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► To cite this version:

Pierre Dupraz, Abdoul Nasser Seyni Abdou, Thomas Coisson, Bertille Thareau. Towards the establishment of a voluntary carbon compensation market: the contributions of a choice experiment method. 13. Journées de recherches en sciences sociales (JRSS 2019), Société Française d'Economie Rurale (SFER). FRA., Dec 2019, Bordeaux, France. hal-02503308

HAL Id: hal-02503308

<https://hal.science/hal-02503308>

Submitted on 2 Jun 2020

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13emes journées de recherche en sciences sociales INRA SFER CIRAD
Bordeaux, 12 et 13 décembre 2019

Towards the establishment of a voluntary carbon compensation market: the contributions of a choice experiment method

Draft version - do not quote, do not distribute

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June, 2019

Abstract

In addition to their role in maintaining biodiversity, producing many ecosystem services or contributing to the landscape quality of the areas, hedgerows have the capacity to store carbon in their above- and below-ground biomass, an environmental function that can provide an opportunity for companies wishing to offset voluntarily their CO₂ emissions. In this paper, we examine the conditions for the existence and development of voluntary carbon offset markets as a new way to improve hedge maintenance and mitigate climate change. Through a series of surveys conducted among companies and farmers in Western France, we aim to determine the existence of a space for negotiation between these actors by adopting a discrete choice experiment method. The results show a certain heterogeneity in the expression of willingness to pay and willingness to receive, but a space for negotiation is well identified for a category of actors and for some modalities of the scheme. From a methodological point of view, our work shows in a new way that the choice experiment method can be used to identify the conditions of existence of a market for environmental goods.

Keywords:

Willingness to pay; Willingness to receive; discrete choice experiment; Conditional logit; mixed logit; Voluntary carbon market; Hedges.

Acknowledgements:

This research is part of the project funded by ADEME ((the French Environment and Energy Management Agency) and supported by CRPdL (Regional Chambers of Agriculture of the Pays de la Loire) in collaboration with the regional chamber of agriculture of Brittany. It also involves several partners: Departmental Chambers of Agriculture of Maine-et-Loire, Morbihan and Sarthe, the Chambers of Commerce and Industry of the Pays de la Loire and Morbihan, and the sustainable development-consulting firm O2M

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1. INTRODUCTION

The Conference of the Parties (COP 21) in Paris in 2015 launched several measures to adapt and mitigate the effects of climate change and food security. One of these measures is the four per thousand initiative, which aims to offset global greenhouse gas emissions and at the same time promote agricultural soils and agroforestry systems such as hedges in certain areas. However, the implementation of this objective is important in terms of mitigating farmers' exposure to the adoption of certain Agri-environmental Schemes (AES) promoted by the CAP (Common Agricultural Policy), some of which may be due to low payments for farmers or high transaction costs for others (Duval et al. 2016; Ducos, Dupraz, et Bonnieux 2009). In the west (Pays de Loire and Bretagne), this situation is in addition to the need to develop hedges, which have an increasingly ageing heritage, thus creating an offer for the development of environmental services from hedges, particularly carbon storage (ADEME 2015). This requires, first, to look for new ways to promote farmers' agri-environmental practices, through the development of hedgerow systems.

Commenté [TB1]: Est-ce suffisamment connu / relayé au niveau international pour se passer d'explication ?

On the other hand, a growing demand for carbon units for the voluntary offsetting of greenhouse gas emissions emerges from companies that are essential economic actors in the implementation of carbon reduction or offsetting actions. Indeed, the IPCC report (2014) clearly established the role of the economic sectors responsible for the majority of GHG emissions. In 2010, the main economic sectors responsible for GHG emissions are electricity and heat production (25% of total GHG emissions), industry (21%), agriculture, forestry and land use (25%), transport (14%) and the residential sector (6%) (US EPA 2016). Thus, several companies have integrated sustainable development strategies into their policies to reduce their emissions. In recent years, some of these companies have taken these actions a step further and are aiming at carbon neutrality through voluntary carbon offsetting actions. It is a strategy that allows them to achieve sustainable development objectives, and thereby demonstrate a high level of leadership on environmental issues, but sometimes to manage risks related to their activities or territory and ensure their development (I4CE 2017).

Thus, voluntary carbon markets appear to be a potential way for farmers to value carbon storage services and provide a means of remuneration for farmers. They also provide solutions for companies wishing to offset their residual greenhouse gas emissions and act on their territories by enhancing the value of existing ecosystem services. However, the implementation of this kind of market device requires finding a space for negotiation between buyers and sellers of carbon credits. Several difficulties lie in determining this negotiating space, including, among others, the allocation of a price and the difference in actors' perception of the advantages of the system, especially since the integration of environmental criteria could constitute growth drivers of the clearing market in the coming years (I4CE 2017).

This paper aims to study the possibilities of setting up a voluntary carbon market and the conditions of engagement of the actors concerned. We therefore ask ourselves the following question: « How to identify a potential negotiating space between suppliers and carbon seekers in a voluntary market? » To define the terms of compatibility between the supply and demand for carbon storage by hedgerows and the associated market conditions, we use a valuation method for non-market good. Indeed, one of the major difficulties of our work lies in the fact that the object of the transaction is not stable from one actor to the other: for companies, "seekers" of carbon to be offset, the argument is based a priori on the quantity of carbon stored but for farmers, "suppliers" of carbon, the transaction is more about creating and maintaining hedges. However, the characteristics of the hedgerow, although related to a quantity of stored carbon, also have other attributes that can be valued, such as the ability to preserve water quality, to fight against soil erosion or to generate landscaping amenities.

The use of evaluation methods from environmental economics therefore seems appropriate here, since they should allow us to identify and estimate the consents of supply and demand stakeholders to pay or receive for a set of environmental services offered by the hedgerow and therefore in particular for carbon storage. It will thus be possible to delimit the multidimensional spaces of negotiation in the balances between supply and demand that may exist. To do this, we present in the following section a literature review to define and justify our methodological approach. We then specify the methodological approach adopted through the sampling and survey method, then we discuss econometric analysis and the specifications of the models used. Finally, we present the results obtained from the estimated models and calculations of the consents to pay and receive, before concluding.

2. LITERATURE REVIEW

Economic valuation methods for environmental goods and services are increasingly gaining interest from policy makers and organizations responsible for implementing environmental policies (Pearce et al. 2002). Despite some authors' criticisms of the hypothetical nature of the questions and the lack of observation of the actual behaviors of the actors (Cummings et al. 1998; Mitchell et Carson 2013), stated preference methods are often preferred when it comes to quantifying the environmental values of non-market goods since their introduction by Adamowicz, Louviere, and Williams (1994). These methods were mainly used since the 1980s in behavioral and experimental economics in the fields of transport, marketing, and then in the fields of safety and health to inform many strategic and investment decisions (Ryan, Gerard, et Amaya-Amaya 2008; J. Louviere et woodworth 1983).

