Terms on benefit-sharing, including in relation to *intellectual property rights*" (emphasis added) (Article 6.3(g)). Article 6 also states that "access to genetic resources for their utilization shall be subject to the prior informed consent of the Party providing such resources that is the country of origin of such resources or a Party that has acquired the genetic resources in accordance with the Convention, unless otherwise determined by that Party" (Article 6.1). In the Annex to the Nagoya Protocol, "Joint ownership of relevant intellectual property rights" is mentioned as a potential monetary and non-monetary benefit derived from access and benefit sharing agreements.

Based on the above-mentioned Article 15 of the CDB, one interpretation is that states have the right to vest the property rights over GR located in their territory and allocate these rights on the government or alternatively on individual or collective owners of land where the GR are located. Consequently, the CBD has strengthened GR providers' claims on benefit sharing (e.g. ten Kate and Laird 1999; Tobin 2002).

[5] A database on access and benefit sharing measures undertaken by Parties of the Convention can be found at: http://www.cbd.int/abs/measures/

[6] The Nagoya Protocol is available at http://www.cbd.int/abs/text/. By October 2011, 65 countries had signed the Nagoya Protocol (http://www.cbd.int/abs/nagoya-protocol/signatories/). The CBD's third objective is "the fair and equitable sharing of the benefits arising out of the utilization of genetic resources" (Article 1).

Under the CBD and the Nagoya Protocol in particular, if the interests of the government and local communities on whose lands GR resides are in tension, the final decision-maker would be the national government and would need to base its decision on the respective national legislation (see Article 15.1, CBD).

Provisions under the CBD (e.g. Article 8(j)) and the Nagoya Protocol recognising the rights of indigenous and local communities to GR and TK include such a limitation by including phrases such as "in accordance with domestic legislation." For example, Article 5 of the Nagoya Protocol entitled "Fair and Equitable Benefit-sharing" mentions: "Each Party shall take legislative, administrative or policy measures, as appropriate, with the aim of ensuring that benefits arising from the utilisation of genetic resources that are held by indigenous and local communities, *in accordance with domestic legislation* regarding the established rights of these indigenous and local communities over these genetic resources, are shared in a fair and equitable way with the communities concerned, based on mutually agreed terms" (emphasis added) (Article 5.2). The recent Nagoya Protocol though may offer certain means of articulating the interests of governments and local communities specifically through notions such as the recognition of biocultural community protocols and customary norms including the use and exchange of GR and associated knowledge within and among indigenous and local communities (see Articles 12.1; 12.3(a); 12.4 and 18.5).[7]

5.3 The Role of Governments in Bioprospecting

In this section, we focus on two key roles played by governments in bioprospecting: firstly, to set the scene for bioprospecting by shaping the national regulatory framework for such projects, and secondly, to enforce that framework by participating in the implementation of bioprospecting projects.

5.3.1 Setting the Market Scene

The CBD aims to provide long-term conservation incentives (e.g. MA 2005; Bille et al. 2010). However, here we question whether the CBD may cause unintended effects in the short term in terms of potentially placing obstacles in bioprospecting projects. Specifically, CBD may cause uncertainty within the projects that may reduce their scope for providing long-term conservation incentives.

[7] At the national level, certain countries such as India and Peru have been very active in developing laws and policies on ABS and local communities (Ituarte-Lima and Subramanian 2011). These countries would be already on their way of implementing certain related obligations derived from such a Protocol. Nonetheless, they would still need to develop and articulate different national provisions in order to fully implement its content and specify many areas that are not detailed in the Nagoya Protocol but which refer to the development of national legislation (see e.g. Articles 15 and 16).

Uncertainty tends to cause transaction costs (Williamson 1985; Bromley 1991) where such costs are broadly understood as the costs of running the economic system (*sensu* Arrow *sensu* 1969: 48) and create concomitant contractual hazard, that is, negatively influencing factors that increase the risk of deviating contract outcomes from the contractual goals (Oxley 1999). Transaction costs in terms of contractual hazard and their links to modes of governance have been explored in the literature, not least regarding business alliances at the domestic and international levels (Oxley and Sampson 2004; Oxley and Silverman 2006) and their effect on project outcomes (Poppo and Zenger 2002; Wang and Chen 2006). Generally, under high uncertainty, leading to transaction costs, coordinated instead of autonomous adaptive capacity to uncertainty is usually held to perform better (e.g. Oxley 1999; Williamson 1999; Oxley and Silverman 2006).

