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CONSERVATION CONTRACT ADOPTION UNDER FIXED AND VARIABLE COSTS

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Abstract: Farmers' conservation contract adoption is usually explained through the technology lens, i.e. with operational costs depending on the subscribed area and environmental efforts. In their 2003 article, Dupraz et al. analysed this issue by introducing utility farmers directly derive from contract environmental outcomes. They specified farmers' willingness to accept, which is the minimum compensation payment the farmer accepts to enrol and produce environmental services on a given area. Here, we deepen this analysis at two levels. First, at the theoretical one, by introducing fixed compliance costs in the willingness to accept approach. Secondly, we empirically show that among fixed compliance costs, fixed transaction costs are a significant contracting barrier. It explains why smallest farms have a reduced probability to contract.

Key words: agro-environmental contract; willingness to accept; fixed compliance costs;

JEL Classification: D23, Q12, Q28

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I) INTRODUCTION

The degradation of environmental quality and rural landscape has induced a strong demand of rural amenities in European countries. This led to a significant increase of agro-environmental schemes in Europe from the 90's. The trend was confirmed with the 1999-Common Agricultural Policy (CAP) reform and the implementation of "agro-environmental contracts". In this policy framework, farmer's voluntary participation is compensated if he adopts more environmental friendly practices than what is mandatory. First appraisals show the adoption rate remains globally low (about 25% of EU farms) and smallest farms are not involved. From this situation, displayed environmental objectives are expected not to be reached. The overall aim of this study is therefore to improve the understanding of farmers' adoption behaviour.

Several studies have examined factors influencing farmers' adoption. Four main determinants have been identified, namely (i) farmer and farm household characteristics, (ii) farm biophysical characteristics, (iii) farm financial/management characteristics, and (iv) exogenous factors such as information availability, sources of information, society social capital (Knowler and Bradshaw, 2007). Even if they give an important insight on the overall adoption behaviour, a sharper analysis is obviously required. In particular, a first distinction between fixed and variable compliance costs should provide some useful explanations. Indeed, while compensation payment are on a per-hectare basis calculation, technology related fixed costs (a hedge cutter or an adapted seeder for instance) and fixed transaction costs (the costs of gathering information on contracts or writing the contract) amount to total significant levels.

This paper thus first seeks to know if fixed compliance costs are a significant adoption barrier. This should explain why smallest farms or farms having a small eligible area are not involved in agro-environmental contracts. The second research question is whether, among fixed compliance costs, transaction costs are a significant adoption barrier. We particularly think of transaction costs as an adoption barrier since we suspect agro-environmental contract to require specific investments. Indeed, contract requirements lead the farmer to entirely modify his production system, which ends up to a non negligible total investment. Most of the time, these investments being non redeployable outside the agro-environmental contract, they are therefore transaction specific and produce transaction costs.

As Dupraz et al. (2003), we base our analysis on a farm household model so that we incorporate the farmer's producer and consumer behavior. The household willingness to accept (WTA) is the minimum per-hectare compensation payment the farmer accepts to adopt an agro-environmental contract on a given area instead of not to adopt while his initial utility level remains the same (eq. Hicksian optimization). Besides, considering the presence of fixed compliance costs, we work the minimal per-hectare payment out from the average WTA and get a minimum compensation payment and a minimum necessary area. Finally, when the per-unit payment is higher, farmers with a higher eligible area will be able to choose over the area to subscribe, this choice being derived from his Marshallian behavior. Therefore, as long as his marginal WTA is lower than the per-hectare payment, they will accept to subscribe an additional hectare.

The empirical analysis is based on a European sample made of 2262 farmers interviewed in 2005. It aims at highlighting the impact of fixed compliance costs on adoption behavior, and transaction cost one in particular. These last costs being not included in the calculation of compensation payments, it is therefore statistically possible to distinguish their effect from

other costs. However, transaction costs being difficult to measure and endogenous to the decision to adopt, their effect is thus indirectly identified through their determinants. It is important to note that some of these determinants impact on transaction costs only whereas others have more complex effects, i.e. they impact on transaction costs, farmer's utility or operational costs too. These multiple effects will complicate the estimation interpretation.

We use the two-stage Heckman method to shed light on whether and to what extent variations in fixed compliance costs are responsible for observed adoption rates. In the first step, the most influential factors on participation are the type of farming system, past experience in agro-environmental contracts and farmer's trust in the implementation process. In the second step, the area under contract is the dependant variable. The disappearance of significant transaction cost determinants from the first step in the second step reveals the presence of fixed transaction costs and their significant effect on adoption behavior. As regard to fixed compliance costs, given that none of variables describing the production system disappear in the second step, we may say that, whether the compensation payment do include fixed operational costs, or, they have no significant effect on adoption behavior. Concerning variables with more complex effects and that are present in both estimations, the interpretation is harder. Whether variable transaction costs exist and their effect is mixed with other variable operational costs, or, they do not exist and we may conclude fixed transaction cost effect on adoption is lower than utility or operational cost effects. Finally, variables appearing in the second step purely highlight the effect of the production system characteristics on the farmer's choice over area to subscribe.

This paper has a double contribution. First, by introducing fixed compliance costs in the usual adoption model, we improve the understanding of farmers' conservation practice adoption behavior. Second, by empirically showing that among fixed compliance costs, fixed transaction costs are a significant contracting barrier, we support the idea fixed compliance costs and transaction costs in particular should be taken into account in participation constraints.

The paper is organized as follows. Section 2 presents the conceptual framework from which we derived propositions. Section 3 describes the transaction cost issue in AEC and the data set on which the empirical analysis is based on. Section 4 provides estimation results and section 5 concludes.