Since the implementation of Agri-environmental Schemes (AES), more and more studies have focused on stakeholder preferences and the conditions for implementing environmental programs and policies, using one of the stated preference methods, the Discrete Choice Experiment (DCE) method (Espinosa-Goded, Barreiro-Hurlé, et Ruto 2010; Ruto et Garrod 2009; Christensen et al. 2011; Siebert, Toogood, et Knierim 2006; Defrancesco et al. 2008; Ndunda et Mungatana 2013). It is a method that provides better stability in individual preferences but, above all, allows simultaneous estimation of marginal effects and attribute values (Competition Commission 2010).

Ruto et Garrod (2009) used this method to study farmers' preferences in designing environmental programs in 10 areas across the EU. The scheme was a choice experiment method whereby the main features of EAS design were presented to farmers in order to identify their preferences. On a sample of 2262 farmers divided between participants and non-participants, 4 main characteristics of the program were studied with each of the different levels. The results showed that all the factors tested were significant, the duration of the contract, flexibility as regards the areas of operation, flexibility to undertake some of the measures required under the program and the average time spent on non-operational aspects. This study found a strong need for financial incentives for farmers to join longer-term schemes, or schemes that offer less flexibility or higher levels of paperwork. In addition, to address the heterogeneity within farmers' preferences, interactions have been introduced between the average of the estimated utility parameters and agricultural factors. By interacting specifically with the term of the contract, they found that age, education, farm successor, rent and financing were negatively related to the term of the contract, while environmental concerns and field size were positively related.

The same conclusions emerge from a study that focused on the case of a program to encourage nitrogen-fixing crops in the dry marginal areas of Spain. Espinosa-Goded, Barreiro-Hurlé, and Ruto (2010) found similar results. Indeed, the 300 farmers surveyed were willing to participate

in the programs provided they did not have strict farm management restrictions. Thus, greater flexibility in the management requirements for EAWs was needed to encourage greater farmer participation.

In Denmark, Christensen et al., (2011) studied the determinants of Danish farmers' participation in a subsidy program for pesticide-free buffer zones, drawing on the experimental design used by Ruto and Garrod (2009). The results also showed that most farmers are willing to exchange their payments for less restrictive requirements. However, they noted that short-term contracts are preferred over long-term contracts. Similarly, flexibility in program requirements plays an important role in encouraging farmers to participate in the program.

Some conditions seem interesting a priori as regards farmers' involvement in environmental schemes. They allow us to propose elements of attributes to our study. However, most of the studies on commitment to environmental schemes concern farmers. Studies on the involvement of companies in environmental measures concern subjects of social and environmental responsibility (CSR) or sustainable development (Labelle et St-Pierre 2010; Reynaud et al 2007; Chenost et al 2010; Cabagnols et Le Bas 2006; Aron et Chtourou 2014). However, these studies did not use a method of choice to determine the utility values of companies with attributes and the calculation of implicit prices. However, they show that companies' involvement in environmental measures depends on organizational, individual, institutional and communication factors.

Beyond the determination of market conditions and the determinants of individuals' preferences to commit to environmental schemes, politicians want to know the economic value that individuals attach to the environmental scheme.

Thus, we also attempt to estimate the implicit price values that individuals assign to attributes of an environmental good. Indeed, it is a method that also has the advantage of estimating the willingness to pay and/or receive from individuals when it comes to implementing a program based on payments for environmental services. There are several methods for estimating the willingness to pay or receive. However, the choice experiment method is the most appropriate in this case for calculating the implicit price values, partly because it is less subject to hypothetical biases in estimates of willingness to pay (Adamowicz, Louviere, et Williams 1994; Hole 2007; Pearce et al. 2002). Although, it remains a method of preferences that are declared by individuals in a non-existent market, but it has the advantage of reproducing more accurately the actual conditions of purchase (or sale) of the actors than the contingent valuation method, which is also a method of declared preferences (Bredert, Hahsler, et Reutterer 2010).

Thus, in general, studies focus on determining the preferences of individuals in the implementation of an environmental program (Espinosa-Goded, Barreiro-Hurlé, et Ruto 2010; Ruto et Garrod 2009) and sometimes in estimating their willingness to receive or willingness to pay for the valuation of an environmental service (Delvaux et al. 1999; Dachary-Bernard 2007). The originality of our study lies in the use of the method of choice to determine both the willingness to pay and the willingness to receive from individuals in the establishment of a voluntary carbon market valuing hedges. The estimation of these consents will make it possible to define and delimit whether there is a negotiating space between these actors to set up the voluntary carbon market. It makes it possible to determine the conditions under which the market will have to be set up. This space will also help to identify the actors potentially able to enter this market.

Commenté [TB2]: Qui ? je ne pense pas utile de se référer à des élus (on ne sait pas bien qui) pour justifier que c'est utile d'estimer les valeur 'échange possibles

3. MATERIALS

3.1. Econometric specification of models

The choice experiment method used for our study was introduced by Louviere (1988) in environmental economics in order to evaluate the value of a property through those of its attributes or characteristics. This method finds its theoretical basis in the Lancaster consumer choice model (Lancaster 1966) and its econometric basis in random utility models (McFadden 1974).

According to Lancaster, consumer satisfaction is defined by the attributes of the goods rather than the goods themselves. In other words, the indirect utility V_{ij} that the individual i obtains from the good j is the sum of the utilities obtained from each of the K characteristics S_{kij} where $k=1, 2, \dots, K$. We assume that the utility V_{ij} is an additive function of the characteristics of the good and can be written as follows:

$$V_{ij} = \beta_{1i}S_{1ij} + \beta_{2i}S_{2ij} + \dots + \beta_{Ki}S_{Kij} \quad (1)$$

Therefore, the choice data are analyzed on the assumption that individuals will choose the alternative that maximizes their utility, i.e. that an individual i will choose an alternative p rather than another q if $U_{ip} > U_{iq}$. According to the literature, this type of experimentation is analyzed by a conditional logit model (McFadden 1974) that is based on random utility theory. The latter assumes that individuals make choices based on a deterministic and a random component. The utility U associated with individual i faced with a choice between two experimentally created devices and a reference level device j is given by the formula:

$$U_{ij} = V(ASC, Z_{ij}, \beta_k) + \varepsilon_{ij} \quad (2)$$

Where V_{ij} now represents the deterministic component of the utility function which is a function of Z_i , the vector of the main attributes of the discrete choice experiment and fixed parameters β_k . ε_{ij} is a random variable that captures the systematic and unobserved random element of individual choice n (Hanley, Adamowicz, et Wright 2005). The ASC (Alternative-specific constants) variable is modeled as a constant variable that captures the effect of the utility of all other attributes that were not considered in the model.

If all parameters in the conditional logit model are fixed, the error independence assumption is not respected, leading to biased estimates. Indeed, this hypothesis corresponds to a model where it is assumed that the population is homogeneous (where the preferences of an average actor are estimated). This is not the case since in the logit model, only the price parameter is fixed (condition allowing the calculation of the willingness of the actors to pay or receive), it is interesting to estimate a model that considers this heterogeneity bias.

