Farmers' Preferences Towards Outcome-based Payment for Ecosystem Service Schemes

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Abstract

In this paper we estimate farmer's preferences for enrolling in an outcome-based payments scheme, using a choice experiment implemented with a sample of Japanese rice farmers. The conservation literature has argued in favour of such outcome-based payment schemes as a means of producing better biodiversity outcomes on farmland, although economists have cautioned about likely lower rates of participation compared to action-based payment schemes. A growing use of outcome-based schemes has been noted in Europe. In the choice experiment reported here, we use the number of fish species recorded in paddy fields to determine payments received by farmers. Other contract attributes included are monitoring arrangements, the provision of technical assistance in switching to more wildlife-friendly farming methods, whether an eco-certification is offered to scheme participants, and the payment rate. Farmers were asked to choose which contract to accept, and how many hectares they would enrol. This allows us to predict the total level of land entered into the scheme, dependent on contract design.

Keywords: agri-environmental payment; choice experiment; conservation agriculture; outcome-based payment; payment for ecosystem services

JEL Codes: Q15, Q18, Q25, Q28, Q53

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1. Introduction

Since the objective of Payment for Ecosystem Service (PES) schemes is to increase the supply of ecosystem services and to enhance biodiversity conservation, an obvious question is whether payments should be targeted at environmental outputs (higher butterfly species abundance) rather than at the management inputs or actions which are intended to produce these environmental outputs or biodiversity outcomes, such as reductions in pesticide use (Hanley et al., 2012). Most current agri-environmental policy in the European Union is targeted at management actions, typically because these are thought easier to observe, and because the 'output' of biodiversity or ecosystem services from a given area of land is determined by a wide range of factors, only some of which are under the direct control of the landowner. This means that output-based contracts are often riskier for the landowner than action-based contracts (Burton and Schwarz, 2013). Moreover, it may be more expensive for the regulator to monitor conservation outcomes (e.g. counting birds) compared to management actions (e.g. whether a landowner has drained a wetland or not). Perhaps for these reasons, payment for actions schemes dominate the policy landscape in Europe, although outcome-based contracts have been increasing in popularity, as noted by Herzon et al (2018) - Figure 1.

Outcome-based payments (also known as results-based payment schemes) have several advantages over payments for actions (Gibbons *et al*., 2011). For instance, if the management actions which are crucial to achieving a biodiversity target are expensive for the regulator to observe, then paying for outputs may be more efficient. Moreover, landowners and managers quite likely hold private information on the best areas of land within their properties for promoting target species populations, and may have alternative options for encouraging such increases in species which are unknown to the regulator or conservation agency. Output-based payments encourage land managers to make use of this information to generate biodiversity conservation more efficiently than payment for actions, just as prices paid for marketed crops provide incentives for finding the most efficient crop production methods. Finally, outcome-based schemes may have benefits in terms of increasing farmers' engagement with the idea of payments for public goods, and reduce conflicts with regulators which emerge from having to meet strict management standards to qualify for payment (Herzon et al, 2018).

Economists have used principal-agent models to investigate circumstances under which payment-for-outcome schemes are preferable to payment-for-actions (Anthon et al, 2010; White and Hanley, 2016). This modelling approach has also been used to study the properties of mixed contracts which partly pay for management actions, and partly pay for environmental outcomes – also referred to as hybrid schemes (Derissen and Quaas, 2013). Variables such as the cost to the regulator of measuring conservation efforts by the farmer, compared to measuring environmental outcomes, turn out to be important in determining the best choice of incentive mechanism. Ecologists have also investigated how changing the ways in which "outcomes" are measured, and thus paid for, can affect the environmental gains associated with outcome-based payment schemes, when the actions of neighbouring landowners have spill-overs (MacDonald et al, 2017).

However, there is little empirical work which investigates how farmers would respond if offered an outcome-based contract. This is an important gap in the literature, since an increasing number of outcome-based schemes are now being implemented. For instance, the UK has recently launched two pilot payment for outcome schemes for farmers in the Yorkshire Dales (livestock farming) and in Norfolk/Suffolk (arable farming). Switzerland introduced a payment for outcomes scheme in 2014, based on plant diversity in alpine meadows (Zabel, 2019). Either "pure" of "hybrid" outcome-based payment schemes are also in place in Germany, France, Ireland and the Netherlands (Herzon et al, 2018).

Many researchers have made use of stated preference approaches to investigate how farmers would respond to different features of a PES-type contract in terms of the determinants of uptake in payment-for-action schemes (Villanueva et al, 2015; Kuhfuss et al,2016; Villamayor-Tomas et al, 2019). However, this approach has not been used so far to predict uptake of a payment for outcomes scheme. Empirical work with farmers has identified potential barriers to uptake and acceptability, but this has been largely qualitative in nature (e.g. Birge et al, 2017).