II) SPECIFYING FARMERS' WILLINGNESS TO ACCEPT

II.1) Model settings

As Dupraz et al. (2003), we consider a utility maximizing farmer with an income constraint depending on farm profit. The restricted profit function, or short-term profit function, π^R , enables to derive the income from the on-farm activity with an agro-environmental contract that is attached to an area v .

$$\begin{aligned}
 & \underset{m,v}{Max} U(m, v, Z) \\
 & m = \pi^R(p, v, Z) + \rho.v + e_0 \\
 & v \geq 0
 \end{aligned} \tag{1}$$

The variables of the utility function are the farmer's income m , expressed in monetary value, the quantity v of an environmental service co-produced by farming activities (the number of hectares submitted to environmentally friendly practices for instance) and other relevant utility characteristics Z . This function is supposed to be increasing, concave and differentiable in m and v .

The farmer's restricted profit function π^R represents the agro-environmental technology using the dual approach by a short-term optimization of products and production factor variables of prices p . Z represents other relevant profit characteristics. π^R is linearly homogenous in prices p . It is assumed to be non increasing and convex in v . The e_0 scalar represents off-farm incomes that are assumed to be exogenous.

The contract payment is based on a positive per-unit premium ρ . The budget constraint always binds. In this model, the farmer is assumed to enroll when the premium is higher than ρ_0 , the farmer's marginal willingness to accept (WTA) for the first unit of co-produced environmental service. It is defined in (2), which provides the corner solution of (1), noted (m^*, v^*) , when the positivity constraint regarding v binds, meaning the contract is rejected.

$$v^* = 0 \Leftrightarrow \rho \leq \rho_0 = -\frac{\partial U(m^*, 0, Z) / \partial v}{\partial U(m^*, 0, Z) / \partial m} - \partial \pi^R(p, 0, Z) / \partial v \quad (2)$$

When $\rho > \rho_0$, the marginal WTA, noted $\rho^m(p, v_m, Z)$, is then defined by (3).

$$\begin{aligned} & \underset{m, v}{\text{Max}} U(m, v, Z) \\ & m = \pi^R(p, v, Z) + e_0 \\ & v \geq v_m \end{aligned} \quad (3)$$

First order conditions bring:

$$\rho_m = -\frac{\partial U(m^*, v^*, Z) / \partial v}{\partial U(m^*, v^*, Z) / \partial m} - \partial \pi^R(p, v^*, Z) / \partial v \quad (4)$$

Where ρ^m is the shadow value, i.e. the lagrangian multiplier, of the minimal area v_m submitted to environmental friendly practices. ρ^m is increasing and convex with v_m . From this specification, when v_m is nil, ρ^m corresponds to the minimum premium ρ_0 .

Let's go back to program (1) and distinguish a fixed cost function $F(\cdot)$ associated with strictly positive v . Fixed costs may come from physical or immaterial investments which are needed to conclude or implement the contract. The optimization programme becomes:

$$\begin{aligned} & \underset{m, v}{\text{Max}} U(m, v, Z) \\ & m = \pi^R(p, v, Z) - F(p, v, Z) + \rho.v + e_0 \\ & v \geq 0 \end{aligned} \quad (5)$$

It depends on Z describing the technology and the transaction environment such as the governance structure type or the asset specificity level. Following is a detailed specification of

$F(\cdot)$. It does not depend on v for strictly positive values. We also assume that this fixed cost deters smallest contracted areas (6).

$$F(p,0,Z) = 0 \quad \text{and} \quad \frac{\partial F(p,v,Z)}{\partial v} = 0 \quad (6)$$

$$\exists \tilde{v} > 0; \quad 0 < v \leq \tilde{v} \Rightarrow F(p,v,Z) > \rho$$

Finally, we specify $C(\cdot)$ the cost function of contracting:

$$C(p,v,Z) = \pi^R(p,0,Z) - \pi^R(p,v,Z) + F(p,v,Z) \quad (7)$$

It is positive, continuous, increasing and concave with all strictly positive v . Under the preceding assumptions, the average cost function is U-shaped. As usual, the profit maximizing farmer will sign a contract if the per-unit payment exceeds the minimal average cost.

Next section is the analysis of the willingness to accept function that we associate to ρ_0 .

II.2) Specifying the farmer's willingness to accept

Under the preceding assumptions, especially those regarding the fixed compliance costs, the farmer will not produce the environmental service without payment. In this case, the solution of (5) is:

$$U_0 = U(m_0,0,Z), \quad m_0 = \pi^R(p,0,Z) + e_0, \quad v = 0 \quad (8)$$

The farmer's willingness to accept (WTA) an agro-environmental contract is the minimum compensation payment ρ_0 the farmer accepts to enroll and produce a fixed amount of environmental services v instead of not to produce those services (eq. $v = 0$) while his initial utility level, U_0 , remains the same. It is specified in two steps (Dupraz et al., 2003).

First, the restricted expenditure function, called e^R , is minimized in m . e^R is continuous, increasing and concave with all strictly positive v . We get the Hicksian optimal consumption $m^*(p,v,Z,U_0)$:

$$e^R(p,v,Z,U_0) = \underset{m}{\text{Min}}(m - \pi^R(p,v,Z) + F(p,v,Z))$$

$$U_0 \leq U(m,v,Z) \quad (9)$$

$$v \geq 0$$

The corner solution described in (8) is also a solution for (9). Then, having assumed a utility maximizing farmer, the utility constraint always binds.

Second, the farmer's WTA is obtained by deriving the surplus variation:

$$\begin{aligned}
WTA(p, v, Z, U_0) &= e^R(p, v, Z, U_0) - e^R(p, 0, Z, U_0) \\
&= \pi^R(p, 0, Z) - \pi^R(p, v, Z) + F(p, v, Z) - \{m^*(p, 0, Z, U_0) - m^*(p, v, Z, U_0)\} \quad (10) \\
&= C(p, v, Z) - WTP(p, v, Z, U_0)
\end{aligned}$$

The first term is the farm profit loss or the cost function of contracting (cf. equation 7). The second term is the farmer's willingness to pay (WTP) for an increase in the environmental service on his farm site. Therefore, when the farmer's utility from environmental services he produces is negligible, his WTA equals the profit loss. Otherwise, the profit loss overestimates the farmer's WTA. With convex preferences, the WTP is positive, increasing and concave with v . Under our preceding assumptions, there is no production of environmental service without strictly positive payment. It means that the WTP is always lower than the cost of contracting for strictly positive v . Hence, the WTA function is positive, continuous, increasing and concave with all strictly positive v . Next section considers the actual policy context in which the farmer chooses the subscribed area.