The Random parameters Logit or mixed logit model (RPL) applied to all variables in the model except price, allows for variations in how individuals evaluate market attributes (Brownstone, Bunch, et Train 2000; Revelt et Train 1998; Ndunda et Mungatana 2013). In this model, the estimated coefficients of the average preference values β are assumed to be normally distributed (Revelt et Train 1998). In addition, individual choices are assumed to be constant overall, but vary from respondent to respondent.

3.2. Calculation of Willingness to Pay and Receive

Since the choice method is compatible with the theory of utility and demand maximization, once the parameters have been estimated, the values of the implicit prices of the actors with respect to the device can be calculated. To do this, generally assuming linear utility functions

Commenté [TB3]: U_{iq} ?

in the attributes, the method first consists of determining the marginal rate of substitution (MRS) between an i attribute and a j attribute. When the observed utility is specified as linear in the alternative attributes, as in (2), the total derivative of U with respect to the changes in attribute i X_i and attribute j X_j is given by $dU = \beta_i dX_i + \beta_j dX_j$. By setting this expression to zero and resolving $dX_i = dX_j$, we obtain the change of attribute j which keeps the utility unchanged given a change in X_i . The marginal rate obtained is therefore obtained as follows (Gatta, Marcucci, et Scaccia 2014):

$$MRS = -1 \left(\frac{\beta_i}{\beta_j} \right) \quad (3)$$

In order to measure preferences for all the characteristics of the scheme in the same currency unit, i.e. in euro, we mainly estimate the marginal substitutions between market requirements and the price per ton of CO₂. Since the selection price of a device is included as a main attribute, the MRS can be used to produce an estimate of the price of the implicit value. This value provides a marginal willingness to pay for companies (CAP) or receive for farmers (CAR) for a discrete change in an attribute level. This helps to understand the relative importance that individuals attach to market attributes. For continuous variables in a conditional logit model, the marginal WTP is simply the estimation coefficient of the observed exogenous variables relative to the compensation payment coefficients (prices). Thus, the CAP or CAR of the value of an attribute j can be estimated as follows:

$$\widehat{CAP} = -1 \left(\frac{\beta_j}{\beta_{prix}} \right) = \frac{dX_{prix}}{dX_j} \quad (4)$$

Where β_j and β_{prix} are the maximum likelihood estimates of attribute j and the price of $teqCO_2$ respectively. These estimates are asymptotically distributed normally for sufficiently large samples (Gatta, Marcucci, et Scaccia 2014).

3.3. Design of the DCE

The aim of this study is to determine a space for negotiation between farmers and companies for the development of hedgerows through the establishment of a voluntary carbon market. This negotiation space concerns the subject of the contract, the price and the conditions of the system. To determine this space for negotiation on these 3 dimensions, the crucial phase of the choice method consists in creating an experimental design to carry out the "card game" presented to the respondents.

The first step in this design consists of a selection of attributes and attribute levels that generate the universe of all possible devices. These attributes and their levels considered to be the most relevant were selected on the basis of a broad literature review on agri-environmental measures, a previous survey of 28 farmers in a pilot territory and also on the basis of expert opinions from the Chambers of Agriculture and Chambers of Commerce and Industry.

In practice, this method asks respondents to select the device they prefer for a given set of cards. A scenario represents a series of market devices (or contracts) randomly distributed so that the respondent chooses between two typical devices of the proposed market and a third device that is the option to prefer neither of the first two devices (Status quo). The devices are defined by some attributes whose modalities or levels vary. The number of choices that an individual must answer depends on the number of possible devices. In general, a discrete choice experiment would consist of 3 to 4 attributes taking a maximum of 5 levels (Orme 2002). The attributes and their levels presented in Tables 1 and 3 were used to produce the design of the set of cards to be presented to the respondents.

Also, the monetary attribute was added in accordance with the experimental choice method approach. This is the price at which the company is willing to buy the carbon credit to offset its CO2 emissions and for farmers it is the price they are willing to receive for the sustainable management of their hedges.

3.4. Experimental design

The differences in the position of farmers and companies regarding the market proposal led us to build 2 partially symmetrical surveys.

- The purpose of the market (the environmental good) was qualified very closely in the farmers' survey and the companies' survey, by proposing to manage (or support) different types of hedges (pluristrates or coppice) chosen for their differences in terms of mitigation potential and environmental Co-benefits. The fact that coppice hedges store more CO2 than pluristrates hedges, and that pluristrates hedges generate more environmental benefits, was explained before the card game phase for both audiences. For farmers, we have clarified what this commitment practically covers by distinguishing a hedge creation contract from a hedge maintenance contract.
- The proposed price levels were the same for both actors. We converted them during the survey and for each scenario into euros/km of hedge for farmers and into km of supported hedges for companies.
- We tested different device attributes for farmers and companies. Indeed, both the literature and the pre-survey phase showed that the conditions of engagement in the system were structurally different for each other. In order to test the parties' ability to agree on asymmetrically tested device attributes in the card set, we included in both questionnaires the same simple choice questions about respondents' preferences for all device attributes (including attributes that we had considered secondary in developing the DCE).

An orthogonal design was randomly performed to obtain sets of cards based on the number of attributes and their levels. The Ngene 1.0 package software was used to design the choice cards. Thus, for the company survey, 18 decks of cards divided into two blocks of 9 sets of cards were produced with a D-efficiency criterion of 61.2% of the DCE. The number of sets of cards depends on the number of attributes and their levels.

Table 1: Attributes and Levels for companies

Attributes	Levels
Type of hedges and associated co-benefits	N1: Coppice Hedges that store more CO ₂ (reference level) N2: Pluristrates hedges that generate more environmental services including biodiversity
Type of intermediary	N1: State-type intermediary (example deposit fund) (reference level) N2: Intermediate type Private Aggregator (example CO ₂ Savings Account) N3: Intermediate type Local organizations chaired by a community
Budget volume committed	N1: 10% (reference level) N2: 30% N3: 60%
Price (euro/teqCO ₂ ⁵)	N1: 5 N2: 56 N3: 150

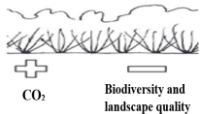
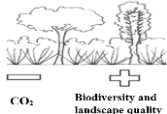
Commenté [TB4]: Cette formulation me semble suggérer qu'on parle de la même chose que précédemment, or ici, on a précisé l'attribut (et non pas clarifié). A valider avec a native speaker !

Commenté [TB5]: Mériterait d'être explicité en note : % du budget RSE ou ligne budgétaire jugée pertinente pour l'entreprise.

⁵ TeqCO₂: or ton of CO₂ equivalent, is a common unit of measurement used to compare all GHGs across global warming power (PRG) that compares all GHGs over 100 years to CO₂.

The following table presents an example of a card of choice offered to companies. Each time, respondents had to choose between options A, B or C (*status quo*). Options A and B represent situations of the environmental device.

