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Martin-Ortega, J orcid.org/0000-0003-0002-6772, Dekker, T orcid.org/0000-0003-2313-8419, Ojea, E et al. (1 more author) (2019) Dissecting price setting efficiency in Payments for Ecosystem Services: a meta-analysis of payments for watershed services in Latin America. Ecosystem Services, 38. 100961. ISSN 2212-0416

https://doi.org/10.1016/j.ecoser.2019.100961

Dissecting price setting efficiency in Payments for Ecosystem Services: a meta-analysis of payments for watershed services in Latin America

Abstract

Despite the increasing scholarly attention that Payments for Ecosystem Services (PES) are receiving, little is yet known about the process of price setting. This is key knowledge that relates directly to the economic efficiency of an instrument that is spreading widely worldwide. Through a meta-analysis of payments for forest watershed services in Latin America, this study finds that there exists a very substantial difference between the price that buyers pay and that sellers receive for ecosystem services and that this difference is not due to transaction costs. Instead, it reveals a substantial subsidising component. Our results would suggest that this discrepancy in prices might be due to the 'start-up' effect and that as programmes mature, this effect is may attenuate. However, the entry of new buyers does not make over for the subsidization of schemes and would require the implementation of specific mechanisms to adjust prices. According to our results, one of such possible mechanisms would be to increase participation on price setting processes, allowing for more price negotiation between parties rather than the predominant top-down approach.

Keywords: forest, market-based instruments, PES, random effects, Tobit

1. Introduction

Payments for Ecosystem Services (PES) are being increasingly promoted in environmental governance (Salzman et al., 2018) under the expectation that pricing ecosystem services might increase the economic efficiency of their management (Pirard, 2012; Wunder, 2015). They were originally advocated for situations in which an environmental externality can be redressed through the creation of ad-hoc markets, based on the Coasean postulate by which the social optimum might be attained via bargaining (Engel et al., 2008; Wunder, 2005). This theoretical basis created the expectation that PES could offer certain advantages over other policy instruments for conservation. For example, PES have been described as more efficient and appropriate than command-and-control measures in weak governance settings (Engel et al., 2008; Wunder, 2015); and have often been assumed to be cost-effective mechanisms to provide public goods (Gómez-Baggethun and Muradian, 2015; Jack et al., 2008). Expectations exist that PES might unlock new or alternative funding opportunities for conservation (Sandbrook et al., 2013; Waylen and Martin-Ortega, 2018). At the same time, PES have provoked emphatic criticism (Chan et al., 2017; Gómez-Baggethun and Muradian, 2015; Muradian et al., 2013). Central to this criticism is the concern about converting nature into a tradable commodity (Brockington, 2011; Gómez-Baggethun and Ruiz-Pérez, 2011; Kosoy and Corbera, 2010; Martin-Ortega et al., 2019) and the crowding-out of not-for-profit conservation initiatives (McCauley, 2006; Rode et al., 2015), that have been associated with a broader agenda for the neo-liberalization of nature conservation (Fletcher and Büscher, 2017; Mcafee, 2012; Sandbrook et al., 2013).

An important part of the PES literature has placed its focus on their very conceptualization, i.e. what is to be considered a PES and what not (Martin-Ortega and Waylen, 2018; Schomers and Matzdorf, 2013; Wunder, 2015) and what criteria should be used to define PES schemes (Muradian et al., 2010; Muradian and Gómez-Baggethun, 2013; Van Hecken et al., 2015). This has led to multiple alternative definitions (Martin-Ortega and Waylen, 2018; Wunder, 2015) and propositions of various forms of PES types (Van Hecken et al., 2015; Vatn, 2010). Scholars have also discussed the effects of PES with respect to environmental effectiveness (Grima et al., 2016; Pattanayak et al., 2010; Porras et al., 2012; Salzman et al., 2018), equity implications (Corbera et al., 2007; Farrell, 2014; Pascual et al., 2014; Wunder, 2008) and their ability to align environmental and social goals (Muradian et al., 2010; Noordwijk et al., 2007; Pirard et al., 2010). Varying proposals on how to improve PES design and implementation practice have also been made (Chan et al., 2017; Reed et al., 2017; Salzman et al., 2018).