This study focuses on paddy fields in Shiga Prefecture in Japan. Paddy fields, accounting for 54.4 percent of total agricultural area (MAFF 2018), provide important habitat for wide variety of species as substitutes of natural wetlands in Japan (Amano et al., 2008; Natuhara, 2013). This ecosystem service from paddy fields is particularly important in Shiga to provide habitats for various waterfowls visiting Lake Biwa, nation's largest lake and one of twelve lakes registered under the Ramsar Convention. Although more than 500 hectares of wetlands is protected for those waterfowls, they tend to use paddy fields as extra feeding grounds. If paddy fields are properly managed with conservation practices, they tend to provide important aquatic ecosystems consisting of various insects, amphibian, and fishes can be sustained in the fields.

In this paper, we use a stated preference choice experiment to understand how rice farmers in one region of Japan would respond to a new type of PES scheme where payments received depend on environmental outcomes realised through a change in farm management. The environmental outcome determining payment is the number of waterfowl (bird) species counted on a farmers' paddy fields. Other attributes of the contracts are the price offered per hectare, who undertakes monitoring of environmental outcomes (the farmer or an external expert), whether technical assistance is provided to the farmer to improve the expected conservation outcome of their farming operation in terms of the expected number of waterfowl, and whether an "eco-label" is awarded to rice grown under such a scheme (so consumers can discriminate amongst rice products in favour of more environmentally-friendly production). This selection of attributes partly reflects a set of important policy parameters identified in the comprehensive review of payment for outcome schemes in Europe undertaken by Herzon et al (2018), notably the choice of appropriate biodiversity indicators on which payments are based; who is responsible for monitoring outcomes; and selection of appropriate payment levels.

Based on a sample of 333 respondents, we find that farmers are willing to participate in outcome-based contacts, and that this willingness to participate is declining in how high bird numbers must be to qualify the farmer for payment, and increasing in the payment level. Higher payment rates must be offered if farmers are required to monitor and report bird numbers rather than experts, whilst a lower price can be offered if farmers are offered an eco-certification scheme attached to rice produced by participating farmers. Finally, although on average participation is not affected by the provision of free technical assistance on how to improve the number of birds on the farm, there is a relatively high level of heterogeneity attached to this contract attribute.

In what follows, we first of all describe the case study area, and then the design of the choice experiment and our sampling procedure. Results follow, then a discussion and conclusions.

2. Study design

Our empirical model consists of two stages. The first stage estimates farmers' decisions on adoption of outcome-based agri-environmental payment. Then the second component estimates adopting farmers' acreage allocation decisions given contract in the first stage. We describe these two analytical stages and then explain data collection procedures including the design of choice experiment in this study.

The first-stage: analysis of adoption

The N surveyed farmers are asked to choose on T choice cards, their preferred alternative contract amongst J alternatives. Farmers' decisions to adopt one of outcome-based contracts can be modeled by the utility maximization from choosing the contracts by comparing possible alternatives. According to Lancaster's theory (1966), this utility is a linear function of the contract attributes. Following random utility theory, we assume that the utility of farmer n

($n=1,\dots,N$) when choosing alternative i ($i=1,\dots,J$) at the t^{th} choice ($t=1,\dots,T$), U_{nit}, is defined by the following:

$$U_{nit} = \beta x_{nit} + \varepsilon_{nit} \tag{1}$$

With x_{nit} the vector of characteristics of contract i, chosen by farmer n on the t^{th} choice card. β is the vector of parameters of interest, reflecting the average weight of each characteristic, or attribute, in farmers' utility function. We assume that the random disturbances (ε_{nit}) are identically distributed among the alternatives and across the population. If the disturbances follow a Gumbel distribution, then the probability that farmer n chooses alternative i in the t^{th} choice takes the conditional logit (CL) form:

$$\Pr(\text{choice}_{nt} = i) = \frac{\exp(\beta' x_{nit})}{\sum_{j=1}^{J} \exp(\beta' x_{nit})} \tag{2}$$

The use of the CL model assumes that irrelevant alternatives are independent (independence of irrelevant alternatives; IIA). This is a strong assumption and often violated in reality. If IIA assumption does not hold, the estimates from the CL model are biased and invalid. As an alternative, the mixed logit (ML) model relaxes the major limitations of the CL model including the IIA assumption by allowing for random taste variation, unrestricted substitution patterns, and correlation in unobserved factors over time (Train, 2009). In the ML model, the parameters are specific to each farmer and randomly distributed across the population with a density function $f(\beta)$. Then, conditional on vector β_n the probability that farmer n chooses alternative i in the t^{th} choice is defined by:

$$\Pr(\text{choice}_{nt} = i|\beta_n) = \frac{\exp(\beta_n' x_{int})}{\sum_{j=1}^{J} \exp(\beta_n' x_{jnt})} \tag{3}$$

Then the probability of a particular sequence of T choices is given by the following:

$$S_n = \int \prod_{t=1}^{T} \prod_{j=1}^{J} \left[\frac{\exp(\mathrm{x}_{jnt}'\beta)}{\sum_{k=1}^{J} \exp(\mathrm{x}_{knt}'\beta)}\right]^{A_{jnt}} f(\beta|\theta) d\beta \tag{4}$$

Where $A_{jnt} = 1$ if farmer n chooses alternative j in the t^{th} choice and 0 otherwise. $f(\beta)$ can be specified to be normal or lognormal: $\beta \sim N(b, \sigma)$ or $\ln\beta \sim N(b, \sigma)$, where parameters b and σ are the mean and covariance of these distributions, respectively. Because equation 4 is not numerically solvable, maximum simulated likelihood is commonly used to find the solution (Train, 2009).