Table 2: Example of a card of choice presented to companies

	Device A	Device B	Device C
Hedge Types and Associated Co-benefits	Hedges Coppice 	Pluristrates Hedges 	None of the devices A and B
Type of intermediary	Private aggregator (company)	Collective (mixed union type)	
Budget volume committed	30%	30%	
TeqCO2 price	56 euro/teqCO ₂	5 euro/teqCO ₂	
Which device do you prefer?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

As for farmers, a set of 36 choice cards is created and divided into three blocks of 12 cards for each surveyed with an optimal criterion of 66.2%. These levels of optimality help to minimize the generalized variance of parameter estimates for a predefined model. The best design is the one with the highest D-efficient criterion. In this case, for both farmers and businesses, the design is more than 60% orthogonal, indicating a good quality of the designs created.

Table 3: Attributes and Levels for Farmers

Attributes	Levels
Creating/improving	N1: Creation of hedges trimmed over 15 years (on bare ground) N2: Creation of pluristrates hedges over 15 years (bare ground) N3: improvement of relic hedges, low shrubs and alignment of pluristrates trees over 15 years. N4: 0 (No creation or improvement of hedges) (reference level)
Maintenance	N1: maintaining existing thicket and pluristrates hedges over 5 years (no cutting) N2: maintaining existing thicket and pluristrates hedges over 15 years (1 cut) N3: maintenance of existing shrub and pluristrates hedges over 30 years (2 cuts) N4: 0 (No maintenance or maintenance of hedges) (reference level)
Methods of control	N1: Remote control (aerial photointerpretation...) N2: Remote control plus a technician's visit N3: Participatory guarantee system (which brings together farmers and buyers) (reference level)
Price (euro/teqCO₂)	N1: 5 N2: 56 N3: 150

Commenté [TB6]: Concerne aussi le type de haie : coppice / pluristrates

Commenté [TB7]: On utilise le terme coppice ailleurs

Commenté [TB8]: Je suis gênée par la différence de présentation // DCR entreprises ou la modalité statu quo n'est pas présentée comme un choix.

3.5. Data coding

The conditional logit model makes it possible to specify for each attribute (excluding price), a reference level and to estimate the coefficients of the other levels. Indeed, all the main attributes except the market price (in euro/teqCO₂) are discrete qualitative variables whose possible levels

reflect multi-attribute changes in the system, so this change must be considered by coding the variables, also called "effect coding".

Coding makes it possible to regress the level of utility on attribute levels and no longer on the attributes themselves. To do this, a reference level must be selected for each attribute and new variables with coded effects or dummies must be created. For example, the attribute of the carbon object of companies with its two levels (coppice hedges and pluristrates hedges) has been replaced by the variable *hedges_plur* with reference to the pluristrates hedge. It will take the value 1 if the attribute is at its level 2 (pluristrate hedges); and -1 if the attribute takes the level 1 (coppice hedges).

As a result, the attribute levels selected as references for each attribute presented to companies are coppice hedges (for the hedge attribute), the type of intermediary "State" and the low budget (10%) for the allocated budget. The utility model on the estimated main attributes thus becomes for companies:

$$V_{ij} = ASC + \beta_1 Hedges_{plur} + \beta_2 Int_{private} + \beta_3 Int_{collective} + \beta_4 Bud_{medium} + \beta_5 Bud_{High} + \beta_6 Price \quad (5)$$

Similarly, for farmers, the selected reference attribute levels are: No creation or improvement of hedges (for the attribute Creation - improvement of hedges), no maintenance or maintenance of hedges (for the attribute type of maintenance) and participatory guarantee system (for the attribute methods of control). The estimated model is then as follows:

$$V_{ij} = ASC + \beta_1 Creation_{coppice} + \beta_2 Creation_{pluri} + \beta_3 Improvement + \beta_4 Maintenance_5 + \beta_5 Maintenance_{15} + \beta_6 Maintenance_{30} + \beta_7 Cont_{distance} + \beta_8 Cont_{visite} + \beta_9 Price \quad (6)$$

The ASC variable takes the value 1 if one of the hypothetical devices is chosen and 0 if none of the options is chosen. Based on this model specification, at the farmer level, a positive value of the dummy ASC value suggests the existence of some omitted variables that have a positive effect on the respondents' ability to choose the "none of the options" option (Ndunda et Mungatana 2013; Christensen et al. 2011). However, for companies, this positive value suggests the absence of some omitted variables that have a positive effect on the respondents' ability to choose the status quo.

Individual variables were added to the models to analyze the individual factors that vary the willingness to pay and receive from actors. As market attributes differ between devices, individual variables can only enter models if they are specified to create a difference in utility between alternatives. That means that they must interact with the attributes of the device to create new variables in the model. These new variables will demonstrate the influence of the interacting characteristic on the utility of the attribute. Thus, when the attribute level coefficient decreases, the attribute becomes less important in the individual's decision making, compared to other attribute levels, as we move towards the socio-economic variable (Train 2009).

3.6. Study Sites

The study area covers four zones in western France (Brittany and Pays de la Loire). These zones were chosen for their relevance to the research project associated with this work and their dynamism on the subject. Indeed, they are known for their determination on energy and climate transition issues, which is reflected in the fact that these four territories are positive energy for green growth, they have set up a Territorial Climate-Air-Energy Plan (TCAEP), and have a long history of work on carbon storage and bocage. These territories are distributed over the two regions as follows: Pays de la Vallée de la Sarthe (72) and Mauges communauté (49) in the Pays de la Loire region, Pays de Roi Morvan (56) and Roche aux fées community (35) in

Brittany. These zones include about a hundred municipalities over an area of more than 3500 km² with a population of nearly 25000 inhabitants. There is also a hedge capacity of more than 21000 km in these areas.

3.7. Sampling and questionnaire

A survey was conducted among the three target actors of the project in the zones concerned. These include farmers as carbon storekeepers via the bocage network, companies as carbon emitters and in potential quest for compensation, and local authorities as initiators of policies to reduce CO₂ emissions via the Territorial Air Energy Climate Plan (TAIECP).

The sampling aimed to test the possibility of setting up a market and its potential characteristics, even if the results concerned a population a priori more inclined to engage in it. We did not aim to measure the potential influence of these markets among all farmers, local authorities and businesses, an objective that would have justified the search for a representative sample. We therefore constructed a reasoned sampling based on two criteria for farmers (belonging to the study territories and prior participation in bocage or agri-environmental projects), three criteria for companies (link to the target territories, sector of activity related to agriculture and/or agri-food or not, and commitment to a diagnosis or carbon offset approach), and two criteria for local authorities (link to the target territories and field of activity: agriculture, climate energy or environment). We sought to encourage respondents who had initiated climate or agri-environmental initiatives in these three categories of actors.

To allow respondents to project themselves into little-known carbon market devices whose declination for hedge storage did not exist, we chose to provide information on carbon storage through hedges and carbon market mechanisms prior to and during maintenance. We also choose to propose device scenarios and test respondents' preferences for possible alternatives.

