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Abstract

Based on a survey of the French population, this study investigates consumer preferences for forest ecosystem services (FES) provision towards efficiency and equity in the context of additionality, and differences in willingness to pay (WTP) for FES between a tax-based and a donation-based payments for ecosystem services (PES) scheme. We show that consumers prefer equity to strict additionality adherence, with this preference being significantly stronger among females. However, consumer preferences are heterogeneous, and respondents with a closer connection to forests express the opposite preference. Regarding WTP, we find no systematic difference between the two payment vehicles, though WTP does vary depending on how respondents perceive potential free-riding. When considering that non-contributors also benefit from a particular PES scheme, a small group perceived this as unfair and reacted by reducing their contribution. A second, significantly larger group interpreted this as an opportunity to contribute to the common good and showed a higher WTP, indicating a markedly altruistic attitude towards FES provision in French society. We conclude by discussing the role of altruism in PES, the dilemma posed by the partial economic and legal incompatibilities of additionality and equity, and the environmental impact of environmental credits when credit buyers do not account for additionality.

Keywords: Ecosystem services valuation, Additionality, Equity, Warm Glow, Free-riding, Payment vehicle

1. Introduction

Alongside the provision of wood, forests deliver a wide range of forest ecosystem services (FES) that do not necessarily have a market price but are of value to forest owners, local communities and the wider society (Pearce, 2001). The provision of these services is in many cases determined by decisions made by private forest owners and thus by the behaviour of individuals. In the absence of market prices and outlets for non-wood FES, expanding their provision may be beneficial to local stakeholders and society at large, but costly and unprofitable for private landowners (Polasky et al., 2014). This lack of economic incentives for FES preservation and provision has led to market failures worldwide, involving over-exploitation of common pool resources and insufficient supply of non-market ecosystem services (ES) (Hardin, 1968; Lant et al., 2008). Assessing the demand for non-market FES can provide a basis for change to the management of private land through regulation and economic incentives, thus ensuring a more socially efficient FES provision.

A common way of bridging the gap between ES beneficiaries and landowner interests is through the establishment of payment for ecosystem services (PES) schemes, which are consensual, conditional arrangements between one or more 'sellers' and one or more 'buyers' over a well-defined ecosystem service — or land use hypothesised to provide that service (Wunder, 2005).

Based on a framework for PES efficiency developed by Pagiola (2005), Engel et al. (2008) identified four main causes due to which PES systems can be economically inefficient: (1) *Social inefficiency*, which refers to funded management changes where the costs exceed the social benefits of ES provision. As it is difficult or impossible to quantify the economic value of ES in many cases, this aspect is often not considered accurately. To address this form of inefficiency, this study is an attempt to provide approximations of the economic value of a range of FES. (2) *Lack of additionality*, where additionality refers to a case where changes in management practices would not have been made without the funding of a corresponding PES programme. To this end, a historical benchmark is usually defined, on the basis of which an evaluation of a PES scheme's impact on ES provision can be monitored and evaluated (Ferraro, 2011; Blanco et al., 2021; Wunder, 2005). A lack of additionality is considered to be particularly problematic when PES funding is tightly constrained. Despite the financial inefficiency of non-additional PES schemes, they might still be socially efficient. In the present study, we focus on the importance of additionality for the population's willingness-to-pay (WTP). (3) *Leakage*, whereby undesirable activities are shifted to geographical zones outside the supported area, leading to an overestimation of the net ES provision of a PES project. (4) *Lack of permanence*, where the provision of ES declines sharply when funding ends.

Our study follows two main objectives: Firstly, by contrast-

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ing a reward for sustainable behaviour that goes beyond the minimum legal standards and has already taken place at the forest owner's initiative (equity) with a more rigorous adherence to additionality, i.e., the exclusive consideration of future projects, we aim to assess whether consumers prefer efficiency (additionality) over equity. We also seek to investigate whether the corresponding consumer preferences are driven by socioeconomic variables. Secondly, by separately modelling the WTP for FES for a tax-based and a donation-based PES scheme, we intend to quantify the effect of the payment vehicle on the WTP. We then aim to assess whether altruism and free-riding concerns affect stated WTP values.

2. Previous work

2.1. Willingness to pay for FES

Since the 1980s, numerous studies have estimated the willingness-to-pay (WTP) for different FES across the world. The Evri© database and the bibliographic analysis of Acharya et al. (2019) register more than a thousand records related to FES valuation. The oldest studies mostly applied the contingent valuation (CV) method, while more recently, choice experiments (CE) have become increasingly prevalent. These studies reveal that forests provide a broad range of ecosystem services and that there is a wide variation in reported economic value (Elsasser et al., 2009, 2016; Binder et al., 2017; Mäntymaa et al., 2018; Grammatikopoulou and Vačkářová, 2021; Taye et al., 2021). Latterly, these economic valuations have been placed in the broader context of the implementation of PES schemes. Choice experiments have been used to assess consumer preferences for management and ecosystem attributes such as forest structure, composition of tree species, visibility of silvicultural interventions, habitat protection and peatland conservation, with some targeting the general population (Horne et al., 2005; Juutinen et al., 2014; Giergiczny et al., 2015; Ouvrard et al., 2020) and others focusing on local communities (Tolvanen et al., 2013).

2.2. Equity and additionality

PES are based on economic logic in a context of limited public resources; placing efficiency at the core of their implementation. In this sense, Karsenty et al. (2017) argue that it is easier, more efficient and more effective to pay for the abandonment of unwanted practices than to reward already-established desired behaviour. This is in line with Wunder (2007), who suggests that ES providers who have already behaved virtuously before the implementation of a PES scheme should not automatically be eligible to claim compensation in the name of equity[1]. He argues that this systematisation could enable blackmail in the sense that corresponding ES suppliers could demand compensation in exchange for simply maintaining their ES provision, which in turn would drive up the cost of PES systems disproportionately.

However, this exclusion of virtually behaving ES suppliers from newly established PES schemes, causes PES potentially being perceived as unfair and highlights the risks associated with strict adherence to the additionality criterion (Sommerville et al., 2010; Martin et al., 2014; Combe, 2020). The most important factor is the crowding-out effect, where a sentiment of injustice is created among those who were already behaving virtuously before the introduction of a PES, potentially leading to ecological blackmail, where affected FES providers threaten to cease their FES provision in order to force financial compensation (Bottazzi et al., 2018; Ezzine-de-Blas et al., 2019). In consequence, as Karsenty and Ezzine de Blas (2014) were able to show in two case studies in Central America, it is not always possible to pursue strict compliance with additionality restrictions. In the first case it was decided already in advance to exclude additionality from the PES scheme, so that the risk of environmental blackmail that may have been formulated by those excluded would be avoided. In the second case, additionality was initially enforced so that compensation was only granted for newly established plantations. The business-as-usual suppliers then threatened to chop down their preexisting trees in order to become eligible, which led to the removal of the additionality criterion from the project. This shows that also strict compliance with additionality restrictions can lead to perverse behaviour, which in turn forces a relaxation or complete abolishment of additionality requirements. However, it is important to consider the differences between countries, as the socioeconomic context in France, for instance, is different from that of these two cases. In this sense, Muradian et al. (2010) argues for consideration of PES within a broader institutional context, where equity is considered together with efficiency, a context which best corresponds to reality in the policy fields concerned.

Besides economic additionality, regulatory additionality, i.e., going beyond existing regulations, must likewise be accounted for (Karsenty et al., 2017). Simply rewarding compliance with environmental legislation risks complicating regulatory enforcement where no financial incentive is provided (Karsenty et al., 2014). The forest management measures we consider in this study are not in conflict with regulatory additionality, as they are complementary to legal requirements.

