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ORIGINAL STUDY

The valuation of forest carbon services by Mexican citizens: the case of Guadalajara city and La Primavera biosphere reserve

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Abstract Adequate demand for, and recognition of, forest carbon services is critical to success of market mechanisms for forestry-based conservation and climate change mitigation. National and voluntary carbon-offsetting schemes are emerging as alternatives to international compliance markets. We developed a choice experiment to explore determinants of local forest carbon-offset valuation. A total of 963 citizens from Guadalajara in Mexico were asked to consider a purchase of voluntary offsets from the neighbouring Biosphere Reserve of La Primavera and from two alternative more distant locations: La Michilía in the state of Durango and El Cielo in Tamaulipas. Surveys were applied in *market stall* sessions and online using two different sampling methods: the snowball technique and via a market research company. The local La Primavera site attracted higher participation and valuation than the more distant sites. However, groups particularly interested in climate change mitigation or cost may accept cost-efficient options in the distant sites. Mean implicit carbon prices obtained ranged from \$6.79 to \$15.67/tCO$_{2eq}$ depending on the surveying methodology and profile of respondents. Survey application mode can significantly affect outcome of the experiment. Values from the market stall sessions were higher than those from the snowball and market research samples obtained online; this may be linked to greater cooperation associated with personal interaction and collective action. In agreement with the literature, we found that valuation of forest carbon offsets is associated with cognitive, ethical, behavioural, geographical and economic factors.

Keywords Stated preference methods · Market mechanisms · REDD+ · Environmental services · Choice modelling

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Introduction

Given the public nature of environmental services, markets often fail to recognize their value, resulting in losses of the environmental assets providing the services (e.g. Bator 1958; Samuelson 1954; Landell-Mills and Porras 2002; Stern 2006). Public interventions and institutional arrangements are required to correct this policy failure and reconcile supply and demand of the services (Pagiola et al. 2003). Market-based mechanisms inspired by Coasean bargaining have emerged as new cost effective governance tools to deal with environmental problems (Coase 1960; Voss 2007).

Market mechanisms for environmental services, such as carbon sequestration in forests, may work better if they are, at least in part, private goods, creating some rivalry and excludability (Samuelson 1954; Farley 2010; Koellner et al. 2010). The Kyoto Protocol created a market for certified emissions reductions (CERs) from afforestation and reforestation projects under the Clean Development Mechanism. A global programme is also under development through the UNFCCC to reduce emissions from deforestation and forest degradation (REDD+) where market mechanisms can be implemented (UNFCCC 2009, 2010, 2011). Demand for CERs has been created through the obligation on Annex I countries of the Kyoto Protocol to reduce emissions; however, demand for offsets is weakened by difficulties in reaching new emission reduction targets for the post 2012 period. This is particularly critical for carbon sequestration credits since these are considered temporary CERs. New market mechanisms are being developed, including domestic schemes in developing and emerging countries, and compliance markets under domestic laws in developed countries (Perdan and Azapagic 2011; Sterk and Mersmann 2011). Technical understanding and political support are required to harmonize the existing and emerging schemes (Perdan and Azapagic 2011).

Parallel to international compliance markets, demand for carbon offsets has also developed in private voluntary markets (Hamilton et al. 2007). Momentum created by REDD+ negotiations under the UNFCCC has promoted an increase of the share of forest-related projects in this market from 8 in 2009 to 25 MtCO$_{2eq}$/year in 2010 (Peters-Stanley et al. 2011), with these carbon credits now commanding a 43 % share. Voluntary carbon markets as a whole are currently small, representing only 0.3 % of total carbon traded (Ziegler et al. 2012); however, they send an important signal on actions needed to mitigate climate change (Linacre et al. 2011). International negotiations have been slow to develop an effective climate policy, but citizens can undertake immediate individual actions to mitigate climate change (Solomon and Johnson 2009). However, individuals are largely unaware of offsetting as a means to mitigate climate change (Ziegler et al. 2012).

Study of demand for carbon, and other environmental services, is a critical area of research for design and successful implementation of policies geared towards funding forest conservation. In particular, market mechanisms based on predictable demand might increase the chances for successful implementation (Pagiola et al. 2003). The research presented here focuses on citizen valuation of forest carbon services in order to identify potential drivers for demand of carbon offsets and participation in voluntary markets. We developed a choice experiment that was applied to citizens of the Mexican city of Guadalajara.

They were asked to consider offset purchase from the nearby Biosphere Reserve of La Primavera in competition with two alternative forest locations. The experiment had three objectives: firstly, to assess how individual profiles of citizens were related to valuation of carbon offsets; secondly, how alternative project locations were valued; and thirdly, to examine how mode of application of the survey affected valuation. The paper is organized as follows: firstly, the literature on valuation of climate change efforts and forest carbon services is reviewed followed by a description of the context of our case study. Secondly, the methodology and survey procedure are presented followed by results and discussion; and thirdly, in the final section, we give our conclusions.

Literature review

Valuation of climate change mitigation

Integration of societal preferences into climate policy is an important challenge (Diederich and Goeschl 2011), and a number of studies have addressed public valuation of climate change mitigation and emissions reductions. Johnson and Nemet (2010) review 27 published studies exploring willingness to pay (WTP) to mitigate climate change. Most of these used the contingent valuation method (CV). The range of WTP figures, standardized by Johnson and Nemet to present the information at the household level, ranges from $22 to $437 per year (median $135). WTP values presented in some of these studies on a carbon basis show values ranging from $5 to $28.6 (Lu and Shon 2012), €25 (Brouwer et al. 2008), £24 (MacKerron et al. 2009) or €47 (Akter et al. 2009) per ton of carbon dioxide (CO$_{2eq}$). Nevertheless, these estimates need to be treated with caution due to possible bias of WTP in stated preference methods, and also because many of these studies targeted non-representative sectors of the society with surveys based on current carbon prices (Diederich and Goeschl 2011). Moreover, most of the studies reviewed by Johnson and Nemet (2010) came from developed countries and higher income groups, mainly in the United States and Europe, with another group of studies from Asia (Japan, Taiwan, South Korea and China).

In a CV study applied in Turkey at household level, Adaman et al. (2011) estimate that for payments of 20 Turkish Lira, there was a 65 % likelihood that the respondents would contribute to climate change mitigation by reducing energy-related emissions. Carlsson et al. (2010) developed a valuation study targeting ordinary citizens in the US, Sweden and China. Their results show that Chinese citizens may be willing to pay $8.32 monthly per household for a 60 % reduction in GHG emissions

(purchase parity power US dollars). This is a lower WTP compared to US and Swedish citizens ($27.9 and $39.5 respectively); however, the share of WTP in relation to household income is similar in China and US, though both of these are lower than in Sweden (Carlsson et al. 2010). To the best of our knowledge, there are no comparable studies valuing the benefits of forestry-based climate change mitigation in México or Latin America.

Valuation of forest carbon services

The studies reviewed by Johnson and Nemet (2010) focused on valuation of climate change mitigation. However, they cover different ways of achieving this, including development of green electricity (e.g. Ethier et al. 2000; Bergmann et al. 2006), reduction in climate change impacts (e.g. Berk and Fovell 1999; Cameron 2005), US ratification of Kyoto Protocol (Berrens et al. 2004; Li et al. 2004), general reduction in emissions (Carlsson et al. 2010), general emissions offsets (Brouwer et al. 2008), certified offsets and co-benefits (MacKerron et al. 2009), preservation of vulnerable species (Tseng and Chen 2008) and the use of ethanol as biofuel (Petrolia et al. 2010). Only the study of Layton and Brown (2000) was related to valuation of forests. These authors assessed the WTP for mitigation of climate change and reduction in the threat of losing vulnerable forested areas and included forestry-based mitigation action as means to do this. Their results show that a population in the US (Denver, Colorado) perceived a cost in the loss of forests as a consequence of climate change (−$11.6 to −$98.5 depending on the extent and time horizon of the loss) and had a positive posture regarding use of forest-based strategies as means of mitigation ($11.5). Brey et al. (2007) developed a choice experiment to value Spanish forests, including carbon services, and showed that respondents from Catalonia would pay €11.79 annually to finance a programme resulting in sequestration of 68,000 tCO_{2eq}. Koellner et al. (2010) used contingent valuation to explore the WTP of national and international firms in Costa Rica for different environmental services, including carbon sequestration, under a scheme of payments for environmental services (PES). Demand for carbon services amongst participants in their study (60 firms) was around 819 km^2 of forest for carbon sequestration in rainforests at a yearly payment of $65 per hectare (Koellner et al. 2010). These studies provide insights into valuation of forest carbon services; however, it is difficult to infer demand side valuation of carbon sequestration from them in terms of carbon ($/$tCO_{2eq}$).