Three different questionnaires were designed and submitted to the three categories of actors. Each questionnaire was structured in four sections: (1) the characteristics of the respondent and the entity (farm, company, community), their relationship to the environment and climate systems, (2) their knowledge of hedges and the carbon market, (3) their preferences towards different possible systems, evaluated on the basis of a set of cards based on the Discrete Choice Experiment (DCE) method, and finally (4) the reasons for their preferences on different attributes of the system. The three questionnaires were designed symmetrically: they tested the same device attributes for all three types of respondents.

We conducted two types of investigations. A first phase of face-to-face interviews was held in the fall of 2018 followed by an online survey phase in the fall of 2019 in order to enlarge our sample. For this second step, the interview guide was simplified by maintaining mainly the variables that were relevant in the first phase. At the investigator's request, each interview was recorded on a voice recorder in order to best reflect the actors' speeches and motivations regarding their preferences. A duration of 30mn to 2 hours was required per survey depending on the type of actors.

At the end of the surveys, 88 stakeholders, including 22 companies, 21 local authorities and 45 farmers were interviewed. These relatively small numbers compared to those planned are mainly due to the choice of an inadequate survey period since it corresponded to a phase of unavailability of the actors (summer holiday period for company agents, unavailability of agents and/or elected officials of local authorities and harvest period for farmers). They are mainly spread over the target territories of the project.

The choice experiment method made it possible to simulate the attitude of actors on a carbon market (to analyze both their preferences on the object and market conditions, but also the price

Commenté [TB9]: Est-ce utile de citer cette partie de l'enquête. Dans l'intro / méthode elle est passée sous silence.

Commenté [TB10]: interview

Commenté [TB11]: dire ici que k'enquête en ligne a été lancée durant une période plus adéquate : l'hiver suivant, mais a recueilli un nombre très limité de réponses (combien).

agreed). This implies being either a buyer or a seller of carbon. However, in our sample, the agents and elected officials of local authorities were intermediaries, they were not concerned by this part of the interview. Eight farmers also did not respond to this part of the survey. Thus, some advanced statistical treatments concern only companies and some farmers.

4. RESULTS

4.1. Socio-economic characteristics of respondents

The farmers surveyed are mainly men (91%), aged around 50 years and with levels of education between long secondary and higher education (Table 2). Agricultural holdings have average areas (UAA), meadow areas and property areas of 107 ha, 52.5 ha and 45 ha respectively. Approximately 30% of the respondents have obtained organic certification and more than 77% of them have already participated in other environmental schemes (AECS, tree planting, Breizh bocage etc.).

In terms of area and gender, this sample differs significantly from the regional averages. Indeed, the average SAU was 53 ha in 2016 in Brittany and 79 ha in 2017 in the Loire Region (Agreste 2017). Indeed, the average UAA was 53 ha in 2016 in Brittany and 79 ha in 2017 in Pays de la Loire (Agreste 2017). In addition, in 2017, a quarter of farm managers in Pays de la Loire are women. Respondents are also more frequently involved in agri-environmental approaches than farmers in the regions concerned. As for organic certification, for example, in 2017, it concerned 8% of farms and 7% of the UAA in Brittany (Réseau GAB-FRAB 2019) and 9.1% of farms and 8.2% of the SAU in Pays de la Loire (Chambre d'Agriculture PDL 2019).

Table 4: Characteristics of the farmers surveyed

Characteristics	Average (sd)
UAA	106.87 (54.01)
Property area (ha)	45.04 (35.69)
Prairie surface (ha)	52.52 (28.16)
Linear hedgerow (Km)	7.46 (3.77)
Age	51.2 (6.8)
	Percentage (%)
Gender	
1 if male and 0 if not	91.11
Level of study	
Secondary (college)	11
Long Secondary (High School)	36
Superior (Bac)	53
Organic certification	29.54
Participation in other environmental devices	77.77

At company level, the sample is dominated by men (68%), relatively young (41% are under 40 years of age) and high levels of education (68% of respondents have 5 years of higher education and engineers). The companies surveyed are divided between SMEs (nearly 41% or 9/22), FTEs (36%) and large companies (22%) (Table 5). There are no microenterprises with less than 10 employees. At company level, the sample is mainly male (68%), relatively young (41% are under 40 years of age) and with high levels of education (68% of respondents have 5 years of higher education and engineers). The companies surveyed are divided between SMEs (nearly 41% or 9/22), FTEs (36%) and large companies (22%) (Table 5). There are no microenterprises

with less than 10 employees. This sample therefore over-represents large companies at the expense of companies with less than 10 employees compared to the national distribution of companies. Indeed, at the national level, 96% of companies excluding financial activities and insurance are microenterprises, while large companies (GE) represent less than 1% of them (Insee 2017). Also, more than 80% of the companies surveyed claim to have carried out a diagnosis of their greenhouse gas emissions and undertaken actions to reduce their carbon footprint. The results are presented in the table below.

Table 5: Characteristics of the surveyed companies

Characteristics	Percentage (%)
Gender 1 if male and 0 if not	68.18
Age Under 40 40 to 54 years old Over 55s	40.9 27.2 31.8
Education level Bac-4 Bac5 Engineer Other	9 31.8 36.3 22.7
Company size Micro-enterprises (less than 10 employees) Small and medium-sized Enterprises (between 10 and 250 employees) Mid-sized ETI companies (between 250 and 5000 employees) Large companies (more than 5000 employees)	0 40.9 36.3 22.7
Making a diagnosis emissions and implementations reduction actions	86.3

4.2. Results of econometric model estimates

The estimated conditional logit and RPL models for determining the willingness to pay for companies and receive for farmers are presented in Tables 6 and 7. These models are estimated with the R and Stata 11 software.

Mean effects (Coef) show the effects on the utility of discrete changes in each attribute for the average respondent. The standard deviation (sd) parameters show the deviation of preferences around this average effect for each attribute and for each level change. Thus, to ensure that standard deviations can change sign throughout the model range, all other attributes were estimated as normally distributed random parameters (Ndunda et Mungatana 2013; Revelt et Train 1998).

To interpret the results of the coefficients of the estimates, we will retain the signs and significance of the coefficients. The absolute value of the coefficients is not interpretable as in a multiple linear regression of panel data since the comparative quantities between attribute levels are utilitarian (Ndunda et Mungatana 2013).

4.2.1. Results of econometric estimates from companies

The results of potential demand are presented in Table 6. Model 1 thus presents information on the means of the estimated coefficients and standard deviations of the main attributes included in the DCE. The explanatory variables contained in this model are the AIC (commitment or not to a market device regardless of the type of hedge), the type of pluristrates hedge (coppice

hedges being the reference level), the levels of private and collective actors intermediary (the state level being the reference), the medium and high budget levels (the low level being the reference) and the price. In order to identify the sources of preferences among participants, we analyzed the potential factors influencing by adding interaction terms to the estimation model, which are presented in model 2.

