SCHRIFTEN DER GESELLSCHAFT FÜR WIRTSCHAFTS- UND SOZIALWISSENSCHAFTEN DES LANDBAUES E.V.

Seyoum, A., Welch, E.W.: Trading off Use Restrictions and Benefit-Sharing for Genetic Materials for Food and Agriculture with an Emphasis on Upfront Payments. In: Kirschke, D., Bokelmann, W., Hagedorn, K., Hüttel, S.: Wie viel Markt und wie viel Regulierung braucht eine nachhaltige Agrarentwicklung? Schriften der Gesellschaft für Wirtschafts- und Sozialwissenschaften des Landbaues e.V., Band 49, Münster-Hiltrup: Landwirtschaftsverlag (2014), S. 307-318.

Schriften der Gesellschaft für Wirtschafts- und Sozialwissenschaften des Landbaues e.V., Bd. 49, 2014, S. 307 – 318

TRADING OFF USE RESTRICTIONS AND BENEFIT-SHARING FOR GENETIC MATERIALS FOR FOOD AND AGRICULTURE WITH AN EMPHASIS ON UPFRONT PAYMENTS

Aseffa Seyoum[1] *and Eric W. Welch*

Abstract

This study investigates the tradeoffs that providers of genetic resources make between constructing a benefits arrangement and establishing use restrictions. The analysis makes use of project level data collected from university and government researchers in the US. Results show that when transfers require upfront payments, recipients are not expected to contribute long-term monetary or non-monetary benefits, nor are there restrictions on the transferred material. When providers seek information from project results they tend not to request upfront payments for providing genetic materials. Rather, researchers tend to acquire genetic materials at cost plus an additional fee when they come from foreign counties and companies. The paper concludes by highlighting the roles that upfront payments and reduced restrictions can play for improving exchange and utilization of genetic materials for public research.

Keywords

upfront payment, benefit sharing, genetic resource, material exchange, use restriction

1 Introduction

The Nagoya Protocol (NP) to the Convention on Biological Diversity (CBD) and the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) are international agreements committed to facilitating access to and fair and equitable benefit sharing for the utilization of genetic resources. These agreements and other international regulations establishing intellectual property rights over genetic materials[2] have begun to shift actors' perceptions about genetic resources away from the "common heritage of mankind" conceptualization toward a sovereign national property or private property conceptualization where genetic resources are increasingly considered to be a potential source of economic benefits (BIBER-KLEMM et al., 2006; BRUSH, 2005). Indeed, the modes of exchanging genetic materials have also begun to evolve from informal social exchange to more formal economic or spot market transactions.

Scholars have argued that the introduction of multiple regulatory instruments have made access to genetic materials worldwide more formal and in some case more restricted (TEN KATE, 2002; BRETTING, 2007; NIJAR, 2011). Providers' efforts to secure economic benefits for exchange have made bilateral contractual agreements more complex and have raised transaction costs (VISSER et al., 2000; EATON and VISSER, 2007; NIJAR, 2011). Prior studies have noted that restrictive contractual agreements may reduce exchange of genetic materials, which in turn may leads to its underutilization and lower remunerations to providers, particularly for international exchange (EATON and VISSER, 2007; MULLER, 2006). However, empirical analysis on the relationships among the various forms of monetary and non-monetary benefits and their association with restrictions on use of genetic materials has received little attention.

[1] Science, Technology and Environment Policy Lab, Department of Public Administration, University of Illinois at Chicago, CUPPA Hall, 412 S. Peoria Street, Chicago, IL 60607, USA, aseffaw@uic.edu

[2] The Convention of the International Union for the Protection of New Varieties of Plants (UPOV) and the Agreement on Trade Related Intellectual Property Rights (TRIPS) provide plant variety protection (van OVERWALLE, 2005).

Understanding current benefit sharing arrangements within the scientific community is a critical first step for identifying appropriate combinations of benefit sharing and regulatory arrangements that improve efficient exchange of genetic material for public sector research.

In this paper we explain the tradeoffs between various benefit sharing and provision arrangements, and levels of restrictions involving in bilateral exchange of genetic material. We conduct an empirical test of our resulting model based on data collected from agricultural researchers working in universities and government in the US. Specifically, the paper addresses the following questions: 1) What are the patterns of association between upfront payment and expected monetary and non-monetary benefits that arise from utilization of genetic material?; 2) How are levels of upfront payment associated with restrictions on use imposed through mutually agreed terms?; and 3) How, if at all, does the upfront payment level differ by source or type of genetic materials exchanged? [3]

The next section discusses how benefit arrangements and contractual agreements could be affected by providers' time preferences when exchanging genetic material. Intertemporal choice and transaction cost approaches provide a foundation for our arguments. Section 3 explains data sources, data collection procedures and methods of analysis. Section 4 presents findings of the study, which show that upfront payments for genetic materials tend not to involve long term monetary and non-monetary benefits, and are less likely to impose use restrictions on recipients. Additionally, providers who desire information from project results tend to require no upfront charge for the transfer genetic materials. Finally, the paper concludes by emphasizing the need to promote an approach that couples upfront payments and unrestricted use under certain conditions to improve efficiency of exchange of genetic materials for research.