2.3. Equity and gender

Many experiments have shown that women are more likely to be inequity averters opting for egalitarian compensation, while men tend to be surplus maximisers (Andreoni and Vesterlund, 2001; Kamas and Preston, 2012, 2015). Other studies show that men are more receptive to extrinsic incentives than women, who are generally more altruistic (Brañas-Garza et al., 2018). Thus we expected females to prefer equity over strict additionality. We also assumed that respondents with a closer connection to the forest would have a different stance on additionality. Beyond that, we did not have any prior hypotheses about French citizens' preferences for either strict additionality adherence or equity, as we were not aware of any empirical studies on this matter.

[1] By equity we refer to the interpretation of the law, including its application to specific cases, which allows it to be interpreted as an ideal, a guideline for balancing the interests to be taken into account (Ikeme, 2003; Langlais, 2012)

2.4. *The role of additionality – some empirical evidence*

Vedel et al. (2015) show that the willingness to accept (WTA) among Danish forest owners for PES programs that increase biodiversity and recreational value for society depends strongly on additionality. For the extension of forest access, for example, those who had already opened their forest to the public had a WTA of around 0, while those who did not demanded 28€ per hectare per year for full access. However, on the side of ES buyers, Blanco et al. (2021) show in an experimental context that additionality leads to higher cost efficiency but not necessarily to a higher provision of public goods. Consequently, these two studies seem to indicate that there is a divergence between the WTA of ES providers and the WTP of ES buyers on the aspect of additionality.

2.5. *Donations versus mandatory payments*

To ensure incentive compatibility, there is a general consensus in the economic valuation literature that the payment instrument should be a mandatory one (Carson et al., 2007; Johnston et al., 2017). This eliminates the possibility of free-riding inherent to donation-based mechanisms (Champ et al., 2002). From a theoretical point of view, it is therefore not guaranteed that a donation-based valuation study will provide the true economic welfare value of ES (Kotchen, 2014). However, in some situations, voluntary donations may be the only acceptable payment vehicle among respondents (Boyle, 2017), and real-world mechanisms for the provision of ES are often based on voluntary contribution and crowd-funding (Bouma and Koetse, 2019).

Although the sensitivity of WTP to the payment vehicle is not a novel subject, a review of the existing literature indicates a need for a more thorough understanding of this matter: Ureta et al. (2022) show that understanding respondents' preferences for the payment vehicle tends to support the implementation of a PES. Sonnenschein and Mundaca (2019) examine policy-relevant differences in WTP between different payment vehicles for air and car travel: mandatory payments generate higher WTP than voluntary payments. This sensitivity has also been tested in the specific sector of forestry, confirming the specific role of payment vehicles on WTP indicators, reaching similar conclusions (Weller and Elsasser, 2018; Kreye et al., 2016). However, in a choice experiment on climate policy issues, Svenningsen and Jacobsen (2018) show that differences in WTP across samples have to be attributable to either the bid range or the elicitation format, with the payment vehicle having little or no effect on WTP.

In our study, we examine the WTP for a mandatory tax versus voluntary donations, the latter being inspired by a growing number of PES crowdfunding schemes (Frey, 2018; Wehnert and Beckmann, 2021) and initiatives to internalise positive forest externalities (Chakrabarti et al., 2019; Li et al., 2022; Rabotyagov et al., 2012). Carlsson and Martinsson (2001) compared real donations for environmental projects with WTP estimates via a hypothetical CE, and found no significant differences. We hypothesised that consumer WTP is lower for voluntary payment schemes than for mandatory ones, but not zero, so that WTP values in the context of a hypothetical voluntary payment scheme are not a suitable means for revealing a population's perception of the economic value of ES, but nevertheless provide a guide to the creation of voluntary PES markets. We also assumed that participants who anticipated the possibility of free-riding would have a lower WTP than those who did not (Wiser, 2007).

3. Material and methods

3.1. *Questionnaire*

Our analysis is based on a questionnaire sent to a representative sample of the French population. The questionnaire comprises five parts, where the first part includes questions on the socio-demographic characteristics of the respondent and also served to define the sample quota. The second and main part of the questionnaire was a discrete choice experiment (CE), a widely used method in environmental valuation that serves to estimate preferences for project or policy attributes (Mariel et al., 2021). The CE is formulated as a choice between different policies supporting forest owners in restoring degraded or climate-vulnerable forests, and is described in the following subsection. The third part of the questionnaire contains follow-up questions designed to help us understand the rationale behind respondents' decisions in the CE, along with some supplementary questions on preferences for forest restoration policies. This part also includes a question designed to detect free-riding concerns and altruistic behaviour, in the same vein as Wiser (2007). The fourth and fifth parts include some questions on the respondents' attitudes and some additional socio-demographic characteristics.

To test whether there are differences in preferences and WTP between a mandatory and a voluntary payment vehicle, we created two versions of the questionnaire, to which each of the participants was randomly assigned. In the first version, the CE was formulated as a choice between public policies, where participants were told that every French household would have to pay the same financial contribution if a policy was implemented, while in the second version, the CE was formulated as a choice of donation, where participants were told that the contribution was voluntary. The two versions of the questionnaire are available in the supplemental material.

3.2. *Choice experiment*

The CE was conducted in the present French context, where large forest areas are facing deterioration due to droughts and insect infestations, along with current discussions and initiatives to support forest restoration and adaptation to climate change (agriculture.gouv.fr, cnpf.fr). While most citizens have probably heard of or seen forest stands with dead spruces, they are less likely to be aware of the initiatives and discussions supporting forest restoration and adaptation. Therefore, we explained this matter in an introductory text, which can be found in the questionnaire documentation.

In French forestry, owners of one or more parcels of land of 25 hectares or more are required to draw up a management plan (Article L.312-1, French Forestry Code) which must be approved by the administration. This document constitutes a road map for management of the forest for a period of 10 to 20 years. Otherwise, the forest is subject to the requirements of the administrative authorisation system (Article L.312-9, French Forestry Code), i.e., all logging must be authorised by the administration, except for wood for domestic use. A management plan is voluntary for an ownership of less than 25 hectares. A plan allows the owner to benefit from tax advantages related to the forest, access to public aid and certification of sustainable management. For an area of less than 10 hectares, it is also possible to voluntarily develop a management plan, which is approved by the administration. As property rights in France are generally highly protected, the choice of silvicultural measures depends largely on the individual owner or manager. There is no legal obligation in terms of species composition (except species classified as invasive), public accessibility, conservation of habitat trees or carbon sequestration. All choice experiment attributes are designed in a way so that legal additionality is ensured.

3.2.1. *Choice experiment attributes*

The six attributes and their levels describing the choice alternatives in the final version of the questionnaire are listed in Table 1 and are explained below. To ensure that the attribute explanations were read carefully, we added a question related to the respective attribute after each explanation. Participants were able to retrieve the attribute descriptions again on each choice card. The formulations of the attribute descriptions presented to the respondent in the questionnaire are documented in the questionnaire.

Forest type refers to the composition of species planted in a reforestation project. We included two options: (1) *Mixed stand*, described as very robust to climate change and composed of rather slow-growing native deciduous and coniferous species; and (2) *Douglas fir*, described as a fast-growing, high quality timber-producing and climate change-robust pure stand (single species stand). We emphasised that Douglas fir is not native to France. We hypothesised that the majority of respondents would prefer mixed stands.