Model 1 is estimated via the RPL (or mixed logit), it provided interesting results in terms of model quality criteria (pseudo R^2 and AIC criteria) than the one estimated via the Clogit for the main attributes of the device. As for model 2 with interactions, the Clogit was more interesting than the RPL model.

The results of Model 1 indicate that all parameters of the utility function have theoretically consistent signs and are all significant except for the collective level of the type of intermediary. Indeed, the ASC is significant and positive, indicating that the attributes chosen are globally relevant for companies to be inclined to join the market (Hanley, Adamowicz, et Wright 2005; Ndunda et Mungatana 2013). In other words, all the attributes included in the model provide an overall incentive for companies to participate in the proposed contract. The market price (price per ton of CO₂ on which the players will have to agree), is significant with a negative sign indicating a decrease in the company's utility with the price of the environmental service it finances.

Respondents prefer financing a market focused on hedges with environmental co-benefits (mixed or pluristrates hedges). Since the "coppice hedge" level is the reference level for the "type of hedge" variable, the positive sign observed for pluristrates hedges indicates that, compared to coppice hedges, companies' willingness to pay (WTP) for the pluristrates hedge is more marked. The results of model 1 also show that companies have a strong reluctance towards private intermediaries in relation to other modalities (State and collective of actors). Also, companies prefer to allocate a low budget (reference budget) rather than a medium or high budget. This result is logical and is partly explained by the fact that some companies have expressed the wish to carry out a first test transaction with a low budget before committing to the market over a long period of time with larger budgets. It should also be noted that the question of the budget should be taken with caution, since at the level of large companies, the people interviewed generally did not have the power to decide on budget and price aspects.

Model 2, considering the heterogeneity bias of the variables, reinforces model 1 regarding the main attributes of the device. Indeed, we tested the preference of a commitment to a system based on pluristrates hedges with several variables specific to the respondent (gender, age, field of training, level of education, knowledge of hedges and the carbon market), and variables specific to the company (size, sector, status, carrying out a GHG diagnosis, relationship to the local, environmental importance, type of emission reduction actions, etc.). The results show that the size of the company and the age and gender of the respondents influence engagement in the scheme. These variables make it possible to identify the categories of companies with higher willingness to pay than those in Model 1.

Table 6: Results of econometric estimates and the measure of willingness to pay from companies

	Model 1			Model 2		
	Mean	SD	WTP (euros)	Mean	SD	WTP (euros)
Attributes						
ASC	0.99**	0.417	83.85 (18.5 ; 151.3)	1.49 ***	0.48	93 (47 ; 139)
Hedges pluristrates	1.09**	0.460	92.6 (16.8 ; 202.8)	3.67***	1.30	230 (70 ; 390)
Private_Int	-2.65***	0.893	-225 (-493 ; -71.4)	-2.13***	0.79	-133.57 (-236 ; -31)
Collective_Int	0,59	0.442		0.36	0.65	
Medium Budget	-2.75***	0.817	-233.6 (-474 ; -105)	-1.19**	0.53	-74.5 (-143 ; -6.1)
High Budget	-2.54**	1.04	-215.4 (-470 ; -43.32)	-4.11***	1.21	-257 (-426 ; -88)
Price	-0,011***	0.003	-	-0.015***	0.003	-
Interactions						
Size2_HP				-3.05*	1.64	-191 (-397 ; 15.5)
Size3_HP				-4.36*	2.24	-273 (-555 ; 8.5)
Size4_HP				-9.31***	2.94	-583 (-969 ; -197)
Age2_HP				1.14	1.45	-
Age3_HP				4.67**	2.29	292 (-0.61 ; 586)
Gender1_HP				1.65	0.260	-
N obs.		594			594	
Log likelihood		-155.14			-145.57	

*p<0.1

** p<0.05

*** p<0.01

Size 2: Medium Etp (50 à 499 employees)

Size 3: large companies (500 à 999 employees)

Size 4: Very large companies (>1000 employees)

Gender1: Female

Age2: 40 to 54 years

Age3: 55 to 64 years

4.2.2. Results of econometric estimates among farmers

The results of the potential offer are presented in Table 7. Models 1 and 2 are estimated via a Clogit. It provided interesting results in terms of model quality criteria (pseudo R² and AIC) that the models estimated with mixed logit. Model 1 thus provides information on the averages of the estimated coefficients and standard deviations of the main attributes included in the DCE. In order to identify the sources of preferences among participants, we analyzed the potential influencing factors by adding interaction terms to the estimation model that are presented in Model 2.

The coefficients of the parameters estimated in model 1 have the expected signs overall and are significant except for the method of control and the level of maintenance of hedges over 30 years. Indeed, the ASC variable has a negative estimated coefficient, this indicates that the attributes chosen for the DCE are globally relevant, the farmers surveyed are reluctant to refuse the market. Similarly, the price coefficient is significant and positive, indicating a willingness to receive funding for market services. This result makes it possible in a second step to calculate a consent to receive from farmers.

In both models, the results show us that farmers prefer to be paid for the creation of pluristrates hedges more than for the other modalities of the object (creation of coppice hedges and improvement of the existing ones). Regarding the modalities of the scheme, farmers seem to prefer a shorter maintenance period (5 or 15 years rather than 30 years). We have no statistically significant evidence regarding farmers' preferences regarding the different control modalities presented to them.

Commenté [TB12]: Le signe négatif pour l'entretien est contreintuitif, ça mériterait d'être interprété

Tableau 7: Results of econometric estimates and measure of farmers' willingness to receive

Commenté [TB13]: Ça aiderait beaucoup à la lecture d'indiquer dans la légende le niveau de référence des variables socio-économiques (niveau d'éducation 1 et 2, ...

