Payments for Forest Ecosystem Services: Global and Local Assessments of Costs and Benefits

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2016

CHAPTER 3 ▪

A global survey and review of the determinants of transaction costs of forestry carbon projects[12]

Summary

Reducing carbon emissions in the forestry sector by means of market-based schemes is considered a cost-effective measure for tackling climate change impacts. However, the transaction costs (TCs) involved are typically unknown or unquantified and therefore often neglected. In this study three types of TCs (search, design and negotiation costs) were measured in person-days and monetary terms based on a global survey of forestry carbon projects implemented across Latin-America, Asia and Africa. Cost estimates vary between zero and 1.201/tCO_2 for person-days and from zero to US$ 1.738/tCO_2 for monetary costs. Key drivers of TCs are identified based on the characteristics of the project in general, the transaction, the transactors involved and institutional design. The latter type of characteristic is shown to have a particularly large impact on TCs.

[12] This chapter is in press as: Phan, D. T-H., Brouwer, R. and Davidson, M. (2016). A global survey and review of the determinants of transaction costs of forestry carbon projects. *Journal of Ecological Economics*.

3.1 INTRODUCTION

Since the establishment of the Clean Development Mechanism (CDM) negotiated under the Kyoto Protocol, marketing carbon credits generated from forests has been considered a promising mechanism for mitigating the consequences of climate change. This is due to its assumed cost-effectiveness and potential scope for carbon emissions reduction (IPCC, 2000; Houghton, 2005; Stern, 2006; Nabuurs *et al.*, 2007; Eliasch, 2008). The fundamental principle of marketing carbon credits is that since carbon is a uniformly mixed pollutant, carbon emitted by industrial countries can be offset by emission abatement activities carried out in developing countries, provided the reduction is additional and without leakage. Within the CDM, industrialized countries are allowed to implement emission reduction projects, including afforestation and reforestation, in developing countries as a way to offset their domestic emissions, hence meeting the Kyoto Protocol's targets. In parallel with an internationally regulated CDM market, a voluntary carbon market has been developed as well, where firms and other organizations can voluntarily compensate for their emissions by purchasing forestry carbon credits generated elsewhere (Bumpus and Liverman, 2008). Additional to A/R, the voluntary market also favours the trading of carbon credits generated from avoided deforestation and sustainable forest management. To ensure the quality of carbon credits (i.e. additionality, no leakage and permanence), credits obtained from both the compliance (CDM) and voluntary (non-CDM) markets are subject to a verification process in which specific standards are used. Being viewed as a new form of environmental governance, these two market-based mechanisms are anticipated not only to help contribute to combating the consequences of climate change, but also to act as a new source of funding from developed to developing countries (Lederer, 2011).

Although forestry carbon projects are expected to help reduce emissions at low cost, little is known about their transaction costs (TC), i.e. the resources used to define, establish, maintain and transfer property rights between transactors (McCann *et al.*, 2005). In fact, the TC incurred by the various actors are typically neither known nor quantified and are therefore usually neglected in project design and evaluation (Falconer and Whitby, 1999; Challen, 2000; McCann *et al.*, 2005). A number of studies have attempted to estimate the size of the TC associated with forestry management (see the work so far by Milne, 1999; Adhikari and Lovett, 2006; Wunder *et al.*, 2008; Alston and Andersson, 2011; Ray and Bhattacharya, 2011; Cacho *et al.*, 2013; Thompson *et al.*, 2013). However, studies attempting to identify the factors driving or determining these TC are lacking. On the one hand, TC are not transparent owing to their confidentiality and inherent political sensitivity, as they are often viewed as wasteful and inefficient. As McCann *et al.* note (2005: 536), "access to the necessary data is a major problem faced by researchers examining transaction costs". On the other hand, measurement of TC is complicated as a result of divergent definitions.

The purpose of this study is to further develop existing analytical frameworks to assess factors influencing TC incurred by project developers in forestry carbon projects and apply this framework to practical cases. The analytical framework developed here builds on the work by Williamson (1979, 1996), Antinori and Sathaye (2007), Mettepenningen and van Huylenbroeck (2009), Coggan *et al.* (2010, 2013), and McCann (2013). With respect to application of the framework, our objective is first to quantify the size of TC and second to determine their main driving factors and how these impact the TC of marketing forest carbon credits. Given the fact that heavily forested nations in developing countries can make a major contribution to reducing carbon emissions, this study analyses and evaluates carbon-credit-generating forestry projects implemented in Latin-America, Asia, and Africa.

The chapter is structured as follows. Section 2 explains the analytical framework of TC in forestry carbon projects. In Section 3 we describe in more detail the data set employed in this study. The main results from applying the analytical framework to selected projects and their economic implications are discussed in Section 4. Finally, Section 5 concludes.

3.2 ANALYTICAL FRAMEWORK

3.2.1 Definition of transaction costs

Although there is a growing body of literature examining TC, a universally agreed and fit-for-all definition for this type of cost is lacking (Falconer and Whitby, 1999; Chadwick, 2006; Meshack *et al.*, 2006; Wang, 2007; Mettepenningen *et al.*, 2009; Garrick *et al.*, 2013; Mundaca *et al.*, 2013). In practice, TC are usually defined based on the activities that generate the costs (see for different definitions: Dahlman, 1979; Matthews, 1986; Woerdman, 2004). McCann *et al.* (2005) classify the TC associated with public policies into seven subgroups, namely research and information; enactment; design and implementation; support and administration; contracting; monitoring; and enforcement. Grieg-Gran and Bann (2003: 36) describe the TC of payments for ecosystem service (PES) schemes as the costs of "seeking, negotiating, agreeing, implementing, monitoring and certifying deals". In a similar manner, Wertz-Kanounnikoff (2006) describes the component elements of PES

TC as the costs of (i) identifying an ecosystem service's sellers and buyers, (ii) quantifying the services and the opportunity costs of conservation, (iii) negotiating and structuring deals, and (iv) implementing accountability and transparency mechanisms within the existing political and legal framework (i.e. monitoring and enforcement). Variations in the definitions of TC imply that this concept can be operationalized in a variety of ways and also depends on "the influence of multiple theoretical traditions and analytical frameworks in transaction costs analysis" (Garrick *et al.*, 2013: 182).