Annual CO_2 uptake described the additional CO_2 uptake that a respective reforestation scenario causes in the first 30 years after replanting in comparison to a reference scenario in which no active reforestation is being conducted. We included four levels: 0, 5, 10 and 15 tCO_2 per hectare per year. Linked to the different growth performances we had modelled beforehand, the possible annual sequestration values per hectare were set at 0-10 tCO_2 for the mixed stand and at 5-15 tCO_2 for the Douglas fir pure stand. The relatively large variation in sequestration values is rooted in the great diversity of site productivity in French forests. We hypothesised that respondents would prefer higher carbon sequestration values.

Recreation defined whether a funded forest owner is obliged to provide public access for non-motorised visitors. Two options were provided: (1) *Accessibility ensured*, and (2) *Accessibility not ensured*. The latter does not necessarily mean that the forest is inaccessible to the public. In fact, about 70 % of French private forests are currently accessible to the public, although forest owners in France are allowed to enclose their forests (Agreste, 2014). We hypothesised that participants would prefer funded forests to be guaranteed accessible.

Eligibility addressed whether consumers prefer efficiency or rewards for sustainable behaviour, and more specifically, whether only strictly additional reforestation projects should be eligible or also those that were already managed at the owner's expense according to criteria meeting the PES guidelines before the PES was implemented. To facilitate understanding, we used the levels (1) *Future projects only* and (2) *Both past and future projects* and explained that the former would lead to larger areas being covered with the same budget, while the latter would be regarded as a reward for sustainable behaviour. We did not have a hypothesis as to whether respondents would favour additionality or equity, but we assumed that such preferences would be determined by the respondents' socio-economic characteristics.

Biodiversity was related to the conservation of habitat trees. Two levels were given: (1) *Additional habitats* and (2) *No additional habitats*, where the former meant that at least three (the French FSC standard is two trees and a legal minimum does not exist) habitat trees, defined as old living or dead trees, must be conserved per hectare of forestland. We hypothesised that participants would prefer habitat trees to be preserved in the forest.

Contribution to forest fund defined the annual contribution per household (tax version) or donation (donation version) to be paid for a given project during ten years. Seven levels were considered: *4, 9, 15, 24, 34, 46, 60* and *80€*. In the donation-based version we included the option that the donation commitment could be cancelled each year, as we considered that most respondents would be unfamiliar with donations involving multi-year commitments and therefore that their choices would not truly reflect preferences for forest restoration. The values are based on cost estimates for reforestation projects, assuming that each French household pays into the fund and that 45,000 hectares are reforested. We expected consumers to try to keep their financial contribution as low as possible, and that the mandatory payment mechanism would yield higher WTP values than the voluntary mechanism.

Table 1: Description of the DCE attributes and the respective levels.

Attributes	Levels
Forest Type	Mixed stand, Douglas fir
Annual CO_2 uptake	0, 5, 10, 15 tCO_2/ha/year
Recreation	Accessibility ensured, accessibility not ensured
Eligibility	Only future projects; both past and future projects
Biodiversity	Extra habitats in the form of at least three habitat trees per hectare, no extra habitats
Payment	Annual financial contribution per household of 4, 9, 15, 24, 34, 46, 60 or 80 euros

3.3. Questionnaire implementation

3.3.1. Questionnaire evaluation

To ensure that our questionnaire was easily understandable to the respondents, and in particular that the CE attributes were relevant and understandable, we organised a focus group with participants not familiar with forestry or related fields. A key finding was that a location attribute (local versus no spatial constraint for restoration projects) was not considered important; it was thus omitted. It was also suggested that we should clarify that if a project criterion is that the forest should be accessible to the public, this should not include motorised access. Alongside these main comments, many suggestions were made on wording and layout, e.g., on the use of pictograms in the CE, which were taken into account in the subsequent revision of the questionnaire. We also ran two pilot trials, each including 200 responses.

We tested for scope sensitivity[2] by dividing respondents into two groups, where participants were told that either 45,000 hectares (Group A), or 90,000 hectares (Group B) would be restored with the fund. We expected higher WTP values for group B.

3.3.2. Statistical design

The choice tasks for the CE were obtained from an updated experimental design which was maximised for D-efficiency using the Ngene software (ChoiceMetrics, 2021), assuming a multinomial logit model. To set up the first pilot trial, we used priors (assuming only signs) for the attribute coefficients, which were based on our experience from the focus group and the literature. Based on these initial estimates, we designed a second pilot trial with updated priors and constraints. These estimates were then used to develop the design for the final launch. Here, the *Carbon* attribute was restricted to 0, 5, or 10[3] for the *Mixed stand* and 5, 10, or 15[3] for the *Douglas fir*.

Our design had two hypothetical alternatives and one opt-out option (not supporting forest restoration). An example of a choice card set is given in Figure 1. In total, we had 16 choice sets, which were divided into two blocks by Ngene, and respondents were randomly assigned to one of these two blocks.

3.3.3. Survey implementation

The data collection was conducted in May 2022 and targeted the whole French population. The questionnaire was distributed by the pooling agency Kantar France which samples participants from a standing panel. To ensure that the survey was representative, we set quotas for age groups, professions and gender, drawing on official French population statistics, on the basis of which participants were included in or excluded from the survey. We were able to meet the quota as planned.

[2]Scope sensitivity means that people's WTP increases when the quality or quantity of a non-market good increases (Dugstad et al., 2021)

[3]Annual CO_2 sequestration in tons per hectare

3.4. Econometric modelling

3.4.1. Data cleaning

To exclude 'speeders', we filtered out observations where the response time was less than 50 % of the median. A conditional question was added to identify protest responses and was only shown to those who had always opted out in the choice experiment. Following Mariel et al. (2021), we then sorted all 'always-opt-out' responses into 'protest zeros' (e.g., "I did not understand the choices") and 'valid zeros' (e.g., "I prefer the natural regeneration of forest stands.") and excluded the former from choice model estimation. To avoid overestimating WTP values, we also excluded respondents who did not consider the *payment* attribute important ('non-price sensitive'), as well as those who reported that they did not believe that the survey would have an impact on real policy, i.e., those who did not believe that their decisions would have consequences ('non-consequential') (Vossler et al., 2012). To test how the data cleaning influenced the results, we run a model with the unfiltered data set (Table A.10).

3.4.2. Modelling framework

The modelling is based on the random utility model (RUM) framework, which is a common approach in the analysis of discrete choice data (McFadden, 1974). This model assumes that respondents select their most preferred alternative among the I alternatives offered. The alternative that maximises the perceived utility, u_{nit}, for respondent n in choice situation t is given by Equation 1:

$$u_{nit} > u_{njt}, \forall j \neq i \quad \text{and} \quad \text{where} \quad u_{njt} = X_{njt}\beta + \varepsilon_{njt} \tag{1}$$

where $j = 1, ..J$, $t = 1, ..T$, and vector X_{njt} is a row vector of K attributes characterising alternative j, β is a column vector of K parameters associated with these attributes, and ε_{ij} is an error term that captures the utility unobserved by the researcher.