The second-stage: analysis of acreage allocation

The second stage of farmers' decision making, is to choose how much of their land to enrol in the contract chosen in stage 1. In the choice experiment, for each chosen alternative contract in a choice card, respondent n is then asked what acreage they would be willing to enrol in said contract. The acreage enrolled, y_{int}, depends on Z_{int}, which includes the characteristics of contract i chosen by n in occurrence t, and the individual characteristics of farmer n and their farm. y_{int} also depends on unobservable factors, u_{int}, as follows:

$$y_{int} = Z_{int}\alpha + u_{int} \tag{5}$$

Since the acreage information is only available for alternatives selected in stage 1, there is a risk of selection bias as the unobserved factors affecting a farmer's choice of a contract, ε_{int}, are likely to be correlated with the unobserved factors that will influence his choice of acreage, u_{int}. Following Kuhfuss et al. (2016), we use Bourguignon, Fournier and Gurgand (2007)'s procedure to address this issue. We include in the regression terms which are functions of the predicted probabilities of choice of each alternative, $P(A_{int} = 1)$, estimated in the first step through the mixed logit model, to control for selection bias in the acreage regression. Unbiased estimates of parameters α in the acreage equation (equation 5) can be obtained by least squares based on:

$$y_{int} = W_{int}\alpha + \sigma\frac{\sqrt{6}}{\pi}\left[\sum_{j\neq i} r_{jt}\left(\frac{P_{jnt}\ln(P_{jnt})}{1-P_{jnt}}\right) - r_{it}\ln(P_{int})\right] + w_{int} \tag{7}$$

where σ is the standard deviation of u_{int}, r_{it} is a correlation coefficient between u_{int} and ε_{int}, and w_{int} is a residual, mean-independent from the regressors. W_{int} includes the characteristics of alternative contract A_{int} of choice card C_t and the individual characteristics of farmer n and his farm. At least one of the variables included in X_{int} in the first stage equation (choice of a contract) is not included in W_{int}.

Data

To collect farmers' responses to the choice experiment of the hypothetical outcome-based AEP contract, we conducted mail survey in Shiga Prefecture, located in the Western part of Honshu Island in Japan. In Shiga, more than 90 percent of total agricultural area is dedicated to paddy fields. As mentioned in the introduction, these paddy fields provide important habitats for various species including waterfowls.

Farmers' environmental attitudes are generally high in Shiga. About 35 percent of total farmland is dedicated to currently implemented action-based AEP[1], while only 2 percent is dedicated on average in the country. Conservation practices are popular in Shiga Prefecture due partly to the fact that the region-specific AEP was launched in Shiga prior to the first nationwide AEP in 2007. Another possible reason is that Shiga Prefecture encircles Lake Biwa, the largest freshwater lake in Japan.

To design the outcome-based AEP, the choice of species is crucially important. In EU member states, different payment program uses different species an indicator of the outcome. These species include mammals, birds, insects, and plants[2]. In this study, after a series of discussions with local farmers and ecologists, waterfowl species is chosen as the indicator because (1) birds are generally in high in the food chain (NARO 2018); (2) their ecology is well studied and understood, so the driving force behind their fluctuations can be identified (Gregory, et al. 2003); (3) their population trends often mirror those of other species (BirdLife International, 2013); (4) they are easy to monitor by farmers; and (5) they are publicly recognized as a flagship of biodiversity.

The survey was jointly conducted with the government of Shiga Prefecture. First, a GIS expert of the government office identified agricultural districts with potential for outcome-based payment schemes. As a result, 90 districts are chosen that are environmentally important and located around the Lake Biwa. We sent a total of 10 survey questionnaires to the leader of the district and asked to distribute them to local farmers in the district. As a result, a total of 900 questionnaires was distributed to 90 districts in the Prefecture.

As already mentioned, the data were collected through a choice experiment survey in which farmers were asked to select their best option between two different contracts and a status quo alternative (Figure 1). Table 1 lists five attributes of the outcome-based contract and their levels. SPECIES is the number of waterfowl species necessary for receiving the payment. This attribute takes values of 1, 2, and 3. MONITOR is about who is in charge of monitoring and reporting. This is a dummy variable and takes a value of one if participated farmer makes these tasks and 0 if done by an external expert. TA is availability of technical assistance for effective farming to achieve the outcome. This is also a dummy variable, taking a value of 1 if assistance is available and 0 otherwise. CERTI is availability of eco-certification for outcome-achieved farming products. It also takes a value of one if eco-certification is available and 0 otherwise. Finally, PAY is payment per hectare that farmers can receive when specified outcome is achieved. Based on the pilot survey, we set payment range to be from JPY 60,000 to 120,000 per hectare per year (about 483 to 967 Euro)[3].