The public or private nature of PES financing has been thoroughly discussed, with scholars having clearly established that a very large part of existing PES schemes are government financed mechanisms (Schomers and Matzdorf, 2013; Vatn, 2010). We also know that in many PES schemes prices are set in top-down decision processes with little direct intervention of buyers and sellers in bargaining prices (Martin-Ortega et al., 2013; Porras et al., 2012). However, little is yet known about price setting processes and what factors affect those. This is key knowledge that relates directly to the instrument's economic efficiency. Inefficiencies are naturally expected to be present in newly created markets, but knowledge on what

determines them in the context of PES and whether they can be expected to be reduced with time is still missing.

This paper contributes to addressing this gap by conducting the first meta-analysis of price differences in PES schemes, using data from 121 of transactions for watershed services from forests in Latin America. We focus on watershed schemes as the most mature and in Latin America as one of the pioneer regions in their implementation (Salzman et al., 2018). The remainder of this paper is organized as follows. In section 2, the data collection and database structure are described and the modelling approach is presented. Section 3 shows the results of the meta-regression and Section 4 discusses them. Conclusions are drawn in Section 5.

2. Data and Method

2.1. Data collection and database structure

A database of payments for ecosystem services transactions was constructed with information from 38 forest watershed schemes in ten Latin American countries, published up to 2012. By transaction we refer to a specific payment arrangement within a scheme, of which there can be more than one, for example if a different payment is established depending on the type of intervention, type of forest or ground slope (Martin-Ortega et al., 2013). Studies were selected from both the peer-reviewed and the grey literature, where a large part of the PES evidence is reported (Engel et al., 2008; Porras et al., 2012).

Relevant literature was identified via computerised searches, using the terms 'water', 'ecosystem service(s)', 'environmental service(s)', 'watershed service(s)', and 'water service(s)' in English, Spanish and Portuguese. These terms were entered both individually and in combination with the terms 'payment(s)', 'contract(s)', 'compensation' and 'fund(s)'. The abstracts of articles and reports identified through these keywords were reviewed, and articles matching the search criteria were examined in their entirety. Reference lists were scanned for other relevant articles. When the schemes have experimented changes since the publication of the paper and updated information was available, this was incorporated in the database. The references and some summary information on the studies analysed here can be found in the Appendix. Further detailed description of these studies can be found in Martin-Ortega et al. (2013).

The database comprises a total of 307 observations (i.e. distinct payment transactions). A preliminary descriptive statistical analysis of these monetary transactions published in Martin-Ortega et al. (2013) showed that seller's average receipts are, on average, 60% larger than buyer's average payments, suggesting large inefficiencies are present in the price setting process. The database was then prepared to dissect such price differences by regressing the observed differences between buyers' payments and sellers' receipts.

Of the 307 observations, 209 contained monetary information on buyers' payments. These payments were expressed in different units (e.g., monetary units only, monetary units per hectare, per year or per m^3), and only for 154 transactions (49.7%) the information was available in (or could be converted into) monetary units per hectare per year. Monetary

information about the payments received by sellers was available for 207 transactions, and in more than half of the cases (66.8%) it was expressed in (or could be converted into) monetary units per hectare per year. Transactions for which there were monetary information for both buyers' payments and sellers' receipts amounts to 121. This is the final number of observations that we can use in our analysis of price differences. Hence, from the original set of 38 schemes, we can retain 14 corresponding to schemes in Bolivia, Costa Rica, Guatemala, Honduras and Nicaragua.

Our data is unbalanced by country and study, with the highest numbers of transactions taking place in Costa Rica (87) and Honduras (24), and to a lesser extent in Bolivia (8), Guatemala (1) and Nicaragua (1). Because one same PES programme can contain several transactions, our database has a nested structure. Monetary values are expressed in 2016 USD per hectare per year.