In order to fully exploit the panel structure of our choice data and to account for individual preference heterogeneity, we estimated a flexible mixed multinomial logit (MMNL) model(Revelt and Train, 1998). This allowed us to estimate individual-specific preference parameters and to account for non-standard substitution patterns between choice alternatives (relaxing the assumption of independence from irrelevant alternatives (IIA)), modelling preference heterogeneity as continuous distribution. We used an unrestricted model that allows for correlated random parameters so that both behavioural phenomena and scale heterogeneity are captured and biased utility estimates are avoided (Mariel and Meyerhoff, 2018). The mixed logit unconditional probability of respondent n choosing the sequence of alternatives $I = \{i_1, ..., i_T\}$ is given by Equation 2:

$$P_n(I, \theta) = \int \prod_{t=1}^{T} \left(\frac{\exp \beta' X_{nit}}{\sum_j \exp \beta' X_{njt}} \right) f(\beta|\theta)\, d\beta \tag{2}$$

where θ is a matrix of mean and variance-covariance for the distributions of the random parameters, and f is the density function for the random parameters, β . The corresponding log likelihood can be maximised using maximum simulated likelihood

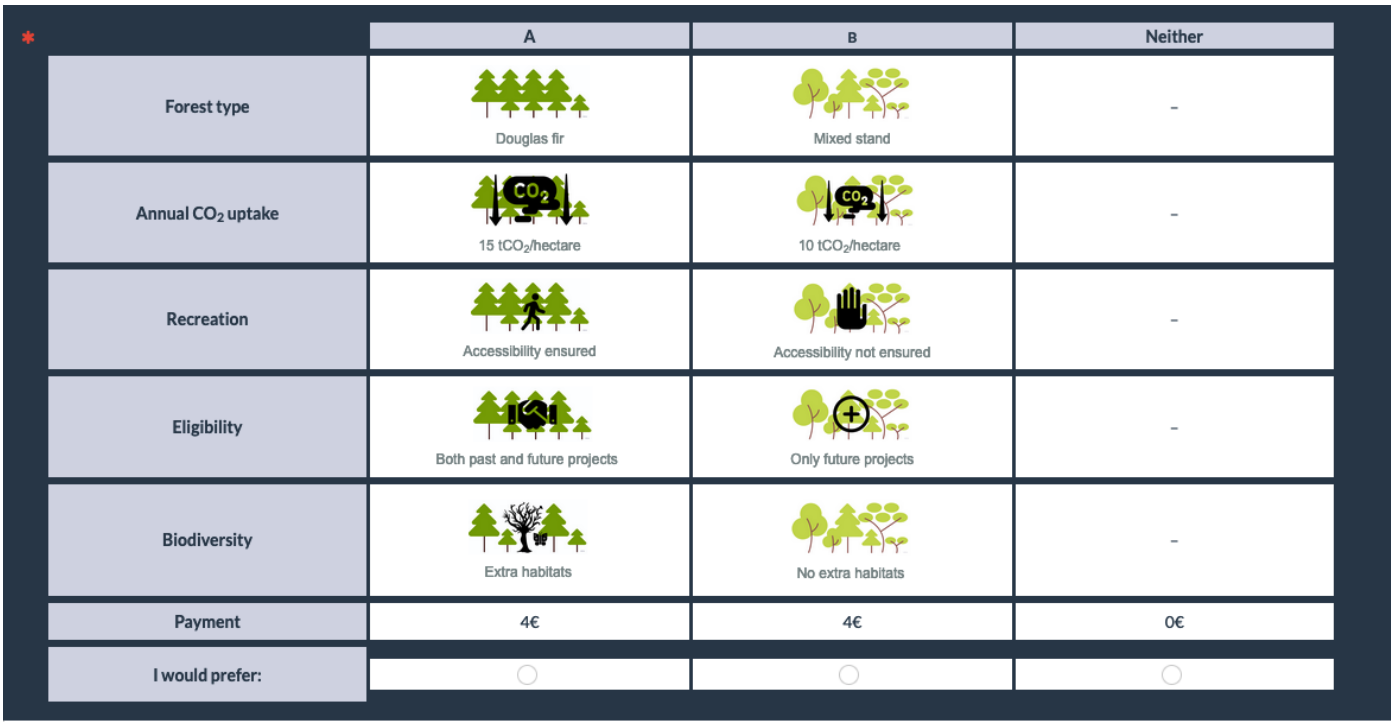

Figure 1: Example choice card

methods, and in the present study this was done using the R package *Apollo* (Hess and Palma, 2019). For generating random draws we used the Modified Latin Hypercube Sampling (MLHS) method proposed by Hess et al. (2006). This approach avoids unwanted correlation patterns, as generated, for example, by Halton draws, as well as larger simulation errors in the choice probabilities implied by uneven covering of the integration area, which can be caused by the randomness in the sequences when employing simpler pseudo-random draws, such as the pseudo Monte Carlo method (Hess et al., 2006). For each model, a number of 3000 MLHS draws were employed.

In all models we assumed a normal distribution for the non-price preference coefficients and a negative log-normal distribution for the payment coefficient. To control for the order effect, we included three alternative specific constant (ASC) values so that the two choice scenarios were considered separately. The ACS for opting out was fixed to 0. Each model was estimated multiple times, with the first run based on assumed starting values for the utility coefficients, and the subsequent runs based on the starting values of the corresponding previous estimation. We selected the final model when we could not find significant changes in the model parameters as compared to the respective previous estimation. All variables included in the models are displayed in Table 4.

3.4.3. Preference-space models

We estimated three MMNL models in preference space, starting (1) with a base model without interaction terms. (2) For investigating the impact of socio-demographic variables on respondents' marginal utility with respect to additionality, we specified a model with interaction terms: Following our initial hypotheses, we included gender (*female*) as well as respondents who themselves or their family own forests in France (*forestowner_ind_fam*), and those who feel very well informed about forests (*very_informed*) as interaction terms in our model. The latter two groups were used as proxies for those participants who have a closer connection to the forest. The interactions were carried out with the attribute variable *additionality*. (3) To allow for an interpretation of the correlations of the base model, we followed Mariel and Artabe (2020) and estimated a model with negative choice attributes reversed. We then interpreted only negative correlations as caused by behavioural phenomena. Here we interpreted those inversely that changed sign due to the previous reversal of the originally negative choice attributes. The corresponding model results can be found in Appendix A (Table A.9)

3.4.4. WTP-space models

To compare the marginal willingness to pay (mWTP) between the donation-based and tax-based payment vehicle, as well as the impact of altruism and free-riding concerns associated with a voluntary payment mechanism, we applied the so-called WTP-space method. This allows for a direct derivation of the mWTP distributions, taking into account the heterogeneity in mWTP between respondents (Train and Weeks, 2005; Scarpa et al., 2008). We reformulated equation (1) to obtain (Train and Weeks, 2005):

$$u_{njt} = \alpha_n(-X_{pnjt} + X^*_{njt}c_n) + \varepsilon_{njt} \quad j = 1,..,J \quad t = 1,...,T \quad (3)$$

where $c_n = \beta^*_n/\alpha_n$ and α_n is the parameter on the payment variable for individual n, β^*_n is the vector of coefficients of the attributes variables, X^*_{njt} without the payment variables, X_{pnjt}. Note that this implies that the WTP (= c) is estimated directly and we also avoid the problem of unstable marginal WTP estimates based on ratios of parameters estimated in preference-space models (Thiene and Scarpa, 2009).

The WTP-space models were estimated with sub-samples of the data set: The first two models were each estimated using only observations from the tax-based version and the donation-based version, respectively. For the other two models, only the donation-based version was used, and two further sub-samples were drawn, one containing only people who showed altruistic behaviour and the other comprising respondents who said they had reduced their WTP due to the possibility of free-riding. We then used two-tailed Student's t-tests to test for significant differences in mean WTP values between each pair of models. If either the variances or the sample sizes were significantly different between the pairs, we instead employed Welch's t-test. It should be borne in mind that potential differences may be due to (random) variations between observations in the different samples rather than to the payment vehicle or the respondent's attitude towards altruism and free-riding.

Due to the reduced sample size, we did not incorporate correlations between the choice parameters in the last two models, as otherwise the estimations would become unstable.

4. Results

Table 2: Data cleaning (more detailed description in subsubsection 3.4.1).