Using an orthogonal design, we obtained 24 possible combinations of the attributes' levels. We then randomly picked and created a total of 12 pairs. The status quo option is added to each pair. Splitting these into three groups, we finally prepared for three versions of choice experiments, each consists of four choice cards. 300 copies of each version were printed and shuffled before enclosed in mail package. An example of choice card is presented in Figure 2.

Survey was conducted from Mid-February to the end of March in 2019. Among 900 farmers, 418 farmers returned the questionnaire (response rate 46.4%). However, 85 responses were incomplete in choice experiment questions. Significant incompletion was somewhat expected because most farmers are not familiar with outcome-based payment and have never participated to a choice experiment survey. Nevertheless, our data includes 333 farmers who responded correctly to our choice experiment (effective response rate 37.0%) and the total number of cases is 1,287[4]. We use these 1,287 cases for our analysis. The descriptive statistics of the sample are presented in Table 2.

3. Results

The first-stage: analysis of adoption

Table 3 reports the estimated results of the first stage analysis - farmers' adoption decisions of hypothetical outcome-based contracts. The CL model gives estimates with fixed parameters across respondents, providing the average effect of contract attributes on farmer's decisions. We conducted the Hausman test and find that the assumption of the IIA does not hold in our data. Violation of the IIA assumption indicates that estimates from the CL logit model are invalid. Thus, table 3 reports two other estimates using ML models. We assume all beta parameters except PAY to be normally distributed. The parameter of PAY is needed to be fixed to avoid identification problem.

The first ML model (ML1) only includes the contract attributes and the alternative specific constant (ASC)[1] as a comparison with the CL model. The second model (ML2) includes two individual characteristics of responded farmers as an interaction with the ASC. The first characteristics is perception of pollution (POLL). This is a dummy variable that takes a value of one if respondent believes that intensive application of chemical fertilizers and pesticides are polluting environment (zero otherwise). The second characteristics is related to farmers' profit maximization behaviours (PROF). This is also a dummy variable that takes one if profit maximization is the most important aspect in his or her farming. These interaction terms tell that how individual characteristics affects farmers' willingness to adopt rather than staying at their status quo.

In both ML1 and ML2, the parameters of all independent variables except TA are highly significant and match our expectation. The coefficient of the ASC is negative and significant, indicating that farmers prefer to choose one of the contracts proposed rather than their status quo.

The negative coefficient of SPECIES suggests that farmers' utilities tend to decrease as this variable becomes larger. This is reasonable because the contracts are less attractive to farmers if the number of species necessary for receiving payment is greater. The negative value of MONITOR indicates that farmers prefer when an external expert implements monitoring and reporting of the outcome.

The coefficient of TA is not statistically significant in all models. In our sample, farmers' experience of agricultural operation is about 34 years on average and half of respondents are currently engaged in an action-based AEP. These figures suggest that respondents are generally experienced and skilled, an extra assistance for effective farming is not an important for their adoption decisions. It should be noted, however, that the SD parameter of TA is highly significant and much greater than the mean effect parameter. This implies that some farmers place significant importance on technical assistance for effective farming practices.

The value of PAY is positive and highly significant, indicating that the contract proposed becomes more and more appealing to farmers as the annual per-hectare payment is greater. This is quite reasonable, and we are interested in whether or not this payment variable affects farmers' acreage allocation as well as adoption decisions. This will be discussed later in this section.

The table shows that two variables of farmers' characteristics interacted with the ASC are estimated to be significant. The negative value of ASC×POLL indicates that farmers believing that intensive application of chemical fertilizers and pesticides are polluting environment are more likely to choose one of the proposed contracts rather than stay at their status quo. Similarly, the negative coefficient of ASC×PROF indicates that farmers placing the greatest importance on maximizing their profits tend to choose one of the contracts. This implies that outcome-based payment schemes are likely to be consistent with their profit-maximizing behaviors.

[1] The ASC is coded 1 when the alternative is the no contract option and 0 for the 2 contract alternatives.

Marginal willingness to accept (MWTA)

Table 4 illustrates the estimated MWTA for three contract attributes of the outcome-based payment (SPECIES, MONITOR, and CERTI). The MWTA of TA is not reported because the estimated parameter is not significant at any statistical levels in all three models. The MWTA of SPECIES is estimated to be JPY 18,022.4 per hectare per year (about 145 Euro). This indicates that on average, at least this amount should be paid for each extra species included in the outcome-based contract's requirements to maintain farmers' adoption rate. For example, if the necessary outcome is three species, an extra JPY 54,067 (about 435 Euros) are needed.

The MWTA of MONITOR indicates that if monitoring and reporting is conducted by farmers rather than external experts, the payment to farmers should increase by JPY 36,465.9 per hectare per year (about 293 Euro). So, if the contract requires an outcome of three species and farmers need to monitor and report, at least JPY 90,533 (about 728 Euro) are needed per hectare per year. This is somewhat expected from discussions with local farmers in our pilot survey.