Given the fact that some of the selected projects are still in the pipeline, in this paper we only examine TC associated with activities undertaken prior to implementation of forest carbon projects, i.e. *ex ante* TC[13]: search for relevant information, project design, and negotiations of contractual agreements. Moreover, our study only focuses on the private TC incurred by project developers. An investigation of public TC borne by the government such as costs relating to the approval of project design or any public administrative costs emerging during project operation (Milne, 1999; Mettepenningen *et al.*, 2009) is beyond the scope of this study. The definitions of TC employed in this paper are based partly on the categorization used for CDM projects developed by Milne (1999). *Search costs* are defined as the costs incurred in obtaining information about the project area, project participants and other legal issues. *Design costs* are the costs incurred in designing the project, including development of (i) an implementation plan, (ii) the methods used for carbon quantification, monitoring, credit verification and certification, and (iii) an assessment of the potential environmental and socio-economic impacts of the proposed project. *Negotiation costs* are the costs incurred for reaching agreements between the project participants on their rights and responsibilities, and any enforcement rules once they participate in the project. Negotiations are needed in order to make sure all parties agree with the contract terms and conditions. Negotiations can take place via a series of face-to-face meetings or through telecommunication, as also reported by the contacted project developers in our study. All three of these TC are measured on a per tonne of carbon basis, and hence the impacts of factors presented later on in this study are related to TC per tCO_2 rather than total project TC.

[13] The reason why we only focus on *ex ante* TCs is due to the fact that we initially targeted a large number of pipeline projects and therefore did not include questions about *ex post* TCs in our survey. However, the response rate for these projects turned out to be very low, making it impossible to compare *ex ante* and *ex post* TC.

3.2.2 Driving factors of transaction costs and expected directions of influence

To facilitate our analysis and capture the particular nature of forestry carbon transactions, we employ a combination of analytical frameworks developed by Williamson (1979, 1996), Antinori and Sathaye (2007), Mettepenningen and van Huylenbroeck (2009), Coggan *et al.* (2010, 2013), and McCann (2013). Among these, the standard framework introduced by Williamson (1979) is most frequently referenced in all other subsequent work. According to Williamson (1979, 1996), the size of TC depends on the transaction's characteristics, the transactors' characteristics, the governance structure (or institutional arrangement), and the institutional environment in which the transaction takes place. Coggan *et al.* (2010, 2013) utilize most of Williamson's work, with more details being incorporated to better fit the context of environmental policies. Adopting a slightly different approach, McCann (2013) classifies the determinants into physical (e.g. asset specificity, uncertainty, scale of intervention, heterogeneity, public versus private goods), cultural (e.g. level of trust, notion of fairness, social capital), and institutional factors (e.g. property rights, existing law and policies, market structure). In the context of European agri-environmental schemes, Mettepenningen and van Huylenbroeck (2009) categorize factors influencing private TC into institutional, farmer-, farm-and scheme-related factors. Antinori and Sathaye (2007) introduce a tiered model for analyzing TC determinants based on societal attributes (societal norms and culture), governmental attributes (government institutions, laws, policies), and individual and transaction attributes (asset specificity, uncertainty, frequency, project size).

Based on these frameworks, we identify four main groups of driving factors (Figure 3.1): transaction characteristics, transactor characteristics, institutional design characteristics, and general project characteristics. Below, we describe each group of influencing factors in more detail. It should be noted that owing to the difficulty of measuring some factors, not all drivers mentioned below can be analyzed and reported[14].

[14] In the end, we were able to measure most of the factors except for asset specificity, uncertainty, opportunism, bounded rationality, and social capital.

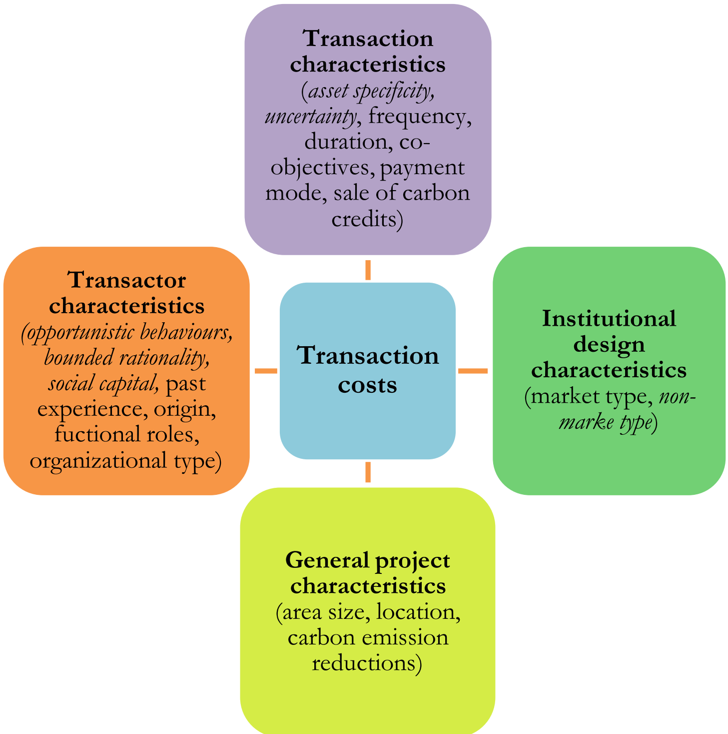

Figure 3.1 Driving factors of transaction costs applied to forestry carbon transactions (adopted from Williamson (1979, 1996), Antinori and Sathaye (2007), Mettepenningen and van Huylenbroeck (2009), Coggan *et al.* (2010, 2013), and McCann (2013)). *Note*: factors that are not included in our survey are indicated in italic.

Transaction characteristics

We define the first group of driving factors, *transaction characteristics*, as six sub-groups: asset specificity, (bio-physical) uncertainty, contract's frequency, project duration, co objectives, and the sale of carbon credits. The first four factors were developed by Williamson (1979), of which asset specificity is the extent to which an investment in a good can be redeployed to alternative uses or by alternative users without loss of productive value. Asset specificity can be classified into spatial specificity (e.g. downstream water users can only buy clean water provided by upstream suppliers), physical specificity (the transaction requires specialized machinery and infrastructure), and human specificity (capacity building and training). A high level of asset specificity will increase TC (Williamson, 1985; Coggan *et al.*, 2013) due to increasing information requirements for implementation, contracting, administration, and monitoring. The second element, bio-physical uncertainty, refers to the uncertainty in determining the outcome of a transaction, resulting from (i) complexity of the asset, (ii) asymmetric information, and (iii) insufficient capacity to anticipate the outcomes (Coggan *et al.*, 2010). Similarly to asset specificity, the greater the uncertainties, the higher the TC are likely to be due to an increase in information collection needs. With regards to the third element, frequency implies how often the transaction between transactors is undertaken, for example whether it is one-off or recurrent, while duration refers to the time horizon of the transaction, i.e. whether it is long-term or short term. In comparison with asset specificity and uncertainty, transaction frequency has received far less attention in the literature (Rindfleisch and Heide, 1997). A variety of assumptions have been made about the impacts of frequency on total TC, depending on whether the transaction occurs between new or the same parties. For instance, according to Williamson (1985) frequency of trade raises TC due to repeated search for new trading partners and negotiations needed for each trade. In contrast, another school of thought suggests that TC can be reduced by having frequent and long-term transactions, owing to (i) enhanced trust and contact (Vatn, 2005), (ii) the ability to re-deploy knowledge, and (iii) capitalize on standardized processes and contracts, provided a transaction is not highly asset-specific (Rørstad *et al.*, 2007; Mettepenningen and van Huylenbroeck, 2009; Coggan *et al.*, 2013). As an illustration, analyzing 12 different agriculture policies in Norway, Rørstad *et al.* (2007) find that more frequent or repeated transactions between the same parties can reduce marginal TC owing to less effort being required for data collection and thus lower search costs for each individual transaction.