2.2. Modelling approach

To account for different schemes contributing multiple transactions where the number of transactions varies across schemes, the meta-analysis is specified as a random effects model. The random effects partition unexplained variation into systematic variation across schemes and residual variation across transactions within schemes. Our dependent variable y_{it} refers to the absolute difference between buyers' payments and sellers' receipts as reported in the studies (converted into 2016 USD per hectare per year) in scheme i for transaction t. Absolute values were considered to give a better insight into the drivers of price (in)efficiencies since it avoids the risk of averaging out effect sizes between positive and negative differences between buyer and seller prices. The direction of the effect, is however, accounted for in the analysis. This results in the following regression equation:

$$y_{it} = c + x_{it}\beta + \nu_i + \epsilon_{it} \qquad (1)$$

Where c is the regression constant, x_{it} is a vector of explanatory variables (i.e. properties of the respective scheme), β captures the corresponding parameters to be estimated, ν_i denotes the schemes random effect component at the study level, and ϵ_{it} represents the regression error term which is assumed to be identically and independently distributed across transactions.

Since our dependent variable is left-censored at zero, due to working with absolute differences, and 9.1% of our observations are at or close to that censoring point, we estimate a random effects Tobit model (Tobin, 1958) instead of a traditional random effects regression model where a latent variable y_{it}^* is defined such that:

$$y_{it} = \begin{cases} y_{it}^* \; if \; y_{it}^* > 0 \\ 0 \; if \; y_{it}^* \leq 0 \end{cases}$$

A set of variables were included to control for various effects possibly affecting price differences in our dataset. One of the big risks when running meta-regressions is to over fit the

data with dummy variables characterizing the underlying studies. In other words, the risk of multicollinearity and picking up spurious effects is present due to accommodating for individual transactions. To this end, it is important to include at least one continuous variable in the model to help scaling the model. The central continuous variable in the model used here is the amount sellers receive. We expect that this variable is associated with size effects. It can be expected that when the payment itself becomes bigger, the price difference with respect to the buyers increases accordingly. Indeed, we find a high correlation of 0.90 between these two variables. To account for this size effect, two interactions terms were included, one for positive and one for negative differences. We label the resulting variables as 'Negative Differences' and 'Positive differences', respectively.

Finally, we include the dummy variable 'Costa Rica' controlling for the larger number of observations coming from this country. We initially included dummy variables for the other countries in the dataset, but did not find any significant effects.

The model has been estimated in STATA 13.

3. Results

3.1. Price difference between buyers and sellers payments

In only 8 cases (6.6%), we observe no difference between what buyers pay and what sellers receive. For 20 transactions (or 16.5%) we find a positive difference between what buyers pay and what sellers receive. In the remaining 93 transactions (76.9%), i.e. for the majority of the transactions, buyer payments are lower than seller receipts.

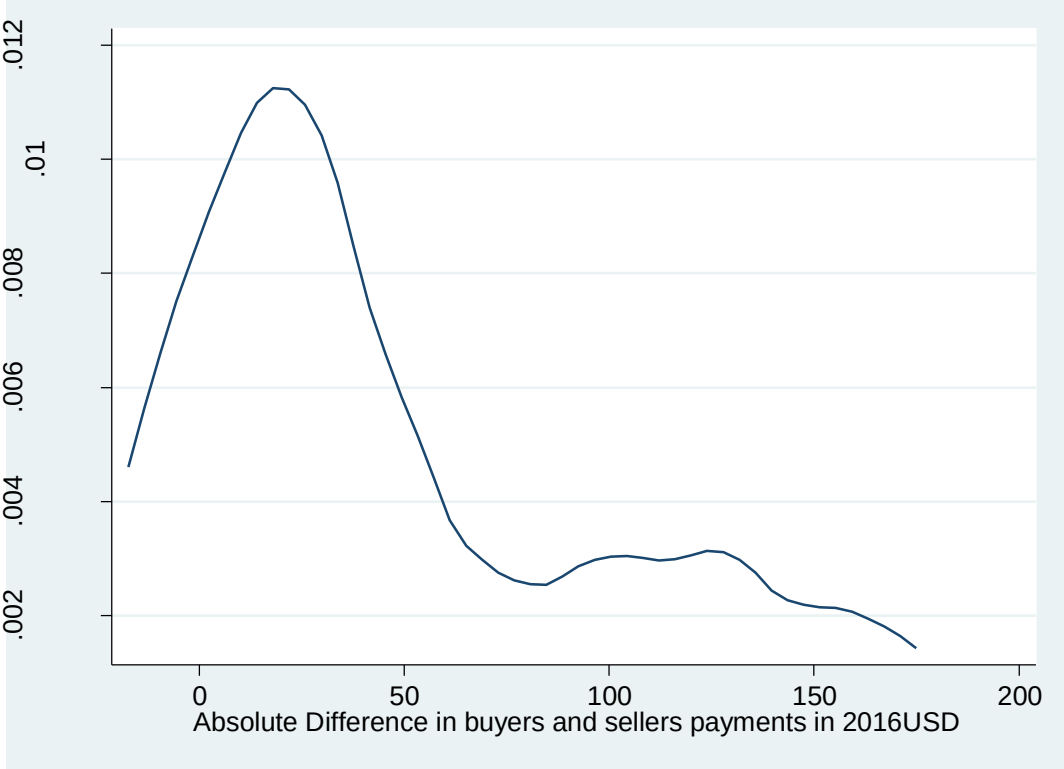
Table 1 provides the descriptive statistics for the observed differences between buyer and seller prices. Figure 1 depicts the (smoothed) kernel density plot of the absolute price differences, showing that the distribution is positively-skewed. There are indeed numerous transactions (25.6%) where the difference between what the buyers pay and sellers receive is greater than 100 $/year. Notably, only in Costa Rica the differences are positive (i.e. sellers pay more than buyers receive), and this is also the country where there is the largest spread in differences. The opposite effect (sellers paying less than buyers) is particularly large in Nicaragua. The next subsection presents the results of the regression models of these price differences.