2 Theoretical framework

Willingness to transfer genetic materials and the conditions under which they are transferred depend at least partially upon on the anticipated economic benefits (PORZECANSKI et al., 1999; CORREA, 2005). From an economic perspective, terms of exchange reflect the time period, magnitude, and uncertainties that parties attach to the benefits and costs of the transaction (WILLIAMSON, 1979; MOLM, 2003; SHORE et al., 2006). For instance, a provider might trade off potential future benefits from research against the more certain immediate benefit of an upfront payment. We examine this type of tradeoff using the intertemporal choice framework from behavioral economics (PEZZEY, 1997; SHELLEY, 1993; LOEWENSTEIN and PRELEC, 1992). Likewise, a recipient who wishes to obtain a specific genetic material with a desired trait, will seek to minimize transaction costs. The transaction costs from the exchange of genetic resources that are borne by the recipient tend to increase with the level of restrictions included in contractual agreements (STREITZ and BENNETT, 2003; EATON and VISSER, 2007). Transaction cost theory (NORTH, 1992; WILLIAMSON, 1979) is used to hypothesize the association between upfront payments and restrictive contracts.

2.1 Time preference and expected benefits

The intertemporal choice framework explains how actors establish preferences for any decision involving tradeoffs among outcomes that occur at different times (READ, 2003; FREDERICK et al., 2002). The framework can be traced back to John Rae's 1834 work on the psychological motives underlying savings or investment accumulation (RAE, 1905). The perspective was further developed by von BÖHM-BAWERK (1891) and FISHER (1930) to understand allocation of production resources and consumer goods over time. Later SAMUELSON (1937) developed the simplified intertemporal choice framework called the discounted utility model. Discount

[3] This paper addresses exchange within a bilateral system for non-plant genetic resources for food and agriculture, not within a multilateral system.

rate has been used to account for the psychological and economic aspects of time preference (FREDERICK et al., 2002). A growing body of literature that addresses time preferences (e.g. LOEWENSTEIN and PRELEC, 1992; HARRIS and LAIBSON, 2001) and has been applied widely to study sustainability (PEZZEY, 1997), natural resources conservation (HOLDEN et al., 1998) and climate change policies (FEARNSIDE, 2002).

Introduction of various international regulatory instruments has created uncertainty about the potential obligations and responsibilities associated with the exchange of genetic resources, including those related to benefit sharing (EATON and VISSER, 2007). Providers increasingly consider the time period, magnitude, and level of uncertainty attached to the accrual of benefits when evaluating genetic material provision decisions. According to FREDERICK and co-authors (2002), time preference refers to situations where actors demonstrate preferences for immediate over future utility when considering factors such as magnitude of benefit, risk and uncertainty, and changing tastes. For example, a magnitude effect leads actors to discount smaller anticipated benefits at higher rate than larger ones (SHELLEY, 1993; FREDERICK et al. 2002); actors prefer to receive smaller rewards sooner than larger rewards later. This is known as hyperbolic discounting (READ, 2003). On the contrary, if expected future benefits are considerably large, then an actor may prefer future over immediate benefits. Moreover, actors tend to attach probabilities to expected benefits to account for uncertainty in their time preference decision (LEVY, 1997). Actors commonly tend to be less motivated by benefits that accrue later than by those that accrue sooner because of loss aversion (LOEWENSTEIN and PRELEC, 1992).

Based on the time preference framework, providers of genetic resources will seek either upfront payments of smaller magnitude than future expected returns, or more restrictive contractual agreements as a loss aversion strategy. Prior case studies provide some evidence of the presence of time preference in the context of access and benefit sharing for genetic resources. For example, a national level study by PORZECANSKI and co-authors (1999) found that provider willingness to exchange genetic resources depends on expectations about short-run non-monetary benefits related to capacity development. Others have found that for international exchange of genetic materials, actors are uncertain that future benefits would accrue (EATON and VISSER, 2007; SUNEETHA and PISUPATI, 2009). Limited ability to effectively monitor the use of genetic resources and enforce fair benefit sharing (MULLER, 2006) may increase uncertainty about long-term benefits and lead to time discounting and preference for upfront payment in bilateral international exchange of genetic resources.

On the other hand, the level of uncertainty may lead to complex contractual agreements and higher transaction costs (WILLIAMSON, 1979). Specifically, transaction costs brought about by uncertainties related to exchange framework may discourage potential recipients from seeking genetic resources from international (compared to domestic) providers (EATON and VISSER, 2007) or may trigger upfront payments which likely have significantly lower transaction costs than more complex arrangements that try to capture expected benefits. In the next section we discuss the implications of such contractual agreements in more detail.