II.3) Introducing the choice over the subscribed area

II.3.1) Specifying the minimum per-unit payment

The cost function including fixed compliance costs, the minimum per-unit payment ρ^* that triggers the contract is therefore the minimum of the average WTA:

$$\rho^* = WTA^M(v^*) = \underset{v}{\text{Min}} \frac{WTA(v)}{v} \quad (11)$$

The first order condition provides (12) and $v^*(p, m^*, Z, U_0)$ the minimum contractible area:

$$-\frac{WTA(v^*)}{v^{*2}} + \frac{1}{v^*} \left(-\frac{\partial \pi^R(p, v^*, Z)}{\partial v} + \frac{\partial m^*(p, v^*, Z, U_0)}{\partial v} \right) = 0 \quad (12)$$

Since the WTA refers to a minimal utility, we set $U_0 = U(m^*, v^*, Z)$ from (9) with $m^*(p, v^*, Z, U_0)$. The total differentiation of the utility function thus gives:

$$\frac{\partial m^*(p, v^*, Z, U_0)}{\partial v} = -\frac{\partial U(m^*, v^*, Z) / \partial v}{\partial U(m^*, v^*, Z) / \partial m}$$

The right part being the marginal rate of substitution between m and v , i.e. the farmer's WTP for environmental services.

We finally get (13) for specifying the minimal per-unit payment:

$$\rho^* = WTA^M(v^*) = -\frac{\partial \pi^R(p, v^*, Z)}{\partial v} - \frac{\partial U(m^*, v^*, Z) / \partial v}{\partial U(m^*, v^*, Z) / \partial m} \quad (13)$$

And, we get (14) from (10) and (11):

$$m^* = \pi^R(p, v^*, Z) - F(p, v^*, Z) + \rho^* v^* + e_0 \quad (14)$$

II.3.1) Specifying the optimal subscribed area

The farmer's choice over the area to enroll is derived from his Marshallian behavior with an unchanged exogenous income e_0 . His Marshallian optimal contracted area $v^{**}(p, m, Z)$ is given by program (5).

The farmer's decision depends on ρ :

$$\begin{aligned} \text{when } \rho < \rho^* & \Rightarrow v^{**} = 0 \\ \text{when } \rho = \rho^* & \Rightarrow v^{**} = v^* \\ \text{when } \rho > \rho^* & \Rightarrow v^{**} > v^* \end{aligned} \quad (16)$$

With $\rho = \rho^m(p, v^{**}, Z)$ the marginal WTA.

II.4) Utility maximizing behaviour with fixed costs

In order to show the contracting decision based on the minimal average WTA is compatible with a utility maximizing behaviour, we shall now prove that $U_0 = U(m^*, v^*, Z)$ is also a solution of program (5) for $\rho = \rho^*$.

Let (\bar{m}, \bar{v}) be a solution of program (5) for $\bar{\rho} = \rho^*$, with $\bar{v} > 0$. Next, we show (\bar{m}, \bar{v}) can not be different from (m^*, v^*) .

First order conditions of (5) bring:

$$\rho^* = -\pi_v^R(\bar{v}) - \frac{U_v(\bar{m}, \bar{v})}{U_m(\bar{m}, \bar{v})} \quad (17)$$

The budget constraint, which is binding, brings :

$$\bar{m} = \pi^R(p, \bar{v}, Z) - F(p, \bar{v}, Z) + \rho^* \bar{v} + e_0 \quad (18)$$

i) First we suppose that $\bar{v} > v^*$. As the marginal cost of contracting is increasing with v , (13) and (17) imply that the marginal rate of substitution (MRS) for (m^*, v^*) is lower than the MRS for (\bar{m}, \bar{v}) .

$$\bar{v} > v^* \Rightarrow -\frac{\partial \pi^R(p, v^*, Z)}{\partial v} < -\frac{\partial \pi^R(p, \bar{v}, Z)}{\partial v} \quad (19)$$

$$(13) \quad \text{and} \quad (17) \Rightarrow \frac{U_v(m^*, v^*)}{U_m(m^*, v^*)} < \frac{U_v(\bar{m}, \bar{v})}{U_m(\bar{m}, \bar{v})}$$

As the MRS is decreasing with v when m is constant, it implies that $\bar{m} > m^*$ must hold, and is compatible with a maximized utility. However, by using (14) and (18) this inequality contradicts our basic assumption of a positive MRS:

$$\begin{aligned} \bar{m} - m^* > 0 &\Rightarrow \pi^R(p, \bar{v}, Z) - \pi^R(p, v^*, Z) + F(p, v^*, Z) - F(p, \bar{v}, Z) + \rho^*(\bar{v} - v^*) > 0 \\ F(p, v^*, Z) = F(p, v^*, Z) &\Rightarrow \int_{v^*}^{\bar{v}} (\pi_v^R(p, v, Z) + \rho^*) dv > 0 \Rightarrow \pi_v^R(p, v, Z) + \rho^* > 0 \end{aligned} \quad (20)$$

This result contradicts both (13) and (17) where the marginal willingness to pay is positive. Therefore $\bar{v} > v^*$ can not hold.