Transaction costs in bioprospecting projects are directly linked to government policies in order to regulate bioprospecting projects and may cause contractual hazard, which often bears a negative effect on their outcomes. A potential consequence is a trade-off between having clearly enforced property rights by governments regarding biodiversity holders such as rural communities, and transaction costs potentially leading to contractual hazard and increasing the risk of failure of bioprospecting contracts. This may be due to contract hazard being a function of the attributes of the providers or the demanders of GR as well as their capacity to adapt their alliance within bioprospecting projects.

Well-defined property rights are generally held as a precondition for reducing uncertainty in investment decisions (Pindyck 1988; Caballero 1991; Dixit and Pindyck 1994; Bell and Campa 1997). This argument has been put forward also for bioprospecting, leading to the idea of the need for clear regulatory frameworks (Bhatti 2003; Larson-Guerra et al. 2004) to facilitate negotiation of new projects (Tobin 2002). Prior to the CBD, access to GR was often gained without consent of GR holders, leading to situations known as *biopiracy*. Demanders used to identify and locate GR that appeared valuable for their aims. Bioprospecting projects were conducted largely without formal contracts, but instead demanders of GR would sometimes pay a small amount of money up-front to the provider of GR, as a compensation only for the labour time local people who helped to locate the GR being sought. However, under the CBD, countries have the right to vest the property rights over GR located in their territory and grant these rights to the state or alternatively on individual or collective owners of the land where the GR can be found (CBD, Article 15). As a result, the CBD has strengthened GR providers' claims on benefit sharing (e.g. ten Kate and Laird 1999; Tobin 2002).[8]

Changes in local institutions often affect contractual hazard because they can potentially open up for disputes of interest in the quest for private appropriation of

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benefits (e.g. Libecap 1989; Ostrom 2007). This is typical, for example, with the entrance of external stakeholders in order to extract locally available natural resources. One example associated with bioprospecting refers to the situation where biotechnology has expanded the use of GR in pharmaceutical research and has increased demand for GR from the South (Parry 2004). Consequently and logically, the CBD is striving to solve the resulting North-South disputes in such situations (Dutfield 1999; Suneetha and Pisupati 2009). But in doing so too, the CBD might have increased transaction costs in bioprospecting (Swanson et al. 2002), for instance, by increasing the need to identify and specify ownership to GR and associated TK. Such transaction costs can be especially high especially in situations where ownership of GR is contested among cross-border communities and whose investment in biodiversity conservation is often distributed across generations (Laird 2002; Parry 2004; Dedeurwaerdere 2005).

The number of stakeholders and the heterogeneity in bioprospecting contractual arrangements have increased significantly, following CBD ratification among countries. Since the notion of "rights" encompasses different definitions for different bioprospecting stakeholders (Parry 2004; Hayden 2008), differences in beliefs and motivations among project participants have also increased (ten Kate and Laird 1999), regarding legal concepts, as well as differences in how the agents involved in projects organise their social and economic activities (Brush 1999). This can result in a higher degree of uncertainty about whether there is, or what is the definition of, a "just sharing of benefits" from GR and TK (Laird 2002). Hence, bioprospecting legislation becomes more complex and harder to use as a means to assist the governance of the different interdependent interests that need to be addressed. The latter ranges from social development and biodiversity conservation to a predictable investment context (Larson-Guerra et al. 2004). For example, even the Costa Rican bioprospecting legislation, which has received much praise in the past, has been criticised for not sufficiently addressing indigenous communities' claims over ownership of GR and TK and hence appropriate compensation levels (Carrizosa 2004).

Additionally, the effectiveness of property rights over GR hinges on the cost of enforcing them. Increasing the level of detail in national laws inspired by the CBD also increases the bureaucracy in source country governments, which tends to further increase transaction costs in bioprospecting. In addition, binding laws with a lack of clear authority can create further obstacles, especially in settings where there is a lack of clearly defined authority to issue the necessary permits for bioprospecting (Laird 2002).

5.3.2 Active Government Participation in Project Implementation

Another way for governments to influence the outcome of bioprospecting projects is by directly engaging in their implementation. The role of transaction costs in contractual hazard and modes of governance, such as in business alliances at the

Table 5.1 Typology of governance attributes of bioprospecting contracts

Governance attribute	Private-private contract	Public-public contract	Public-private contract
Incentive intensity of management	High	Low	Medium
Adaptive capacity to uncertainty	Autonomous	Coordinated	Autonomous/ coordinated

domestic and international levels (Oxley and Sampson 2004; Oxley and Silverman 2006), and the effect that transaction costs have on project outcomes (Poppo and Zenger 2002; Wang and Chen 2006) can be explained focusing on ideas from new institutional economics.