Other studies have valued carbon sequestration services in forests and from reforestation/afforestation practices using different approaches, but mainly focusing on the supply side by estimating provision costs and willingness of landowners to participate in carbon markets (e.g. de Jong et al. 2000; Richards and Stokes 2004; Brainard et al. 2009; Balderas Torres et al. 2010; Markowski-Lindsay et al. 2011). While figures based on these approaches are necessary to estimate the potential provision of carbon sequestration, they need to be complemented with studies of the potential demand to evaluate the feasibility of market-based mechanisms.

Demand side drivers of WTP for climate change mitigation

The most frequently cited explanatory variables of WTP in the studies reviewed by Johnson and Nemet (2010) relate to: environmental engagement, attitudes and beliefs, education, and perceived efficacy of the proposed policies. Other studies also report that WTP for climate change mitigation is related to environmental awareness (Adaman et al. 2011), perceived awareness and uncertainty of climate change impacts (Nomura and Akai 2004; Akter and Bennett 2009), payment vehicle type (Wiser 2007), higher income and material well-being (Dietz et al. 2007; Li et al. 2009; Solomon and Johnson 2009; Adaman et al. 2011), level of trust in the institutions implementing the activities (Adaman et al. 2011), younger age (Hersch and Viscusi 2006; Dietz et al. 2007; Li et al. 2009; Solomon and Johnson 2009; Achtnicht 2011; Adaman et al. 2011), gender (Viscusi and Zeckhauser 2006; Dietz et al. 2007; Li et al. 2009; Solomon and Johnson 2009), the feeling of responsibility (Brouwer et al. 2008; Akter et al. 2009), the access to other local co-benefits (Longo et al. 2012), and, as expected from economic theory, it is negatively correlated with cost (Loomis and Ekstrand 1998; Akter et al. 2009). Previous information related to carbon-offset prices and familiarity with offsetting practices are also positively related to WTP (Lu and Shon 2012; Ziegler et al. 2012).

These observations on drivers of WTP coincide with meta-analysis research from environmental psychology that concludes that attitude, behavioural control and moral norms explain a great proportion of pro-environmental behaviour (Hines et al. 1987; Bamberg and Möser 2007). Studies on environmental values, as experiments in environmental economics, indicate that responses may represent an attempt to balance individual self-interest (mainly financial) with communal shared goals (Lynne 2002; Ovchinnikova et al. 2009; Sautter et al. 2011). In an environmental economics experiment on carbon offsetting, Ovchinnikova et al. (2009) found that empathy and locus of control are strong factors influencing environmental decision-making and can dominate the effect of pecuniary incentives. The constant reflection on individual actions regarding empathy and selfism related positively to environmental decisions, and when decisions were made

without this reflection, a profit maximization behaviour was favoured (Ovchinnikova et al. 2009).

As also noted by Ovchinnikova et al. (2009), Cai et al. (2011) indicate that including attitudinal questions and information before the valuation questions affects the result of stated preference surveys and WTP values. Thus, environmental valuation studies should carefully consider inclusion of information or attitudinal questions before the valuation questions in stated preference studies, since this may significantly distort WTP values (Cai et al. 2011). This was reported earlier by MacMillan et al. (2006) who showed that provision of specific information, or the opportunity to deliberate, can affect results of environmental valuation studies. However, the provision of such information is critical when respondents are unfamiliar with the environmental good. This is not a minor issue as economic theory underlying stated preference methods requires preferences to be invariant and developed after the optimal gathering of information (Kahneman 1986). In the words of Gregory et al. (1993), practitioners of stated preference methods may play roles ranging from 'archaeologists' to 'architects' of the environmental values. In addition to the information received, and reflections made as part of the studies and valuation experiments, respondents' familiarity with the environmental good under valuation can be directly related to previous experiences or behaviours (Cameron and Englin 1997; Berrens et al. 2004).

Survey application mode may also be a factor determining the WTP obtained. As mentioned above, provision of specific information, or the opportunity to deliberate, can affect results of environmental valuation studies (e.g. MacMillan et al. 2006). Moreover, results from public good experiments show that when individuals are allowed to interact in person with other participants, this increases the potential for cooperation and collective action in situations where self-interested behaviour might have been expected (Ostrom 2000). This is an important point to consider because many environmental valuation studies have been applied online or are computer based due to the advantages of the internet for communication and sampling (e.g. Berrens et al. 2004; MacKerron et al. 2009; Diederich and Goeschl 2011).

Background to selection of Mexico as a case study

Mexico was chosen as a case study because the federal government has expressed the will to cut GHG emissions 50 % by 2050 on a voluntary basis (PECC 2008). Local markets for forest services independent of government budgets are envisioned as a national strategic policy (Presidencia 2007; CONAFOR 2008). In Mexico, there is a small voluntary market for carbon offsets with most of the projects being developed in the south-western region; for example, in the mid-nineties, the Scolel Té project was set up in Chiapas as a research demonstration project using the Plan Vivo system (de Jong et al. 1995; Plan Vivo 2010). Since then a number of small projects have been developed by non-governmental organizations (NGOs). Carbon prices have ranged from 3.5 to 10 US$/tCO$_{2eq}$ (de Jong et al. 2004; Esquivel, personal communication). However, in general the population in Mexico is not aware of these projects or of any individual options regarding the mitigation of climate change by offsetting; thus, most offsets are sold internationally to companies or individuals.

La Primavera is an oak-pine forest located in the western part of Mexico. It covers 30,500 hectares and was declared a protected area in 1980 (CONANP 2000), and a Man and Biosphere Reserve in 2006. It is adjacent to the metropolitan area of Guadalajara (4.4 million habitants). Guadalajara is the capital of the state of Jalisco that accounts for 6.6 % of national gross domestic product (INEGI 2001). In general, there is public awareness regarding environmental services provided by La Primavera; 65 % of the general population has visited the forest at least once (Berumen 2005), and when forest fires occur, smoke and deterioration of air quality are widely noted in the city (El Universal 2005). However, there has been no formal valuation assessment of the services, and there is at present no system to channel financing for conservation or restoration activities directly from society. The ecological and economic dynamics between La Primavera and the metropolitan area of Guadalajara offer an attractive case to explore the potential for a local scheme to finance and enhance forest carbon services in the context of voluntary carbon markets.

Methodology

Choice modelling (CM) is a stated preference technique used in environmental non-market valuation and has been increasingly applied to elicit environmental non-market values (Rolfe et al. 2000; Bennett and Blamey 2001). In addition to climate change mitigation, CM has also been used to address other aspects of forest valuation, such as rainforest conservation by Australian citizens (Rolfe et al. 2000), the design of forest management strategies for multiple use (Horne et al. 2005), the valuation of enhancements related to recreation (Christie et al. 2007) or to value biodiversity benefits (Meyerhoff et al. 2009).

In CM, respondents are asked to choose between different options describing a specific intervention modifying the quality or level of provision of a specific environmental service or asset. The options describe different characteristics or attributes related to the environmental intervention

including a monetary component (scenarios). Respondents are asked to choose which of the scenarios they prefer, for which they would have to pay a given amount. Usually, two scenarios are presented in a choice set with a third opt-out option included allowing for participants who do not want to choose any of the alternatives presented. The opt-out represents the baseline for what would happen to the environmental asset if no specific action is taken. This allows estimation of welfare changes and WTP for the environmental services or goods.

CM is based on consumer choice theory and the random utility model (RUM) (MacFadden 1974). The assumption in CM is that consumers' choices maximize their utility given the characteristics of the options presented and income restrictions (Bennett and Adamowicz 2001). We follow the method as described by Rolfe et al. (2000). The utility of the choice is represented by an observable component of the utility of individual and an error term:

$$U_{ij} = V_{ij} + e_{ij} \qquad (1)$$

The observable component of the utility can be expressed as a function of the characteristics of the scenario proposed (Z_{ij}) and the characteristics of the individual (S_i):

$$V_{ij} = V(Z_{ij}, S_i) \qquad (2)$$

Then, the choices made will depend on the probability that the utility associated with one alternative is higher than for the other alternatives presented:

$$P_{ij} = \text{Prob}\left(V_{ij} + e_{ij} > V_{ih} + e_{ih}\right) \qquad (3)$$

for j different to all h in the choice set.