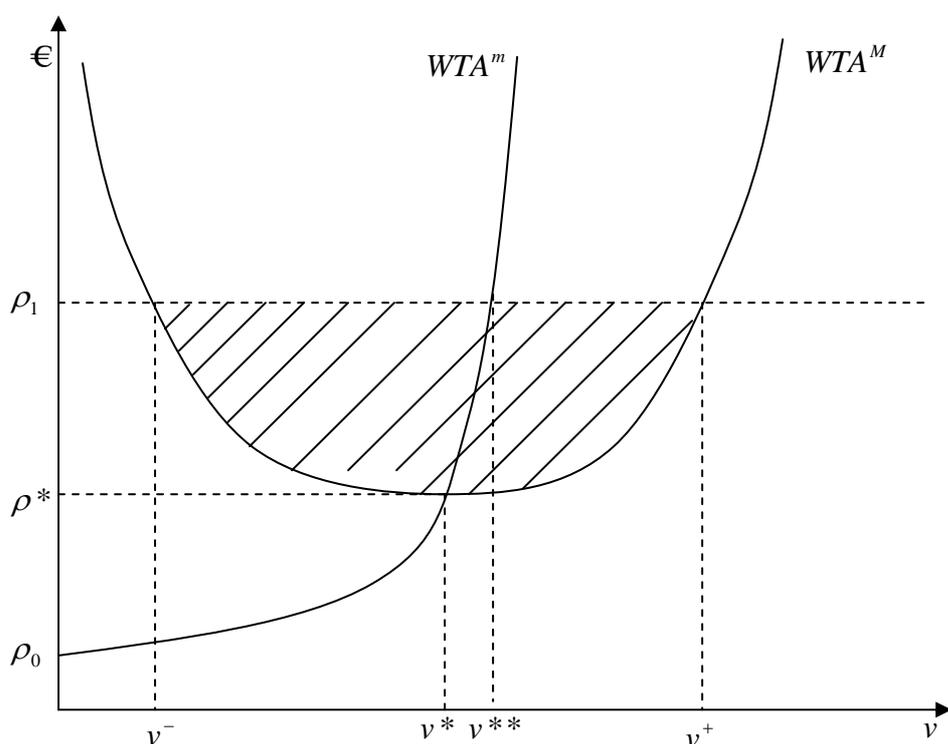
ii) Secondly, we suppose that $\bar{v} < v^*$. As the marginal cost of contracting is increasing with v , (13) and (17) imply that the MRS for (m^*, v^*) is higher than the MRS for (\bar{m}, \bar{v}) . As the MRS is decreasing with v when m is constant, it implies that $\bar{m} < m^*$ must hold. It implies $U(\bar{m}, \bar{v}, Z) < U(m^*, v^*, Z) = U_0$. This inequality contradicts the optimization program (5). Indeed, the relationships (13) and (14) shows that (m^*, v^*) respects the necessary conditions of this program, as stated in (17) and (18), and provides an higher utility than (\bar{m}, \bar{v}) . Therefore (\bar{m}, \bar{v}) can not be a solution of (5) if $\bar{v} < v^*$.

From i) and ii) we can conclude $(\bar{m}, \bar{v}) = (m^*, v^*)$.

II.5) Synthesis

We can observe from graph (1), the marginal WTA curve (WTA^m) where, in the absence of fixed compliance costs, the minimum WTA is ρ_0 .

In the presence of fixed compliance costs, we can observe the U-shaped average WTA curve (WTA^M) whose minimum is located in v^* and the associated minimum per-unit payment for contracting is ρ^* .



Graph 1: Average WTA and marginal WTA with the number of hectare under contract

When the per-unit payment is higher than ρ^* , ρ_1 for instance, as long as $WTA^M \leq \rho_1$, farmers respecting the area condition enroll. This corresponds to the hachured area between v^- , the minimal necessary area to enrol, and v^+ , the maximal possible area to enrol, without utility loss. Farmers with an eligible area higher than v^* will prefer to subscribe the optimal area v^{**} . If the eligible area of their farm is lower than v^{**} , they will enter 100% of this available suboptimal area.

III) FIXED AND VARIABLE COMPLIANCE COSTS: APPLICATION TO AGRO-ENVIRONMENTAL CONTRACTS

We here seek to observe the impact of fixed compliance costs on adoption behavior, and fixed transaction costs in particular. The empirical analysis is based on a European sample made of 2262 farmers interviewed in 2005. They come from 10 different regions spread among 9 EU countries, namely France, the Netherlands, Belgium, England, Germany, Italy (two regions: Emilia Romagna and Veneto), Ireland, Finland and Czech Republic. 55% of interviewed farmers have subscribed an agro-environmental contract and the proportion of contractors is quite similar in every region except for Finland where only 32% of farmers are considered as contractors. Next table presents an overview of the origin population.

Table 1: Overview of the origin population

Sub-samples	Farmer population	Participation rate	Farm production system
France	34000	7%	Predominance of dairy farms
Netherlands	6000	11%	Predominance of dairy farms
Belgium	20667	15%	Mixed farming
England	5690	33%	Mainly cattle and sheep farms
Germany	1054	10%	?
Italy Em. Rom.	34919	40%	?
Italy Ven.	?	2.5%	Arable farms and dairy farms
Ireland	13233	26%	Mainly cattle farming
Finland	4600	15%	Mainly grain crops
Czech Republic	46400	26.5%	Combined production

This table highlights an over-coverage of contractors. Indeed, 60% of surveyed farms are contractors while they represent only 25% of farms on average. It also shows an over-coverage of some types of farming systems, namely breeding systems (82%) and dairy systems (38%) . This makes a high proportion of grassland in total farmland (52%).

The questionnaire addresses issues concerning farmers' socio-demographic and cultural characteristics, their farm, their professional environment, their perceptions on agro-environmental contract and their income. The sample is quite representative although contracting farmers are over represented on purpose in order to get better information on contracts.

III.1) The empirical methodology

Agro-environmental contracts (AEC) involve various compliance costs we can present as follows. Fixed compliance costs do not vary with the enrolled area. Fixed transaction costs are information gathering before contracting, contract writing, or bureaucratic costs for the contract follow-up. Variable compliance costs are varying with the enrolled area. Variable transaction costs are maladaptation costs and the costs of contract renegotiations. Indeed, we assume that the more the farmer has hectares under AEC, the more hazards may appear and lead him to be trapped in contracts commitments.