	#	%
Total	4426	100
Not completed	1905	43.04
Completed	2521	100
Speeders	340	13.49
Protesters	64	2.54
Non-consequential	247	9.80
Non-price sensitive	392	15.55
Sample used for analysis	1709	67.79
No. of choices	41016	100
Opt out choices	14043	34.24

4.1. Data and respondents' characteristics

Table 2 shows the sample used for estimation after data cleaning (subsubsection 3.4.1). We note that 43 % of respondents did not finish the questionnaire. This figure also includes respondents who were screened out due to the specified quotas. The relatively high proportion of drop-outs is most likely due to the screening process: It was difficult for the survey company to complete the quotas with young respondents and in the social professional categories of self-employed, managers and civil servants. As a result, many respondents who belonged to already completed groups were actively removed after the first page of the questionnaire. The survey population statistics are displayed in Table 3. When estimating an MMNL model without data cleaning, respondents' preferences differed slightly, but the observed signs and significance levels were the same (Table A.10) as compared to the base model estimated on the cleaned data set (Table 5).

Table 3: Descriptive statistics, showing percentages for the sample as compared to the French population statistics (*Pop.*)

Response	Sample [n]	Sample [%]	Pop. [%]
Age			
18-24	186	10.88	10.50
25-34	244	14.28	14.44
35-44	280	16.38	15.77
45-54	308	18.02	16.40
55-69	423	24.75	23.35
older than 70	268	15.68	19.56
Socio-professional categories			
Farmer, craftsman, manager, civil servant	541	26.39	28.1
Employees and workers	481	28.15	28.10
Pensioners and others	773	45.23	43.90
Gender			
Female	896	52.43	52.35
Male	805	47.10	47.65
Did not identify as either	6	0.35	–
Did not wish to answer	2	0.12	–
Altruists (donation sample)			
Total	230	28.19	–
Female	109	26.27	–
Male	118	29.72	–
Free-riding concerned (donation sample)			
Total	86	10.54	–
Female	40	9.64	–
Male	46	11.59	–

4.2. Respondent preferences

The results are largely in line with our preliminary assumptions: The price attribute is negative, respondents favour mixed forests over Douglas fir plantations, and prefer higher carbon uptake, increased biodiversity and guaranteed forest accessibility (Table 6). In all our models, as indicated by positive alternative-specific constants, *asc.alt1* and *asc.alt2*, which are constants included in the utility function for the hypothetical alternatives, respondents show a clear preference for one of the proposed scenarios relative to the status quo alternative. Furthermore, we demonstrate a clear preference for FES provision, including recreation, biodiversity and carbon sequestration, as the corresponding coefficients are significantly positive in all models. However, these preferences are not homogeneous within the population, as indicated by the significant standard deviations in both the preference-space and WTP-space models

Table 4: Choice-specific and socio-demographic variables included in the models. More details are displayed in Table 3 and 8.

Variable	Description
Choice-specific	
forest_type	Mixed forest = 1, 0 otherwise
carbon	Continuous variable ranging from 0 to 15
access	Forest guaranteed publicly accessible = 1, 0 otherwise
addition	Strictly additional = 1, 0 otherwise
biodiversity	At least three habitat trees per hectare = 1, 0 otherwise
Individual-specific	
female	Female = 1, 0 otherwise
forestowner_ind_fam	Forest owner, and/or family member owns forest = 1, 0 otherwise
very_informed	Respondents who considered themselves very informed about forests = 1, 0 otherwise

(Table 5, 6 and 7). The unrestricted models also show significant correlations between a number of attribute coefficients. However, given the model-immanent limitations in distinguishing between behavioural effects and scale heterogeneity, we could not distinguish for each of these whether they belonged to one or the other category. We could, however, identify positive behavioural correlations between *forest type* and *additionality*, *biodiversity* and *additionality*, and negative correlations between *carbon* and *access*, *carbon* and *biodiversity*, and *access* and *biodiversity* (Table A.9).

4.3. Additionality

A fairly large proportion of respondents (35 %), when asked directly, expressed a preference for rewarding sustainable behaviour over efficiency (additionality), while 55 % rated efficiency as more important and 10 % preferred neither option (Table 8). However, in both the base model and the additionality model, respondents show a significantly negative utility for additionality, indicating a preference for rewarding sustainable behaviour over economic efficiency in the choice experiment (Table 5). In line with our assumptions and the literature, we can show that respondents who feel very well informed about forests and/or own forests themselves or have a family as owners tend to prefer additionality, while female respondents seem to have an even clearer preference for rewarding sustainable behaviour as compared to the population as a whole. It should be noted, however, that the confidence level for the variable *very_informed* is only 90 % (Table 5).

4.4. WTP in tax-based versus donation-based payment vehicles

Contrary to our original hypothesis, the mWTP values modelled with the WTP-space models are not systematically different between tax-based and donation-based subsets of the questionnaire (Table 6). Only the WTP for the choice attribute *biodiversity* differed significantly between the samples, being higher for the tax-based version.

By separately modelling the WTP of individuals who reported (a) altruistic behaviour and (b) those who stated they had reduced their WTP due to the possibility of free-riding (Table 8) in a WTP space model (Table 7), we show that the altruists do in fact have significantly higher WTP for *forest type* and *carbon*. The attribute *biodiversity* was only significant for the altruistic group, while *additionality* was only significant for the free-riding group (Table 7). The only WTP value which is slightly higher in the group concerned by free-riding is corresponding to forest accessibility (*access*).

4.5. Scope sensitivity

We tested for scope sensitivity by adding interactions between attributes and a dummy variable for participants who were told that the project would cover 90,000 hectares. Since we did not find a significant interaction (not reported here), we cannot reject the absence of scope sensitivity. One should therefore be careful using our results for a welfare economic analysis if it is aimed at estimating the total WTP for forest restoration by the French population.

5. Discussion

5.1. Preferences and WTP for the restoration of French forests

In this study, we assessed the French population's preferences and WTP for forest restoration and adaptation projects in French private forests. We find that both preferences and WTP are highly dependent on policy formulation, i.e. the definition of what types of projects are eligible for financial support. In line with our initial expectations, the population on average prefers mixed forest stands with native species over Douglas fir plantations. Additionally, projects with a high degree of carbon sequestration, which provide open access for recreational activities and preserve habitats for wild plants and animals, are favoured. However, whether projects should be additional or should also include compensation for existing restoration projects is less clear. We also find significant preference heterogeneity for all forest project characteristics. As a consequence, crowdfunding-based PES companies can benefit from a diversified portfolio of forest projects: Although the average donor prefers a native mixed forest, there is, e.g., a (small) market segment favouring fast-growing species no matter their origin.

The WTP for supporting PES projects in the tax-based subset ranges from 23.43€ to 76.58€ per household per year, with the lowest value for a project with Douglas fir, an additional annual

Table 5: Preference-space MMNL base model without interactions and MMNL model for investigating the impact of individual specific variables on respondents' marginal utility with respect to additionality.