The MWTA of CERTI is minus JPY 26,448.6 (about minus 213 Euro). The value is negative because eco-certification provides an extra value on crops produced from result-achieving farmland. This implies that farmers would be willing to choose the contract at the lower payment if extra values is guaranteed such as eco-certification. (add some evidence here)

The second-stage: analysis of acreage allocation

If the respondent chooses one of the contracts (A or B) rather than the status quo, he or she then chooses how much of his or her farmland (in percentage) to be allocated for the contract. 333 farmers responded to 1,287 cases and chose one of contracts (not status quo) in 956 cases. 253 farmers responded to acreage questions (80 farmers never responded). Among these farmers, 25 farmers provided only one acreage response and did not respond to this question on the other three choice cards. 47 farmers provided to two or three acreage values, within these, 34 famers always stated the same acreage value over their choices, and only 13 adjusted the stated acreage according to the alternative's attributes levels. 181 farmers provided four acreage values, with 134 that always state the same acreage value independently of the attributes' levels. Remaining 47 farmers adjusted their stated acreage to the alternative. In total, 60 out of 333 farmers adjusted their stated acreage to the alternative (and do not always state the same acreage over four choice cards) over 223 choices.

It should be noted that, in about one-third (288 case) of 872 cases with valid acreage response, farmers would be willing to devote his or her whole farmland to the outcome-based contract ($y_{int} = 1$). This might imply that the process of farmers' decisions of engaging his or her whole farmland is different from that of engaging only a fraction of the total farmland. Under this assumption, we use a one inflated beta regression (OIB) model (Cook, Kieschnick and McCullough, 2008; Kuhfuss et al., 2016). The OIB model fits by maximum likelihood a one inflated beta distribution to a distribution of a dependent variable that ranges from zero to one.

The estimated results are presented in table 5. The first part of table 5 presents the 584 observations (67.0 percent of total observations with a valid acreage response) with partial acreage allocation ($0 < y < 1$). The table shows that no significant factors exist for farmers' fractional acreage decisions.

In our pilot survey with various local farmers, we felt that their adoption decisions on their whole paddy fields is straightforward, but fractional enrollment decisions seemed not to be an easy task for them. They tend to answer quickly when they decide to allocate whole farmland but take much longer time to decide how much of the farmland to allocate for the contract. They seemed to be struggling when deciding an exact portion among many possible options. This difficulty might be one possible explanation of nearly no significance of the variables.

The second part of table 5 presents the estimations on the 288 observations (33.0 percent of total observations with a valid acreage response) when farmers declare to be willing to enroll their whole farm ($y = 1$). Overall, the results are quite different from those obtained when only a proportion is enrolled. The per hectare annual payment (PAY) is positive and highly significant, implying that payment levels are positive inducements for farmers' acreage decisions as well as adoption decisions.

The coefficient of SPECIES is also positive and significant. This suggests that farmers tend to enroll whole farmland if the number of species necessary for receiving payment is greater. This can be explained by the size effect, a relationship between species abundance and area of conservation. For example, in the case of urban green space, several studies empirically show such relationship (cite them and seek for studies in the context of conservation agriculture). As table 3 shows, SPECIES is a negative inducement for farmers' adoption decisions. But once adopted, farmers would be more likely to enroll whole farmland if the outcome is harder to achieve by requiring more waterfowl species for payment.

Table 5 also shows that two of farmers' characteristics are statistically significant. The coefficient of POLL is positive, implying that farmers believing that intensive application of chemical fertilizers and pesticides are polluting the environment are more likely to devote whole farmland to the contract. This is consistent with the results of adoption decisions. In contrast, PROF provides mixed results for different decisions. Although this variable is a positive inducement at the first-stage analysis, it has a negative influence on the decision of allocating whole farmland. This result is quite reasonable because devoting whole farmland to the outcome-based contract is too risky for farmers placing the highest importance on maximizing his or her profit from farming. They would probably allocate only a portion of farmland with relatively higher probability of achieving the outcome. We could also speculate that they would allocate their least productive land to the AEP, therefore maximizing the profit from these land through the AEP payment.

Table 6 summarizes the estimated results from the two-step sample selection models. As explained in section 2, at least one of the variables included in selection equation cannot be included in acreage equation. The estimated results from the one-inflated model in Table 5 indicates that three contract variables (MONITOR, TA, CERTI) do not have significant impact on acreage decisions. This suggests the use of one of these contract attributes as an instrumental variable in the selection equations. Using one of these variables, we estimated three separate models.

As shown in Table 6, the three models produce somewhat similar results. In all models, the variable POLL has positive and significant impact on acreage decisions. This suggests that farmers with environmental concerns about chemical-intensive agriculture are more likely to devote greater proportion of their farmland under given contract. Similarly, the coefficient of PROF is negative and significant, implying that farmers tends to allocate less amount if they put greater emphasis on maximizing its profit. These results imply an importance of farmers' individual characteristics on acreage decisions as well as contract decisions of outcome-based payment schemes.