In summary, due to time preference and uncertainty involving in exchange of genetic materials it is likely that providers of genetic materials seek short-term benefits such as an upfront payment over anticipated future benefits or detailed restrictions in contractual agreements. Therefore, we expect that 1) *upfront payments will be negatively related to anticipated non-monetary benefits and long-term monetary benefits*; and 2) *upfront payments will be positively associated with the international exchange of genetic materials*.

2.2 Use restriction and expected benefits

As noted in the preceding section, providers who expect long-term benefits may seek detailed and restrictive contractual agreement to minimize uncertainty or risks of default associated with benefit sharing (WILLIAMSON, 1979). This neoclassical contract approach depicts a com-

plex contract that considers future contingencies, including dispute resolution mechanisms. As the complexity of contractual agreement increases, transaction costs to actors will also increase. Transaction costs include financial and non-monetary costs related to negotiation and renegotiation, communication and administrative activities, monitoring and enforcement of agreements, as well as transfer of compensation or benefit sharing. For genetic resource exchange, fortunately or unfortunately, most of these transaction costs are borne by recipients (EATON and VISSER, 2007).

For researchers, anticipated benefits from acquired genetic materials include value for research and potential for publication and innovation, which depend on the level of restrictions on use, type of genetic resources acquired, and information accompanying the materials. Restrictions on the exchange of research material have been growing within scientific communities as has the use of material transfer agreements. STREITZ and BENNETT (2003) state that the increasing complexity and fragmentation of ownership of research tools and materials are impeding the implementation of multifaceted science projects, particularly those with industry partners.

Regulation induced transaction costs and contractual restrictions on use can limit recipients' willingness to engage in formal exchange of genetic materials. Restrictions in material transfer agreements (MTAs) on publishing to protect confidential information or to preserve patentability of inventions may discourage scientists from engaging in research with certain materials (STREITZ and BENNETT, 2003). Currently, there is relatively low use of material transfer agreements among scientific community in the US (WELCH et al., 2013). Expanding the use of MTAs may require new incentives, rules, or voluntary programs. Others noted that high transaction costs and contractual restrictions may function as disincentives for use of genetic materials (e.g. EATON and VISSER, 2007; NIJAR, 2011), while regulatory, administrative and other factors create uncertainties around accrual of long-term benefits and reduce incentives for provision of genetic resources.

O'CONNOR (2006) suggests the possibility that providers may obtain higher benefits from upfront payments if they sell genetic materials rather than lease them under some form of agreement. Upfront payments may be preferred unless providers are able to generate continuous returns through ownership or eliminate the risk that a third party could obtain and distribute the material. Upfront payments lower the risk of default, improve partnership and may involve lower anticipated monetary benefits such as in the form of loyalty (ROSENTHAL, 1996). It seems that the *upfront-payment-no-restriction* system may improve the access and use of genetic materials by scientific communities to the benefit of society. At least in part, policies might begin to consider mechanisms for reducing transaction costs to researchers while simultaneously enabling providers to realize higher upfront payments.

A system of upfront payment with no restrictions already exists; many researchers pay nominal fees to obtain materials. This system may be particularly evident in international exchange where providers realize that they have limited control over use of genetic materials once the materials leave their national boundary. It also appears reasonable from the perspective of bounded rationality that actors would have difficulty accounting for all the contingencies in long term contractual agreements (WILLIAMSON, 1979).

In sum, as argued we expect: 3) *upfront payments will be positively associated with private sources*; and 4) *upfront payments will be positively associated with no restrictions on genetic materials*.

3 Data source and methods of analysis

The data for this study were collected using an online survey of agriculture scientists working in government agencies and universities in the United States. The sample frame includes the population of active scientists who use one of the different species of non-plant genetic resources categorized within four subsectors of agriculture: livestock, microbes, aquatics and

insects. University scientists included in the frame were either employed in Carnegie designated research intensive and research extensive universities in the US or in a handful of other US veterinary schools under different designation. Government researchers were employed in USDA Agricultural Research Services (ARS). In all, 201 universities and 262 subunits of Agricultural Research Services are represented in the frame. Contact information of authors and coauthors was verified through detailed searches of employer institution websites. The survey was administered to final sample of 1058 individuals from November 5, 2010 to February 7, 2011. A total of 411 responses were received, giving a final response rate of 38.8 percent. The survey design included questions at the individual and project levels. Individual level questions asked about the respondent's behavior, experiences, perceptions and demographics. The project level questions were designed in a two-step format in which the respondent first reported the research projects on which they were actively using the organism before answering specific questions related to each of the named projects. A total of 270 researchers named 684 research projects. The project specific questions focused on the domestic and international exchange behavior of active scientists such as recent acquisition and provision of genetic materials, use of agreements and restrictions that accompany the materials, sources of the material and purposes of the research.