The RUM indicates that there is a stochastic or unobserved component in the utility, denoted by an error term. In multinomial logistic models (MNL), the utility function takes the form of a linear relationship on the parameters and variables with errors distributed according to a Gumbel distribution.

$$P_{ij} = \exp(\lambda V_{ij})/\Sigma(\exp(\lambda V_{ih})) \qquad (4)$$

where λ is a scalar parameter normally set to one. Thus, the MNL model can be written as:

$$V_{ij} = \lambda(B_0 + B_1 Z_1 + B_2 Z_2 + \cdots + B_n Z_n + B_a S_1 + B_b S_2 \\ + \cdots + B_m S_j) \qquad (5)$$

where B_0 is a constant term that can be separated into alternate specific constants (ASC) for different options posed and $\boldsymbol{B}_1$ to B_n and B_a to B_j are the coefficients of the vector of attributes and individual characteristics influencing the utility (Z_1 to Z_n and S_1 to S_j, respectively). Implicit prices or part-worth values can be obtained by dividing the coefficient of an attribute of interest by the coefficient of the monetary attribute.

$$W = -1\left(B_{\text{attribute}}/B_{\text{money}}\right) \qquad (6)$$

It is possible to compare the implicit prices from different models as the scalar terms cancel out when the implicit prices are obtained (Rolfe and Bennett 2001). In MNL models, the errors are assumed to be independently and identically distributed (MacFadden 1974; Louviere 2001). Violations to the assumption of the independence of irrelevant alternatives (IIA) imposed by MNL models can be detected through the test developed by Hausman and McFadden (Maddala 1983; Hausman and McFadden 1984). If MNL assumptions are violated, parameters and estimates obtained will be biased (Ben-Akiva and Lerman 1985). The IIA can be violated due to differences in tastes across the sample (heterogeneity), but this can be overcome by including socioeconomic variables in the model in combination with alternative specific constants (ASC) (Bennett and Adamowicz 2001). Confidence intervals for the part-worths or implicit prices can be created following the method of Krinsky and Robb (Krinsky and Robb 1986; Haab and McConnell 2002); the differences between the implicit prices of two different samples considering a non-normal distribution can be analysed through the Poe test, based on the complete combinatorial analysis of the implicit prices modelled (Poe et al. 2005; Ohdoko, 2008).

Survey design

In carbon markets, projects from different locations compete internationally to attract potential offset buyers. A basic assumption of market theory is that buyers will choose the least cost option, given similar products, aiming for cost efficiency. Although it is known that the effect of proximity might increase environmental valuation and produce spatial heterogeneity (e.g. Bateman et al. 2006; Johnston and Duke 2009), previous research focusing on the valuation of forest carbon services and climate change mitigation has not thoroughly explored the implications of local projects in the design of market mechanisms. Bearing this in mind, we designed the CM experiment to identify how project location may influence valuation of carbon offsets. We focused particularly on valuation of carbon removal from the atmosphere through forest sequestration, which may contribute to achieving a sustainable rate of carbon assimilation (Daly 1990). In consequence, the message given to participants in the survey focuses on the need to remove excess carbon from the atmosphere.

Three Mexican Biosphere Reserves were chosen as hypothetical project locations: La Primavera in Jalisco and two other Biosphere Reserves more distant from

Fig. 1 Geographic location of proposed projects

Guadalajara, La Michilía in the state of Durango, and El Cielo in Tamaulipas (Fig. 1). These areas were chosen because they all offer opportunities to reduce emissions and to increase carbon stocks through conservation and afforestation activities resulting in reduction in loss of woody biomass (and hence carbon), forest growth, carbon sequestration and enhancement of forest stock. They have similar types of vegetation (oak-pine forests) and none has special or distinctive characteristics that might also be particularly valued by respondents (i.e. they are not associated with emblematic ethnic groups or charismatic animal species).

We invited the respondents to consider a hypothetical situation in which a NGO develops carbon sequestration projects in coordination with local landowners in each of the three areas, offering them the opportunity to buy offsets. The payment vehicle was a one-off voluntary and tax deductible payment to the NGO, to be used to finance conservation and reforestation activities to mitigate climate change. Thus, the scenarios present three attributes that were defined after preliminary interviews and consulting with local experts. These were the total cost that the respondents would be asked in order to remove a certain amount of carbon, the quantity of offsets and the project location.

The attributes and levels chosen were three project locations (La Primavera, La Michilía, El Cielo), five payment levels ranging from $23 to $177 ($23, $50, $77, $131 and $177, all figures are given in US dollars at a exchange rate of $13 Mexican pesos per dollar), and four offset levels (2, 5, 9 and 19 tCO_{2eq}). These levels of the payments and carbon offsets bound the range of possible carbon prices to between $1.2 and $88/$tCO_{2eq}$ when the maximum and minimum values are compared. These carbon prices are within a reasonable range given current and expected carbon prices for this kind of project (Galindo 2009; UN 2010). The quantity of carbon offsets is also similar to the

per capita yearly emissions in Mexico (6.8 tCO_{2eq}) (SEMARNAT 2009). Three focus groups and two pilot tests were carried out to verify that the survey could be understood, and to adjust the attributes and levels. The choice sets did not present the carbon price, but only the amount of offsets offered and the payment associated with each specific location. It is important to make sure that both costs and offsets are in relevant and reasonable ranges, since in CM, the valuation levels are strongly determined by the selected levels of the attributes (Alpizar et al. 2001; Bennett and Adamowicz 2001). Taking into account the number of attributes and their levels, there are 60 possible combinations. Twelve choice sets were selected orthogonally and were presented in two questionnaires containing six valuation questions, with each question presenting two scenarios and an opt-out option; each location appeared eight times in the choice sets.

In order to explore motivations, questions about previous environmental behaviour, ethical attitudes and socioeconomic and demographic characteristics were included. A question was asked about the most important factor when choosing, in order to identify the general preference of the respondents and whether it was focused on cost, carbon or location. People were asked about: the likelihood of purchase whether the projects became operational; whether they had ever estimated their carbon footprint; visited La Primavera; participated in reforestation campaigns or donated to environmental NGOs. Respondents also were asked to state whether they agreed or not with the following statement: 'I will buy carbon offsets because it is my responsibility to offset the emissions I generate'.

Survey application

The survey was applied using three methods: the first using the market stall technique allowing a direct interaction with respondents (MacMillan et al. 2002, 2006). The second sample was obtained applying the survey through the internet where the respondents were contacted using the snowball technique; and the third sample was also through the internet but using a market research company (e.g. Diederich and Goeschl 2011) in order to create a more systematic selection of respondents since in internet-based surveys, it is difficult to select randomly or obtain representative samples of the population (Thurston 2006).

For the market stall sessions, a list of neighbourhoods within the metropolitan area of Guadalajara was used to select neighbourhoods at random and ensure areas representing different socioeconomic profiles were included. The city was divided into three zones depending on the distance to La Primavera (Close 0–3 km, Medium 4–6 and Distant 6–10 km). In each zone, four neighbourhoods of low-, medium- and high-income levels were selected at

random from the list as target areas for the market stall sessions. For the second sample, the questionnaire was created in SurveyMonkey®. Links to access the survey were circulated through local universities, companies and social networks. When respondents finished the survey, they were invited to send the link to their contacts. It was expected that this sample would have a larger share of highly educated people with higher environmental awareness, who would be more likely to distribute the link. In order to reduce this potential bias, for the third sample, a market research company with an extensive database of citizens was engaged and instructed to contact a representative sample of the population. A specific profile of mid-high and high-income adults with high school education or above was selected. This group was chosen because they are economically most able to buy carbon offsets. The education filter reduced the cognitive burden of the exercise. Respondents with the desired profile were invited by email to answer the survey.