Table 1. Price difference between buyers and sellers payments (N= 121) in 2016 USD/ha/year*

	Real differences	Absolute differences
Mean	-45.77	48.58
Std. deviation	52.82	50.23
Maximum	22.41	157.60
Minimum	-157.60	0.00

*Prices converted from local currencies to USD and updated to 2016 prices using World Banks' Consumer Price Indexes (World Development Indicators: http://data.worldbank.org/indicator/FP.CPI.TOTL.ZG).

Figure 1. Density plot of the absolute difference in buyers and sellers payments (N=121)



3.2. Factors affecting price differences

Table 2 presents the descriptive statistics of the variables that have been found to significantly affect price differences between buyers and sellers. The variable 'Stage' refers to the various stages (or reforms) a scheme has gone through. Reforms can refer to redefinitions of the good or service under consideration (e.g. primary rather than secondary forests) or enlargement of the area under contract, among others. 'Top Down' is a dummy variable capturing whether the

price-setting is established through top-down decisions or whether it is the result of the negotiation between participants. The variable 'New Buyer' captures whether new buyers have entered the market with respect to the start of the program.

Table 2 also shows the descriptive statistics of the country control variable 'Costa Rica' and the two interaction terms that have been included to control for size and sign effects (i.e. 'Negative Differences' and 'Positive Differences'). The effects of these variables in the price differences between buyers and sellers are shown in the Tobit regression results in Table 3.

Table 2. Descriptive statistics of independent variables

Variable	Mean	Std. Dev.	Min	Max	Description
Negative Differences interaction term	66.09	69.10	0	173.37	Amount received (in 2016 USD/year per hectare) by sellers when difference in payments between buyers and sellers is negative
Positive Differences interaction term	10.69	24.25	0	68.94	Amount received (in 2016 USD/year per hectare) by sellers when difference in payments between buyers and sellers is positive
Costa Rica	0.72	0.45	0	1	Dummy variable that takes a value of 1 when the scheme is in Costa Rica
Stage	3.62	2.24	1	7	Number of stages in a scheme, i.e. number of times a scheme has undergone a change or reform
Top Down	0.84	0.37	0	1	Dummy variable that takes a value of 1 when the price is set up as a top-down decision
New Buyer	0.17	0.37	0	1	Dummy variable that takes a value of 1 when a new buyer arrives

Table 3 shows that there is indeed a size effect on sellers' receipts in the presence of price differences, as indicated by the statistically significant positive effects of the two interaction terms on the absolute differences (i.e. the more money the seller receives, the larger is the difference with the buyers' payments).