Decentralised organisations tend to provide high-performance incentives, also known as "incentive intensity" (Williamson 1985).[9] They also tend to have high capacity for autonomous adaptation to uncertainty. However, when transaction costs are high, due to contractual uncertainty, coordinated as opposed to autonomous adaptive capacity to uncertainty tends to perform better (e.g. Oxley 1999; Oxley and Silverman 2006; Williamson 1999). It follows that contractual hazard in bioprospecting could be reduced by an adequate organisational set-up (ten Kate and Laird 1999). Table 5.1 characterises bioprospecting projects as conforming to either two private participants ("private-private"), two governments ("public-public") and a mixture ("public-private"), with their respective expected characteristics.

Governments are an example of strong vertical integration with high capacity for coordinated adaptation to uncertainty. They may be well placed to handle complex project coordination tasks that are themselves a result of multifunctional resources. Governments can also build and transfer knowledge collectively about how to manage complex projects, such as in the context of the CBD. The question thus arises as to whether government participation in the implementation phase of bioprospecting projects, by, for instance, providing capacity for coordinated adaptation to the inherent uncertainty of such projects, can help to reduce transaction costs and contractual hazard in the context of bioprospecting. Similarly, one could ask whether weakening the role of the private sector as a bioprospecting partner reduces the capacity of projects for autonomous adaptation to uncertainty. Answering these questions helps to shed light on the potential role of public-private alliances to reduce the level of transaction costs that are common to most bioprospecting endeavours. In the next sections, we provide an empirical analysis to shed light regarding this issue.

[9] The concept of incentive intensity can be exemplified by contrasting the market mechanism with governments (Williamson 1999). The profit goal of a private company is likely to provide a more direct link between performance and reward, that is, high incentive intensity. As a comparison, this link is in general lower for government activities, partly as a consequence of the public good nature of many of the goods and services it provides, which among others makes monitoring more difficult.

5.4 Methods

5.4.1 Data

A database of 190 bioprospecting case studies was constructed from a systematic review of the literature that for the most part contained information from individual project case studies described by social scientists who revised individual projects in which they were not themselves directly involved. In a few cases, the reports were written by the bioprospector themselves (e.g. ICBG), and these were quality checked with interviews with independent experts from academia, ex situ collections for GR and the private industry.

A detailed analysis was conducted on a subset of 67 cases which held sufficient information for the purpose of the analysis. The dataset included bioprospecting projects that were initiated between the years 1990 and 2003. The geographical spread is Africa (11 cases), Asia (16 cases), Latin America (28 cases) and Small Island Developing Nations (12 cases). These projects were associated with the transaction of principally plant GR but also microorganisms and in one case, animal GR. Most of these cases were also associated with TK and in some cases involved the explicit participation of traditional communities in the bioprospecting projects.

Since there is no centralised accurate dataset of bioprospecting cases, it was not possible to determine the actual number of all bioprospecting cases in the world. While the results cannot be directly extrapolated directly, the cases in the sample used here are fairly representative of typical North-South bioprospecting contracts. It could be argued, though, that there might be some bias as data for relatively successful cases might be overrepresented. However, the fact that the database includes also a large part of more or less failed contracts partly responds to this concern. Nonetheless, the overall results should be taken with due caution as they represent a first attempt at understanding contractual hazard based on available data rather than on all existing bioprospecting cases.

5.4.2 Identification of Relevant Variables

Following the discussion in Sect. 5.2, it is held that contractual hazard constitutes the link between the market setting and project outcomes. We expect that higher transaction costs in the contracts cause contract hazard, which in turn increases the likelihood of negative project outcomes.

Bioprospecting projects are re-evaluated along the contracting process as typically any investor faces repeated situations where they need to choose whether to continue the contracting process or to wait in order to acquire additional information. A variable is specified that denotes the outcome of individual bioprospecting projects. Projects that have either been cancelled or experienced substantial

interruption are distinguished from those that have proceeded uninterrupted.[10] Table 5.2 describes the variables and adds additional information and a principal component analysis is conducted (Sect. 5.1).