In all three methods, the survey started by providing general background information. This was done in order to provide common information to all the participants on the characteristics of this type of project, which is unfamiliar to most people. The attitudinal questions were asked after the choice sets were presented. First general information regarding climate change, carbon sequestration by forests, and development of forest projects to mitigate climate change was explained. The information included: how carbon sequestration is quantified in a per tCO_{2eq} basis based on the content of carbon in biomass; production of oxygen from photosynthesis; the potential for reversal of benefits, for example, through fires; the implementation of projects by umbrella NGOs coordinating a group of landowners according to international standards; and the verification and certification of activities by third parties. The characteristics of project locations were described in terms of type of habitat, reserve size and opportunities to mitigate climate change: this information was presented in slides. Professional designers helped in the production of the visual support material. The slides were printed out and distributed amongst the participants during the market stall sessions. For the internet-based samples, the slides were shown as an introductory presentation before the questions. The participants were told that variations in the costs within and across the sites may arise from differences in specific conditions such as soil productivity, slope and labour required; and respondents were also asked to consider their income available. To simplify the policy proposal, we made no reference to cap and trade systems or the possibility to trade the offsets.

For survey application in market stall sessions, three sociology consultants and two environmental engineering undergraduate students were trained to become part of the research team. Local associations of residents and groups of neighbours from each area selected were contacted and invited to participate in the research and help in session organization. These associations frequently represent the community and participate in public affairs (e.g. in relation to local authorities) and in some cases provide public services (e.g. waste collection). The date, place, time and people invited to the sessions were agreed jointly by the research team and the associations to ensure a representative group of participants. The study was presented as research to evaluate the potential to develop climate change mitigation projects in forests in general. The objective was to gather from 8 to 10 persons for each session. During the sessions, the research team was firstly introduced and the general information printed in the slides presented; then, there was a space for questions and answers after which the questionnaires were distributed in unlabelled envelopes to be answered individually and anonymously. Finally, there was a period for final comments and a small present was given to the participants for their time. In the internet surveys, there was no space for questions and exchange of opinions other than an opportunity for respondents to write their comments. Questionnaires were all answered anonymously. The questionnaires for the market stall sessions were applied between July and September of 2010; the responses of the internet snowball sample were gathered from July 2010 to January 2011, and the surveys from the market research company were applied between from November 2010 and January 2011.

Results and discussion

General characteristics of the samples

For the market stall sample, 332 surveys were obtained, 473 surveys were obtained through Survey Monkey® and 158 through the market research company. Table 1 shows the general characteristics of the respondents for each sample. The internet market research sample was specifically targeted at the high-income/high-education segment while the market stall sample deliberately included a wider range of socioeconomic conditions. This can be seen in the differences in education, income, economic activity and entrepreneurship of these two samples. The snowball sample shows a higher participation of students and younger respondents who may have relatively higher access to the internet; however, their socioeconomic profile, aside from the marked difference in age and presence of students, is similar to that from the market research sample. There is a lower percentage of females in the market research sample, the contract for the company required a range between 40 and 60 % for gender. Males responded faster to the invitation.

Table 1 Socioeconomic and demographic characteristics

	Market stall	Internet snowball	Internet market research
Age (years)	40.22	33.04	32.73
Gender (% of females)	60.1 %	48.9 %	37.3 %
Civil status (% married)	69.4 %	37.0 %	40.5 %
Head household (%)	54.2 %	45.2 %	46.8 %
Size of household (persons)	4.49	3.60	3.89
Respondent has children (%)	72.1 %	32.7 %	43.0 %
Education (class)[a]	3.62	5.15	4.84
Income (class)[b]	2.78	4.12	4.74
Daily income per capita ($/cap-day)[c]	7.7	15.9	15.6
Student (%)	10.8 %	30.2 %	24.7 %
Employee (%)	34.3 %	54.0 %	49.4 %
Domestic occupation (%)	31.0 %	7.3 %	5.1 %
Entrepreneur (%)	12.0 %	25.9 %	24.1 %
Economically active (%)	51.8 %	75.9 %	70.9 %
n	332	473	158

[a] Education classes: (1) Elementary School, (2) Jr. High School, (3) High School, (4) Technical studies, (5) Undergraduate, (6) Postgraduate

[b] Income classes: (1) below $150, (2) $151–$307, (3) $308–$615, (4) $616–$1153, (5) $1154–$2307 and (6) above $2307 per household per month

[c] Using the mid value of the income class, and the maximum value for class 6

When preferences and previous environmental behaviour across the samples are compared, important differences appear (Table 2). The snowball sample has a larger proportion of respondents who had previously estimated their carbon footprint and hence have an initial interest in carbon rather than in project location. The market stall and the market research samples have comparable percentages in terms of previous environmental behaviour such as the knowledge of carbon footprint and participation in reforestation. Difference in previous donations arises from differences in socioeconomic profiles within the market stall sample. The market research sample has practically the same percentage of visitors to La Primavera for this socioeconomic group as that reported in an independent study based on random selection of households using individual surveying (86.1 vs. 85.9 %) (Berumen 2005). When the percentage of visits for different income groups is considered in the market stall sample (below and above $615 per month), the values obtained are higher than those reported in Berumen (2005) (81.1 vs. 76.8 % for the lower income group and 94.8 vs. 85.9 % for higher income groups). The internet market research sample had a lower percentage of people assuming offsetting as a personal responsibility (about 10 % lower); however, it had the highest percentage of persons previously donating to environmental NGOs. These donations may not necessarily be related to climate change mitigation projects and so do not require the assumption of responsibility over own emissions. These differences may indicate that in general there was a higher self-selection towards individuals feeling 'more responsible' for their emissions in the market stall and snowball samples; and towards individuals with a higher degree of environmental awareness related to climate change affairs in the snowball one (i.e. carbon footprint previously estimated). The market research sample may offer a more representative view of the population of Guadalajara with a higher socioeconomic profile; however, some self-selection towards pro-environmental respondents could also be present, as reflected by the higher percentage of people who previously had donated to environmental NGOs.

Protests

The responses of the participants who found the questions confusing or who decided not to offset in any of the six valuation questions were excluded from the regressions of the MNL models.[1] These cases correspond to protests (as indicated by the participants' comments), incomplete questionnaires and those who stated that the questions were confusing in one of the debriefing questions; thus, these observations were not considered in the analysis, in accordance with standard methods (e.g. Scarpa et al. 2009; Diederich and Goeschl 2011; Longo et al. 2012). Results in

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[1] There were 67 protests and confused respondents in the market stall sample (20 %), 78 in the snowball (16 %), and 19 in the market research sample (12 %).

Table 2 Preferences and previous environmental behaviour

	Market stall	Internet snowball	Internet market research
Focus on cost (%)	28.0 %	32.2 %	30.4 %
Focus on carbon (%)	24.9 %	31.3 %	21.5 %
Focus on location (%)	47.1 %	36.5 %	48.1 %
Positive probability offsetting (%)	83.7 %	80.3 %	84.2 %
Assumes responsibility for own emissions (%)	84.8 %	82.0 %	70.9 %
Previous carbon footprint (%)	7.7 %	32.6 %	7.6 %
Participate in reforestation (%)	53.8 %	62.2 %	56.3 %
Visited La Primavera (%)	86.3 %	88.8 %	86.1 %
Donation to environmental NGOs (%)	13.8 %	13.2 %	18.4 %
Protest, chose always option A (%)	9.0 %	5.9 %	7.6 %
Found the survey confusing (%)	11.1 %	11.2 %	8.9 %
n	332	473	158

the MNL models show the valuation of those accepting the offsetting scheme proposed. These results can be related to the potential demand for offsets from a marketing perspective for the citizens with these socioeconomic characteristics. Any general welfare estimates based on these results need to consider this limitation. However, this approach is in agreement with previous studies valuing specific aspects of climate change mitigation targeting particular segments of the population and excluding protests (e.g. MacKerron et al. 2009; Scarpa et al. 2009). In this case, the objective was to offer a general perspective on valuation of forest carbon sequestration in México and the effect of project location.