Additional to these aforementioned factors, we factor in payment mode (cash versus in-kind), the sale of carbon credits, and a project's co-objectives (in addition to carbon benefits) as new elements. The presence of co-objectives is expected to raise the TC as this may trigger extra work. No prior expectations exist regarding the effect of carbon sale and payment mode. Carbon sale refers here to the case where projects have managed to sell their carbon credits in the market. As reported by some project developers, sale of carbon credits is often hindered by difficulty in finding interested credit buyers.

Transactor characteristics

The second group of driving factors, transactor characteristics, refers to: (i) the boundedly rational, opportunistic behaviour of transactors, (ii) social capital, (iii) past experience of working together, and (iv) transactor's origin, organizational type, and functional roles. The last two factors are new and not mentioned explicitly in other existing frameworks. Opportunistic behaviour can manifest itself in many different ways, such as providing limited amounts of information, hiding actions and free riding, all due to transactors being strategically self-interested (Slangen *et al.*, 2008). Meanwhile, bounded rationality acknowledges the fact that people have a limited ability to acquire and process all the available information: "human behaviour is intendedly rational, but only limitedly so" (Simon, 1947: xxiv). Both bounded rationality and opportunism lead to an increase in TC, especially when a transaction is highly specific, as a result of higher information search costs in the negotiating and monitoring phase (Buitelaar, 2008). Social capital can be described in various forms, including trust, reputation, reciprocity, common ideology, shared norms and values, and social connectedness within the community (Slangen *et al.*, 2008). Both past experiences and built-up social capital are expected to help lower TC. As shown by Taylor and Singleton (1993) and Coggan *et al.* (2010), trust together with shared norms and values may lower the cost of bargaining, monitoring, and enforcement by reducing opportunistic behaviour and the likelihood of renegotiation. Past experience is also expected to reduce TC as transactors make use of relevant knowledge and information gained from previous transactions (Coggan *et al.*, 2013).

Last but not least, transactors' origin, (multi-functional) role, and organizational type are studied too. As noted by Coggan *et al.* (2010), the relative distance between participants, proxied here by their country of origin, may influence TC as a result of varying degrees of information and communication efforts in all three phases of search, implementation and monitoring. In this study, we test whether having projects funded by foreign parties have a negative or positive impact on TC. With respect to the multi-functionality of participants, i.e. if they perform multiple roles, we expect this to reduce TC as a result of shorter lines of communication, integrated administration and lower levels of effort and expenditures in all phases. We look at the number of functions simultaneously played by project developers, but also project participants where land owners and land users are, for example, the same entity. The organizational type of participants is included to examine if the participation of governmental and non-governmental organizations, private companies or individual farmers who are not in any organizational group has a particular impact on TC. If large numbers of non-organized farmers are involved, as is often the case, we anticipate that projects incur higher TC.

Institutional design characteristics

Although the first two groups of driving factors are defined in approximately the same manner across different frameworks, factors relating to the *institutional embedding* and *arrangements* in which the transaction occurs turn out to vary substantially from one study to another. Williamson (2000) distinguishes in this context four levels of social analysis of which social embeddedness (i.e. informal institutions, customs, traditions, norms, and religion) is defined as the top level, followed by the institutional environment (i.e. constitutions, laws, property rights), governance choices (i.e. aligning governance structures with particular transactions), and lastly resource allocation and employment. In the field of public policy, McCann (2013) describes institutional factors as property rights, existing legal systems, market structure, administrative boundaries, choice architecture, and the use of intermediaries, while Mettepenningen and van Huylenbroeck (2009) explain them as constitutional choice rules (collective versus individual choice rules) and state structures (centralized versus decentralized). These sets of institutional factors proposed by Mettepenningen and van Huylenbroeck (2009) and McCann (2013) seem to fit into Williamson's (2000) broader framework of four levels of social analysis.

Our analytical framework highlights the importance of institutional design in order to also acknowledge the public-private nature of many if not most forest carbon projects. They typically involve coalitions among a range of actors from businesses and non-governmental organizations (NGOs) to states and international organizations (Benecke *et al.*, 2008). As mentioned in McCann (2005: 529), "factors that are assumed to affect transaction costs […] (frequency, uncertainty, and asset specificity) may not be the most important factors for environmental and natural resource policy. Other factors, such as monitoring technologies (Fullerton, 2001), property rights (De Alessi, 1983; Allen, 1991), and other institutions [formal and informal rules] (North, 1990), may be paramount". In this study, we define institutional design as either market or non-market based projects. Market based projects sell carbon credits in the carbon market while non-market based projects focus mainly on non-marketing objectives such as biodiversity conservation, poverty alleviation, and social equality. Furthermore, we distinguish between regulated (CDM) and voluntary (non-CDM) markets. In this research, we only focus on market-based projects with a clear distinction between CDM and non-CDM projects.

General project characteristics

General bio-physical characteristics such as a project's location, area size, and carbon emissions reductions (CERs per hectare per year) are incorporated in the analysis, too. Our theoretical expectation is that both area size and CERs will negatively impact TC as a result of economies of scale (Antinori and Sathaye, 2007; Mettepenningen and van Huylenbroeck, 2009), while no prior expectations exist with regard to the influence of variations in location on TC, which is subject to empirical analysis here.