In order to look into the potential effect of the legal framework for bioprospecting causing transaction costs which in turn may increase contractual hazard, hence potentially undermining contract outcomes, a set of three categorical variables which are interpreted together is introduced: "*CBD RATIF*" denotes the strongest form of formal legal certainty, that is, projects initiated in a country that has ratified CBD.[11] "*CBD NONE*" denotes projects subject to low formal legal certainty because they were initiated before CBD entered into force globally in 1993. The comparison variable "*CBD WORLD*" denotes whether the bioprospecting project was initiated before CBD came into force globally (which implies it must have been initiated before source country ratification of CBD) or after the CBD came into force globally (which can imply either before or after source country ratification of CBD). *CBD RATIF* could be expected to have a negative effect on bioprospecting project outcomes by incrementing transaction costs and contractual hazard. *CBD NONE* is expected to have a positive effect.[12,13]

The complementary question regarding the potential effect of government participation in bioprospecting projects is addressed in a tentative way by analysing how the participation of different kinds of project participants affects the outcome of the projects. A supply side and a group of three demand side variables as well as an interaction variable are introduced to represent the level of government participation in the project. "*PROVIDER GOV*" denotes whether the source country government participates as an active partner in the bioprospecting contract.[14] We primarily

[10] "Interruption" refers to any delay anticipated to obstruct any progress towards completion of the project in the foreseeable future. Project initiation refers to when project funding was approved for the demander, or, when not available, the first year we have a record of that the project was negotiated or implemented. The lower limit, 1990, allows for pre-CBD cases to be included as a control group. We assume that the years outside the 1990–2003 period are not as well reviewed and hence less representative than within the period. This is because we do have records of projects existing beyond this period, but we have not been able to obtain review reports about their outcome. The upper limit, 2003, allows for reasonable time for the project to have been scrutinised in available case studies. A sensitivity analysis shows that more recent projects did not experience fewer interruptions.

[11] Because CBD is binding once it is ratified, and one of the components of CBD is to legislate about bioprospecting, we expect that on average, there is a positive and reasonably strong correlation between CBD ratification and implementation of bioprospecting policies.

[12] The *CBD WORLD* variable is time dependent and may be correlated with the maturity of direct and indirect source country stakeholders. That is, *CBD WORLD* may be related to the maturity of international watchdogs (because such non-governmental organisations and other actors can be argued to have been affected by the CBD coming into force at the international level). *CBD RATIF* helps to control for the time dependency. Namely, while *CBD WORLD* represents 1 year, 1993, *CBD RATIF* relates to different years in different countries, from 1994 to 2003.

[13] Regarding the interpretation of the CBD variables: the fact that bioprospectors did not acknowledge prior informed consent and access and benefit sharing issues prior to CBD signals that it is the regulatory pressure that drives CBD compliance and not the demander's project rationale *per se*.

[14] That is, beyond providing the necessary permits and similar bureaucratic tasks.

Table 5.2 Description of variables

Variable	Explanation	Mean	Min	Max
OUTCOME	1 = Project without cancellation or substantial interruption, 0 = cancelled or substantially interrupted project	52%	0	1
Market setting for bioprospecting				
CBD NONE	Dummy.1 = Project started before that CBD entered into force globally, 0 = lse	10%	0	1
CBD RATIF	Dummy.1 = Project started after CBD ratification in provider country, 0 = else	81%	0	1
CBD WORLD	Dummy.1 = Project started after that CBD entered into force globally, but before CBD ratification in provider country, 0 = else	9%	0	1
Type of government involvement in project				
PROVIDER GOV	Dummy. 1 = The provider country government participates in the project (with or without other, non-governmental, participants), 0 = not (only non-governmental provider/s participates)	66%	0	1
ICBG	Dummy. 1 = The demander is ICBG, 0 = else	28%	0	1
NCI	Dummy. 1 = The demander is NCI, 0 = else	13%	0	1
DEMANDER PRIVATE	Dummy. 1 = The demander a private firm, university or botanical garden, 0 = else	58%	0	1
NCI ICBG-GOV	Dummy. 1 = Project is an alliance of NCI or ICBG + the provider government, 0 = not (any of the three alternative combinations of market and non-market participants, that is, a government provider + private demander; non-governmental provider + private demander; or non-governmental provider + NCI/ICBG demander)	37%	0	1
Other variables: industry type				
DEMANDER RnD	Dummy. 1 = The demander is a pharmaceutical R&D firm (without commercialisation to end market), 0 = else (demander organisation is either *DEMANDER NON-PHARM or DEMANDER ENDMARKET*)	52%	0	1
DEMANDER NON-PHARM	Dummy. 1 = The demander organisation is not in the pharmaceutical sector, 0 = else (demander organisation from the pharmaceutical sector)	13%	0	1