From this observation, taking back our theoretical model, fixed compliance costs $F(.)$ encompasses fixed costs of production and fixed transaction costs, whereas the variable compliance cost function $\pi^R(.)$ gathers variable production costs and variable transaction costs. Equations (?) give the new specification, where Z^T are determinants of fixed and variable transaction costs.

$$\pi^R(p, 0, z^\pi, z^T) - \pi^R(p, v, z^\pi, z^T) = y(p, v, z^\pi) + t(p, v, z^T)$$

$$F(p, v, Z^\pi, Z^T) = Y(p, v, Z^\pi) + T(p, v, Z^T)$$

It is important to remind that farmer's characteristics, Z^U , determine neo-classical preferences, variables describing the technology, Z^π , determine the profit according to the duality theory, and, variables describing the transaction environment, Z^T , determine transaction costs according to the transaction cost theory. Some of these determinants being common to the utility function, the profit function and the transaction cost function, we clarify these relationships in table 2 in order to simplify our estimation interpretations. This table is based on the previous work of Ducos and Dupraz (2007) analyzing determinants of the choice over asset specificity level in agro-environmental contracts. It provides determinants expected effects on each component of farmers' WTA, namely the production cost variation, the transaction cost variation and the WTP, other things being equal.

Table 2: Synthesis of the WTA determinant expected effects

Determinants of WTA	ΔY or Δy	ΔT or Δt	WTP
Trust		-	
Uncertainty		+	
Bounded rationality		+	
Utility		-	+
Technology/ Similarity	-	-	
- means a reduced variation + means an increased variation			

Among these five determinants, three have an impact on the transaction cost function only and two impact on other components of the WTA too. Before providing propositions about the relationship between these determinants and the choice over contracting and the area to subscribe, some assumptions are to be set. First, agro-environmental contracts are centrally designed, i.e. the European commission has specified agro-environmental contract provisions (duration, flexibility¹, eligibility and compensation payment calculation). Consequently, contract design is assumed to be the same whatever the EU state. Second, we assume agro-environmental contracts involve non negligible investments and their magnitude is similar across contractors. Third, we assume agro-environmental contract involve specific investments, such investments being non redeployable without sacrifice of productive value (Ducos and Dupraz, 2007). More precisely, we assume contracting farmers got engaged in the same specificity level of investments. This is a reasonable assumption since they subscribed for the least specific suggested environmental friendly practices such as “extensive management of grassland, “extensive management of arable land” or “landscape maintenance”. We thus consider the asset specificity level does not vary from a contractor to an other.

In other respects, in line with the 1999-CAP regulation, the implemented compensation payment is a per-unit payment based on average operational costs and income foregone in each region and do not include transaction costs. We therefore expect transaction costs originating from involved investment specificity to affect agro-environmental contract uptake rate, *ceteris paribus*.

¹ A contract is said to be flexible when some terms are left open to ex post renegotiation.

From this last observation, we set the following testable propositions² on the relationship between transaction characteristics and farmers' choice to enroll an agro-environmental contract:

Proposition 1: The more the farmer trusts in the State, the lower the transaction cost variation, the lower his WTA and the higher the probability he enrolls, *ceteris paribus*.

We argue the same effects for less uncertainty and less bounded rationality.

Proposition 2: The more the agro-environmental transaction is similar to ones the farmer is already engaged, the lower the transaction cost variation and the profit loss. The probability to enroll is thus higher and because of the compensation payment calculation, we may argue this is due to transaction cost effect, *ceteris paribus*.

Proposition 3: The more utility the farmer gets from environmental services he produces through the agro-environmental contract, the lower the transaction cost variation and the greater his WTP. The probability to enroll is thus higher but it is not possible to distinguish both effects, *ceteris paribus*.

By introducing the prospect of estimating the structural relationships underlying the adoption decision, the application of the two-stage Heckman method stands to shed light on the issue of whether and to what extent variations in fixed costs (fixed transaction costs) are responsible for observed adoption rate.

The econometric specification is based on the optimal area the farmer would contract if he were obliged to contract: this is the notional area v^n where the marginal WTA equals the per hectare premium (). It does not depend on fixed costs. So contracting this area may entail a utility loss under a threshold area because of fixed costs. Or this optimal area is negative if the premium do not reach the marginal WTA for any positive contracted area. In fact, the farmer refuses the contract in these both cases.

$$\rho = \rho^m(p, v^n, z^\pi, z^T) \Rightarrow v^n = v^n(p, \rho, z^\pi, z^T)$$

The first step of the Heckman method analyses the decision to contract or not, using a probit model. It is based on the probability that the premium exceeds the minimal average WTA, which depends on fixed costs according to (14), or ρ_0 in the absence of fixed costs. Alternatively this is the probability that the notional area v^n exceeds v^* or zero. The latent variable of the probit model is the difference b between v^n and v^* . This first step enable the calculation of the inverse Mills ratio to be used in the second step.

$$b = v^n - v^* \Rightarrow b = b(p, \rho, Z^\pi, Z^T)$$

The second step analyses the contracted area with a least square regression. The contracted area is the optimal area, knowing that the contract is accepted. Hence the regression is augmented with the inverse Mills ratio to take into account the outcomes of the first step.

Accordingly, the econometric specification assumes that the pair (v^n, b) has a bivariate normal distribution:

$$\begin{aligned} E(v^n / x) &= x' \alpha & \text{Var}(v^n) &= \sigma_1^2 \\ E(b / X) &= X' \beta & \text{Var}(b) &= \sigma_2^2 & \text{Cov}(v^n, b) &= \theta \cdot \sigma_1 \cdot \sigma_2 \end{aligned}$$

² These propositions are derived from Ducos and Dupraz (2007).

The probability of contracting is $P(b \geq 0) = \Phi(X'(\beta/\sigma_2))$ with Φ the cumulative function of the normal distribution. The parameter (β/σ_2) is estimated by the maximum likelihood estimator in the probit model.

The area under contract is $E(v^n / b \geq 0, x) = x' \alpha + (\theta \cdot \sigma_1) \cdot \lambda$
 $\lambda = \varphi(X'(\beta/\sigma_2)) / \Phi(X'(\beta/\sigma_2))$

We use the same linear specification, with the same explanatory variables, to model the expected optimal area. If there were no fixed costs both steps would bring more or less the same results, scaled by the estimated parameter of the inverse Mills ratio. With fixed costs, the results will diverge if the determinants of fixed costs are different from the determinants of the marginal WTA. These determinants will more affect the first step than the second, possibly in opposite directions.