Attributes	Model 1			Model 2		
	Coef	Std Err	WTA et IC (Euros/teqCO2)	Coef	Std Err	WTA et IC (Euros/teqCO2)
ASC	-1.69***	0.28	174.4 (117 ; 254)	-4.16***	1.38	538 (218 ; 1130)
Creation of coppice hedges	-0.64**	0.26	65.9 (12.3 ; 132)	-1.2***	0.359	140 (53 ; 313)
Creation of Pluristrates hedges	-0.98***	0.30	101 (40.7 ; 175.6)	-1.76***	0.44	205 (95 ; 416)
Improvement of existing hedges	0.96***	0.24	-99.45 (-172 ; -48)	0.82***	0.32	-95.7 (-226 ; -21)
5-year maintenance	0.64**	0.28	-66 (-138 ; -8.5)	1.41**	0.41	-164.6 (-368 ; -61.4)
15-year maintenance	0.54**	0.27	-96 (-130 ; 0.06)	1.37**	0.40	-160 (-380 ; -58.6)
30-year maintenance	0.10	0.28	-	0.70*	0.41	-80.8 (-243 ; 11.4)
Control by distance	-0.24	0.23	-	-0.21	0.31	-
Control by visit	-0.032	0.22	-	-0.30	0.30	-
Price	0.009***	0.001	-	0.008***	0.002	-
ASC_Level of education 3				6.21***	1.60	-726 (-1526 ; -340)
ASC_Level of education 4				4.20***	1.44	-490 (-1115 ; -161)
ASC_Relation to hedges 2				-5.07***	1.01	592 (318 ; 1217)
ASC_relation to hedges 3				-1.28**	0.62	150 (7.3 ; 375)
ASC_relation to hedges 4				-4.38***	0.81	511 (288 ; 1000)
ASC_Organic certification1				-2.90***	0.85	339 (137 ; 729)
ASC_Prod-orientation 2				3.26***	1.25	-380 (-898 ; -90)
ASC_Prod-orientation 4				3.73***	1.00	-435 (-916 ; -191)
ASC_Prod-orientation 5				7.37***	1.97	-860 (-1830 ; -377)
ASC_Prod-orientation 6				2.67***	0.78	-312 (-673 ; -120)
ASC_Status 4				2.95***	1.16	-345 (-802 ; -80.8)
ASC_relation to climate 4				1.72**	0.85	-200 (-515 ; -6.32)
ASC_Grassland area				-0.05*	0.03	6.14 (-1.07 ; 16.56)
N		1332			1332	
R ² adj		20%			34%	
AIC		778.3			499.6	

*p<0.1

** p<0.05

*** p<0.01

Production orientation 2: Beef cattle horticulture
Production orientation 6: Poultry pigs

Production orientation 4: Field crops
Status 4: CSAE

Production orientation 5: market gardening and
Relation to climate 4: Very sensitive and ready to act

Level of education 3: High school

Level of education 4: Bacalalaureate+2/+3

Relation to hedges 2: Extensive and traditional hedge management

Relation to hedges 3: Ongoing development of large hedgerow lines to improve agricultural production facilities

Relation to hedges 4: I have few hedges, and I take care of them as little as possible, it is above all a cost

In Model 2, the socio-economic variables that have a significant effect on the incentive to engage and increase the utility and willingness to receive from farmers are the farm profile (status, production orientation, grassland area), the farmer profile (level of education) and the values it supports (the relationship to the hedges and the climate).

4.3. Estimation of implicit supply and demand prices

In order to estimate the implicit price values of the attributes as well as the 97.5% confidence intervals, the method of Krinsky et Robb (1986) was used to estimate equation (4). It is a method based on the bootstrap approach of confidence intervals and consists in simulating an asymptotic distribution of parameter coefficients by considering several random draws of a normal distribution defined for the estimated parameters and their variance-covariance matrix. This is to obtain interval estimates of parameters of interest instead of analytical distributions (Gatta, Marcucci, et Scaccia 2014; Dachary-Bernard 2007).

The results of the estimates of the different models were used to calculate the implicit average prices of the farmer and company samples. They are presented in Tables 6 and 7. The interpretation of the results concerning the willingness of the actors to pay and receive will mainly focus on the valuation of the carbon object (pluristrates hedges or coppices) or not (ASC) as well as on the evolution of prices according to the market conditions to be put in place. It will be based on the sign of the coefficients of estimates of the significant attributes of the market according to whether it is a supplier (farmer) and a requester (company). Indeed, the willingness to receive from farmers indicates a willingness not to buy for the proposed service since the price coefficient is negative. On the other hand, the willingness to pay of buyers is positive indicating a willingness to pay for this service.

Commenté [TB14]: Not to be paid ?

4.3.1. Companies' willingness to pay

Regardless to the demand, Table 6 presents the companies' willingness to pay (WTP) for the hedge management projects to be financed. Regardless of the type of hedge, the CAP of companies for the commitment to the scheme (ASC) is 84 euros indicating a clear willingness to pay for a market scheme. About the object of the contract, companies have a greater willingness to pay for the valuation of pluristrates hedges amounting to 92.6 euros/teqCO₂ compared to coppices when only the principal scheme is considered (model 1). This willingness to pay varies between 17 and 202 euros/teqCO₂ when considering the device composed only of the main attributes. This variation indicates a heterogeneity in the responses of companies to engage in the market. These results justify the emphasis placed on the valuation of pluristrates hedges, since the latter has a higher CAP than that of a company commitment regardless of the type of hedge (ASC).

Model 2 identifies the factors that influence willingness to pay. The interaction of the valuation of pluristrates hedges with socio-economic variables of the respondent and the company indicates that the size of the company as well as the gender and age of the respondent significantly influence willingness to pay. Indeed, the results indicate that the size effect has a negative impact on the willingness to pay to value pluristrates hedges. The larger is the company, the lower is the willingness to pay compared to the reference level (small companies). Thus, small companies (less than 50 employees) are willing to pay more for a TeqCO₂ with multiple hedges. This result corresponds to a target category of the VOCAL study on the potential and determinants of voluntary demand for carbon credits in France. According to this study, small companies are buyers who want low volumes of carbon to be offset but at high prices and targeting smaller perimeters, unlike large companies who want large perimeters and volumes at lower prices (Tronquet C., Grimault J., et Foucherot C. 2017). Also, respondents between the ages of 55 and 64 are more willing to pay in the market than younger respondents.

Commenté [TB15]: Pluristrates ?

Indeed, as the age level increases, the willingness to pay increases relative to the reference level (under 40 years of age). According to the literature, one argument that supports this result is that younger people are more concerned about business development through the search for competitiveness and resources (Labelle et St-Pierre 2010).

4.3.2. Farmer's willingness to receive

On the supply side, the results show that, as a first step, farmers' willingness to commit to the scheme regardless of the type of hedge (ASC) is substantial (174 euros/teqCO₂) compared to their willingness not to commit. For the preferences of the object on the market, farmers prefer to receive more to enhance the value of Pluristrate hedges than coppice hedges. Indeed, the average willingness to receive is 100 euros/teqCO₂ over the term of the contract for the creation of pluristrates hedges. This willingness to receive varies at 97.5% probability between 40 and 175 euros/teqCO₂. A sum that would allow them to commit to fulfilling the terms of the management contract considering the main attributes of the contract.

The coppice hedges for which farmers are willing to receive less expensive correspond to an average willingness to receive of 66 euros/teqCO₂ that varies between 12 and 132 euros/teqCO₂. And when the contract mechanism is to maintain and improve existing hedges to pluristrates hedges, farmers seem ready to engage in the mechanism regardless of price level. This indicates a greater need for remuneration than that of the Agri-Environmental and Climate Schemes (AECS) in which farmers have already participated, which amounted to 0.54 euros per linear meter committed (DRAAF 2019) in 2016 for the best of the hedgerow measures submitted. About the duration of the contract, farmers tend to want more compensation for short-term contracts.