(continued)

Table 5.2 (continued)

Variable	Explanation	Mean	Min	Max
DEMANDER ENDMARKET	1 = The demander is a pharmaceutical firm, with commercialisation to end market (with or without conducting R&D), 0 = else (demander organisation is either *DEMANDER RND* or *DEMANDER NON-PHARM*)	34%	0	1
DEMANDER DOMESTIC	Dummy. 1 = The demander is from the provider country, 0 = else	10%	0	1
RENEWAL	Dummy. 1 = Project is a renewal of a previous bioprospecting project, 0 = else	26%	0	1
GDP CAP	Continuous. Gross domestic product per capita in the provider country, the year the project started (USD 2008 value)[a]	4,265	223	688,337
POP GROWTH	Continuous. Rural population growth (annual percentage) in the provider country, in 1998[b]	0.19	–2.06	3.0
PHILIPP	Dummy. 1 = The project is implemented in the Philippines, 0 = else[c]	15%	0	1

[a]World Bank. http://ddp-ext.worldbank.org/ext/DDPQQ/report.do?method=showReport. Accessed 20 May 2008
[b]World Development Indicators, World Bank
[c]The variable is included in the CatPCA analysis only

expect that active government participation makes it more likely that the CBD provisions are implemented, adding a layer of transaction costs to the project. But source government participation may to some extent also provide further capacity for coordinated adaptation to uncertainty. A positive coefficient associated with this variable may suggest that the positive influence of such capacity is stronger than the negative bureaucratic influence on project outcomes.

A group of three variables representing different levels of government participation is also accounted for, reflecting different levels of vertical integration. The strongest government participation case is represented by the variable "*NCI*" which is associated with projects by the US National Cancer Institute, a governmental organisation. Another variable, "*ICBG*", denotes the International Cooperative Biodiversity Group and represents a consortium of governmental, industry participants and often academic participants. The comparison variable "*DEMANDER PRIVATE*" denotes a non-governmental demander such as those from the pharmaceutical sector.[15]

Since the capacity for adaptation to uncertainty represented in the entire project alliance is expected to be relevant key aspect affecting project outcomes, the variable "*NCI ICBG-GOV*" denotes that the provider government participates and that the government is present on the demander side (either by ICBG or NCI). We expect a negative effect because both capacities for coordinated and autonomous adaptation may be needed to govern GR.

Further, it is also necessary to analyse the determinants of the various project outcomes both at the contract level and at the level of the provider country. Firstly, the intended use of GR by the demander may affect project uncertainty, and to control for this, two categories of pharmaceutical companies are taken into account.[16]

We expect that the pharmaceutical sector in general has attributes associated with high uncertainty, transaction costs and therefore high likelihood of contract interruptions. The reason is the high uncertainty associated with developing new drugs, gaining patent approval and regulatory approval for marketing and subsequently successfully markets the drug. The variable "*DEMANDER END*" represents pharmaceutical organisations that commercialise products at the end of the innovation chain (although they may additionally enrol in research and development, R&D, activities). Another type of demander not engaged in commercialisation, but only in research and development activities, is denoted by "*DEMANDER RND.*" Lastly, the third variable in this group, "*DEMANDER NON_PHARM*", denotes a minor number of bioprospecting cases in which the demander is from other than the pharmaceutical sector.

The variable "*DEMANDER DOMESTIC*" denotes whether the organisation on the demander side of the project is located in the provider country, with an expected

[15] "Private" is used in the meaning that there is not explicit participation in the project on behalf of the demander governments. The category includes both for profit organisations such as Pfizer, but also universities and botanical gardens. Notably, in the sample provider, country governments tend to participate more often in such private endeavours as compared to in NCI or ICBG projects.

[16] Both are GR demanders that are dedicated to pharmaceutical products. "Industry" is used to denote the orientation of the demander, that is, applied research and/or product development aimed for commercialisation, as opposed to basic research.

positive association with uninterrupted outcomes (due to e.g. an informational advantage concerning the cultural setting, as well as national legal and institutional frameworks).[17]

It is also important to control for whether the bioprospecting projects constitute an extension to prior bioprospecting projects. Project renewals are expected to affect project outcomes positively by giving more room for sequential decision-making and hence reduced problems of measurement and behavioural uncertainty (e.g. Balakrishnan and Koza 1993; Williamson 1985). This is taken into account by the variable "*RENEWAL*".