III.2) Explanatory variables

Several types of variables were collected so as to capture the notion of the determinants previously described. They describe the farmer (education level, environmental awareness...), his production system (farm legal status, number of Full Time Equivalent workers...), his professional environment (involvement in agricultural organizations, administrative and technical external services,...) and his relationship with the State (trust in administrations, ...). From these raw data, we created variables providing a measure of the determinants of the WTA as presented in table 3.

Table 3: Determinants of the WTA and their respective explanatory variables

Determinants of asset specificity	Related constructed explanatory variables	Variable values³
Bounded rationality	Agricultural education (<i>AGRI EDUC</i>) General education	6 classes 7 classes
Trust	To trust the implementation process of agro-environmental contracts (<i>TRUST IMPL</i>) Strong belief in the Government goodwill (<i>GOODWILL</i>)	Continuous variable [-1;1] Continuous variable [-1;1]
Uncertainty	To regularly receive technical and administrative advices (<i>ADVICES</i>) To be involved in an agricultural organization (<i>ORGA</i>)	Continuous variables [-1;1] Continuous variable [-1;1]
Similarity of transaction	Grassland share (<i>GRASSLAND</i>) Farm land area (<i>UAA</i>) Arable land share Labor (<i>FTE</i>) Animal population Milk quota Production system type (organic or conventional)	Continuous variable (%) Continuous variable (hectares) Continuous variable (%) 5 classes Continuous variable (Livestock units) Continuous variable (litre) 0=organic; 1=conventional
Utility	Environmental awareness (<i>ENV AW</i>) Children Free time dedicated in nature related hobbies	Continuous variable [-1;1] 3 classes Continuous variable [-1;1]
Control variables		
Changes in the production system in the last 5 years (<i>CHANGES</i>)		Continuous variable [-1;1]

³ See the annex for a more detailed description of how explanatory variables measure determinants of the WTA.

To have already enrolled an agro-environmental contract (<i>EXPERIENCE</i>)	0=no; 1=yes
Age (<i>AGE</i>)	3 classes
NUT region	0=Calvados; 1=Manche; 2=Orne
Machinery ownership	Continuous variable [-1;1]
Land share in ownership	Continuous variable (%)
Land share in long term tenant tenure	Continuous variable (%)
Land share in short term tenant tenure	Continuous variable (%)
Farm legal status	5 classes

Next table provides average annual payment per hectare of enrolled area.

Table 4: Average annual payment per hectare of contracted area

	France	Netherlands	Belgium	England	Germany	Ireland	Finland	Czech Republic	Italy_ Em. R.	Italy_ Veneto
Mean (€ha)	119.7	168.4	455.6	389.1	163.4	164.7	124.1	90.8	317.4	334.4
Median (€ha)	109.4	137.1	180.9	76.9	129.9	169.2	105.8	90.9	277.8	183.6

The lowest payments per hectare are in France, Netherlands, Germany, Ireland, Finland, and Czech Republic. The highest are in Belgium, England, Italy Emilia Romania and Italy Veneto.

IV) RESULTS

This section provides estimation results. Probit estimates allow to distinguish factors of transaction cost variation from those of the profit ones. Heckman estimates allow to distinguish factors of fixed transaction cost from those of variable ones;

IV.1) Probit estimations

The reference choice is not to enroll. The reference farmer is high agricultural education, intermediate general education, no experience in previous AEC, no children under 6 years-old, his production system is conventional and dairy farming oriented, and, for other variables, average values of continuous explanatory variables have been taken. Country specificities, including characteristics of sampling in each case study, are taken into account through country dummies, which are introduced as control variables. France is the reference. The different parameter estimations are gathered in table 7. Significant variables are presented only. The model has kept every observations.

Table 5. Model of participation (pooled sample with country dummies)

PARAMETERS (Mac Fadden R ² = 30.01%)		Estimation	Standard error	Pr > Khi 2
Intercept		-0.7666	0.1268	<.0001
TRUST				
<i>TRUST IMPL</i>		0.6756	0.0393	<.0001
<i>TRUST INST</i>		0.1802	0.0376	<.0001
BOUNDED RATIO				
<i>GEN EDUC</i>	Non response	-0.1714	0.1508	0.2557
	None	0.3177	0.1351	0.0187
	Low	0.0872	0.0830	0.2935
	High	0.1683	0.1133	0.1375
UTILITY				
<i>NAT HOBBIES</i>		-0.1735	0.0432	<.0001
<i>ENV AW</i>		0.2423	0.0471	<.0001
<i>CHILDREN</i>		0.3659	0.0892	<.0001
SIMILARITY				
<i>PROD</i>	Non response	1.1070	0.5030	0.0278
	Organic	0.8475	0.1389	<.0001
<i>GRASSLAND</i>		0.8191	0.1123	<.0001
CONTROL VARIABLES				
<i>EXPERIENCE</i>		0.9820	0.0754	<.0001
<i>COUNTRY</i>	Netherlands	-0.2252	0.1766	0.2023
	Belgium	0.4276	0.1297	0.0010
	United Kingdom	0.2569	0.1332	0.0538
	Germany	-0.0672	0.1508	0.6560
	Ireland	-0.6353	0.1442	<.0001
	Finland	-0.9524	0.1734	<.0001
	Czech Republic	0.0769	0.1404	0.5837
	Italy E. Romagna	-0.5395	0.1674	0.0013
	Italy Veneto	0.2729	0.1604	0.0888

Looking at variable signs, we observe seven expected factors, namely trust factors (“to trust in the implementation process of AEC”, “to trust in institutions”), bounded rationality factor (“to have a high general education”), similarity factors (“environmental awareness”, “to have children under 6 years-old”), and similarity factors (“organic production system”, “grassland share”). Trust and bounded rationality factors thus support the proposition 1 whereas similarity and utility factors support propositions 2 and 3.