The dependent variable for this study is based on a survey question that asks respondents whether they received the material for each project for free, at cost, or cost plus an additional fee (free=1, at cost=2; cost plus = 3). This variable is called upfront payment. There are four categories of key explanatory variables: expected benefits, use restriction, and two types of sources. Expected benefits may be either monetary or non-monetary. Four non-monetary benefits that the receiver is anticipated to provide were captured in the survey: expected storage services for genetic materials, expected provision of research and technical services, expected provision of information about project results, and expected provision education and training service. Each of these measures is a dummy variable where 1 indicates anticipated receipt of the benefit to the provider and 0 indicates no expectation. Expected monetary benefits comprises one question asking how frequently the recipient shares financial returns from commercial applications with the provider of genetic resources (1=never, 2=sometimes, 3=always). The second category of key variables is captured by a question asking whether there were restrictions on the use of the transferred genetic material. It is measured using a dummy variable coded 1 for no use restrictions and 0 for restrictions. The last two key variables capture whether or not the material comes from a foreign source (1=yes) and from a private company source (1=yes).

Other control variables are used in the regression estimations. These include dummy variables for the four types of organisms (1=yes), whether or not the aim of the research is 'basic research' (1=yes), whether the source of the material is the same type of institution – either both university or both government (1=yes) and how actively the respondent provides genetic resources to others (1= does not send, 2=send to US, 3= send to foreign countries, 4= send to US and foreign countries). Additionally, the model includes the recipients' socio-economic and demographic characteristics including age (years), gender (1=female), race (1=white), job tenure (years) and whether or not the respondent is a member in a professional association that addresses access, exchange and use of genetic resources (1=yes).

This study uses both descriptive statistics and ordered logic model to investigate the association between upfront payments, use restrictions, expected benefits of material exchange and foreign source. Given that the dependent variable is an ordinal variable – no cost, at cost, cost-plus – ordered logistic regression was used to estimate the model and compute odds ratios (LONG and FREESE, 2006). The ordered logistic regression model is specified as: $y_i^* = x_i\beta + \varepsilon_i$, where y_i^* refers to the latent variable of the model, x_i is the explanatory variable and β is a vector for parameters to be estimated, ε_i is the disturbance term while i is the observation.

The latent variable for the ordinal response variable y_i^* is given as $y_i = j$ if $\tau_{j-1} \leq y_i^* < \tau_j$, where the observed variable y_i refers to the level of upfront payment for access to genetic material, τ is the threshold parameter, and j is the ordinal category (WOOLDRIDGE, 2010). Ordered logistic regression outcome probabilities are given as $\Pr(y_i = j) = Pr(\tau_{j-1} \leq x\beta < \tau_j)$, where regression and threshold parameters of the model are estimated using maximum log likelihood $\Pr(y_i = j)$. The sign of parameters, β, indicate whether the latent variable, y^*, is positively or negatively associated with the explanatory variable.

4 Findings

4.1 Descriptive findings for upfront payments, types of genetic materials and use

Prior research suggests that because the magnitude of expected benefits depends on expected commercial viability (GHOSE, 2003), the level of upfront payment for genetic materials could vary by type of organism. Table 1 shows that most of genetic materials are exchanged without any upfront monetary payment, regardless the type of organism. Most genetic materials are provided free or at cost. The high percentage of free exchange could be attributed to social norms existing in the sciences that encourage low cost exchange of genetic resources.

Table 1. Upfront payment by category of organism (percent)

Levels of upfront payment	Microbial (N=345)	Cattle (N=118)	Aquatics (N=133)	Insects (N=88)
No charge	91.6	66.9	51.1	67.0
At cost	6.1	29.7	41.4	26.1
Cost plus fee	2.3	3.4	7.5	6.8
Chi-square	104.46***			

Note: *** $p < 0.01$.
Source: Own survey data, 2012.

Nevertheless there are some differences in percentage of materials transferred at each level of upfront payment across organism categories that are statistically significant. For example, while 91.6% of the microbial genetic resources are provided free of change, only half (51.1%) of aquatic genetic resources are given away. And although only 2.3% and 3.4% of microbial and cattle genetic resources transactions require cost-pus payments, transactions for aquatics and insects require nearly twice that percentage.

Providers' willingness to contribute genetic material and recipients' provision of benefits, including upfront payment, are likely to differ depending upon the anticipated use. When materials are used for basic research, there is a lower likelihood that they will be incorporated into new innovation or saleable products, than if the purpose of the research is applied or for product or process development. Table 2, which differentiates the level of upfront payment by anticipated use of genetic resources, provides only partial support for these expectations. While there is a statistically significant difference for product development where there are more cost (19%) or cost-plus (9.5%) transactions, most resources are provided free of charge, regardless the anticipated use.

This could have several different explanations. For example, it is possible that when materials are requested there is either little disclosure about (or interest in) anticipated use or there are few concerns about the aim of the underlying research (particularly for government or university science). Alternatively, there may be a broad perception that genetic material has little specific value for the provider without significant effort on the part of the receiver. Or, that

the material is widely available and if one source does not provide it, another will. It is also possible that other types of benefits are more important than monetary benefits. Providers may believe that new information and knowledge from research are key benefits from research. Finally, since universities and government agencies have limited monetary resources available to purchase genetic resources, longer-term non-monetary benefits may represent more feasible returns for exchange.