As expected, PAY is positive and highly significant in all models. This clearly indicates that farmers will allocate a greater portion of farmland if the payment levels are higher. Unlike the one-inflated model, SPECIES is not significant.

4. Discussion and Conclusions

Output-based payments seem attractive as a way to increase the cost-effectiveness of PES schemes by conditioning payments to farmers to the actual achievement of environmental objectives, therefore saving highly pressured budgets when no environmental improvement is observed. Indeed, from the scheme operators' perspective, input-based payments come with the risk that payments are made when ultimately no improvements in environmental conditions are achieved due to low conservation efforts by farmers (moral hazard) and/or external factors such as climate or other sources of contamination outside farmers' control. While under outcome-based payments farmers might be more likely to provide high conservation efforts, they are still subject to external factors potentially compromising the environmental impact of their efforts, which makes this type of scheme less attractive than input-based payments from their perspective.

Despite this higher uncertainty on payments, our results confirm that farmers would be willing to take part in such output-based PES schemes. However, they also demonstrate that for a given per hectare payment, participation rates would decrease when payments are conditioned to higher environmental objectives, in our case an increased number of bird species observed on the farm. Maintaining participation rates constant would therefore require higher payments, as illustrated by the substantively increased WTA associated with an increase in the number of bird species required to achieve environmental objectives in our study. These increased payments demanded by farmers can be interpreted as a need to compensate for the costs of higher conservation efforts to achieve higher environmental objectives.

The positive effect of higher environmental requirements (number of bird species to be observed) on farmers' likelihood to enrol their whole farm might indicate that farmers are indeed willing to increase their efforts (reduced moral hazard) to achieve environmental objectives. If outcome-based payment reduces the risks of moral hazard, it also transfers the whole external risks to farmers. Therefore, this increased WTA can also be seen as a risk premium that needs to be paid to farmers to compensate for the increased uncertainty of payment. Depending on farmers' risk preferences, and perception/knowledge of uncertainty of environmental processes, and how much of the risk the land-manager (perceives he) is in control of, the risk premium that will need to be paid might exceed the potential losses related to paying farmers while no environmental outcomes are achieved. In our study, profit maximizing farmers, which can be assumed to be less risk averse, seem to be more likely to adopt outcome-based schemes. This result comforts the expectation that farmers' risk preferences play a key role in their participation in outcome-based schemes. Therefore, the idea of enhancing the environmental impact of PES scheme through the use of outcome-based payments would only be true if a larger budget was allocated to these schemes to sustain a level of enrolment sufficient to achieve the environmental objectives. By using outcome-based payments rather than action-based payments, the scheme operator is transferring risks to landowners and this comes at a cost. In the end, the scheme operators should compare the costs of paying farmers despite no environmental benefits in some instances (in some areas or in some years) to the cost of paying this risk premium to all participants when the environmental objectives are achieved before concluding on which approach is likely to be most cost-effective.

Additionally, and as explained in the introduction, the cost of monitoring actions vs. outcome is a key factor in determining whether output-based schemes should be favoured over action-based schemes. One way to reduce this cost is to ask farmers to monitor themselves the outcomes of the scheme. Again, our results show that this would come at a cost, as farmers would demand an increased payment, that should be compared the monitoring costs for the scheme operator.

Farmer's lower WTA when the scheme is associated with an eco-certification demonstrates that by complementing outcome-based PES schemes with an eco-certification scheme, scheme operators could use the price premium associated with the label to reduce payments offered to farmers, and transfer some of the conservation costs to consumers. However, this would also add a layer of uncertainty to farmers' income. An alternative way of interpreting this result is to say that for a same level of payment offered to farmers by the scheme operator, adding a certification scheme, would increase participation rates and increase the chances of achieving the environmental objective. In both cases, this combination is likely to increase the cost-effectiveness of a PES scheme.

While technical assistance could have been expected to reduce WTA by reducing the uncertainty of environmental outcomes through better conservation practices, this attribute of the PES scheme is not significant on average in our study. Farmers do not seem to perceive benefits from free advisory services. However, the large heterogeneity of preferences for this contract attribute might be related to the heterogeneity in knowledge and awareness or different levels of access to other sources of advice amongst farmers. Free technical advice might therefore be a determinant of participation for some of the farmers.

Our data analysis is still ongoing, and the next steps of this research will include simulations of adoption rates and acreage enrolment under alternative scheme designs, and under alternative payment rates to better inform the design of such outcome-based PES schemes.

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Notes

[1] In Japan, the first national AEP ("conservation payment for farmland, water, and environment") was implemented during 2007–2011. Current and second generation of AEP ("payment for conservation agriculture") has been in use since 2012, and the program was enhanced as permanent law since 2015. Under these payments, farmers who voluntarily participate in the program are required to reduce their use of chemical fertilizers and insecticides by 50 percent and adopt one of the conservation practices effective for biodiversity conservation and/or carbon sequestration. These practices include cover cropping, use of compost, and organic farming and region-specific practices specified by each of 47 Prefectures in Japan.