Factors that positively affect price differences include whether payments are decided in top-down decision processes and the introduction of new buyers. On the contrary, an increased number of stages that the scheme undergoes reduces price differences. The implications of these results are discussed next.

Table 3. Random effects Tobit meta-*regression of difference between buyers and sellers'* payments (absolute values)

Explanatory variables	**Coefficient (SE)**	**z**	**p-value**
Negative Differences interaction term	0.794	25.83	<0.001 ***
	(0.307)		
Positive Differences interaction term	0.336	4.23	<0.001 ***
	(0.079)		
Costa Rica	-17.863	-3.13	0.002 ***
	(5.705)		
Stage	-2.232	-2.33	0.020 *
	(0.956)		
Top Down	16.621	3.22	0.001 **
	(5.161)		
New Buyer	14.242	3.98	<0.001 ***
	(3.577)		
Constant	-5.843	-1.08	0.280
	(5.414)		
Random effects			
	Coefficient (SE)		
σ Scheme	5.704 (2.807)		
ρ	0.184 (0.154)		
Model Summary Statistics			
Log-Likelihood	-448.705		
Number of observations	121		
Number of groups	14		

*** significance at the 1‰ level; ** at the 1% level; * at the 5% level.

4. Discussion

Only in a perfect world, an efficient Coasean market would see no differences between buyers and payments sellers. In reality, one might expect higher values for buyers than sellers. This positive difference between what buyers pay and what sellers receive would be attributed to transaction costs, e.g. expense of negotiating contracts, performing scientific baseline studies, and monitoring and enforcement, (Jack et al., 2008). Our results show only a small proportion of transactions with higher prices for buyers than sellers. Low transaction costs in PES for watershed services have been attributed to the presence of pre-existing institutions, such as water utilities, which already have mechanisms for collecting fees from beneficiaries without increasing transaction costs (Salzman et al., 2018). However, other evidence indicates that the role of water utilities as intermediaries in Latin America is marginal compared with that of NGOs (Martin-Ortega et al., 2013), which could have been expected to generate transaction costs to fund their own operations. In whichever case, we observe instead a substantial subsidizing component towards the sellers of watershed services, with most of the transactions

analysed here displaying greater sellers' receipts than buyers' payments. This is consistent with observations that have been made on individual schemes. For example, this has been for long the case of the famous Costa Rican Pago for Servicios Ambientales programme, which received World Bank's loans and contributions from different national and international organizations (Pagiola, 2008; Pagiola and Platais, 2007). Which begs the question: to what extent this is driven by initial mark-ups by scheme promotors to get the market off the ground, i.e. to make it attractive for suppliers to sell their services and establish the market, or to other factors? Our analysis can provide some answers to that.

Firstly, schemes that have more stages, i.e. that have undergone change and adapted in time, have lower price differences between buyers and sellers. This could be interpreted as that as schemes mature, price setting becomes more efficient, i.e. schemes that have undergone an evolution process or reforms have better adjusted prices between buyers and sellers. This is also related to temporal evolution: we get the same effect using a variable 'Transaction year', made of the difference between the year when the transaction takes place with respect to the start year of the programme, i.e. as more time passes since the start of the scheme, prices between buyers and sellers are more adjusted.

On a similar vein, it could have been expected that as new beneficiaries enter into the schemes as buyers, the subsidizing effect from external sources would have been reduced with the new buyers taking over the payment from the schemes' promotors (Pagiola, 2008). However, we find that the entry of new buyers actually has a statistically significant positive effect, i.e. it increases the price differences between buyers and sellers, rather than decreasing it. As the market expands with new buyers, one could have expected transaction costs to be reduced as they get distributed across a larger base (Kraft et al., 2013), but there is no clear explanation as per why, instead, positive price differences increase. What this would indicate, in any case, is that while first movers driving the rapid increase of PES for watershed services may have contributed to developing institutions, expertise and market infrastructure and to broadening the base of political support (Vogl et al., 2017), they have not yet managed to make them independent from promotors' subsidizing contribution despite the entry of new buyers.