Coefficient	Utility estimates (s.e.) base model	Utility estimates (s.e.) additionality model
asc.alt1	2.202^{***} (0.109)	2.211^{***} (0.105)
asc.alt2	2.092^{***} (0.107)	2.101^{***} (0.104)
foresttype	0.842^{***} (0.073)	0.843^{***} (0.065)
sd.foresttype	1.410^{***} (0.089)	1.423^{***} (0.071)
carbon	0.720^{***} (0.094)	0.703^{***} (0.006)
sd.foresttype.carbon	0.027 (0.017)	0.024 (0.083)
sd.carbon	1.300^{***} (0.111)	1.291^{***} (0.074)
access	0.386^{***} (0.065)	0.366^{***} (0.048)
sd.foresttype.access	−0.104 (0.089)	-0.116^{***} (0.078)
sd.carbon.access	−0.063 (0.084)	−0.061 (0.079)
sd.access	1.028^{***} (0.084)	1.015^{***} (0.069)
addition	-0.256^{***} (0.051)	-0.123^{***} (0.028)
sd.foresttype.addition	0.076 (0.069)	0.080 (0.067)
sd.carbon.addition	0.334^{***} (0.066)	0.338^{***} (0.064)
sd.access.addition	0.182. (0.114)	-0.1617^{*} (0.078)
sd.addition	0.576^{***} (0.083)	0.530^{***} (0.077)
addition.female	–	-0.1219^{*} (0.072)
addition.very_informed	–	0.155. (0.118)
addition.forest_ownerind_fam	–	0.326^{*} (0.143)
biodiversity	0.419^{***} (0.058)	0.413^{***} (0.047)
sd.foresttype.biodiversity	0.202^{*} (0.091)	0.189^{***} (0.065)
sd.carbon.biodiversity	0.474^{***} (0.072)	0.475^{***} (0.068)
sd.access.biodiversity	0.197^{**} (0.078)	-0.215^{***} (0.072)
sd.addition.biodiversity	-0.678^{***} (0.136)	-0.757^{***} (0.064)
sd.biodiversity	0.399. (0.289)	0.203^{**} (0.085)
log.payment	-0.893^{***} (0.145)	-1.9170^{***} (0.121)
sd.log.foresttype.payment	−0.163 (0.275)	−0.066 (0.140)
sd.log.carbon.payment	0.098 (0.513)	0.015 (0.073)
sd.log.access.payment	0.384 (0.601)	0.211^{*} (0.093)
sd.log.addition.payment	0.195 (0.767)	0.126. (0.081)
sd.log.biodiversity.payment	0.954^{**} (0.344)	1.937^{***} (0.120)
sd.log.payment	1.711^{***} (0.112)	0.446^{***} (0.093)
n individuals	1709	1709
n choice situations	13640	13640
n inter-individual draws	3000 (mlhs)	3000 (mlhs)
n estimations	3	3
Log-likelihood (final)	−10994.23	−10981.74
Adj.Rho^2 vs equal shares	0.2644	0.2650
Adj.Rho^2 vs observed shares	0.2184	0.2191
AIC	22046.46	22027.49
BIC	22264.56	22268.15

$^{\cdot}$p<0.1;*p<0.05; **p<0.01; ***p<0.001

Table 6: WTP-space MMNL models, one each for the split samples of tax-based and donation-based payment vehicles

Coefficient	mWTP estimate (s.e.) for tax-based (mandatory) payment vehicle [€/year]	mWTP estimate (s.e.) for donation-based (voluntary) payment vehicle [€/year]
asc.alt1	22.190*** (1.448)	23.820*** (1.624)
asc.alt2	21.065*** (1.481)	22.605*** (1.592)
foresttype	26.574*** (2.871)	23.283*** (3.421)
sd.foresttype	40.551*** (5.871)	42.168*** (4.300)
carbon	1.804*** (0.292)	1.847*** (0.191)
sd.foresttype.carbon	1.244* (0.616)	1.313*** (0.298)
sd.carbon	2.989*** (6.874)	3.503*** (0.428)
access	9.988*** (2.070)	10.778*** (2.703)
sd.foresttype.access	0.696. (0.499)	0.936*** (0.260)
sd.carbon.access	0.049 (0.276)	−0.136 (0.422)
sd.access	21.468*** (1.886)	18.565*** (2.963)
addition	−1.215 (4.833)	−1.645 (1.839)
sd.foresttype.addition	3.579 (0.297)	0.312 (0.250)
sd.carbon.addition	6.941*** (0.184)	0.571* (0.289)
sd.access.addition	1.810 (0.288)	−0.539** (0.202)
sd.addition	12.244** (4.131)	12.851*** (2.426)
biodiversity	14.784*** (3.226)	12.332*** (1.499)
sd.foresttype.biodiversity	1.371** (0.437)	1.398*** (0.285)
sd.carbon.biodiversity	1.365*** (0.173)	1.898*** (0.247)
sd.access.biodiversity	0.549** (0.225)	0.502* (0.301)
sd.addition.biodiversity	−0.752 (0.978)	−0.178 (0.329)
sd.biodiversity	12.535 (13.610)	11.055* (6.230)
log.payment	−0.678*** (0.117)	−0.794*** (0.082)
sd.log.payment	1.095*** (0.211)	1.262*** (0.121)
n individuals	891	814
n rows in database	7128	6512
n inter-individual draws	3000 (mlhs)	3000 (mlhs)
n estimations	4	4
Log-likelihood (final)	-5803.18	-5267.55
Adj.Rho^2 vs equal shares	0.2559	0.2604
Adj.Rho^2 vs observed shares	0.2101	0.2133
AIC	11654.35	10583.1
BIC	11819.27	10745.85

$^{\cdot}p<0.1$; $^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$

Table 7: WTP-space MMNL models, one for the split samples of respondents who reported contributing more (altruism) or less (free-riding) when considering that also non-contributors benefit from a corresponding PES programme.

Coefficient	Altruism estimate (s.e.) [€/year]	Free-riding estimate (s.e.) [€/year]
asc.alt1	25.945*** (2.683)	29.039*** (5.775)
asc.alt2	25.766*** (2.590)	26.965*** (5.548)
foresttype	31.382*** (2.522)	9.011*** (1.725)
carbon	1.689*** (0.187)	0.600*** (0.1601)
access	14.228*** (2.689)	16.141*** (1.673)
addition	−1.406 (6.602)	−3.102* (1.699)
biodiversity	10.068** (3.332)	1.863 (1.639)
log.payment	−1.346*** (0.246)	−0.397. (0.265)
sd.foresttype	54.341*** (9.586)	31.798*** (1.548)
sd.carbon	4.250*** (0.870)	3.977*** (0.4395)
sd.access	24.288*** (7.262)	24.616*** (2.525)
sd.addition	20.695** (8.440)	21.921*** (2.093)
sd.biodiversity	23.989*** (4.043)	18.237*** (1.567)
sd.log.payment	1.622*** (0.357)	1.545*** (0.2782)
n individuals	230	86
n choice situations	1840	688
n inter-individual draws	3000 (mlhs)	3000 (mlhs)
n estimations	4	4
Log-likelihood (final)	-1478.42	-548.57
Adj.Rho^2 vs equal shares	0.2617	0.2557
Adj.Rho^2 vs observed shares	0.1496	0.2254
AIC	2984.84	1125.14
BIC	3062.08	1188.61

$^{\cdot}$p<0.1;*p<0.05; **p<0.01; ***p<0.001

sequestration performance of 5 tCO_2 per hectare, no guaranteed forest access, and without habitat tree requirements. The highest value was achieved by projects with mixed stands, an additional annual sequestration performance of 10 $tC0_2$ per hectare, guaranteed public access and preserved habitat trees. The corresponding values for the donation-based subset are 25.06€ and 73.30€ per household per year. However, as our bid vector (4-80€) was oriented towards cost estimates for plausibility reasons, our WTP estimates may underestimate French consumers' true WTP.