In order to investigate which factors are associated with higher chances of protesting against offsetting, Spearman's rho bivariate correlations were computed. The correlations are presented Table 6 in the ''Appendix''; they show different results for the three samples but in general the results agree with the reported determinants of WTP. Higher willingness to participate is positively related to income and economic activity, education, responsibility on emissions, younger respondents and previous visits to La Primavera, which can be considered as a proxy of familiarity with the site. For the market stall and snowball samples, when respondents are not primarily focused on cost but on the amount of offsets and project location, there is a higher chance to participate in offsetting. Interestingly for the market research company sample only one factor had a statistically significant correlation with protests: this factor showed that if respondents had previously donated to environmental NGOs, they were more likely to protest against the scheme proposed. These protesting respondents may have no more income available for new environmental schemes. If we assume that the market research sample offers a more representative sample of the population, it will be difficult to predict who will participate and who will

not. This was reported previously by Solomon and Johnson (2009) who indicated that it was possible to assess the WTP for green electricity from those accepting to pay; however, determining who will actually pay for it was more difficult. The impossibility of identifying a profile of those protesting based on general individual characteristics supports the position that there will be other underlying ethical, social and moral factors driving this decision as suggested by Ovchinnikova et al. (2009), and Bamberg and Möser (2007). Nevertheless, the percentage of protests can be considered to delimit the maximum expected share of the population that may participate in offsetting.

MNL models

Table 3 presents the MNL models generated for the three samples. In addition, five more models were estimated to study the effect of particular characteristics of each sample (models 2, 3, 5, 6 and 8). As mentioned above, the market stall sample was stratified by household income, setting the limit at $615 per month. The snowball sample was divided into those who had previously estimated their carbon footprint and those who had not. A subsample of the market research sample was created in order to compare it with the higher income group of the market stall. The socioeconomic and demographic characteristics of the subsamples are presented in Table 7 in the "Appendix".

The MNL models include the attributes used in the choice experiment in combination with ASCs for each site option and individual characteristics as explanatory variables. An intercept term is included to capture the effect of missing variables. The inclusion of the variables indicating the preference for cost, carbon or location helps to reduce heterogeneity and increase model performance. All models are highly significant, and with pseudo-R^2 values within the recommended levels, the coefficients are also

Table 3 MNL models

		Market stall			Internet snowball			Internet market research	
		1. All	2. Income low	3. Income high	4. All	5. No carbon footprint	6. Carbon footprint	7. All	8. Restricted
1	Intercept	−1.9229***	−2.0743**	−2.4600***	−1.8630***	−1.8828***	−1.8077***	−1.7590***	−2.0630**
2	Payment	−0.0095***	−0.0093***	−0.0060***	−0.0073***	−0.0070***	−0.0068***	−0.0113***	−0.0120***
3	Carbon	0.0827***	0.0633***	0.0940***	0.0718***	0.0679***	0.0771***	0.0935***	0.1070***
4	Michilía	0.7703***	1.1079***	1.7090***	0.9697***	0.9097***	1.5385***	0.8197***	0.9100***
5	Primavera	3.5831***	2.8432**	5.8040***	2.9809***	2.8586***	2.7787***	3.9712***	4.7160***
6	Cielo	−0.4990*	−0.1367	−0.5520	−0.2498	−0.6244***	−1.3980***	−1.0933***	−1.0720***
7	ASC1*cost	0.8460***	0.6366*	1.2370***	0.9800***	1.0914***	0.5649+	0.9541***	1.3040***
8	ASC1*carbon	0.8084***	0.6936***	0.8100***	1.1367***	1.2516***	0.8328***	1.1606***	1.0580***
9	ASC2*cost	−1.6915***	−1.5327**	−1.5160***	−1.6384***	−1.6337***	−1.5132***	−2.6792***	−2.8510***
10	ASC2*carbon	−1.6258***	−1.6166***	−2.0270***	−1.5667***	−1.6323***	−1.3876***	−2.3511***	−2.6080***
11	ASC3*cost	0.5337***	0.4409+	0.8440*	0.1048	0.2311	−0.0521	0.2907	0.6470+
12	ASC3*carbon	1.3092***	1.1415***	1.6330***	1.0468***	1.1764***	0.9162***	1.2690***	1.4590***
13	ASC3*payment/carbon	0.1001***	0.1114***	0.0880***	0.1104***	0.1051***	0.1146***	0.1432***	0.1560***
14	ASC1*payment/carbon		−0.0290+		−0.0524***	−0.0524***	−0.0490***		
15	ASC2*payment/carbon	0.0230***	0.0241**	0.0270***				0.0115+	0.0210*
16	ASC1*payment	0.0055*	0.0101**		0.0075***	0.0082***			
17	ASC1* entrepreneur				−0.4215***	−0.4366***	−0.5422+		
18	ASC2*R.E.		0.9603**	−1.7170***	0.2377	0.5686***		−0.5751*	−1.0650***
19	ASC2* entrepreneur				0.3844***	0.3985*			
20	ASC2* domestic		−0.2780		−0.6472***	−0.4747+	−1.0024*		
21	ASC2*married				0.5404***	0.4781***	0.5367*		
22	ASC2* reforestation				0.1365		0.3724+		
23	ASC3*visit primavera				−0.3570+				
24	ASC1*head H.H.						−0.6560***		
25	ASC1*children						0.8904***		
26	ASC1* domestic						1.7551***		
27	ASC3*RE						0.8515***		
28	ASC3* donation						0.6375*	0.5234*	0.3480
29	Female*payment/Carbon		−0.0073						
30	ASC3*carbon footprint		0.9252+						
31	ASC1* reforestation	−0.3370*		−0.6110*				−0.4225*	−0.4390+
32	ASC1*married	−0.2395		−0.7240***				−0.3485+	−0.4240*

Table 3 continued

		Market stall			Internet snowball			Internet market research	
		1. All	2. Income low	3. Income high	4. All	5. No carbon footprint	6. Carbon footprint	7. All	8. Restricted
33	ASC2* size H.H.	−0.0696*		−0.1630*				−0.9910**	−1.0180**
34	ASC3*married			0.4520[+]					
35	ASC1* donation							0.5630*	0.7380*
36	ASC3*children							−0.6962*	−0.4770[+]
37	ASC2*age							0.0361**	0.0360**
Model Statistics									
Model chi-square		1045.0**	522.8**	458.8**	1666.0**	1149.0**	545.6**	790.9**	680.9**
Valid cases (n)		4140	1962	1296	6498	4248	2214	2430	1782
Pseudo R^2-Nagelkerke		31.0 %	32.5 %	41.4 %	31.4 %	32.9 %	30.3 %	38.6 %	44.1 %

The reference corresponds to the 'opt-out' option, not buying offsets

ASC1 La Michilia, *ASC2* La Primavera, *ASC3* El Cielo

+ Significant at 90 %; * Significant at 95 %; ** Significant at 99 %

significant and with the expected signs. The Hausman-McFadden test was performed on all the models by alternatively removing the different project locations and the opt out. No violations to the IIA restriction were found; Table 8 in appendices shows the chi-squared values obtained.

The coefficients in Table 3 indicate that the utility derived from each project location changes depending on the general preference of the respondents. While La Primavera is the location more highly valued for those focused on location, as shown by coefficients in row 5 in Table 3 (42 % of the respondents[2]), other respondents may give up a project in La Primavera if they are focused on cost (row 5) (31 % of respondents) or on carbon (row 10) (28 % of respondents). This is shown by the negative signs of the coefficients for ASC2*Cost and ASC2*Carbon in all the models. This behaviour is consistent with market theory. People focused on cost or carbon gave up a project in La Primavera because it was not always the cheapest option, or that offering more offsets or offering them at lowest cost. It is important to note that the coefficient for La Primavera for the group focused on location (row 5 in Table 3) is always larger than those of the other locations for any of the three preference groups for all sub/samples (rows 4, 6–12). This implies that *ceteris paribus* it will be more likely that the group focused on location offsets their emissions in La Primavera, than those focused on cost or carbon buy offsets from other locations.

If a project is developed in La Primavera, there would be a higher potential for participation amongst those focused on cost and carbon. People focused on carbon gave up a project in La Primavera because in some choice sets the alternative sites offered more offsets; if a project is created in La Primavera, as long as the project can continue generating offsets, the potential participants may be able to buy the same amount of offsets from La Primavera as from other locations. Likewise, if the cost of carbon from a project in La Primavera is similar to that from other projects, the group constrained by cost would choose this site. The valuation of La Primavera by the group focused on location may be a proxy of valuation of the local Biosphere Reserve by the local population of Guadalajara.

Part-worth analysis

We used the results of the MNL models to estimate the implicit carbon price and benefits associated with each location and then followed the method of Krinsky and Robb, with 7,500 iterations to create 95 % confidence

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[2] The percentage of the population focused on location, carbon or cost refers to the percentage of complete questionnaires (Table 5).