Non expected variables are “to have no or a low general education” and “Free time dedicated to nature related hobbies.

Instead of looking at estimation coefficient magnitude, we observe marginal effects on the probability to enrol an AEC in table 6. They are calculated for the reference farmer whose probability to participate is 0.41. Only significant effects are indicated.

Table 6: Marginal effects (pooled sample with country dummies)

Variable	Marginal effect
TRUST	
<i>TRUST IMPL</i>	0.25
<i>TRUST INST</i>	0.07
BOUNDED RATIONALITY	
<i>GEN EDUC</i>	0.12
UTILITY	
<i>CHILDREN</i>	0.14
<i>NAT HOBBIES</i>	-0.06
<i>ENV AW</i>	0.09
SIMILARITY	
<i>PROD</i>	0.33
<i>GRASSLAND</i>	0.31
CONTROL VARIABLES	
<i>EXPERIENCE</i>	0.37
<i>BE</i>	0.17
<i>UK</i>	0.10
<i>IRL</i>	-0.20
<i>FIN</i>	-0.27
<i>IT-R</i>	-0.18
<i>IT-V</i>	NS

Marginal effects allow ranking variables according to their estimated effect on participation. The most influential factors are the type of farming, past experience in AEC and farmer's trust in the implementation process.

IV.2) Heckman estimations

Table 7 provides the estimation with the Heckman procedure. The inverse Mills ratio, λ , is calculated in the first step and used in the second one to correct data. This specific parameter accounts for differences between participants and non-participants that are captured by the error term. λ being non-significantly different from zero, it may be considered that omitted factors do not account for differences between the two categories. In other words, explanatory variables are enough to discriminate farmers and to estimate the share of area entering AECs.

Table 7: Estimation of the proportion of Farmland which is enrolled (Heckman model)

PARAMETERS		Estimate	Std Error	Pr > t
Intercept		-.8727	0.1674	<.0001
λ		-.0439	0.1041	0.6736
UTILITY				
<i>ENVAW</i>	Environmental awareness	0.0807	0.0344	0.0192
SIMILARITY				
<i>PROD</i>	Non response	0.2143	0.4045	0.5964
	Organic	0.2723	0.1192	0.0225
<i>GRASSLAND</i>	Share of grassland	0.8977	0.1316	<.0001
<i>DAIRY</i>	No	0.2394	0.0940	0.0110
<i>UAA</i>	Surface	-.00164	0.0004	<.0001
<i>UAA</i> ²	Square-surface	0.0001	0.0001	<.0001
CONTROL VARIABLES				
<i>CHANGE</i>	Past change	0.0856	0.0457	0.0616
<i>COUNTRY</i>	Netherlands	-.9754	0.1404	<.0001
	Belgium	-.9450	0.1274	<.0001
	United Kingdom	-.3397	0.1659	0.0408
	Germany	0.0818	0.1913	0.6690
	Ireland	0.3155	0.3239	0.3302
	Finland	0.5412	0.2114	0.0106
	Czech Republic	-.1289	0.1401	0.3576
	Italy E. Romagna	0.2997	0.1833	0.1024
	Italy Veneto	-.3639	0.1706	0.0332
R ² = 23.17%. Number of observations= 1996. Number of participants = 981				

Three additional explanatory variables appear and describe the similarity of transactions, namely “to have a dairy production system”, “farm land area”, and “square farm land share”. An other one appear and is a control variable “changes in the production system in the last five years”. On the other hand, variables describing trust and bounded rationality disappeared and a utility variable (“to have children under six years-old”) too. From this observation, and concentrating on trust and bounded rationality variables, which impact on transaction cost only, we can argue the presence of fixed transaction costs as a barrier of contracting AEC.

Two variables describing the similarity of transaction (“production system type”, “grassland share”) and the utility in the transaction (“environmental awareness”) positively influence the relative area under AEC. They support the presence of variable costs but, since they impact on the profit loss and the WTP respectively, it is not possible to disentangle their effect on transaction costs. An additional explanatory variable (“changes in the production system in the last five years”) whose effect is positive is also considered. As expected, farmers who made significant changes over the last five years enter a larger area than the others.

In addition, there is a significant effect of farm size on the contracted surface. This effect has been modelled using two components, a linear one and a quadratic one. Based on the estimation of the coefficient of the surface and square surface, a threshold (around 2 600 ha) has been calculated. There is a negative effect under the threshold and a positive one over, this threshold.

Finally there is a specific country effect which is mainly due to the difference of Schemes proposed to farmers.

V) CONCLUSION

Estimation results support the presence of fixed transaction costs among fixed compliance costs and their significant negative effect on participation. The policy implications of this case study are straight forward. In order to increase farmers' adoption, the State seems to have two possibilities, whether to compensate farmers' transaction costs with a higher subsidy, or to reduce farmers' transaction costs. The first option requires an evaluation of the magnitude of transaction costs borne by the farmer, which is not an easy operation. The second option is to act on transaction cost significant determinants, namely trust and bounded rationality. For instance, knowing that farmers' trust in the implementation process has a major role, the State may work on the clarity of contract requirements so as to narrow its implementation interpretation spectrum. Trust may also be restored by balancing the State and the farmers' rights when a case is brought to private negotiation or to court. Finally, it is important to remind that this study focuses on transaction costs borne by the farmer only, whereas the agro-environmental transaction generates transaction costs borne by the State too. Consequently, reducing farmers' transaction costs may increase the State's one. This relation remains unknown and provides interesting future researches.

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ANNEX : Measure of the WTA determinants

Determinants of transaction costs, which we identified and defined in the previous section, are notions that do not allow any direct measurement. When available, previous studies characterizing conditions in which these determinants may increase or decrease helped us to build a measurement framework.

Explanatory variables measuring “Trust”

Trust is an expectation held by an agent that its trading partner will behave in a mutually beneficial manner (Sako and Helper, 1998).