Other factors at the more macro level which might influence the outcome of bioprospecting projects can be controlled for to some extent. For example, GDP per capita in the provider country ("*GDP CAP*") is included to control for the possibility that governments in poorer countries have fewer resources to set aside for implementing and enforcing regulation of bioprospecting (Gupta 2004; Siebenhuner and Suplie 2005). Likewise, information about rural population growth ("*POP GROWTH*") is included, since rural population growth might put pressure on local institutions and property rights regimes, thereby affecting project outcomes in a negative way.[18]

5.4.3 Description of the Data

Figure 5.1 depicts the main group of variables related to market setting attributes associated with the property rights setting of bioprospecting projects. The figure relates property rights regime (the three CBD variables) to project outcome and is consistent with the expectation as developed in Sect. 5.2, that is, that the market setting for bioprospecting, measured by the status of CBD, is associated with the outcome of bioprospecting projects. As it can be seen, the highest share of unsuccessful project is in countries that have ratified the CBD.

Table 5.3 describes the data regarding the type of active government participation in the project. The table orders the variables with respect to project participation by provider country governments. It can be seen that slightly more than half of the projects in the sample proceeded without cancellations/interruptions (the mean value of *OUTCOME* is 53%). Interestingly too, it can be seen that provider country governments participate more frequently in countries that have ratified the CBD.

[17] US demanders, by originating in a country that has not ratified CBD, could be expected to apply CBD guidelines only seldom and hence face lower transaction cost. However, this is counterintuitive to the fact that the US data is biased by NCI and ICBG cases (headquartered in the USA), both of which often adopt fairly detailed ABS regulations.

[18] Note that due to data constraints, this variable represents the year 1999, for all projects. Although this is not fully representative since some projects were active during other years, the majority of the projects were active close to this year. Furthermore, it is perceived that rural population growth is relatively stable across short periods of years, such as in the dataset. Hence, we hold that it is reasonable to use this specification of the variable.

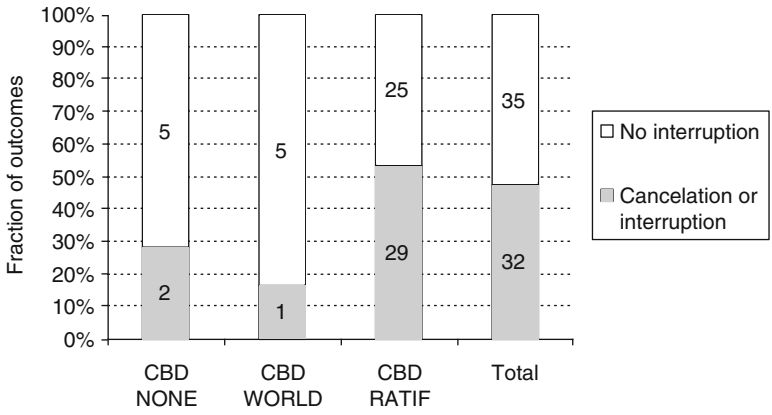

Fig. 5.1 Project outcome and status of CBD for the cases used in the categorical principal component analysis (the numbers in the bars indicate number of cases per outcome, $n=67$)

Table 5.3 Variables ordered by whether the provider country government participated or not (mean, $n=67$)[a]

Variable	Government participation	No government participation	Average
OUTCOME	53%	50%	52%
CBD RATIF	84%	73%	81%
CBD WORLD	11%	5%	9%
CBD NONE	4%	23%	10%
NCI	13%	14%	13%
ICBG	40%	5%	28%
DEMANDER PRIVATE	47%	82	58%
DEMANDER ENDMARKET	33%	36%	34%
DEMANDER RND	60%	41%	54%
DEMANDER OTHER	7%	23%	12%
DOMESTIC DEMANDER	9%	14%	10%
RENEWAL	27%	23%	26%
POP GROWTH	0.09	0.43	0.20
GDP CAP	5,193	2,414	4,280

[a]The table reads as follows (e.g. for the variable *OUTCOME*): the mean of *OUTCOME* in projects with participation of the source country government is 53% for the sample (i.e. in 47% of projects with government participant, the outcome was negative). When the source country government does not participate, the outcomes were somewhat lower on average, that is, only 50% of projects had a positive outcome

However, participation by provider country governments in the contracts does not appear to be associated with project outcomes. Additionally, the private sector is the most common bioprospector in our sample with pharmaceutical RnD organisations being the most common demander, followed by pharmaceutical organisations that also engage in manufacturing and sales (*DEMANDER ENDMARKET*). The most

notable difference in the level of government participation from the source country is among RnD pharmaceutical organisations and non-pharmaceutical organisations. A minority of projects, 26%, are renewals.