To sum up, this analytical framework yields a set of 19 possible explanatory factors, classified into four main groups. Although some factors such as asset specificity, uncertainty, bounded rationality, opportunism and social capital remain outside this analysis due to the lack of information and measurement complexity, the inclusion of new variables such as past experience of collaboration, the presence of co-objectives, the sale of carbon credits on carbon markets, participants' institutional characteristics, and market type, is expected to generate new insightful results. In the regression analysis, only 13 of the 19 abovementioned variables could effectively be used[15]. In addition, our regression model also factors in "external TC", i.e. any monetary payment to external parties to test the impact of outsourcing on TC. We expect that outsourcing activities results in lower internal TC since they reduce the necessary number of labour days to perform the activities involved.

3.3 DATA COLLECTION

The data reported in this paper were collected primarily from an online survey sent to 150 project developers worldwide. Project developers are defined as those initiating the carbon sequestration project and are in most cases sole responsible for developing and implementing the projects. Their main tasks as a project developer include searching for interested project participants, designing a project document, negotiating the terms of agreements with participants, and (co-)implementing the project. Some project developers examined in this study play multiple roles at the same time, i.e. as project implementer, funder and land owner. Most of the interviewed project developers are private companies, followed by NGOs, and state agencies. No public-private partnerships are included. Financially, these project developers fund or co-fund their organization's activities in most

[15] Although being asked in the survey, the variables payment mode and payment frequency were not included in the regression model due to many missing data points.

cases, while a small number are paid by external parties.

The project developers and their contact information (email addresses and phone numbers) were identified via a web search, mainly via the United Nations Framework Convention on Climate Change (UNFCCC) website on CDM projects (http://cdm.unfccc.int/), the Forest Carbon Portal (http://www.forestcarbonportal.com/), and the Reduced Emissions from Deforestation and Forest Degradation (REDD) Desk (http://www.theredddesk.org/). Personal contacts were utilized in some cases as well. In addition, secondary data and information such as project reports and other documents were used, accompanied by in-depth follow-up interviews where possible and necessary. After three reminders, 30 completed questionnaires were received. Although the response rate is low (20%), it is considered reasonable when compared to the very few national and local TC studies who report their surveys' response rates. These national and local response rates tend to be somewhat higher. Examples include Douglas *et al.* (1993) who targeted farmers and landowners in Nebraska and South Dakota in the US and had a response rate of 33 percent and Coria and Jaraite (2015) who contacted Swedish firms only and reported a response rate of 34 percent.

Based on relevance and data quality, 17 projects were selected for this study (Table 3.1). These forestry projects aim to generate certified carbon credits as offsets for carbon emissions, mostly by industrialized countries. Buyers of these carbon credits range from firms, governmental to non-governmental organizations who are legally obliged or voluntarily wish to reduce their carbon emissions. While more than half of them (n=9) receive funding from multiple sources (i.e. a mix of public and private organizations and individuals), only 4 of the 17 projects are exclusively funded by firms or organizations from abroad. Forestry activities range from forest conservation (i.e. avoided deforestation) to reforestation, afforestation, and forest rehabilitation. The carbon credits generated from these projects are subject to different verification standards (e.g. the CDM Standard versus the Verified Carbon Standard), depending on the market (CDM versus non-CDM) where they are traded.

The survey is structured into two parts, starting with questions related to a project's TC, with guidance provided in the questionnaire regarding the definition of each type of TC, followed by questions concerning their main driving factors (see Annex A). The projects' starting dates vary between 1992 and 2013, with most of the projects initiated in the period 2002-2006, immediately after A/R activities became qualified under the CDM in the year 2001. Fourteen of the 17 projects have already been implemented, while three are still under design. Given that three of the selected projects are still in the design phase, we only examine TC that arise *ex ante* project implementation, including search, design, and negotiation costs, and all incurred by the project developers. Costs that occur *ex post* implementation, i.e. verification, certification, monitoring and enforcement costs are not investigated in this study.

In the survey, developers were asked to state the amount of time, personnel, and money spent in each stage of project development, thus providing cost figures in both monetary and non-monetary units. While the TC in person-days (i.e. a combination of time and personnel costs) mainly relate to activities carried out internally by the project developer (i.e. internal TC), the monetary TC comprise cash payments to parties outside the organization and expenses related to meetings between the project developer and other project participants (i.e. external TC).

To facilitate inter-project comparison, we calculated unit costs on a per tonne of carbon basis by dividing the total costs (person-days and US$) by the total carbon emissions reduction (tCO_2). We asked project developers to report the number of staff involved and days spent related to their search, design, and negotiation activities. Costs measured in terms of person-days were then calculated by multiplying the number of personnel involved by the total number of days. Monetary costs, as an indicator for external TC, were obtained by asking the amount of money paid by developer for hiring people from outside their organization. Costs measured in local currencies were all converted to US$ using the World Bank's Purchasing Power Parity index and standardized to a common price year (2010) using the World Bank's Consumer Price deflator index. Total CERs were calculated by multiplying the CERs per year [16] by the project duration since the start.

[16] Information on CERs was obtained from the answers of project developers and where possible double checked with data presented in other literature such as project design documents.

Table 3.1 Carbon projects included in the study

No.	Project name	Country	Starting date	Foreseen project lifetime (years)	Status	Project type (CDM/Non-CDM)	Forested area (ha)	Carbon emissions reduction (tCO_2/ha/year)	Name of project developer
1.	Ecomapuá Amazon REDD project	Brazil	2002	30	Under design	Avoided deforestation (Non-CDM)	86270	0.84	Ecomapua
2.	Carbon Fix - Terra Boa	Brazil	2005	25	In operation	Reforestation (Non-CDM)	391	12.18	Atlantica Simbios Environmental Consulting and Services
3.	Nerquihue Small-Scale CDM Afforestation Project using Mycorrhizal Inoculation	Chile	2003	20	In operation	Afforestation (CDM)	7500	4.17	Mikro-tek
4.	Forestry Project in Strategic Ecological Areas of the Colombian Caribbean Savannas	Colombia	2003	36	In operation	Reforestation (CDM)	18600	3.58	Pizano S.A.
5.	Restoration of degraded areas and reforestation in Cáceres and Cravo Norte	Colombia	2002	100	In operation	Afforestation and Reforestation (Non-CDM)	11000	2.73	South Pole Carbon Asset Management Ltd.
6.	Humbo Ethiopia Assisted Natural	Ethiopia	2006	8	In operation	Afforestation and	2728	1.34	World Vision Ethiopia