Table 4 Part-worths, implicit carbon prices and valuation of project locations

Part-worths[a,b]	Market stall			Internet snowball			Internet market research	
	1. All	2. Income low	3. Income high	4. All	5. No carbon footprint	6. Carbon Footprint	7. All	8. Restricted
Carbon ($/tCO$_{2eq}$)	8.74 (5.96, 13.20)	6.79 (3.56, 10.25)	15.67 (9.50, 36.10)	9.77 (7.81, 12.54)	9.69 (7.21, 13.79)	11.29 (7.88, 17.95)	8.25 (6.20, 10.91)	8.92 (6.72, 12.27)
La Michilia ($)	81.4 (2.7, 267.5)	118.8 (30.1, 353.2)	284.8 (149.6, 740.8)	132.0 (71.5, 223.7)	129.8 (54.1, 259.3)	225.1 (109.9, 467.5)	72.4 (28.2, 122.1)	75.8 (23.5, 138.4)
La Primavera ($)	378.8 (229.2, 803.7)	305.0 (173.9, 668.1)	967.3 (536.6, 2611.1)	405.8 (311.9, 561.5)	408.1 (290.3, 631.4)	406.7 (273.0, 728.3)	350.7 (239.3, 514.2)	393.0 (256.9, 606.3)
El Cielo ($)	−52.7 (−143.2, 30.1)	−14.6 (−93.6, 88.4)	−92.0 (−395.2, 75.4)	−34.0 (−112.9, 39.2)	−89.15 (−180.5, −20.9)	−204.6 (−430.4, −79.2)	−96.5 (−173.4, −34.8)	−89.3 (−176.1, −21.5)

[a] The valuation of project sites corresponds to that of the groups focused on Location

[b] Brackets denote 95 % confidence intervals

intervals. The part-worths obtained from the models and the confidence intervals are shown in Table 4.

The market research sample has generally tighter confidence intervals, which may indicate that respondents from this group had fewer difficulties and had a more homogenous behaviour when answering the survey. This may be explained partly by previous experience in answering online questionnaires and because the sample had a more homogenous profile.

The implicit carbon price for the three full samples (models 1, 4 and 7) is similar, ranging from $8.25 to $9.77/tCO$_{2eq}$. Nevertheless, the figures show that deeper differences appear in the subsamples; in this case, the mean carbon prices go from is $6.79 per tCO$_{2eq}$ to $15.67 per tCO$_{2eq}$ in models 2 and 3. The range of the utility derived from La Primavera also changes from $350.7 to $405.8 for the complete samples to $305 to $967.3 for models 2 and 3. These results show a positive correlation of the environmental valuation with income. The Poe tests for the implicit carbon price and the valuation of La Primavera (Table 4) are presented in Table 9. When the three samples are compared, there are no statistical differences in the implicit prices (models 1, 4 and 7). When the market stall sample is controlled for income, the valuation of carbon in model 3 is statistically higher than that of models 2 and 8; but not higher than models 5 and 6 (snowball sample). In the case of the utility derived from La Primavera, it also produces statistically similar values when models 1, 4 and 7 are compared. However, in this case, the values of model 3 are statistically higher than in all the other samples.

The utility derived from La Michilía for model 6 (snowball sample with previous knowledge of carbon footprint) can help to identify the effect of familiarity of personal carbon emissions. In the snowball sample, those with previous knowledge of their carbon footprint have a slightly higher valuation of carbon than those who did not

have it. The valuation of La Primavera amongst these two subgroups is almost the same ($406.7 and $408.1); however, the group with knowledge of their emissions valued La Michilia almost twice as much as their counterparts in model 5 ($225.1 and $129.8). Nevertheless, the only significant difference in the utility derived from La Michilía according to the Poe et al. test is between model 5 and model 8 (Higher income group in the market research sample) (Table 9 in the "Appendix"). This higher valuation associated with the familiarity of carbon accounts also agrees with previous research (e.g. Ziegler et al. 2012).

The higher income group in the market stall sample is the group with the highest valuation of carbon and La Primavera. In order to assess the effect of the survey application mode (i.e. in-person *versus* internet-based mode), model 8 was prepared aiming to reduce the differences between the profiles of the subsamples used to build models 3 and 7. The subsample of model 8 has the same composition regarding gender, income, education, sense of responsibility on emissions and previous visits to La Primavera as model 3. However, there are still differences, these are factors mainly related to age: respondents from the market stall session tended to be older (mean of 41.2 vs. 32.2. years) ("Appendix"; Table 6). In comparison with the sample of model 7, the sample of model 8 had a higher percentage of respondents who felt responsible for their own emissions (83.3 vs. 70.9 %) and fewer respondents focused on cost (23.1 vs. 30.4 %). Although valuation of carbon and La Primavera improved from model 7 to 8, these modifications did not produce a meaningful increase comparable to that of model 3.

The positive correlation of carbon valuation with income is consistent with economic theory, indicating that the usual figures of WTP may be strongly restricted by the ability to pay and income (e.g. Brouwer et al. 2008). Although the results are constrained by the limits of the

experiment, they indicate that citizens may pay carbon prices similar to those in the market (e.g. UN 2010; Peters-Stanley et al. 2011), and they may be ready to participate in the market (Solomon and Johnson 2009).

Although self-selection towards people with pro-environment views was present in the market stall sample, this may have not been the main driver behind the higher valuation in model 3. The profile of respondents in the market stall sample is not as skewed towards persons with pro-environmental knowledge and behaviour as in the snowball sample, where self-selection was stronger. Moreover, when results from the snowball and market research samples are compared, there are no major differences in the part-worths, as can be confirmed by the Poe tests in Table 9. People coming to the market stall sessions may have responded to the invitation primarily due to a higher disposition for cooperation in addition to an interest in environmental affairs. Bonds between neighbours are part of local social networks and interaction between them may be strong and frequent. Personal interaction and particularly group interaction may boost the sense of cooperation and collective action as mentioned in the literature (e.g. Ostrom 2000). This feature can be used by NGOs promoting offsetting practices as means to engage with the public in these projects.

Table 4 shows the implicit prices for carbon and the valuation associated with the different project sites by the respondents focused on location; this allows us to obtain a proxy of the value of La Primavera for the citizens of Guadalajara.[3] Results indicate that the valuation associated with La Primavera as a one-off payment for project development in this site ranged from $305 to $967.3 per person amongst this group. When compared with the valuation of carbon offsets, the valuation of the locations seems higher. The MNL models obtained can be used to explore which options would be accepted by the respondents depending on the cost, the number of offsets and location; the trade-off between carbon offsetting and the development of a project contributing to the restoration and conservation of a specific location can then be assessed. For instance, the extra benefits experienced from a project in La Primavera for the respondents focused on location would be equivalent to the offsetting of 16–44 tCO_{2eq} in La Michilía, if the mean values in Table 4 are considered.[4] Since we only posed the possibility of one time offset

purchase, these values are expressed in dollars per project per person. Had we asked instead for a yearly offsetting of emissions then the benefits could be interpreted as the yearly benefits. We decided not to ask for a yearly payment because of the unfamiliarity of the respondents with the offsetting schemes. Although respondents could make periodic purchase of offsetting motivated by previous positive experience (e.g. Welsch and Kuhling 2009), this would have to be studied in more detail and would also be conditioned by the possibility of the projects to deliver more offsets in the future.

Consistency of choices

The way in which respondents choose in a CM can be used to test specific economic hypotheses (Alpízar et al. 2001; MacKerron et al. 2009). Evidence that respondents answered consistently with economic theory is represented by the difference in coefficients for La Michilía and El Cielo. When these coefficients are compared (row 4 with row 6 and row 7 with row 11, in Table 3), the coefficients of La Michilía imply higher chances of being selected in comparison with El Cielo. This is because on average the payments asked for La Michilía were lower than those asked for el Cielo. The value for La Primavera was in the middle: La Michilía ($83, SD 49), La Primavera ($86, SD 56), and El Cielo ($105, SD 57). Thus, the coefficients are consistent with an effort to minimize expenditure by those respondents focused on cost and location, when the local option (La Primavera) was not offered. The average carbon price of all the options included in the choice sets was $17.3/tCO_{2eq}$ (SD 15.4; range, $2.5–$65.4/tCO_{2eq}$). The design did not produce the same values for the three locations. The carbon prices for each location were: El Cielo $8.0/tCO_{2eq}$ (SD 7.3), La Michilía $12.8/tCO_{2eq}$ (SD 14.1) and La Primavera $13.7/tCO_{2eq}$ (SD 21.9). This helps to test consistency in the choices of those who had a higher preference for carbon. When the coefficients in rows 8 and 12 in Table 3 are compared, it can be seen that in general they are higher for El Cielo than for La Michilía, which is to be expected considering that on average more offsets were offered in this site.