Table 2. Upfront payment level by type of anticipated use (percent)

Upfront Payment Level	Basic research (N=396)	Applied research (N=408)	Technical research[#] (N=94)	Product development (N=84)	Process development (N=50)
No charge	76.8	76.0	79.8	71.4	66.0
At cost	19.9	19.6	19.1	19.0	26.0
Cost plus fee	3.3	4.4	1.1	9.5	8.0
Chi square	1.59	0.67	2.62	7.12**	3.89

Note: ** $p < 0.05$; [#]Analytical or extension services
Source: Own survey data, 2012.

4.2 Upfront payment levels by type of restriction

As noted above, formal mechanisms that increase the transaction costs of exchange may limit researcher access to and use of genetic resources and thereby reduce the benefits that could be realized. Material transfer agreements (MTA) are common means by which genetic resource transfers and their contractual conditions are formally documented (GHOSE, 2003). The provisions of the agreements determine the level of restrictions on the use and subsequent transfer of the material to third parties. However, MTAs are not always, or even often, used as part of an exchange and when they are used, the restrictions vary significantly.

Table 3 presents findings from descriptive analysis of survey data for the use of MTAs and restrictions that accompanied genetic resources obtained for projects (asked in separate questions). Findings show a positive association between the use of material transfer agreements and restrictions on further use of the transferred genetic materials ($p < 0.01$). Also, the level of upfront payment tends to be positively associated with MTA use ($p< 0.10$); MTA use is weakly positively related to higher costs of access to genetic resources (at cost or cost-plus). Additionally, upfront payments are higher (though not significantly so) for materials received without restrictions (22.3% at cost and 4.5% cost-plus) as compared to materials received with restrictions (16.6% at cost and 3.7% cost-plus). Finally, scientists who report using MTAs to obtain genetic resources are significantly more likely to report restrictions than those who do not use MTAs.

4.3 Tradeoffs between upfront payment and long-term benefits on genetic materials

In this section, we further examine the tradeoffs between the upfront payment level, long-term benefits and use restrictions for the exchange of genetic resources. Table 4 presents the ordered logistic regression model results. Statistical tests for the model show overall goodness of fit, while the threshold parameter significance ($p < 0.000$) implies that the distinct upfront payment categories should not be collapsed to binary outcomes. In general, findings support our expectations that the long-term non-monetary benefits will be negatively related to upfront payment level, although non-monetary benefits are not equivalent; provision of resulting information is strongly significant while the other non-monetary benefits are either not significant or weakly significant. Findings also show support for the expectation that ‘no restrictions

on use' will be positively related to upfront payment level. Finally, foreign and company sources are more likely to request higher upfront payments. Odds ratios indicate change in probability of a higher upfront payment versus lower upfront payment, holding other factors constant.

Table 3. Upfront payment level, materials transfer agreements, and restriction (percent)

	No MTA (n=503)	**MTA (n=181)**	**Chi-square**
No charge	77.7	72.4	4.616*
At cost	19.1	21.0	
Cost plus fee	3.2	6.6	
	No use restrictions (n=358)	**With use restrictions (n=326)**	**Chi-square**
No charge	73.2	79.8	4.136
At cost	22.3	16.6	
Cost plus fee	4.5	3.7	
	No use restrictions (n=358)	**With use restrictions (n=326)**	**Chi-square**
No MTA	79.3	67.2	12.95***
MTA	20.7	32.8	

Note: *** $p < 0.01$, * $p < 0.10$
Source: Own survey data, 2012.

4.3.1 Upfront payment and providers' expected long-term benefits

As discussed in the introduction and outlined in the intertemporal choice model, when expected benefits involve high uncertainty, providers may prefer upfront payments on genetic materials over the long-term monetary or non-monetary benefits, particularly when the magnitude and accrual period of the expected benefits are not well-defined. Non-monetary benefits expected of recipients that are considered in this study include provision of storage services for genetic materials, provision of research and technical services, provision of information from project results, and provision of education and training. Expected monetary benefits include sharing of financial benefits from commercial application of the genetic resources.

Findings show a statistically significant negative relationship ($p < 0.01$) between expected provision of information from research results and level of upfront payment, while other types of non-monetary benefits – storage, research, and education and training services – are not significant. Possibly, providers exchange genetic materials for future information and knowledge when they do not otherwise possess the equipment or human capital to produce it, but need or desire a better understanding of the genetic material. Likely, these exchange arrangements are made when the value that providers attach to information on project results outweighs the immediate benefit of upfront payment. The odds of obtaining genetic materials free of charge are 0.38 times higher when there is an expectation that useful or valuable information about results will be provided. This finding supports prior work showing that scientists collaborate as a means of accessing research inputs that they did not have (LANDRY and AMARA, 1998).