	Regeneration Project					Reforestation (CDM)			
7.	Improving rural livelihoods through carbon sequestration by adopting environment-friendly technology-based agro-forestry practices	India	2004	30	In operation	Afforestation (CDM)	1605	3.05	Veda
8.	Societé Verama Madagascar afforestation project	Madagascar	2013	40	Under design	Afforestation (CDM)	6412	3.12	Societe VERAMA
9.	Avoided deforestation in the Tambopata national reserve and the Bahuaja Sonene national park - Madre de Dios	Peru	2009	20	In operation	Avoided deforestation (Non-CDM)	541620	0.85	AIDER
10.	Kariba REDD+ project	Zimbabwe	2011	100	In operation	Avoided deforestation (Non-CDM)	860000	6.4	South Pole Carbon Asset Management
11.	Kikonda Forest Reserve reforestation project	Uganda	2002	60	In operation	Reforestation (Non-CDM)	8000	3.33	Global Woods
12.	Reforestation project using native species in Maringa-Lopori-Wamba region:	DR of Congo	2010	30	In operation	Afforestation and Reforestation (CDM)	1606	12.66	AVSI

	establishment of the Bonobo Peace Forest								
13.	Orellana Community REDD+	Ecuador	2007	30	Under design	Avoided deforestation (Non-CDM)	40000	2.5	Face the Future
14.	Community-based Reforestation on Degraded Lands in East Lombok	Indonesia	2010	20	In operation	Reforestation (CDM)	300	13	KOICA
15.	INFAPRO rainforest rehabilitation project	Malaysia	1992	99	In operation	Forest rehabilitation (Non-CDM)	25000	5.2	Face the Future
16.	Reforestation project using Paulownia for carbon sequestration	Panama	2011	60	In operation	Reforestation (Non-CDM)	800	50	Sustainable Capital Group Panama S.A.
17.	Posco Uruguay afforestation on degraded extensive grazing land	Uruguay	2010	30	In operation	Afforestation (CDM)	20000	17.5	Posco Uruguay

Focusing on the project phase, the average unit costs in person-days of the search, design, and negotiation phase are 0.018, 0.110, and 0.087 person-days/tCO_2, respectively (see Table 3.2). Average monetary costs are observed to be highest in the design phase (US$ 0.213/tCO_2), while these figures are respectively 0.065 and 0.051 US$/t$CO_2$ for the search and negotiation phases. Overall, the sum of TC in search, design, and negotiation phase in person-days and monetary unit are 0.215 person-day and US$ 0.328 per tCO_2, respectively. Furthermore, we also attempted to convert person-day TC into monetary terms using the International Labour Organization's (ILO) average country wages in 2009[17]. On average, the estimated total TC is US$ 3.3/tCO_2, with the shares of internal and external costs being 90 and 10%, respectively. Compared with the average carbon credit price in the European Union Allowance market in 2010, i.e. around US$ 18.7 per tCO_2 (Kossoy and Ambrosi, 2010), the average TC estimated in our study is almost 6 times lower and makes up 17.6% of the market price.

Table 3.2 Summary statistics of the transaction costs

Transaction costs	Mean value	Std. Error	Min-max values	No. obs.
Internal TC (Person-days/tCO_2**)**				
Search costs	0.018	0.012	0 - 0.180	17
Design costs	0.110	0.075	0 -1.199	17
Negotiation costs	0.087	0.071	0 - 1.201	17
Total	0.215	0.157	0 - 2.581	17
External TC (US$/t$CO_2$**)**				
Search costs	0.065	0.041	0-0.423	17
Design costs	0.213	0.134	0-1.738	17
Negotiation costs	0.051	0.024	0- 0.641	17
Total	0.328	0.164	0 – 2.326	17
Total TC (US$/t$CO_2$)	3.332	2.186	.0001 - 35.873	17

[17] To ensure comparability, where possible we employed wage data for the occupational group of "clerical and service workers" as specified in the ILO's database. We acknowledge the fact that using the country average wage instead of the actual wage paid by the organizations might bias our cost estimation.

3.4 RESULTS

3.4.1 Transaction characteristics

Project duration is usually considered a transaction characteristic in the TC literature. The average project lifetime in this study is 44 years, ranging between 8 and 100 years (Table 3.2). The sale of carbon credits was reported in 10 of the 17 projects, implying that not all generated credits are already marketed, mostly due to difficulties in finding credit buyers. In all cases, cash is either the only payment mode (n=5) or combined together with in-kind payments and the provision of technical assistance in some cases (n=5).

Co-objectives in addition to carbon credit generation are reported in most projects (n = 15). Co-objectives comprise both environmental and socio-economic objectives, such as wildlife and biodiversity conservation, sustainable timber production, reduction of fires, improved health and education for local communities, poverty alleviation, and capacity building.

3.4.2 Transactor characteristics

Project participants are classified into seven groups, consisting of land owners, land users, carbon credit owners, carbon credit buyers, funders, developers, and implementers of whom their origin, (multi-)functionality and organizational type were extensively studied. The origin of participants is specified as either domestic (from the host country) or foreign (from abroad), while their organizational type differs from state to individual farmers and farming community (hereafter farmers), private companies, NGO's, and a mix of the above. Regarding their (multi-)functionality, we examined specifically if land is owned and used by the same party, and how many roles are played by the project developer. Our purpose is to test to what extent having participants playing multiple roles within the project can help reduce TC, for example as a result of reduced communication needs.

Given the complexity of cases where property rights are unclearly defined or absent, considerable effort was invested in classifying the various projects, distinguishing explicitly between land and carbon ownership[18]. Forested land is exclusively owned and used by actors from the host country, with various types of public and private ownership and user rights. Overall, land is mostly owned by the state (36%), followed by land owned by farmers, private companies, and a mix hereof (32%, 19%, and 13% respectively). Land users exhibit a slightly different distribution compared to land owners, with 38 and 11 percent of land used by farmers and state respectively. Private companies and a mix of parties account for 26 percent of the land users. A majority of projects (n=11) reported that the land owners and land users are the same. Projects where this is the case are furthermore found to be less likely to have poverty alleviation as a co-objective. This may be due to the fact that those who are both land owners and users are already better off given their official ownership to the land. Credit owners are defined as individuals or organizations who have the right to transfer or sell the carbon credits and come mainly from the host country, with only one project sharing credits between both domestic and foreign actors. In many cases (n=15), agents who own or use the land also hold the rights over the carbon credits involved.

Carbon credits are sold to either domestic or foreign credit buyers. Private companies buy these credits in 40 percent of the cases, followed by the state and mixed buyers (both 30%). Regarding a project's funding origin, domestic sponsors account for the largest share (n=13) in our sample and funding is often generated from various sources (n=9). In most cases projects are developed by private companies, with 68 percent of the project's developers based in the host countries. More importantly, it is observed that a project developer typically plays three different roles at the same time, and often is also the implementer and co-funder of the project. With regards to past experience, eight projects state that their organization has worked with the participating partners before.