Economic theory suggests that buyers would choose the most cost effective option independently of the location. The results of this experiment show that offset buyers will make trade-offs between total cost and carbon price. However, for the levels offered in our experiment, an important proportion of the population will be willing to pay for local carbon offsets from La Primavera even when offsets from this location were not the cheapest. The potential premium for local carbon offsets in $/tCO_{2eq}$ can be obtained after applying the survey in areas away from the project locations proposed.

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[3] As mentioned in the previous section the groups focused on carbon and cost may give up a project in La Primavera if cost-efficient options are not available locally, as shown by the negative signs for La Primavera in rows 9 and 10 in Table 3. We use the valuation figures from the group focused on location only as proxy for the local benefits of La Primavera.

[4] These figures can be computed as (La Primavera–La Michilía)/Carbon.

Table 5 Significant Spearman's rho correlations between primary interest factor and individual characteristics

	Focus on cost	Focus on carbon	Focus on location
Age (years)		−0.126**	0.155**
Time living in the city (years)	−0.091**	−0.080*	0.156**
Civil status (% married)		−0.092**	0.112**
Head household (%)		−0.071*	0.087*
Respondent has children (%)		−0.072*	0.112**
Income (class)	−0.068*		0.061[+]
Student (%)		0.112**	−0.099**
Entrepreneur (%)			0.082*
Economically Active (%)			0.071*
Positive probability offsetting (%)	−0.241**	0.123**	0.113**
Responsibility on emissions (%)	−0.186**	0.060[+]	0.117**
Previous carbon footprint (%)		0.110**	−0.118**
Visited La Primavera (%)	−0.085*	−0.094**	0.164**
Protest (%)	0.299**	−0.142**	−0.150**
n[a]	273	246	375

* Correlation is significant at the 95 % (2-tailed)

** Correlation is significant at 99 % (2-tailed)

[+] Correlation is significant at 90 % (2-tailed)

[a] There were 69 cases where this question was not answered

General preferences

As discussed above, whether the respondents are focused on cost, carbon or location determines how the choice sets were answered and how they valued carbon and the proposed project sites. Spearman's rho bivariate correlation coefficients were estimated between the selection of cost, carbon and location as the primary interest factor and individual characteristics of the respondents (Table 5).

Only significant correlations are shown in Table 5. The profile of the respondents focused on carbon shows a larger presence of students and those who had previously estimated their carbon footprint. There is a negative correlation between focus on cost and income class and a positive one between income and focus on location. People who had visited La Primavera correlated negatively with the choice of cost and carbon but positively with location. There is also a correlation between protests and higher focus on cost, implying that these concerns were one of the reasons why some of these respondents chose not to buy offsets at all. The focus on carbon or location is negatively correlated with protests.

When respondents were focused on location, the valuation of La Primavera was higher, indicating that the respondents would be willing to pay more in order to get benefits additional to carbon removal. It could be hypothesized that these respondents behaved strategically and indicated they would pay more for La Primavera only because it was an exercise. The expected behaviour was to choose cost-efficiently, thereby reducing their expenditure. However, there are indications that respondents responded rationally. In Table 5, it can be seen that the group focused on location is positively related to higher income and economic activity, which implies that they might indeed be

more able to pay for a local project (e.g. Dietz et al. 2007; Adaman et al. 2011). It can also be seen that this group correlates positively with those who have lived longer in the city, have visited La Primavera and have children. These factors may indicate a higher familiarity with the site and the environmental services it provides, which affects the valuation (e.g. Ziegler et al. 2012). Also, as described above, the respondents chose as expected when no local options were offered. Within the limits imposed by the experiment, this group of respondents would be willing to pay a premium on a per carbon basis in order to favour the restoration and conservation of La Primavera and access these benefits.

Survey application modes

The application of surveys through market stalls permitted inclusion of a wider socioeconomic profile in comparison with internet-based techniques since it was possible to contact people with relative lower internet access (e.g. senior citizens, females occupied in domestic affairs). It also enabled participant's questions to be answered. However, it was difficult to reach economically active middle aged men; this group was more easily contacted through the internet, at least for the groups with more years of formal education and higher income levels.

If the target group can be reached through the internet, this can reduce the cost of application and processing of the surveys. The cost of applying the surveys in person through market stalls including the design of the instrument and sampling strategy can range from around $8 to above $20 per person surveyed; plus the cost of any incentive that may be given to the participants in return for their time.

Had we included more cities in the study, the cost would have been higher. Comparatively the cost for each completed questionnaire online through market research companies may start at around $3 or less per person surveyed, depending on the specific requirements. The use of free internet surveying tools can reduce the cost of a study even more. However, if the researcher does not have an adequate method to contact the population of interest, the scope of the research may be limited. Another factor that needs to be taken into account, at least in certain areas, is personal security during application of surveys. This is now a major consideration in Mexico and the use of the internet can help to overcome this problem.

The use of a market research company to contact a specific a group through the internet helped to control self-selection and reduced the cost of the study. This method can be used to test specific hypothesis in environmental valuation, for instance studying the valuation of environmental assets by changing only one characteristic of the population of interest (e.g. age, occupation, distance to the asset). However, while using the internet can help to identify specific determinants of valuation, it may generate consistently lower figures of valuation in comparison with methodologies using personal and group interaction. The characteristics of the population and objective of the study dictate the methodology used to approach the population of interest, which can significantly affect the results.

Conclusions

The results presented here show that valuation of carbon sequestration in forests is constrained by ethical, cognitive, behavioural and economic conditions such as: acceptability of the scheme, sense of responsibility, knowledge of emissions, previous visits to the forests and marked differences in income. Whether the respondents had a primary focus on cost, carbon or location affected their valuation of carbon and forests. The general model of choice, assuming that the respondent considered carbon offsetting as an acceptable scheme, would vary depending on the characteristics of the person. Firstly respondents would be focused on cost until they reach a certain degree of environmental responsibility and level of income. The preference for carbon or location would be affected by factors such as previous visits to the reserve and previous knowledge of personal carbon footprint. Additionally, selection of location as the primary factor of preference, within the scenarios posed in this experiment, is related to indicators of relatively higher economic wellbeing such as higher income class, higher economic activity, economic independence and entrepreneurship. Respondents focused on location may value the environment, and specifically La Primavera, not only for their benefit but also for that of their

children. Results imply that the population of Guadalajara would in general accept the development of activities to mitigate climate change in La Primavera and that if the project is developed in this location, other direct co-benefits would be enjoyed by the population.

Results also indicate that the choice of cost as a primary interest is negatively correlated with the assumption of off-setting as a personal responsibility. This is important because, at least at the international level, compliance carbon markets are designed with the assumption that they are tools for cost effective climate change mitigation. While economic incentives are important for enhancing the demand for carbon offsets, the creation of a sense of responsibility amongst the emitters may be a necessary precondition. The experiment shows that the results varied according to mode of survey application and the population sampled. The highest environmental valuation was obtained in the market stall sample, and it was correlated with income. The possibility of interacting directly with the respondents helped to answer their questions during the experiment and the higher valuation may be linked to a greater cooperation associated with personal interaction and collective action.

Creation of a project to enhance forest carbon services in La Primavera might increase the probabilities of participating in a domestic market for forest carbon offsets amongst citizens from Guadalajara. The higher value that the residents from the city give to La Primavera is strongly related to proximity of the Biosphere Reserve. As an area for further research, it would be worth exploring how near a forested area should be to a population of interest in order to generate this extra valuation or whether the higher valuation of nearby forests is also present amongst residents from other regions in Mexico. Studying these aspects may contribute to the design of the appropriate incentives for PES programmes focused on carbon services, the design of domestic forest carbon markets built on local demand and the development of activities under REDD+.

Appendix

See Tables 6, 7, 8 and 9.