Table 4. Estimation results

Variables	Ordered logistic			Stereotype logistic	
	Coefficient	Std. Err.	Odds Ratio	Coefficient	Std. Err.
Expected storage service	0.325	0.289	1.384	0.523	0.369
Expected research services	-0.445*	0.263	0.640	-0.480	0.335
Expected information provision	-0.962***	0.240	0.382	-1.167***	0.367
Expected training service	0.358	0.294	1.429	0.529	0.371
Expected financial sharing	0.255	0.208	1.291	0.434	0.267
No use restriction	0.465**	0.218	1.593	0.625**	0.283
Foreign source	0.591*	0.356	1.806	0.780*	0.473
Private source	0.904***	0.240	2.469	1.072***	0.328
Basic research	0.121	0.218	1.129	0.151	0.276
Same institution	-0.784***	0.240	0.457	-0.865***	0.353
Send genetic resources abroad	-0.430***	0.142	0.650	-0.604***	0.201
Microbial organism	-1.821***	0.363	0.162	-2.223***	0.543
Cattle	0.020	0.351	1.021	.0479	0.438
Aquatic organism	0.456	0.324	1.579	0.652	0.409
Membership in association	0.784***	0.242	2.191	0.972***	0.349
Job tenure	-0.016	0.016	0.984	-0.022	0.021
White	-0.279	0.331	0.756	-0.676	0.422
Female	0.761***	0.272	2.139	0.927***	0.371
Age	-0.047***	0.017	0.954	-0.054**	0.023
/cut1	-2.694	1.018			
/cut2	-0.223	1.017			
LR chi2(19) =	195.34			48.92	
Prob > chi2 =	0.000			0.000	
Pseudo R2 =	0.218				
Log likelihood =	-351.338			-351.3024	

Note: Number of observations = 684; test _b[/cut1]=_b[/cut2]; chi2(1) = 137.43, Prob > chi2 = 0.000;
*, **, and *** denote statistical significance at P≤ 0.1, P≤ 0.05, and P≤ 0.01 probability levels, respectively.
Source: Own survey data, 2012.

Another way to think about the negative coefficient for provision of information services is that upfront payments are required when the provider perceives high uncertainties about receiving benefits. This could be particularly true for international exchange of genetic materials when foreign providers face higher transaction costs and uncertainties imposed by distance, national borders, lack of familiarity about and low control over the recipient. As validation for this expectation, model results show that the variable foreign source, which indicates whether genetic materials were acquired from foreign countries, is positively associated ($p < 0.10$) with the level of upfront payment. This shows that researcher tend to pay higher upfront payments to acquire genetic materials from foreign as opposed to domestic suppliers. Odds ratios show that cost plus additional fees are about 1.8 times more likely when materials are provided by other countries.

4.3.2 Upfront payment and use restrictions on genetic materials

The growing use of MTAs and increasing complexity of restrictions and obligations are making exchange of genetic materials more difficult (STREITZ and BENNETT, 2003). The increasing transaction costs and uncertainties involved with material exchange may lead researchers to

seek genetic resources in which upfront payments are higher but restrictions on use are lower. Results from the regression analysis seem to support this expectation.

The variable measuring no restrictions on exchange is negatively and significantly associated with the level of upfront payment ($p < 0.05$). This indicates that exchanges that involve higher upfront payments are more likely to have no restriction on use. The odds of exchanging at cost-plus additional fees are 1.59 times more likely when arrangements have no use restrictions, as compared to those that impose restrictions. Decisions to pay more upfront may indicate a preference for minimization of transaction cost and maximization of the use of genetic materials. Providers may also prefer upfront payments with no restrictions as the magnitude and accrual period for potential benefits is not clear (SUNEETHA and PISUPATI, 2009) and because of the high level of regulatory uncertainly (EATON and VISSER, 2007).

The variable private source of genetic resources is, as expected, positively related to levels of payment on genetic resources ($p < 0.01$). This implies that researchers obtaining genetic resources from companies tend to pay higher upfront payments. The odds for cost plus additional fees are about 2.5 times higher for materials coming from private companies than from other organizations.

Several other control variables were included in the model. The variable *same institution*, which measures whether both the provider and recipient are from either government or university, is positively related to upfront payment level ($p < 0.01$). This indicates that exchange of genetic materials between institutions that share values or have similar regulatory or administrative systems tends to have lower upfront costs as compared to exchange that occurs across different institutions. The odds of obtaining genetic materials free of charge are 0.46 times higher if the transfer takes place between similar institutions as opposed to across different institutions. STREITZ and BENNETT (2003) also reported sharing materials between university scientists to be less problematic and less restrictive due to similar institutional cultures and motivations for exchange.

Additionally, the variable *send genetic resources* abroad indicates whether the research sends material to foreign entities. Findings show that individuals who are more involved in sending materials out have lower upfront payments. Respondents who are more actively exchanging genetic resources likely have established reciprocal exchange relationships with other domestic and international providers.