[2] See Allen et al. (2014) for details in the types of indicators used in outcome-based payment schemes in EU member States.

[3] 1 Euro is equivalent to about JPY 117 (as of September, 2019).

[4] The total number of cases is not $333 \times 4 = 1{,}332$ because some farmers answered only a part of 4 choice cards.

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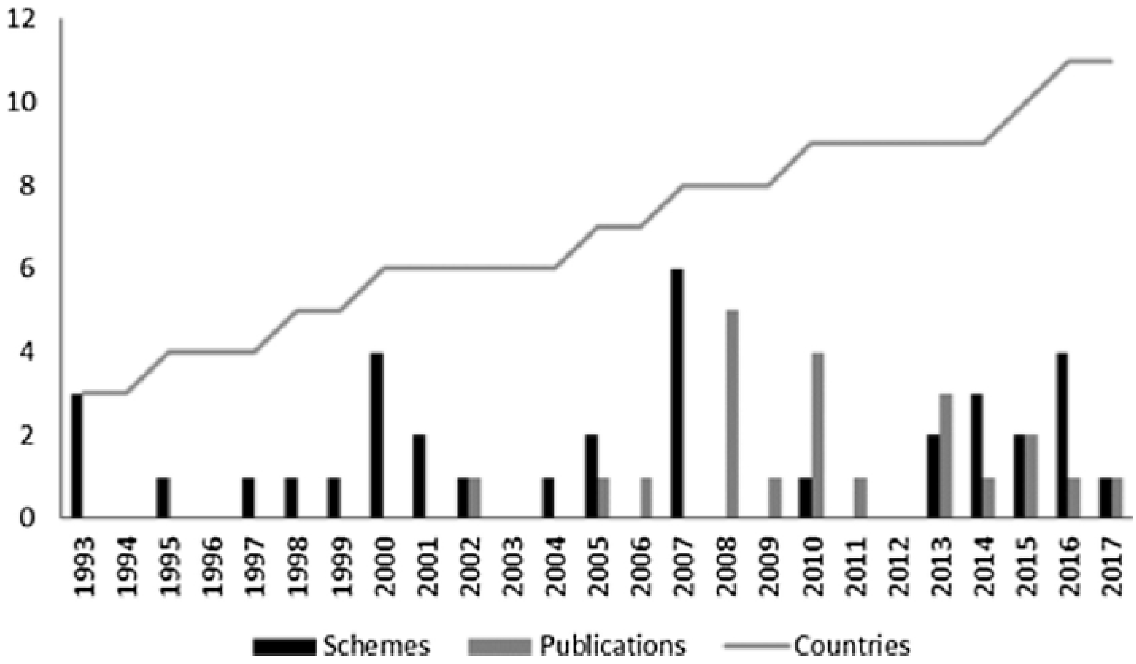

Figure 1 – Growth of outcome-based payment schemes over time in Europe (Source: Herzon et al, 2018)

	Contract A	Contract B	No contract (status quo)
The number of species for receiving payment	3 species 	2 species 	–
Mehtod of monitoring and reporting	By farmer 	By expert 	–
Technical assistance for effective practices	Not available 	Available 	
Eco-certification for achieving the result	Available 	Not available 	–
Annual payment per ha.	JPY 100,000	JPY 60,000	–
Please check one ✓	☐	☐	☐

Please answer if A or B is chosen. How much of your farmland can be participated? ______%

Figure 2 – Example of choice card

Table 1 – Attributes and attribute levels for the choice experiment

Attribute	Description	Levels
SPECIES	The number of waterfowl (bird) species necessary for receiving payment	Quantitative variable: 1 species; 2 species; 3 species
MONITOR	The number of species is monitored and reported by the farmer	Dummy variable: 1 if yes; 0 otherwise
TA	Technical assistance of effective farming for achieving the outcome	Dummy variable: 1 if available; 0 otherwise
CERTI	Eco-certification for outcome-achieved farming products	Dummy variable: 1 if available; 0 otherwise
PAY	Payment per hectare when achieving the outcome	Quantitative variable: JPY 60,000/ha; JPY 80,000/ha; JPY 100,000/ha; JPY 120,000/ha

Table 2 – Descriptive statistics of responded farmers

Variable	Description	*N*	Mean	S.D.	Min.	Max.
FULL	1 if full-time farmer	333	0.32	0.47	0.00	1.00
EXP	Years in agriculture	325	33.61	15.28	0.00	77.00
AREA	Area of farmland	331	5.14	10.73	0.00	93.00
WORKER1	# of full-time workers	193	2.02	2.27	0.00	17.00
WORKER2	# of part-time workers	240	1.78	1.96	0.00	28.00
SUCCESSOR	1 if successor is available	333	0.29	0.46	0.00	1.00
AEP	1 if currently adopting the AEP	333	0.50	0.50	0.00	1.00
POLL	1 if believes intensive application of chemical fertilizers is polluting the environment	333	0.30	0.46	0.00	1.00
PROF	1 if profit maximization is the most important for his/her farming	333	0.39	0.49	0.00	1.00