[18] As observed by Bumpus and Liverman (2008: 136), "ownership can take a variety of different forms: a local community may own and use the wood grown in a forest for carbon sequestration, but a foreign investor or project developer may own the carbon reductions (as credits) created through the forest". In many cases landholders are not necessarily the land users since "in many tropical developing countries, the owner and the manager of the land often are not the same", e.g. national governments may own the forest but communities may collectively manage it (Ingram and Wilkie, 2008: 8).

3.4.3 Institutional design characteristics

Projects are distinguished based on the market type to which they belong, i.e. CDM or non-CDM, with the latter accounting for about 60 percent of the total number of projects included in our sample (n=7 and 10, respectively). As can be seen from Table 3.1, while CDM markets only relate to A/R activities, non-CDM markets also include carbon credits generated from avoided deforestation and sustainable forest management.

3.4.4 General project characteristics

The average forested area is 95,990 hectares (varying between 300 and 860,000 ha). These forested areas are reported to help reducing, on average, 8.4 tCO_2 per hectare per year (ranging from 0.8 to 50 tCO_2/ha/year). Variations in the amount of carbon emissions reduction may result from different calculation techniques, for example whether or not the calculation includes all sources of carbon sinks above and below ground. With respect to project location, most projects in our sample are found in Latin-America (n=8), followed by projects launched in Africa and Asia (n=6 and 3 respectively).

3.4.5 Regression analysis

Regression analysis was used to examine the joint effects of the various explanatory factors on the TC. In the regression model, the dependent variable is the total internal TC, i.e. the sum of the TC in the search, design, and negotiation phase measured in person-days per tCO_2. Multi-collinearity between the driving factors was carefully checked. Table 3.3 presents the summary statistics of all variables.

The regression model is captured in Eq. (3.1):

$$y_{ij} = \sum \beta X_{ij} = \beta_0 + \beta^{TRANS} Transaction_{ij} + \beta^{ACTOR} Transactor_{ij} + \beta^{MAR} Market_{ij} + \beta^{GEN} General_{ij} + \beta^{OTHER} Other_{ij} + \omega_{ij} \quad (3.1)$$

In Eq. (3.1), y_{ij} is the vector of TC i from project j and X_{ij} is the matrix of corresponding regressors, consisting of the four aforementioned categories of driving factors. β is the vector of associated effect estimators, with the superscript referring to the group of regressors to which the estimated coefficient belongs. β_0 is the intercept and ω_{ij} is the vector of residual terms, which are assumed to be normally distributed with mean zero and variance σ^2.

Model selection is based on the outcomes of statistical testing procedures related to underlying distributional assumptions and the potentially cross-sectional correlations between multiple observations from the same projects. First, the Shapiro-Wilk statistic was employed to test the normal distribution of the dependent variable. The null hypothesis of a normal distribution was rejected at the one percent level (see Table 3.4). Given the censored nature of the data distribution, a fixed effects Tobit model was considered more appropriate than the Ordinary Least Squares (OLS) or Generalized Least Squares (GLS) model. Overall, factors that are found to have significant influences on the TC (we apply a significance threshold value here of 10% or better) are: the presence of co-objectives, whether carbon credits are sold on the market, past experience collaborating with the project participants, land ownership, foreign and mixed funders, the developer's number of roles, market type, and project area size.

Table 3.3 Overview of variables used in the meta-regression model

Variable	Description	Unit	Mean value	St. Dev.	Min-max values
Dependent variable					
Unit cost	Sum of internal transaction costs incurred in search, design, and negotiation phase	Person-days/tCO_2	0.215	0.647	0 - 2.581
Independent variables					
1) Transaction characteristics					
Project duration	Expected project lifetime	Years	43.412	29.841	8-100
Co-objectives	Dummy variable if the project has other objectives in addition to carbon credit generation (baseline is no co-objectives)	Dummy	0.882	0.332	0-1
Sale of carbon credits	Dummy variable if carbon credits generated from the project have been sold in the market (baseline is if no carbon credits have been sold yet)	Dummy	0.588	0.507	0-1
2) Transactor characteristics					
Past experience	Dummy variable if the project developer has worked with project participants before (baseline is if this is not the case)	Dummy	0.471	0.514	0-1
Farmer is land user	Dummy variable if the project land is used by farmers (baseline is if this is not the case)	Dummy	0.353	0.493	0-1
Foreign funding	Dummy variable if the project is funded by foreign parties (baseline is if this is not the case)	Dummy	0.235	0.437	0-1
Mixed funding	Dummy variable if the project gets funding from various sources (baseline is single source)	Dummy	0.529	0.514	0-1

Land ownership	Dummy variable if the land is owned and used by the same party (baseline is if this is not the case)	Dummy	0.647	0.493	0-1
Developer's number of roles	Number of different roles played by the project developer	Numeric	3.118	1.616	1-5
3) Institutional design characteristics					
Market type	Dummy variable if the project is set up in a CDM (baseline is non-CDM market)	Dummy	0.412	0.507	0-1
4) General project characteristics					
Latin America	Dummy variable if the project location is in Latin America (baseline is elsewhere)	Dummy	0.471	0.514	0-1
Area size	Total project area	Hectare	95990	235454.6	300-860000
Carbon emissions reduction	Carbon emissions reduction per hectare per year of the area	tCO_2/ha/year	8.379	11.820	0.84-50
5) Other characteristics					
External TC	Dummy variable if TC include payments to external organizations (baseline is if this is not the case)	Dummy	0.824	0.393	0-1

Table 3.4 Estimated Tobit fixed and random effects model explaining *internal, external,* and *total* TC

	Tobit fixed effects model						**Tobit random effects model**	
Dependent variable	**Internal TC (Person-days/tCO₂)**		**External TC (US$/ tCO₂)**		**Total TC (US$/ tCO₂)**		**Total TC (US$/ tCO₂)**	
Explanatory variable	Coefficient estimate[a]	Std. err.	Coefficient estimate[a]	Std. err.	Coefficient estimate[a]	Std. err.	Coefficient estimate[a]	Std. err.
Intercept	1.839	0.929	-0.102	0.285	31.797**	9.002	11.569***	3.990
1) Transaction characteristics								
Project duration (years)	-0.003	0.005	-0.001	0.002	-0.102**	0.046	-0.029**	0.013
Co-objectives (yes=1)	0.259***	0.061	0.242***	0.023	3.885***	0.857	1.219***	0.350
Sale of carbon credits (yes=1)	-0.513**	0.217	-0.541***	0.054	-7.606***	2.842	-1.890**	0.922
2) Transactor characteristics								
Past experience (yes=1)	0.484**	0.212	0.966***	0.047	6.041**	2.858	1.530*	0.883
Farmers as land users (yes=1)	0.317	0.273	1.089*	0.055	2.671	2.428	0.582	0.689
Land owner is land user (yes=1)	-1.084***	0.234	-1.669***	0.074	-14.758***	3.227	-4.305***	1.310
Foreign funders (yes=1)	-0.265*	0.169	-0.323**	0.042	-5.779***	1.439	-1.706***	0.506
Mixed funding (yes=1)	-0.299*	0.163	-0.070*	0.041	-3.664*	2.030	-0.793	0.596
Developer's number of roles	-0.115*	0.073	0.021	0.036	-2.258***	0.894	-0.552**	0.251