Other control variables such as category of genetic organism, *membership in association*, *female* and *age* of the recipient researcher also turned out to be associated significantly with upfront payment levels. The negative association ($p < 0.01$) between *microbial genetic materials* may indicate that the perceived value and transaction costs of microbes may simply be much lower than insects, which is the reference group. Certainly microbes are smaller and more easily exchanged. Membership in an association that formally considers access, exchange and use of genetic resources is positively associated with upfront payment. Possibly, membership provides awareness of the benefits of upfront payments for exchange in the face of increased restrictions. The variable female shows that women tend to receive genetic resources at either cost or cost plus, while the positive result for age shows that older, likely more senior, researchers pay less upfront for genetic resources, possibly because they have stronger personal connections with resource providers.

5 Conclusions and policy implications

The analysis presented in this paper demonstrates the relationship between level of upfront payment, expected monetary and non-monetary benefits, and use restriction. While findings show that a considerable portion of genetic materials are still accessed by the US researchers free of any upfront monetary charge, there were differences depending upon type of use reported. Product and process development tended to be associated with higher upfront pay-

ments. Additionally, material transfer that occurs when recipients are expected to provide information about research results requires lower upfront payments. Alternatively stated, when research materials are acquired with higher upfront payments, recipients are not expected to provide information as a long-term non-monetary benefit. This finding provides some evidence for the substitutability between upfront payment and informational non-monetary benefits.

There is also some evidence that the upfront payments to acquire genetic materials from foreign sources are higher, as compared to domestic sources. As discussed, this reveals that exchange of genetic materials may involve time preference and high uncertainty, raising questions about the inadequacy of current benefits arrangement in facilitating exchange of genetic materials for food and agriculture. Additionally, upfront payments tend to be higher when material is received from private companies

Finally, findings show that restrictions on use are associated with lower payments; fewer restrictions are realized with higher upfront payments. It is possible, that higher upfront payments can be assessed in ways that avoid complex restrictions and obligations that may hinder research and further innovation. Policies that promote upfront payments coupled with no or low restrictions on use could reduce pressure by countries and material suppliers to speculate about the potential future benefits of genetic resources. Speculation about potential benefits is likely to result in an inflated valuation of genetic resources and in turn reduced exchange in case of sole ownership of certain genetic materials.

In sum, this research suggests that in some cases, policies that promote a simple fee system could improve the flow and use of genetic material exchange. We suggest further empirical investigation to better understand how transaction costs associated with MTAs, contracts and regulations along the value chain of genetic material exchange impact the private and social value from the use of genetic resources.

Acknowledgments and Disclaimers

The authors wish to thank the anonymous reviewers for their valuable comments on the earlier version. Data analyzed in this article were collected under the auspices of the three-year (2008-2010) research project titled 'Knowledge for Policy: Critical Research for Understanding Potential Impacts of ABS on Eight Sectors of Genetic Resources for Food and Agriculture', funded by the National Institute for Food and Agriculture, US Department of Agriculture (PI: Dr. Eric Welch). The views expressed in this paper are the authors', and do not necessarily reflect those of USDA.

References

BIBER-KLEMM, S., T. COTTIER, P. CULLET, and D.S. BERGLAS (2006): The Current Law of Plant Genetic Resources and Traditional knowledge. In: S. Biber-Klemm, and T. Cottier (eds): Right to plant genetic resources and Traditional knowledge: Basic Issues and Perspectives. 56-11. CABI, Wallingford.

BRETTING, P.K. (2007): The U.S. National Germplasm System in an Era of Shifting International Norms for Germplasm Exchange. Proceedings XXVII IHC-S1 Plant Gen. Resources. Acta Hort. 760: 55-59.

BRUSH, S.B. (2005): Protecting Traditional Agricultural Knowledge. Journal of Law and Policy, 17: 59-109.

CORREA, C.M. (2005): Do national access regimes promote the use of genetic resources and benefit sharing? Int. J. Environment and Sustainable Development 4 (4):444-463.

EATON, D. and B. VISSER (2007): Transaction Costs of Tracking and Monitoring the Flows of Genetic Resources. In: M. R. Muller and I. Lapena (eds.): A Moving Target: Genetic Resources and Options for Tracking and Monitoring their International Flows. IUCN Environmental Policy and Law Paper No. 67/3.

FEARNSIDE, P.M. (2002): Time Preference in Global Warming Calculations: A Proposal for a Unified Index. Ecological Economics 41: 21-31.

FISHER, I. (1930): The Theory of Interest as Determined by Impatience to Spend Income and Opportunity to Invest It. Macmillan. New York.

FREDERICK, S., G. LOEWENSTEIN, and T. O'DONOGHUE (2002): Time Discounting and Time Preference: A Critical Review. Journal of Economic Literature, Vol. XL: 351-401.

GHOSE, J.R. (2003): Access and Benefit Sharing Systems: An Overview of the Issues and the Regulation. http://rana.lilypadresources.com/research/abs.pdf [accessed August 2013].

HARRIS, C. and D. LAIBSON (2001): Dynamic Choices of Hyperbolic Consumers. Econometrica 69 (4): 935-957.