Table 5.3 also shows that source country governments participate more frequently in richer developing countries (the mean GDP per capita is higher in projects in which the source country government participates, with USD 5,193 as compared to USD 2,414). This may indicate that countries with more solid government institutions (as typically associated with higher GDP per capita) have a higher ability to implement international legal obligation and country level legislation in general.

5.4.4 Analysis of Contractual Hazard in Bioprospecting

In order to understand the link between government intervention and specific outcomes of bioprospecting contracts, it is necessary to understand the role of government intervention beyond the contract level. Therefore, we empirically explore the role that the two mentioned government functions have on the overall contractual context of the projects. Although the data does not allow controlling for all potential factors that might affect project outcomes, the included variables can together be related to a substantial source of influence in contractual hazard.

Based on a principal component analysis (PCA), we identify dimensions (or groups of variables) which account for underlying relationships in the data beyond the effect of isolated individual variables alone. Specifically, we use a categorical PCA (henceforth CatPCA) to provide insight by (1) identifying which groups of variables associated with the role of the government in setting the market scene, or actively implement bioprospecting project as an active participant, have influence over the project contractual context and the degree of that influence; (2) pointing out pre-established expected relationships or, in an explorative way, gain insight into the role of variables not envisioned to have an influence on project outcomes; (3) looking at how such dimensions rank in importance between each other; and (4) looking at how individual variables rank in importance within each dimension.

A particularly useful feature of CatPCA that adds to standard PCA is a rescaling procedure. In standard PCA, only continuous or categorical variables can be analysed separately, not together. The CatPCA rescaling procedure transforms continuous variables to categorical variables ordered in seven levels. While this means that information is lost as compared to the original continuous variable, it does allow including considerably more information as compared to a transformation to a dichotomous variable as typically used in standard PCA.

5.5 Results and Discussion

Table 5.4 shows the results of the CatPCA. All three dimensions included have an eigenvalue above one: 3.67, 2.83 and 1.95, respectively. The overall explanatory power of the variables is reasonable, at 49.7%, with 21.6%, 16.6% and 11.4% of the

Table 5.4 Summary of categorical principal component analysis ($n = 67$, variables ordered along dimensions and along their factors loadings with highest loadings to the left)

Principal component dimension	Variance explained	Cumulative (%)	Variables with moderate to high loadings (above 0.3)
1. Type of government involvement	21.59	21.59	*NCI ICBG-GOV, DEMANDER PRIVATE, ICBG, PROVIDER GOV, CBD WORLD, DEMANDER NON-PHARM, DEMANDER END, DEMANDER DOMESTIC*
2. Market setting	16.64	38.23	*CBD RATIF, DEMANDER RND, CBD NONE, POP GROWTH, DEMANDER END, NCI, PHILLIP, PROVIDER GOV, DEMANDER NON-PHARM, OUTCOME*
3. GR use	11.44	49.67	*NCI, DEMANDER DOMESTIC, DEMANDER END, DEMANDER RND, CBD NONE, CBD RATIF*

variance explained, in the first, second and third dimension, respectively. We follow Kline (1994) and classify loadings higher than 0.30 as "moderate to high." According to this criterion, all variables except for *RENEWAL* and *GDP_CAP* have reasonably high explanatory power in at least one of the three so-called underlying, or latent, dimensions.

The first dimension is largely explained by variables relating to the governments' active implementation as a project counterpart in the bioprospecting cases (Table 5.2). The highest component loadings are represented by projects with governments at both the supplier and demander side *(NCI ICBG-GOV*), followed by project with private demanders (*DEMANDER PRIVATE*) and ICBG projects. Fourth are projects in which the provider country government participates (*PROVIDER GOV*). A key focus is in interpreting the interaction variable, since the contract hazard is a function of the overall capacity for adaptation in the alliance of providers and demanders, not only of the attributes of the providers or the demanders as analysed separately. Hence, when analysing the supplier and demander side together instead of separately, the variable "*NCI ICBG-GOV*" shows that strong government participation (i.e. governments participate as both supplier and demander) has a strong influence over the bioprospecting contract context as compared to other projects where there is no governmental participation at all. This may suggest that capacity for coordinated adaptation is important in order to address the high level of uncertainty about, for example, commitment to contractual terms in bioprospecting.