3) Institutional design characteristics								
Market type (CDM=1)	0.387**	0.170	0.587**	0.029	4.495***	1.772	0.883*	0.492
4) General project characteristics								
Area size (ha)	-5.65e-7*	0.01e-7	-2.52e-7**	0.01e-7	-88.7e-7**	0.01e-7	-34.3e-7**	0.01e-7
Latin-America (yes=1)	-0.009	0.247	0.052	0.080	-3.276	2.184	-0.620	0.638
Carbon emissions reduction (tCO_2/ha/year)	0.005	0.005	0.006	0.001	0.079	0.069	0.012	0.020
5) Other characteristics								
External TC (yes=1)	-0.387	0.426	n/a[b]	n/a[b]	n/a[b]	n/a[b]	n/a[b]	n/a[b]
Model summary statistics								
F	33.00***		78.94***		34.39***		80.14***	
Shapiro-Wilk test	5.105***		4.476***		5.017***		7.365***	
N	17		17		17		51	

*, **, *** statistically significant at 10%, 5% and 1% respectively.

[a] All estimated coefficients except the constant terms are calculated as marginal effects for the expected value of the dependent variable, conditional on being uncensored E(y|y> 0).

[b] The variable "external TC" is not included in these models since the dependent variable in these cases is defined either as the external TC per se or the sum of internal and external TC.

Two of the three factors relating to transaction characteristics were found to have a significant impact on the TC with the coefficient signs matching our a priori theoretical expectations. Projects having co-objectives in addition to carbon generation were observed to increase the TC *ceteris paribus* by 0.259 person-days/tCO_2 compared to the baseline project without co-objectives. Similar results were found in the PES literature where the existence of multiple objectives significantly reduces the effectiveness of ecosystem services delivery (Brouwer *et al.*, 2011). Although having co-objectives induces more TC at project level, this may help generate additional social benefits as well, e.g. enhanced forest governance, capacity building, and equity, and hence increase the overall economic efficiency of the projects at community and national level. Compared with cases where no sales exist yet, TC of projects that trade their carbon credits are *ceteris paribus* 0.513 person-days/tCO_2 lower. The significant negative coefficient between the sale of credits and TC suggests that once credits are traded, *ex ante* TC go down as a result of the diminishing need to search for information and negotiate the terms and conditions of contracts.

Five of the six transactor characteristics were detected to significantly influence TC. Among these, the sign of the coefficients for land ownership and the number of roles played by the project developer reflect our prior expectations. If land is owned and used by the same party, this is found to help significantly reduce TC by 1.084 person-days/tCO_2 compared with the situation where this is not the case (*ceteris paribus*). Similarly, having multi-functional developers will *ceteris paribus* help reduce the TC by 0.115 person-days/tCO_2, most probably as a result of savings on investments in communication and information channels. Contrary to our expectation, past experience was observed to have a positive relationship with TC, with an increase of *ceteris paribus* 0.484 person-days/tCO_2 in the unit cost compared with the situation where there is no previous collaboration. Projects funded by foreign and multiple parties were also unexpectedly found to exhibit lower TC in comparison to the case of domestic and single funders, decreasing the costs *ceteris paribus* by 0.265 and 0.299 person-days/tCO_2, respectively.

With respect to institutional design characteristics, CDM-market-related projects face *ceteris paribus* significantly higher TC of 0.387 person-days/tCO_2 than non-CDM-related projects. This finding matches what has been reported in the literature so far (e.g. see Luttrell *et al.* 2007; Jindal *et al.*, 2008; Palm *et al.*, 2009; Thomas *et al.*, 2010).

Regarding general project characteristics, an increase in forest area by one hectare results *ceteris paribus* in a statistically significant but almost negligible decrease in the unit cost. Finally, project duration, carbon emissions reductions, whether a project is located in

Latin-America or elsewhere, if land is used by farmers, and external payments were all observed to have no significant effects in the estimated regression model.

The results for the external monetary TC (n=17) are similar to the results for the internal TC based on measured labour days. The following explanatory variables were found to exert a significant influence on the external TC: co-objectives, past experience, (CDM) market type, if farmers are the land users, landownership, carbon sales, foreign and mixed funders, and forest area. Among these, the first four variables are positively correlated to the external TC, while the others exhibit a negative correlation. Compared with the case of internal TC, there are two changes in the results relating to the variables "farmer land users" and "developer's number of roles". While the latter has no significant effects, if land is used by farmers is shown to *ceteris paribus* increase external TC by 1.089 US$/t$CO_2$. To test the model's robustness even further, we estimated the Tobit fixed effects regression model also for the total TC, i.e. the sum of the monetary external and the monetized internal TC in US$/t$CO_2$ (n=17). These model results are directly comparable to the models based on the separate cost components in Table 3.4, except for the variable "project duration". Matching our prior expectation, this variable is significantly negatively correlated to TC, where a project that is one year older results *ceteris paribus* in a 0.10 US$ decrease in unit transaction costs. Also, a Tobit random effects model for the total TC was furthermore estimated where we treat the monetary TC across the three phases [19] as separate and independent observations and control for the subsequent panel data structure of the model, i.e. where we account for variations between and within projects. Since there are 17 projects, this yields 51 observations in total. In this random effects model, the project number identifies the panel structure of the data. The results of this latter model are comparable to the model of the total TC with 17 observations, except for the variable "mixed funding", which turns insignificant. Last but not least, in the estimated regression model for the internal TC in Table 3.4 replacing the dummy for the monetary external TC by the actually reported monetary amounts yields essentially the same results."

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[19] Here we also tried to add in the dummy variable "negotiation phase" (baseline is search and design phase). We expect the size of TC to vary depending on the phase where costs occur with no prior expectations as to the direction of influence. Results from the Tobit random effects model showed that whether the TC are incurred during the negotiation phase were observed to have no significant effects in the estimated regression model.