Results also show how price discrepancy between buyers and sellers in these watershed PES transactions is larger for settings in which the price is established in top-down decisions. The Coasean basis at the origin of PES stipulates that externalities can be overcome through private negotiation between affected parties (Coase, 1960). If, as it has been suggested (Porras et al., 2012; Tacconi, 2012), the seller only has the option to accept or decline entry, but cannot negotiate the price, or if the buyer has taxes or fees imposed upon them in governance financed schemes, then the principle of bargaining amongst parties is not met. It has been argued that greater stakeholder participation in PES crafting rules may limit PES to bespoke schemes with high transaction costs (Martin-Ortega and Waylen, 2018) . However, our results would indicate that top-down price setting processes are less efficient than those in which the parties are left to negotiate. One such alternative to top-down price setting processes are conservation auctions, where the buyer invites bids from potential sellers and then buys from the lowest bidder (Leimona and Carrasco, 2017) and which have been trialled to increase economic efficiency of ecosystem services transactions (Rolfe et al., 2017). There are, of course, many

socio-institutional factors that influence the performance of conservation auctions (or any other form of party negotiation), and that would affect their economic efficiency, such as facilitation, leadership, networks, self-efficacy (Leimona and Carrasco, 2017) and information asymmetries (Ferraro, 2008). Furthermore, costs of negotiating may be prohibitively high when large numbers of dispersed buyers attempt to buy ecosystem services from a large number of potential suppliers (Scheufele and Bennett, 2017). Obviously, direct price negotiation arrangements also need to be weighted in the broader context of franchise equity and power (a)symmetries (Farrell, 2014), where both parties may or may not have the same capacity of influencing the process.

There were a number of variables for which we had expectations of having an effect on price differences that we could not test due to lack of sufficient observations or to multicollinearity. Lack of sufficient reporting on the details of PES schemes have already being noted as important impediments to furthering our understanding of these schemes (Jack et al., 2008; Martin-Ortega et al., 2013; Salzman et al., 2018). We believe some of these variables might have indeed revealed valuable information. For example, with respect to the effect of (the presence of) an intermediary in price differences. One or various intermediaries are present in many PES schemes globally (Schomers et al., 2015) - in our database specifically, 81.6% of the schemes have an intermediary (Martin-Ortega et al., 2013). Intermediaries play diverse roles in facilitating transactions between buyers and sellers (Huber-Stearns et al., 2013) and have been identified as being key to understanding PES performance (Muradian et al., 2010). We found that there is a significant positive correlation between the presence of an intermediary and the price difference (0.480). Further investigation would be needed to determine if there is causation and how to separate this effect from the effect of other control variables currently in the model. We speculate that, in the case where a subsidy is occurring, the intermediary might be in part responsible for it. Further research may also provide corroborating evidence of intermediaries reducing transaction costs and increasing cost-effectiveness (by reducing information asymmetries and better connecting the parties), as has been suggested by institutional analysis on PES performance (Schomers et al., 2015).

Lessons from previous experiences on incentive-based mechanisms also show how the properties of the ecosystem services targeted in a PES scheme interact with the policy design (Jack et al., 2008). We would have therefore liked to test if the type of ecosystem services (e.g. provisioning or regulating services) also has an effect in price setting efficiency, but this was not possible with the available data.

5. Conclusions

Current discussions on PES have so far not placed enough attention on an aspect critical to their operation in practice: price setting. What is the current status of price setting processes and what factors affect them is essential knowledge, as it directly relates to the economic efficiency of the instrument. This is relevant to the debate on whether payments for watershed services are or will become, in the long-run, fundamentally different from pre-existing incentive-based mechanisms, such as taxes or subsidies, and therefore if anything different can be expected from them.

Through a meta-analysis of payments for forest watershed services in Latin America, this study has established that there exists a very substantial difference between the price that buyers pay for forest watershed services and the payments that sellers receive for the provision of those services in many of the schemes for which information is available. For the vast majority of them, this difference corresponds to greater seller's receipts than buyers payments, i.e. they are not transaction costs, but on the contrary, reveal a substantial subsidizing component. Our results suggest that part of the current discrepancy in prices might be due to the 'start-up' effect, i.e. the effect of money that is being introduced into the schemes as a means to get them started. As programmes mature and evolve, this effect is likely to attenuate, with schemes that have gone through a number of changes displaying lower discrepancies. However, based on the evidence that we could gather, the entry of new buyers does not make over for the subsidization of schemes and would require the implementation of specific mechanisms to adjust prices. According to our results, one of such possible mechanisms would be to increase participation on price setting processes, allowing for more price negotiation between parties rather than the predominant top-down approach (power asymmetries problems and other socio-institutional aspects aside).