This information provides tentative support for the role that different kinds of government participation plays in explaining the bioprospecting contractual context. This dimension being the first in terms of component loadings, it means that among the variables included, government participation of one kind or the other is what most influences the bioprospecting contract context.

The second dimension relates somewhat to the market setting of bioprospecting contracts.[19] The variable representing the specification and protection of property rights for GR has the highest component loading (*CBD RATIF*). *CBD NONE* also has a significant loading in the second dimension and also represents the market setting. Rural population growth (*POP GROWTH*) with the fourth strongest loading might be assumed to proxy the broader institutional context of the project. Taken together, the results of these three variables can be interpreted as that the second strongest influence to the bioprospecting contractual context among all the variables assessed is the government's role to specify the market context.

Lastly, the third dimension can be said to represent the purpose (commercial/non-commercial) of the demanded GR, with the two variables denoting a demander from the pharmaceutical industry (*DEMANDER END* and *DEMANDER RnD*) having the third and fourth highest component loadings within this dimension according to the categorical PCA.

The activity of the demander (*DEMANDER RND, DEMANDER NON-PHARM*) is less clear to interpret, since they are distributed across two different dimensions, and does not have significant loading in any of the two. Therefore, it is not possible to interpret the different effects of having pharmaceutical end market firms, pharmaceutical R&D organisations or non-pharmaceutical organisations playing a role in bioprospecting contracts. One possible interpretation is that uncertainty related to institutional factors (e.g. market setting and government participation) has a greater role in project outcomes as compared to technical uncertainty of downstream research and commercialisation activities. Interestingly, the fact that projects might be renewed (*RENEWAL*) does not seem to influence the contractual context, possibly due to the strong influence of the government's role both as active implementation participant and by setting the market scene.

The results of the CatPCA analysis are fairly consistent with the conceptual framework regarding the role that active government participation in project implementation plays in the bioprospecting contractual context. The results indicate that governments might not only influence the project by setting the property rights scene (through ratification of CBD) but more importantly by actively implementing such projects as a project partner.

5.6 Conclusions

Against the background of the recent Nagoya Protocol (October 2010) on access and benefit sharing of genetic resources, in this chapter, we have attempted to cast new light on how the CBD might be, in an unintended way, affecting bioprospecting

[19] Note that many of the variables are represented in both dimensions. However, their component loadings are in several cases very different (see Annex A2), hence suggesting their different roles in each dimension.

projects in the short term. The focus has been on assessing the government's role in setting the market scene for genetic resources by specifying the property rights and implementing the bioprospecting policy framework. Based on a systematic review of bioprospecting case studies, we suggest that the CBD, which has led to more clearly defined property rights over genetic resources regarding ownership of the providers, might have had a strong effect on the contractual context. The reason is that stricter property rights, while being the foundation for linking southern conservation effort with financial incentives, might have also caused a novel contractual situation. From reviewing bioprospecting cases and interviewing bioprospecting stakeholders, we think that by the emergence of new stakeholders and socio-economic contract contexts, contract uncertainty might have increased, in turn increasing contractual hazard. Such contractual hazard can be ameliorated by the type of government involvement in the implementation of bioprospecting projects.

After the adoption of the Nagoya Protocol, a major critique has been raised against it, on the basis that the Protocol is ambiguous in parts, etc. Here, we put forward an additional idea: even a clear and specific protocol would in fact not be sufficient to overcome the high contract uncertainty built into any bioprospecting project due to their inherent heterogeneity in terms of both asymmetric information and expectations about the outcomes of such projects.

It is a fact that there are ample difficulties to implement benefit sharing for genetic resources at the international level. It is important to note in this context that if the allocation of private property rights over genetic resources is envisaged, special attention ought to be paid to the institutional set-up of bioprospecting projects. As private property rights might be further strengthened in bioprospecting cases, the role of governments become increasingly more important. But there is still much to be learnt about the way public and private stakeholders can efficiently and equitably interact to help achieve the CBD's goal of conservation, access to and benefit sharing of global biodiversity. It will be necessary to systematically assess how the Protocol has affected contract hazard in bioprospecting projects as new data on projects become available.

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