Table 6 Spearman's rho bivariate correlation between attitudinal and individual characteristics and protest responses

	Market stall	Survey monkey	Market research
Focus on carbon	−0.117*	−0.188**	
Focus on location	−0.120*	−0.130**	
Positive probability of offsetting (probably yes and certainly yes)	−0.233**	−0.339**	
Previous visit to La Primavera	−0.150**		
Age	0.299**	0.104*	
Years of residence in Guadalajara	0.200**		
Income (mid class)	−0.112*	−0.102*	
High school education	−0.142**		
Technical studies	0.115*		
Employee	−0.175**	−0.111*	
Economically active	−0.117*	−0.136**	
Responsibility on emissions		−0.322**	
Student		−0.155**	
Previous donation			0.190*

Correlations with positive signs indicate the contribution to protest against offsetting

* Correlation is significant at 95 % (2-tailed)

** Correlation is significant at 99 % (2-tailed)

Table 7 Socioeconomic and demographic characteristics of the sub-samples

	Market stall		Internet snowball		Internet market research
	2. Income low	3. Income high	5. No carbon footprint	6. Carbon footprint	8. Restricted
Age (years)	40.60	41.2	34.90	29.10	32.20
Gender (% of females)	66.3 %	49.5 %	51.2 %	44.2 %	49.1 %
Civil status (% married)	76.1 %	60.8 %	43.4 %	24.1 %	38.0 %
Head household (%)	54.0 %	57.7 %	45.6 %	44.5 %	40.7 %
Size of household (persons)	4.59	4.12	3.70	3.42	3.86
Respondent has children (%)	78.5 %	60.4 %	38.2 %	21.3 %	39.8 %
Education (class)	3.07	4.62	5.10	5.24	4.82
Income (class)	1.73	4.77	4.13	4.10	4.72
Daily income per capita	2.99	14.89	15.40	17.02	16.19
Student (%)	7.1 %	15.5 %	26.9 %	37.2 %	24.1 %
Employee (%)	32.4 %	50.5 %	52.8 %	56.9 %	50.0 %
Domestic occupation (%)	44.0 %	14.4 %	7.7 %	6.6 %	5.6 %
Entrepreneur (%)	7.7 %	23.7 %	28.7 %	20.4 %	24.1 %
Economically active (%)	45.1 %	79.4 %	77.6 %	73.0 %	71.3 %
Focus on cost (%)	31.3 %	24.2 %	32.0 %	31.7 %	23.1 %
Focus on carbon (%)	24.5 %	23.1 %	27.9 %	38.7 %	24.1 %
Focus on location (%)	44.2 %	52.7 %	40.1 %	29.6 %	52.8 %
Positive probability offsetting (%)	85.2 %	89.7 %	86.1 %	83.2 %	88.9 %
Responsibility on emissions (%)	86.2 %	88.2 %	83.5 %	79.0 %	83.3 %
Previous carbon footprint (%)	5.5 %	12.6 %	0 %	100 %	7.4 %
Participate in reforestation (%)	51.7 %	55.2 %	60.5 %	65.7 %	56.5 %
Visited La Primavera (%)	81.1 %	94.8 %	88.2 %	90.2 %	92.6 %
Donation to Env. NGOs (%)	11.7 %	14.7 %	12.5 %	14.7 %	22.2 %
Choose always option A (%)	9.3 %	7.2 %	6.4 %	4.9 %	3.7 %
Found the survey confusing (%)	8.8 %	11.3 %	7.8 %	4.9 %	6.5 %
n	174	96	296	143	108

Table 8 Results of the Hausmann-McFadden test when the different options are removed

Option removed	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
La Michilía	9.3 (12), $\chi^2 = 21.02$	3.9 (15), $\chi^2 = 24.99$	1.1 (14), $\chi^2 = 23.68$	7.6 (16), $\chi^2 = 26.3$	6.1 (14), $\chi^2 = 23.68$	0.6 (15), $\chi^2 = 24.99$	4 (16), $\chi^2 = 26.3$	4.3 (16), $\chi^2 = 26.3$
La Primavera	7.5 (13), $\chi^2 = 22.36$	17.0 (14), $\chi^2 = 23.68$	0.2 (13), $\chi^2 = 22.36$	2.9 (14), $\chi^2 = 23.68$	2.4 (13), $\chi^2 = 22.36$	1.8 (17), $\chi^2 = 27.6$	0.4 (15), $\chi^2 = 24.99$	7.6 (15), $\chi^2 = 24.99$
El Cielo	5.8 (14), $\chi^2 = 23.68$	3.8 (15), $\chi^2 = 24.99$	1.6 (14), $\chi^2 = 23.68$	1.6 (17), $\chi^2 = 27.6$	5.2 (16), $\chi^2 = 26.3$	0.0 (17), $\chi^2 = 27.6$	2.0 (16), $\chi^2 = 26.3$	3.3 (16), $\chi^2 = 26.3$
Opt out	0.5 (17), $\chi^2 = 27.6$	0.0 (19), $\chi^2 = 30.1$	0.8 (18), $\chi^2 = 28.9$	0.1 (21), $\chi^2 = 32.7$	0.6 (19), $\chi^2 = 30.1$	1.0 (22), $\chi^2 = 33.9$	0.0 (21), $\chi^2 = 32.7$	0.0 (21), $\chi^2 = 32.7$

The number in parenthesis shows the degrees of freedom, χ^2 shows the critical value

Table 9 Results of the Poe test to identify differences in implicit prices

Implicit prices to be compared	Samples to be compared		Alternative hypothesis for the Poe test and γ value[b]		
	Sample X	Sample Y	$Price_X = Price_Y$	$Price_Y > Price_X$	$Price_X > Price_Y$
Carbon price ($/tCO$_{2eq}$)	(1) Market stall	(4) Snowball	0.017*	0.690	0.293
	(1) Market stall	(7) Market research company	0.020*	0.385	0.595
	(4) Snowball	(7) Market research company	0.015*	0.167	0.818
	(2) Market stall, low income	(3) Market stall, high income	0.000**	0.994	0.005**
	(5) Snowball, no previous carbon footprint	(3) Market stall, high income	0.004**	0.937	0.059
	(6) Snowball, previous carbon footprint	(3) Market stall, high income	0.006**	0.825	0.169
	(8) Market research, high income	(3) Market stall, high income	0.002**	0.968	0.030*
	(8) Market research, high income	(5) Snowball, no previous carbon footprint	0.019*	0.632	0.350
	(8) Market research, high income	(6) Snowball, previous carbon footprint	0.011*	0.826	0.163
Utility derived from a project in La Primavera ($)[a]	(1) Market stall	(4) Snowball	0.000**	0.589	0.411
	(1) Market stall	(7) Market research company	0.000**	0.409	0.590
	(4) Snowball	(7) Market Research Company	0.000**	0.263	0.736
	(2) Market stall, low income	(3) Market stall, high income	0.000**	0.987	0.013*
	(5) Snowball, no previous carbon footprint	(3) Market stall, high income	0.000**	0.988	0.012*
	(6) Snowball, previous carbon footprint	(3) Market stall, high income	0.000**	0.978	0.022*
	(8) Market research, high income	(3) Market stall, high income	0.000**	0.991	0.009**
	(8) Market research, High Income	(5) Snowball, no previous carbon footprint	0.000**	0.558	0.442
	(8) Market research, high income	(6) Snowball, previous carbon footprint	0.000**	0.551	0.448

Table 9 continued

Implicit prices to be compared	Samples to be compared		Alternative hypothesis for the Poe test and γ value[b]		
	Sample X	Sample Y	Price$_X$ = Price$_Y$	Price$_Y$ > Price$_X$	Price$_X$ > Price$_Y$
Utility derived from a project in La Michilía ($)[a]	(1) Market stall	(4) Snowball	0.000**	0.765	0.235
	(1) Market stall	(7) Market research company	0.001**	0.431	0.569
	(4) Snowball	(7) Market research company	0.000**	0.065	0.934
	(5) Snowball, no carbon footprint	(6) Snowball, previous carbon footprint	0.000**	0.861	0.138
	(3) Market stall, high income	(6) Snowball, previous carbon footprint	0.000**	0.315	0.685
	(2) Market stall, low income	(6) Snowball, previous carbon footprint	0.000**	0.845	0.155
	(8) Market research, high income	(6) Snowball, previous carbon footprint	0.000**	0.987	0.013*

* The alternative hypothesis can be rejected at 95 % confidence level

** The alternative hypothesis can be rejected at 99 % confidence level

[a] Respondents focused on location

[b] The statistic of the Poe test (γ) can be considered as the *p* value (Ohdoko 2008)

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