5.2. Comparison with existing WTP estimates

In a survey on preferences for forest management alternatives affecting the recreational attractiveness of state forests in Finland, the estimated household WTP is at a similar level to that in our study (Juutinen et al., 2014). For example, households would pay 34-43€ annually to increase the width of scenic buffer zones along rivers and lakes and 16-21€ to increase the number of managed courting grounds for capercaillies. Also based on a CE, Müller et al. (2020) estimates an annual household WTP of 32€ in Switzerland to support forest owners to establish stands with mixed tree species (deciduous and coniferous) compared to pure conifer stands. This largely corresponds to the 23-27€ household WTP we find in the present study for mixed forests compared to Douglas fir stands. The total household WTP for forest programs promoting recreation, containing mixed tree species and showing no visual impacts of forest exploitation ranges from 107€ to 162€, depending on the region. Brey et al. (2007) estimated the WTP for increasing forestland by 10 % in Catalonia through afforestation, applying a CE and focusing on the mWTP of forest attributes. They find an annual mWTP for allowing picnic and mushroom collection of 6€ and 13€ per individual, respectively. The WTP for storing 68,000 $tC0_2$ through afforestation is estimated at 12€ per year per person. In a valuation of different forest management scenarios for Aleppo pine forests in Catalonia, Varela et al. (2017) estimate the annual WTP per adult individual at 52-70€, depending on the scenario evaluated (focus on biodiversity, fire prevention, etc.), corresponding to annual hectare values of 683-2044€.

5.3. Scope sensitivity

We could not find a sensitivity to scope among the participants. We believe that this is due to (1) the difficulty of imagining area sizes on a regional level, and (2) the lack of a reference to compare with. This result also casts doubt on the per-hectare WTP estimates of other CEs in the field of ES valuation investigating the consumer perspective, which were not specifically tested for scope sensitivity. This shows that improvements are called for in the currently established methodology. This finding seems particularly relevant because, as shown for instance by Dugstad et al. (2021), unlike for Contingent Valuation (CV) studies, explicit testing for scope sensitivity is un-

Table 8: Follow-up questions, with the first two presented to all respondents and the third only to those assigned to the donation-based subset.

Response	#	%	Total
How informed do you consider yourself to be about the forest?			
Very informed	165	9.65	1709
I don't know anything about it	372	21.77	
A little informed	1172	68.58	
Do you or your family own forestland in France?			
No, neither I nor my family own forestland in France	1574	92.10	1709
Yes, I personally and other members of my family own forestland in France	9	0.53	
Yes, I personally own forestland in France	40	2.34	
Yes, my family owns forestland in France	86	5.03	
When you donate to a project, it benefits everyone, including non-payers. Has this influenced your decisions?			
No, I didn't care about the behavior of others, I only wanted to contribute something positive myself.	343	42.14	814
No, I was not aware of the fact that others benefit without paying anything.	155	19.04	
Yes, I would have donated more if I had known that others would also donate, because it is not fair if only I pay but others who pay nothing also benefit from the restored forests. (*Free-riding concerned*)	86	10.57	
Yes, it was important for me because I want to contribute to the common good. (*Altruists*)	230	28.26	

common in CEs. As a consequence, we suggest avoiding the use of large hectare values to define the dimension of a potential PES project. One option could be to completely dispense with per-hectare values and directly assess WTP values for large projects or entire countries, or for fiscally uniform areas in tax-based payment systems, which can then be used as direct policy recommendations. In a tax-based payment system, such total WTP values in a population could then be used to calculate area sizes that could potentially be treated with a corresponding PES system, if WTA values are available from FES providers. Additionally, in a donation-based payment mechanism, it is questionable whether assessing per-hectare values is truly necessary to aid in the establishment of markets for PES, as potential donors evidently lack the sophisticated ability to perceive spatial dimensions. In the context of this work, a follow-up study assessing per-hectare WTA values of forest owners for the same attributes could allow the estimation of total area sizes that could be treated with a potential tax or donation PES scheme in France.

5.4. The role of payment vehicles and free-riding concerns

We initially expected the possibility of free-riding in donation-based payment schemes to reduce consumers' WTP for FES. However, our results show that there is no systematic difference in the distribution of individual WTP between participants in the donation-based version compared to the tax-based version. This is in line with Svenningsen and Jacobsen (2018), who show that for the WTP for FES, especially those considered as rather "distant" by participants, the payment vehicle is of minor importance. In our case, this is probably due to the fact that, in their own words, only about 11 % of respondents had their WTP negatively affected by the possibility of free-riding. About 40 % responded that they do not care about the behaviour of others, they just want to contribute "something positive" themselves, and 28 % even said that it would be important for them for others to benefit from their contribution because they "want to contribute to the common good", suggesting an explicit altruistic attitude. We show that the group concerned about free-riding actually has a significantly lower WTP than those who indicated altruist intentions (t-tests of the mean mWTP estimates). As opposed to several previous studies in which women were found to be more altruistic (Kamas and Preston, 2012, 2015; Brañas-Garza et al., 2018), we find a slightly higher share of males among the altruistic and free-riding-concerned respondents (Table 3). This is consistent with Andreoni and Vesterlund (2001), who find that men are more inclined to be either perfectly selfish or perfectly selfless, they are slightly over-represented in both groups.

Similarly to Faber et al. (2002), Ojea and Loureiro (2007) and many other studies in the field of ecological and environmental economics, our results challenge the assumption that a lack of incentive compatibility triggered by the possibility of free-riding significantly reduces consumers' WTP for public goods and common pool resources in an ES-related context. We even found evidence that an awareness of other people benefiting from a donation can actually increase certain consumers' WTP, suggesting an altruistic attitude in sections of French society. This finding is consistent with Svenningsen and Jacobsen (2018), who applied both stated-hypothetical and revealed preference methods and argue that concerns about free-riding would lower the WTP in a revealed preference context, while altruistic behaviour would increase it.

Another way of interpreting this would be to follow the argument of Nyborg (2000) and Faber et al. (2002), who distinguish between two roles that a questionnaire participant can play: a) The classical 'homo oeconomicus' and b) the 'homo politicus', whereby the former mainly tries to maximise his personal (short-term) utility and the latter acts from the perspective of a "good citizen" who considers the common good when making decisions. Nyborg argues that stated preference methods aimed at ES valuation specifically address the role of homo politicus, as such studies are embedded in an ethical/political context related to public goods and common pool resources, which by definition only benefit ES buyers in a non-exclusive and indirect way. This is likely to result in higher WTP values compared to those that may be indicated from the homo oeconomicus' perspective. Our follow-up question (Table 8) would thus not only reveal the respective participant's attitude towards free-riding and altruism, but also which role he or she played when answering the questionnaire, whereby both aspects are barely distinguishable and probably linked with one another.

Faber et al. (2002) identified a number of external conditions required for a person to adopt the role of homo politicus, such as a participatory and decentralised structure of political decision-making and the existence of a functioning public capable of exerting control upon the government. It is therefore important to bear in mind that the role someone plays in such a study—and also in real-life decisions—is likely to be related to the context, e.g., the type of political-economic system in which the decision-maker is situated, as both estimated and true WTP values may be influenced by this. As a result, we were able to provide further evidence that the payment vehicle is of little importance to consumers' WTP for FES, and we suggest that this indifference can be explained by respondents taking a "good citizen" position (homo politicus).

5.5. Equity and additionality

We show that being female is significantly related to a particularly strong advocacy of equity. This is in line with the literature on gender differences in equality, which shows that women are significantly more likely to be inequality-averters (Kamas and Preston, 2012, 2015; Brañas-Garza et al., 2018). In contrast, owning forests, either as an individual or in the family, and feeling very well informed about forests, links to a preference for strict additionality adherence, while the remaining respondents are indifferent. This pronounced heterogeneity in consumer preferences also highlights that although PES is an economic and thus efficiency-oriented instrument, social and legal considerations cannot be disregarded in its design. Moreover, the fact that the majority of respondents prefer equity to additionality could indicate that consumers are more concerned with achieving a feel-good experience (warm glow) than with real environmental enhancements.