3.5 CONCLUSIONS AND DISCUSSION

In this study, we measured the (private) transaction costs experienced by project developers of 17 forestry carbon projects implemented across Latin-America, Africa, and Asia and endeavoured to determine the driving factors behind these costs using an analytical framework developed specifically for forestry carbon schemes. Given that the forestry sector in developing countries has major potential to contribute to carbon emission abatement, the results of this study are of special relevance for the future design of cost-effective PES scheme in general and carbon forestry projects in particular. We measured TC incurred both inside and outside the organization, indicated as person-days and monetary terms respectively. While the TC in person-days account for activities carried out primarily internally by the project developer (i.e. time spent and personnel involved), the monetary TC mainly comprise cash payments to parties outside the developer's organization and expenses related to communications between the project developer and other project participants. Our approximate estimate for the total TC, i.e. the sum of internal and external TC measured in US$, shows that internal TC account on average for 90% of the total TC. Compared with other studies, for instance Krey (2005)'s estimates for TC associated with the preparation for Project Design Document, searching for buyers, and project validation reported in 65 Indian CDM projects, the average total TC of US$ 3.33/tCO_2 thus extends considerably beyond the range of values between US$ 0.07/tCO_2 and US$ 0.5/tCO_2. This is probably due to differences in the types of estimated TC as well as our smaller data set compared to Krey (2005)'s study. In view of the fact that the operational status varied a lot across projects, with a number of projects still being in the design phase and not yet in an operational phase, we were unable to compare TC with total project costs.

We tested the research question to what extent the magnitude of TC depends on the characteristics of the transaction, transactor, institutional design, and project in general. Remarkably, the three first groups appeared to be the main driving factors explaining the variation in TC between various carbon projects. Among these, market type is an interesting influencing factor. A plausible explanation for this seems to be the inherent difference in project administrative regulation and governing mechanisms of the market within which the project is operated. While the CDM market is essentially based on strict and formalized procedures and standards, e.g. carbon accounting methodology, regulations for project registration, credit verification and certification, the non-CDM market is operated on the basis of voluntary participations in a (more) flexible and informal manner. With regards to the governing mechanism of the CDM market, Bumpus and Liverman (2008: 137) commented that while the CDM governance structure is "hierarchical and highly regulated" parties involved in the voluntary market, in contrast, tend to work more closely with local stakeholders and develop their projects based on horizontal networks.

Contrary to expectations, past experience was observed to have a positive relationship with TC compared with the situation where there is no previous collaboration. A possible explanation may be the limited knowledge transferability, i.e. the ability to utilize knowledge gained from previous experiences that affects how past experience interacts with TC (Coggan et al, 2013). Similarly, foreign and multiple funders were unexpectedly found to have a significantly negative effect on TC, that is, TC are lower when projects receive funding from overseas and various sources.

Equally important, there are several study limitations relating to (i) the limited number of observations, (ii) overlooking other unknown driving factors in the regression model as well as potential interactions between explanatory factors, and (iii) the fact that the TC are based on the project developers' self-reported estimates. The first two limitations may also have played a role in explaining some of the unexpected results, such as the negative impact of multiple foreign funding sources on TC compared to a single domestic funder. These findings cannot be cross-checked in the existing literature, because they have never been tested before, and further investigation is needed to better understand the underlying reasons for these results. Regarding the limited number of observations, this shortcoming is somewhat offset by the fact that projects were included that are considered representative for the current global carbon market. For example, the selected projects are located worldwide (i.e. Latin America, Africa, and Asia) and involve a diverse range of forestry activities, ranging from forest conservation to afforestation and reforestation and sustainable forest management. Both the regulated CDM and voluntary market mechanisms are included, with market transactors varying from state to private company and NGOs. Secondly, possible interactions between independent variables may have been overlooked. For instance, there may be linkages between social capital and past experience, while more frequent transactions can help minimizing behavioural uncertainty (e.g. opportunism) by means of trust and reputation (Rørstad *et al.*, 2007). In the regression model, only uncorrelated explanatory variables were included in order to avoid biased regression results due to multi-collinearity. Hence, concerns about multi-collinearity prevailed over tests of possible interaction effects. The inclusion of too many explanatory factors is also prohibited because of the low number of observations. Last but not least, although surveys are the principal and in many cases only possible data collection approach for TC, the collected survey data can be criticized for being based on respondents' self-reported data and information, which was hard if not impossible to scrutinize by us as researchers (Macher and Richman, 2008). Unfortunately, there exist no secondary, published data on TC of selected projects in order to be able to validate the respondents' answers. To cope with this data quality challenge, it seems paramount to find the right contact persons (financial officer, project manager) and provide them the right incentives to invest their valuable time in looking up the required data and information and not lie about them. Minimum requirements here include a clear explanation of the goals of the study and the benefits to the respondents to participate and a clear definition of the required data and information with follow-up questions or discussions in cases where the provided data and information is unclear. Here different communication tools can be used such as emails and overseas skype calls. The latter are very helpful because they allow the researcher and project developer to see each other, which will help to reduce anonymity between researcher and respondent and create trust that the provided information will be used completely confidential and will not be traced back to individual projects.

To conclude, this study supports the importance attached to incorporating TC into project design evaluation. As stressed by Garrick *et al.* (2013: 184), and following Williamson (1998), "it is not enough to acknowledge that transaction costs matter - it is necessary to incorporate them into empirical analysis", which in turn will support effective decision making. More empirical studies on identifying and measuring TC and their underlying driving forces are very much needed. At the same time, there is a need for an improved and harmonized monitoring system to account for differences in project design and implementation, including institutional terms and conditions, which permits valid and reliable cross-project comparisons, and more systematic detection and better control of influencing factors.

Acknowledgements

The work presented in this paper was funded by the Innovation Research Incentives Scheme (VIDI) of the Netherlands Organisation for Scientific Research (NWO) and the EU F7 project POLICYMIX: Assessing the Role of Economic Instruments in Policy Mixes for Biodiversity Conservation and Ecosystem Services Provision (Grant agreement no. 244065). The authors are grateful to the project developers for their willingness to participate in the survey and share their information with us. We realize this was a time-consuming process, explaining the low response rate. Without this information, this paper would not have seen the light of day. We are also grateful to Mónica Marcela Jaime Torres, César Antonio Salazar Espinoza and Joao Almeida for helping us with the survey translation into different languages. We thank Oleg Sheremet for helping us with the online survey and Nigel Harle of Gronsveld for proofreading the text. The authors bear sole responsibility for the content of the paper.