Conditions favouring trust (Sako and Helper, 1998) :

- “Long-term trading and future expectations of customer commitment”: (i) the longer the informal commitment made by the customer to continue trading with the supplier, the higher is the supplier’s trust for its customer; (ii) the longer the duration of past trading, the higher is the supplier’s trust of its customer.
- “Reciprocity in information exchange”: the more a supplier’s disclosure of information to its customer is matched by the customer’s provision of information to the supplier, the higher the supplier’s trust for its customer.
- “Technical assistance”: the more technical assistance is provided by the customer, the higher the supplier’s trust in the customer

TRUST IMPL

This variable encompasses farmers’ opinions (strongly disagree; somewhat disagree; somewhat agree; strongly agree; do not know) on the following statements:

- “The eligibility rules are fair”
- “The financial compensation is sufficient to cover the extra costs incurred by the farmer”
- “Compensation payments are always made on time”
- “The rules and requirements are easy to understand”
- “The measures can easily be implemented on my farm”
- “The intended environmental benefits are clear and easy to understand”
- “The current policy rules and regulations will remain constant over a longer period”
- “There is a lot of control when implementing measures”
- “The sanctions for not carrying out the contract are reasonable”

These statements were chosen because they tend to describe farmers’ expectation that the State will behave in a mutually beneficial manner. The global variable *TRUST IMPL* was created from these primary data using a Multiple Correspondence Analysis.

A positive *TRUST IMPL* is assumed to indicate the farmer trusts in the State. The higher it gets, the more the farmer trusts in the State.

TRUST INST

In addition of *TRUST IMPL*’s statements, this variable encompasses:

- “The local government can be trusted”
- “Our government can be trusted for their commitments”
- “The agricultural administration can be trusted”
- “The European Union can be trusted”
- “Generally speaking, other farmers’ can be trusted”
- “Generally speaking, most people can be trusted”

As for *TRUST IMPL*, a positive *TRUST INST* is assumed to indicate the farmer trusts in the State. The higher it gets, the more the farmer trusts in the State.

GOODWILL

Similarly, *GOODWILL* gathers the following statements:

- “The procedures for contract applications are easy”
- “The rules and requirements are easy to understand”
- “It is easy to find the right person to contact in the administration when there are problems”
- “Regarding agro-environmental schemes, administration behaviour is fair and responsible”

A positive *GOODWILL* indicates the farmer trusts in the State. The higher it gets, the more the farmer trusts in the State.

Explanatory variables measuring “Bounded Rationality”

Same definition as Williamson (1985). Bounded rationality implies “economic agents do not know all the solutions to the problems they face, are unable to calculate the possible outcomes of these solutions, and cannot perfectly arrange these outcomes in order in their space of preferences. With regard to contracts, this means that they are unable to design the optimal solutions (behavioral rules) taking into account every relevant contingency without high, and sometimes prohibitive, costs and delays” (Brousseau and Fares, 2000).

Conditions favouring bounded rationality:

We argue initial education and any form of improved knowledge reduce each individual rationality.

GEN EDUC + AGRI EDUC

Bounded rationality is characterized with qualitative variables by creating classes of variables. Variables describing farmers’ education were assumed to measure their rationality since education is expected to provide solutions to problems and unable farmers to calculate the possible outcomes to these solutions (cf. section II.3.1).

The higher the education level, the less bounded the farmer’s rationality.

Explanatory variables measuring “Uncertainty”

Conditions favouring uncertainty (Mahul, 2002):

The agricultural production is subject to various risk sources. A classification of those risks is provided in numerous studies (see for instance USDA 1999) and is provided below:

- “Production risks” from climatic uncertainties (drought, flooding,...), technological uncertainties, sanitary conditions and epidemics.
- “Market or price risks” characterizes price production factor changes.
- “Institutional risk” created by policy or regulation changes.
- “Financial risks” includes interest rate variation uncertainties or those of exchange rate, non-payment risk,...
- “Human and personal risks” are common to any individual. They are related to illness, accidents,...

ORGA

This variable reports farmers’ membership and participation frequency in agricultural organizations. It was created using a Multiple Correspondence Analysis.

We assumed a farmer regularly meeting other farmers and people from the profession or involved in professional organizations better feel what is going on and what are policy orientations. This refers to the volatility aspect of uncertainty.

A positive *ORGA* indicates the farmer's perception about future conditions is rather clear and thus shows low uncertainty. The higher it gets, the less uncertain the farmer perceives future conditions.

ADVICES

This variable gathers information on organizations or persons farmers get technical, financial or administrative advices from. It was created using a Multiple Correspondence Analysis.

ADVICES follows the same logic as *ORGA*, namely a positive *ADVICES* indicates the farmer beneficieate from conditions lowering uncertainty about future conditions. The higher it gets, the less uncertain the farmer perceives future conditions.

Explanatory variables measuring the “Similarity of Transactions”

Except from the production system type which is a qualitative variable, every variables describing the similarity of transactions are continuous.

As Masten et al. (1991), the similarity of transactions is measured by comparing the initial technology with the technology required by enrolled environmental friendly practices. Therefore, from what we know about farm technology dedicated to the production of environmental services, the similarity of transactions is characterized as follows:

- the higher the grassland share, the more similar the transactions;
- the higher the farms land area, the more similar the transactions;
- the lower the arable land share, the more similar the transactions;
- the more labour force, the more similar the transactions;
- the bigger the animal population, the less similar the transactions;
- the bigger the milk quota, the less similar the transactions;
- An organic production system indicates similar transactions.

Explanatory variables measuring “ Utility”

Conditions favouring utility in the transaction:

We argue any form of interest for environmental or nature issues is an indicator of farmers' utility in environmental services he may produce through an AEC.

ENVAW

This variable contains information on farmers' hobbies, readings and involvement in environmental associations. It was created using a Multiple Correspondence Analysis.

We assumed a positive *SENSI* indicates farmers' environmental awareness and thus derive utility from environmental services. The higher *SENSI* gets, the more the farmer derives utility from environmental services.

We follow the same logic for the variable “free time dedicated in nature related hobbies”.

As regard to children, which gives the number and age of farmers's children, we assumed a farmer with young children will be more aware of environmental issues than farmers with no child.