As shown in Table 7 above, the ASC's interaction with socio-economic variables reveals sub-populations of farmers who are more or less inclined to engage in the scheme. Indeed, the socio-economic variables that have a significant effect on the incentive to enter the market concern the farmer (level of education) on the one hand, and the farm on the other hand (status, production orientation, grassland area) as well as two variables that indicate the farmer's relationship to the bocage and to the climate.

The results indicate that the higher the respondent's level of education, the more willing he is to commit to the device for a higher price. Indeed, the level of study affects the commitment to the system and the willingness to receive in a decreasing way. The utility decreases as the level of education decreases. In addition, farmers with careful management of the hedgerows and who are very sensitive to environmental and climate issues are willing to commit to lower financial compensation. Indeed, the relationship to the climate interacts with the commitment to the scheme and reduces the willingness to receive. However, farmers who have a low relationship with hedges and who do not regularly maintain them ask for more expensive funding to commit to the scheme than those who have a high relationship with hedges. Concerning the farm, the results indicate that farms certified "Organic Farming" and already very committed to the agri-systemic and market valuation of the environment require a higher level of financing than others. It should also be noted that farms with the CSAE (Civil Society of Agricultural Exploitation) status, and those with a market gardening or pig-poultry orientation are ready to commit to the scheme at a lower cost.

4.4. A well-identified negotiating space

When we ask the actors about the device scenarios through a set of cards, the preferences they indicate make it possible to show the existence and characterize a negotiating space in which some companies are willing to pay a price higher than the minimum acceptable by some

Commenté [TB16]: Il faudrait refaire les calculs avec les bons niveaux de stockage et discuter de l'effet de notre estimation initiale, les agris répondent en euros par km (et non par teqCO₂, je pense que ca serait donc juste à ce stade de fire un note pour réévaluer le prix.

Commenté [TB17]: Je trouve que trois phrase pour la même idée c'est un peu beaucoup

Commenté [TB18]: Concern for climate change issues

Commenté [TB19]: Low et high ne sont pas très explicites. Il faudrait peut être mieux reprendre le libellé des modalités

farmers. The results indicate that a negotiation space exists for pluristrates hedges. Indeed, the intervals between willingness to pay (WTP) and willingness to receive (WTP) have a wide intersection, since the WTP of companies varies between 17 and 200 euros and the WTP of farmers varies between 40 and 175 euros/ teqCO₂ (tables 6 and 7). The negotiation space is therefore between 40 and 200€. 40€ is the price that all companies are willing to pay but only one farmer is willing to accept, while 200€ is the price that all farmers accept but only one company is willing to pay. On average, companies are willing to pay 92 euros per TeqCO₂ and farmers are willing to accept an average of 100 euros in the case of a pluristrates hedge plantation.

The results also tell us that this negotiating space varies when other key variables of engagement in the scheme are considered. Indeed, when we interact socio-economic characteristics of actors and their entities, the willingness to pay and receive from actors varies substantially. The willingness to receive average from farmers for the creation of pluristrates hedges doubles when we make the willingness to engage interact with variables specific to the respondent (Level of education and professional experience before installation) and to the farm (UAA, length of shelf space, production orientation, status, etc...). The average willingness of companies to pay for pluristrates hedges increases from €92 to €230 when we interact the choice of pluristrates' hedges with the age and gender of the respondent as well as the size of the company.

DISCUSSION AND CONCLUSION

The objective of this article is to identify opportunities for implementing a voluntary carbon offset market through the creation and maintenance of hedges. It contributes to the literature on the preferences of farmers, communities and companies to set up a market mechanism. In addition, this research complements the literature on preference analysis and the estimation of both willingness to pay and willingness to receive using a discrete choice experiment.

The main result of this study is that the method of choice makes it possible to demonstrate that the establishment of a voluntary carbon market seems to constitute an important and plausible mechanism for the development of hedgerows in the Great West areas. This is through the existence of a negotiation space between buyers (companies) and sellers (farmers) for the implementation of the project to develop hedges with the maximum co-benefits (mixed or pluristrates hedges). Indeed, our survey makes it possible to define a common price range prefiguring a trading space for this market, with a price maximizing trade around the intervals of willingness to pay and to receive. Compared to the VOCAL study, for which prices were below 30 euros/teqCO₂, the price ranges from our study are higher (Tronquet C., Grimault J., et Foucherot C. 2017).

In addition, the review of willingness to pay and receive illustrates the behaviors and expectations of stakeholders on the valuation of environmental services and the contribution to the climate issue. Indeed, one of the lessons we can learn from these results is that companies are more willing, on a voluntary basis, to finance projects to promote environmental services with a territorial impact. Farmers are mainly inclined to manage existing hedgerows in exchange for a higher financial incentive than recent AECS. Some market attributes that have been shown to be important for companies and farmers through the DCE allow, through multivariate analysis of secondary attributes, to identify several desirable mechanisms of the voluntary carbon market. About the contract object, the same terms and conditions were not presented to the actors during the DCE, which would have made it possible to compare the different levels in order to identify the desirable objects.

Commenté [TB20]: Pourquoi ne pas traiter le cas de l'entretien des haies pluristrates ?

Commenté [TB21]: Reprendre les données agris avec le bon taux de conversion des km en teqCO₂

Commenté [TB22]: Est-ce que ça ne serait pas plus pertinent de dire dans quelles conditions ils diminuent ?

Commenté [TB23]: Je ne suis pas d'accord avec cette conclusion (ou je n'ai pas compris...). Sur l'entretien ils sont prêts à y aller pour rien. C'est sur la plantation qu'ils demandent un paiement plus élevé que les actuels MAEC.

Commenté [TB24]: or

Commenté [TB25]: citer ici la traçabilité, la durée d'engagement de 15 ans

This study also allows us to identify sub-populations of actors likely to have a greater willingness to participate in the scheme thanks to the socio-economic characteristics of the actors and their entities. This characterization needs to be further developed given the heterogeneity of the responses and the insignificance of certain organizational and structural factors that may influence the willingness to pay and receive.

Finally, despite the relatively small number of the sample, the choice experiment method allowed to determine interesting overall results of the stakeholders' preferences. Indeed, the size of the sample and its non-representativity, both among farmers and companies, prevents any generalization of the results obtained to other territories or other work scales, but our approach remains relevant from a methodological point of view and with the objective of supporting the occasional implementation of such a system in a given territory. Thus, the detailed identification of the negotiating space requires an extension of the research through consultation and discussion workshops between the various stakeholders, among others. The existence of anchoring biases in the choice of attributes and their levels, particularly the type of hedge and duration of the contract, did not allow a strict comparison of the systems between the two types of actors. However, these choices are specific to the type of actors because they are not concerned in the same way by the system. Nevertheless, the secondary attributes on which the respondents were questioned in a second step make it possible to ensure a certain coherence between the two types of actors. Finally, the DCE should be conducted by specifying an estimation method that would not extrapolate the results to the calculation of implicit prices. Indeed, the choice of a linear mathematical function has led to an extrapolation of the willingness to pay and receive beyond the area of definition of the study, which is between 5 euros and 150 euros per exchanged carbon unit.

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