HOLDEN, S.T., B. SHIFERAW and M. WIK (1998): Poverty, market imperfections and time preferences: of relevance for environmental policy? Environment and Development Economics 3:105-30.

LANDRY, R. and N. AMARA (1998): The impact of transaction costs on the institutional structuration of collaborative academic research. Research Policy 27: 901-913

LEVY, J. S. (1997): Prospect Theory, Rational Choice, and International Relations. International Studies Quarterly 41 (1): 87-112.

LOEWENSTEIN, G. and D. PRELEC (1992): Anomalies in Intertemporal Choice: Evidence and an Interpretation. Quarterly Journal of Economics 107 (2): 573-597.

LONG, J.S. and J. FREESE (2006): Regression Models for Categorical Dependent Variables Using Stata. Second Edition. Stata Press, Texas.

MOLM, L.D. (2003): Theoretical Comparisons of Forms of Exchange. Sociological theory 21 (1): 1-17.

MULLER, M.R. (2006): The International Regime on Access to Genetic Resources and Benefit Sharing: In Search of the Right Path. Peruvian Society for Environmental Law, Lima-Peru No. 17.

NIJAR, G.S. (2011): Food security and access and benefit sharing laws relating to genetic resources: promoting synergies in national and international governance. Int. Environ Agreements 11: 99-116.

NORTH, D.C. (1992): Transaction Costs, Institutions, and Economic Performance. An International Center for Economic Growth. San Francisco, California.

O'CONNOR, S. (2006): The Use of MTAs to Control Commercialization of Stem Cell Diagnostics and Therapeutics. http://www.btlj.org/data/articles/21_03_01.pdf [accessed August 2013].

PEZZEY, J.C.V. (1997): Sustainability Constraints versus "Optimality" versus Intertemporal Concern, and Axioms versus Data. Land Economics 73 (4): 448-466.

PORZECANSKI, A.L., R. SEARS, T. GRANT, L. PUTZEL, L. DAVALOS,T. BARNES, H. CROSS, G. RAYGORODETSKY, B. SIMMONS, and P. CHASEK (1999): Access to Genetic Resources: An Evaluation of the Development and Implementation of Recent Regulation and Access Agreements. Columbia University, School of International and Public Affairs, Environmental Policy Studies, Working Paper, 4.

READ, D. (2003): Intertemporal Choice. Working Paper LSEOR 03.58, Department of Operational Research, London School of Economics and Political Science, UK.

RAE, J. (1905): The Sociological Theory of Capital. Charles Whitney Mixter, ed. Macmillan, New York.

ROSENTHAL, J.P. (1996): Equitable Sharing of Biodiversity Benefits: Agreements on Genetic Resources. Paper presented at the International Conference on Incentive Measures for the Conservation and the Sustainable Use of Biological Diversity in Cairns, Australia.

SAMUELSON, P. (1937): A Note on Measurement of Utility. Review of Economic Studies 4 (2): 155-161.

SHELLEY, M.K. (1993): Outcome signs, question frames and discount rates. Management Science 39: 806-815.

SHORE, L.M., L.E. TETRICK, P. LYNCH, and K. BARKSDALE (2006): Social and Economic Exchange: Construct Development and Validation. Journal of Applied Social Psychology 36 (4): 837-867.

STREITZ, W.D. and A.B. BENNETT. (2003): Material Transfer Agreements: A University Perspective. Plant Physiology 133: 10-13.

SUNEETHA, M. and B. PISUPATI (2009): Benefit sharing in ABS: Options and Elaborations. UNU-IAS Report.

TEN KATE, K. (2002): Global Genetic Resources: Science and the Convention on Biological Diversity. Science 295:2371-2372.

VON BÖHM-BAWERK, E. (1891): Capital and Interest: Positive Theory of Capital, Translated with A Preface and Analysis by William Smart. Photographic reprint in 1930, G. E. Stechert and Co., New York.

VAN OVERWALLE, G. (2005): Protecting and Sharing Biodiversity and Traditional Knowledge: Holder and user tools. Ecological Economics 53: 585-607.

VISSER, B., D. EATON, N. LOUWAARS and J. ENGELS (2000): Transaction Costs of Germplasm Exchange under Bilateral Agreements. Strengthening Partnership in Agricultural Research for Development in the Context of Globalization, Global Forum on Agricultural Research, May 21-23, Dresden, Germany.

WELCH, E.W.E. SHIN and J. LONG (2013): Potential effects of the Nagoya Protocol on the exchange of non-plant genetic resources for scientific research: Actors, paths, and consequences. Ecological Economics 86: 136-147.

WILLIAMSON, O.E. (1979): Transaction-Cost Economics: The Governance of Contractual Relations. Journal of Law and Economics 22 (2): 233-261.

WOOLDRIDGE, J.M. (2010): Econometric Analysis of Cross Section and Panel Data. Second Edition, MIT Press, Cambridge.