As Karsenty et al. (2017) show, the feeling of being evicted from a PES scheme due to additionality requirements can lead to cases of blackmail on the part of FES providers, which may even cause an affected PES scheme to fail. Equity at the expense of additionality, on the other hand, leads to a multiplication of eligible FES providers, which ultimately reduces a PES scheme's economic efficiency. Vedel et al. (2015), however, demonstrate that the WTA of forest owners for non-additional projects is close to zero. This, in combination with the high WTP for non-additional projects among parts of the population, can be interpreted as an opportunity to create win-win situations: Non-additional reforestation projects could be supported with relatively low funds so that large areas can be covered while avoiding major efficiency losses due to the lack of additionality. Here, however, it is essential not to lose too many funds in transaction costs.

Moreover, studies across various contexts suggest that people tend to chalk up their prosocial behaviour as a kind of social surplus in order to subsequently justify antisocial or morally dubious actions (Monin and Miller, 2001; Merritt et al., 2012; Brañas-Garza et al., 2013; Sass and Weimann, 2015; Clot et al., 2018; Engel and Szech, 2020). This so-called 'moral self-licensing dilemma' is particularly delicate for voluntary, non-additional PES programmes, where the absence of an effective behavioural change on the part of FES providers could result in a net deficit of prosocial behaviour at the societal level. In this respect, one could consider requiring PES projects that focus on carbon sequestration to always be additional, so that a net CO_2 emission increase caused by moral self-licensing in combination with non-additional carbon sequestration projects is avoided at the societal level.

Generally, if there is no strict additionality obligation, there is a risk of environmental law losing its power, which can also lead to a logic of blackmail in remuneration. Thus, either way, there may be tensions and risks of blackmail, or even of net losses in FES supply. These PES-inherent moral dilemmas, which transcend technical issues, suggest the inclusion of stakeholder participation and interdisciplinary dialogue in their design process. Consequently, eligibility criteria should be specified on a case-by-case basis, rather than being dictated by one-dimensional objectives or general consumer preferences.

6. Conclusion

We show that consumers are willing to pay for both additional and non-additional projects in tax- and donation-based PES schemes. Their respective preferences are heterogeneous for all attributes studied. Given consumers' rejection of additionality and their lack of spatial understanding, as we found when testing for scope sensitivity, they seem to have difficulties—or little interest—in assessing the environmental effectiveness of PES projects. This may also imply that consumers' decisions are aimed at a feel-good factor (warm glow) rather than actual ecological enhancements. Thus, our study can be interpreted as a call for stricter regulation of FES markets, especially when it comes to carbon sequestration projects where moral self-licensing could lead to a net increase in CO_2 emissions. However, given the pronounced altruistic attitude and high WTP for FES that we observed, this work also allows for some optimism: Consumers seem willing to contribute financially to a greater supply of FES. In addition, the pronounced heterogeneity in consumer preferences allows for the establishment of diverse markets in which a wide variety of FES can be traded.

In light of these findings, we propose that further assessments are needed of the impact of warm glow, free-riding and altruism, and the moral self-licensing dilemma in tax-based and donation-based PES schemes in the context of additionality. We also suggest including real payments and identifying the WTA of FES providers for the FES and eligibility criteria analysed in this work, so that appropriate spatial estimates of the areas potentially covered by a respective PES can be calculated.

Author contribution

Oliver Frings: Conceptualisation, Resources, Investigation, Methodology, Writing – original draft, Data curation, Formal analysis, Writing – reviewing and editing. **Jens Abiltrup**: Supervision, Resources, Conceptualisation, Investigation, Writing – original draft, Project administration, Validation, Writing – reviewing and editing. **Salomé Gorel**: Writing – original draft. **Claire Montagné-Huck**: Writing – original draft, Validation. **Anne Stenger**: Supervision, Writing – original draft, Funding acquisition.

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Appendix A.

Table A.9: Preference-space MMNL model for interpreting correlations, where *additionality* and *payment* were reversed

	Estimate (s.e.)
asc.alt1	1.805*** (0.090)
asc.alt2	1.724*** (0.090)
asc.optout	0
foresttype	0.057 (0.056)
sd.foresttype	1.603*** (0.067)
carbon	0.018** (0.005)
sd.foresttype.carbon	0.076*** (0.009)
sd.carbon	−0.140*** (0.006)
access	0.104** (0.043)
sd.foresttype.access	0.122* (0.068)
sd.carbon.access	−0.159* (0.072)
sd.access	−0.978*** (0.0659
addition	0.484*** (0.036)
sd.foresttype.addition	−0.274*** (0.058)
sd.carbon.addition	0.139* (0.060)
sd.access.addition	0.004 (0.071)
sd.addition	−0.521*** (0.081)
biodiversity	0.052 (0.042)
sd.foresttype.biodiversity	0.403*** (0.063)
sd.carbon.biodiversity	−0.537*** (0.063)
sd.access.biodiversity	−0.182** (0.071)
sd.addition.biodiversity	−0.480*** (0.123)
sd.biodiversity	0.625*** (0.120)
log.payment	−1.304*** (0.181)
sd.log.foresttype.payment	0.645*** (0.085)
sd.log.carbon.payment	0.280*** (0.041)
sd.log.access.payment	0.051* (0.025)
sd.log.addition.payment	0.109*** (0.029)
sd.log.biodiversity.payment	0.012 (0.017)
sd.log.payment	−0.026** (0.009)
n individuals	1705
n choice situations	13640
n inter-individual draws	3000 (mlhs)
n estimations	4
Log-likelihood (final)	-11725.84
Adj.Rho-squared vs equal shares	0.2156
Adj.Rho-squared vs observed shares	0.1665
AIC	23509.68
BIC	23727.79

·p<0.1;*p<0.05; **p<0.01; ***p<0.001

Table A.10: Preference-space MMNL model estimated with the entire uncleaned data set

	Estimate (s.e.)
asc.alt1	2.191*** (0.083)
asc.alt2	2.154*** (0.082)
asc.optout	0.000
foresttype	0.564*** (0.046)
sd.foresttype	1.240*** (0.056)
carbon	0.509*** (0.043)
sd.foresttype.carbon	0.096. (0.072)
sd.carbon	−1.170*** (0.058)
access	0.248*** (0.036)
sd.foresttype.access	−0.071 (0.064)
sd.carbon.access	0.014 (0.065)
sd.access	−0.812*** (0.058)
addition	−0.295*** (0.032)
sd.foresttype.addition	0.065 (0.056)
sd.carbon.addition	0.236*** (0.052)
sd.access.addition	−0.099. (0.065)
sd.addition	0.500*** (0.062)
biodiversity	0.215*** (0.039)
sd.foresttype.biodiversity	0.290*** (0.053)
sd.carbon.biodiversity	−0.447*** (0.054)
sd.access.biodiversity	−0.167** (0.067)
sd.addition.biodiversity	−0.524*** (0.056)
sd.biodiversity	−0.415*** (0.065)
log.payment	−0.233*** (0.015)
sd.log.foresttype.payment	−0.024*** (0.006)
sd.log.carbon.payment	−0.013. (0.010)
sd.log.access.payment	−0.020** (0.007)
sd.log.addition.payment	−0.078*** (0.008)
sd.log.biodiversity.payment	0.289*** (0.014)
sd.log.payment	−0.060*** (0.007)
n individuals	2521
n rows in database	20168
n inter-individual draws	3000 (mlhs)
n estimations	4
Log-likelihood (final)	-16093.1
Adj.Rho-squared vs equal shares	0.2724
Adj.Rho-squared vs observed shares	0.2557
AIC	32244.19
BIC	32473.64

·p<0.1;*p<0.05; **p<0.01; ***p<0.001