Table 3 – The results of the first-stage analysis (adoption decisions) using the conditional and mixed logit models

Dependent variable:		**Conditional logit (CL)**			**Mixed logitt 1 (ML1)**			**Mixed logit 2 (ML2)**		
Choice		Coefficient		Std. error	Coefficient		Std. error	Coefficient		Std. error
Mean Parameters	ASC	0.336		0.209	-5.888	***	1.289	-3.006	***	1.102
	ASC×POLL	-		-	-		-	-4.139	***	1.079
	ASC×PROF	-		-	-		-	-2.533	**	1.023
	SPECIES	-0.102	*	0.209	-0.373	***	0.122	-0.376	***	0.125
	MONITOR	-0.133	*	0.053	-0.612	**	0.239	-0.660	***	0.242
	TA	0.105		0.077	0.079		0.158	0.117		0.153
	CERTI	0.270	***	0.076	0.669	***	0.174	0.607	***	0.165
	PAY	8.8E-06	***	2.1E-06	2.1E-05	*** ***	5.1E-06	2.4E-05	***	5.3E-06
S.D. Parameters	ASC	-		-	-10.780	***	1.608	-11.773	***	1.720
	ASC×POLL	-		-	-		-	9.716	***	1.466
	ASC×PROF	-		-	-		-	-3.028	***	0.705
	SPECIES	-		-	1.173	***	0.186	-1.235	***	0.178
	MONITOR	-		-	2.918	***	0.397	-2.916	***	0.368
	TA	-		-	1.192	***	0.341	-0.956	***	0.257
	CERTI	-		-	1.099	***	0.306	-0.980	***	0.279
	# of obs.	3,861			3,861			3,861		
	# of cases	1,287			1,287			1,287		
	Log-likelihood	-1,378			-965			-960		
	AIC	2,768			1,949			1,931		

Note: *, **, *** indicates statistical significance at 10, 5, 1 percent, respectively.

Table 4 – The estimated marginal willingness to accept (MWTA)

Attribute	*n*	Mean	Std. Dev.	95% c.i.	
SPECIES	333	18,022.4	1,883.8	14,330.3	21,714.6
MONITOR	333	36,465.9	4,192.0	28,249.6	44,682.1
TA	—	—	—	—	—
CERTI	333	-26,448.6	954.3	-28,318.9	-24,578.2

Note: MWTA of TA is not reported due to statistical insignificance at the fist-stage analysis.

Table 5 – The results of the second-stage analysis (acreage decisions) using the ZOIB model

Dependent variable: % of farmland allocated (y)	Variable	Coefficient		Std. error
Proportion	Intercept	-0.355		0.170
($0 < y < 1$)	POLL	-0.128		0.142
(n = 584)	PROF	-0.046		0.120
	SPECIES	-0.027		0.044
	MONITOR	0.027		0.080
	TA	0.041		0.065
	CERTI	-0.023		0.087
	PAY	1.1E-06		1.3E-06
One inflated	Intercept	-2.014	***	0.439
(y = 1)	POLL	0.805	***	0.296
(n = 288)	PROF	-0.685	**	0.291
	SPECIES	0.195	**	0.099
	MONITOR	0.055		0.171
	TA	-0.110		0.132
	CERTI	-0.204		0.176
	PAY	1.2E-05	***	3.3E-06
	Ln_phi intercept	1.664	***	0.091
	# of obs.	872		
	Log-pseudolikelihood	-382		
	AIC	775		

Note: **, *** indicates statistical significance at 5 and 1 percent, respectively.

Table 6 – The results of the second-stage analysis (acreage decisions) using the ZOIB model

Dependent variable:	Model 1			Model 2			Model 3		
% of farmland allocated (y)	Coefficient		Std. error	Coefficient		Std. error	Coefficient		Std. error
Intercept	-0.286		0.357	-0.346		0.353	-0.398		0.356
POLL	0.188	***	0.044	0.189	***	0.044	0.196	***	0.044
PROF	-0.067	***	0.023	-0.066	***	0.023	-0.064	***	0.023
SPECIES	0.008		0.015	0.007		0.015	0.005		0.015
MONITOR	—		—	-0.005		0.023	-0.006		0.023
TA	-0.009		0.024	—		—	-0.004		0.023
CERTI	-0.022		0.029	-0.019		0.029	—		—
PAY	2.2E-06	***	5.5E-07	2.2E-06	***	5.6E-07	2.3E-06	***	5.3E-07
$\_m1$	-0.167		0.155	-0.178		0.154	-0.150		0.154
$\_m2$	-0.474		0.448	-0.542		0.434	-0.534		0.463
$\_m3$	-1.191	***	0.447	-1.243	***	0.458	-1.266	***	0.462
# of obs.	872			872			872		

Note 1: *** indicates statistical significance at 1 percent.
Note 2: Model 1, 2, and 3 uses MONITOR, TA, and CERTI in the selection equation, respectively.