As any meta-analysis, this study is limited by the quality and availability of the underlying information and results can only be referred to the set of studies analysed here. There were also a number of relevant hypotheses that could not be tested. Exploring the role of intermediaries in reducing market asymmetries and increasing efficiency seems to be a key aspect considering the predominant presence that these have in existing schemes and one that would require further attention. Whether the lessons learnt here also apply to some other of the most extended payments for ecosystem services, namely biodiversity and habitat PES and forest and land-use carbon markets (Salzman et al., 2018), would also require further investigation. As these schemes are further studied and documented, further analysis will become possible, but for that, it is crucial that the information on them is more systematically recorded, and importantly, that more attention is paid to the so far largely disregarded issue of price setting.

Acknowledgements

Authors are grateful to Martin Dallimer and Rosalind Bark for enriching comments to an earlier version of this paper. The authors acknowledge the support of the 'Shut up and Write' writing club and the Women's Writing initiative of the Faculty of Environment of the University of Leeds.

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Appendix

Details of studies analysed

References*	Study year	Country	Site	Scale	Targeted service	Sellers	Buyers
(Robertson and Wunder, 2005)	2005	Bolivia	Los Negros	Local	Extractive quantity	Landowners	External donor, local NGO, municipality
(Asquith and Vargas, 2008)	2007						
(Robertson and Wunder, 2005)	2005	Bolivia	La Aguada	Local	Extractive quality and quantity	Landowners, farmers	Water cooperative, local NGO
(Rojas, M. and Aylward, 2003)	2003	Costa Rica	Volcán, Don Pedro/San Fernando	Local-national	In-stream, damage mitigation	Landowners	Hydropower producer
(Pagiola, 2008)	2007						
(Blackman and Woodward, 2010)	2010						
(Rojas, M. and Aylward, 2003)	2003	Costa Rica	Platanar	Local-national	In-stream, damage mitigation	Landowners	Hydropower producer
(Pagiola, 2008)	2007						
(Rojas, M. and Aylward, 2003)	2003	Costa Rica	Monteverde	Local	In-stream, damage mitigation	Local NGO	Hydropower producer

(Corbera et al., 2007) **(Barrantes and Gomez, 2007)**	2007	Costa Rica	Rio Segundo	Local-national	Extractive	Farmers	Domestic and other commercial users
(Rojas, M. and Aylward, 2003) (Porras and Neves, 2006)	2003 2006	Costa Rica	Rio Aranjuez	Local-national	All services, instream quality and quantity	Landowners	Hydropower producer
(Pagiola, 2008)	2007						
(Rojas, M. and Aylward, 2003) (Porras and Neves, 2006)	2003 2006	Costa Rica	Rio Balsa	Local-national	All services, instream quality and quantity	Landowners	Hydropower producer
(Pagiola, 2008)	2007						

(Rojas, M. and Aylward, 2003) (Porras and Neves, 2006)	2003 2006	Costa Rica	Rio Laguna Cote	Local-national	All services, in-stream quality and quantity	Landowners	Hydropower producer
(Pagiola, 2008)	2007						
(Pagiola, 2008)	2007	Costa Rica	National	National	All services	Landowners	Several hydropower producers, domestic and commercial water users, farmers, recreation
(Corbera et al., 2007)	2006	Guatemala	Las Escobas (Cerro San Gil)	Local	Extractive, in-stream, damage mitigation	National NGO	Domestic water users, hydropower
(Kosoy et al., 2007)	2004	Honduras	Jesús de Otoro	Local	Extractive, quality	Farmers	Domestic water users
(Kosoy et al., 2007) (Martinez Tuna, 2008)	2004	Nicaragua	San Pedro del Norte	Local	Extractive, quality and quantity	Landowners	Domestic water users