Farmers' Preferences Toward an Outcome-based Payment for Ecosystem Service Scheme in Japan

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Abstract

We estimate farmers' preferences for outcome-based (or results-based) payment for ecosystem service scheme in Japan. To this end, we use a two-stage stated preference approach—the first stage models farmers' decisions to adopt outcome-based contracts using a discrete choice experiment. The second stage estimates the areas of land which farmers who choose to participate will enrol in the scheme. Based on a sample of 333 respondents, our results show that most farmers are willing to participate in outcome-based contacts. A variety of contract attributes are found to influence farmers' decisions on participation. However, once a farmer decides to participate, his or her decision on how much farmland to enrol in is likely to be influenced solely by the per-hectare payment. Therefore, to encourage more farmers to participate and enrol more farmland, policymakers' decisions on the level of payments offered are critically important.

Keywords: agri-environment schemes; choice experiments; Japan; outcome-based payments; results-based payments; payment for ecosystem services; stated preferences.

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1. Introduction

The objective of payment for ecosystem service (PES) schemes is to sustain or increase the delivery of socially valuable ecosystem services and protect high nature value areas. An obvious question in this context is whether payments should target environmental outputs (e.g., higher butterfly species abundance) or the management inputs and actions that are expected to lead to these biodiversity outcomes, such as reduced pesticide use (Hanley et al., 2012). Most current agri-environmental payments (AEP) target management actions, typically because these are easier to observe (Burton and Schwarz, 2013). Furthermore, the "output" of biodiversity or ecosystem services from a given land area is determined by a wide range of factors, only some of which a landowner can directly control. This means that outcome-based payments (also known as results-based payments, payments by results, or pay for success) are often viewed as riskier for landowners than action-based ones (Burton and Schwarz, 2013; Russi et al., 2016; Ayambire and Pittman, 2021; Šumrada et al., 2021). Moreover, it may be more expensive for a regulator to monitor conservation outcomes (e.g., the number of bird species) than monitor management actions (e.g., whether a landowner has drained a wetland). Perhaps for these reasons, payment for action schemes dominate the policy landscape, although outcome-based contracts have increased in popularity (Herzon et al., 2018).

Outcome-based payments have several advantages over action-based payments (Gibbons et al., 2011). If it is expensive for a regulator to observe the management actions, then paying for outputs may be more efficient[1]. Moreover, landowners and managers may withhold private information about the best areas of their properties to promote target species populations and may know better ways to promote species populations that regulators or conservation agencies are unaware of. Compared to payment for actions, output-based payment encourages land managers to use this private

[1] For example, White and Hanley (2016) show theoretically that with perfect information, the regulator can contract equivalently on actions or outcomes. With hidden information, action-based contracts are more cost-effective at reducing the informational rent related to adverse selection than outcome-based contracts. Mixed contracts (both actions and outcomes) are also cost-effective, especially where one input is not observable.

information to promote biodiversity conservation most efficiently, just as crop prices promote the most efficient means of crop production (Hanley and White, 2014). Finally, outcome-based payment may have an advantage in increasing farmers' engagement with the idea of payments for public goods and may reduce conflicts with regulators that result from farmers having to meet strict management standards to quality for payments (Herzon et al., 2018).

There is an increasing number of outcome-based schemes now being implemented. For instance, the UK has recently launched three pilot outcome-based payment schemes for farmers. One focuses on livestock farming in the Yorkshire Dales, and another at arable farming in Norfolk and Suffolk (Natural England 2020). The last pilot, the POBAS project, is being led by NatureScot to arrange initiatives across Scotland (NatureScot n.d.)[2]. Switzerland introduced a payment for outcomes scheme in 2014 based on plant diversity in alpine meadows (Zabel, 2019). "Pure" and "hybrid" outcome-based payment schemes have also been implemented in France, Germany, Ireland, and the Netherlands (Herzon et al., 2018).

Economists have used principal-agent models to investigate circumstances under which payment for outcomes is 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 that pay separately for management actions and environmental outcomes, often referred to as hybrid schemes (Derissen and Quaas, 2013). This literature finds that variables related to a regulator's cost of measuring a farmer's conservation efforts relative to the costs of measuring ecological outputs are critical 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 the outcome-based payment schemes when the actions of neighbouring landowners have ecological spillovers (McDonald et al., 2018).

[2] For details, please see NatureScot's website (https://www.nature.scot/doc/piloting-outcomes-based-approach-scotland-pobas-project).

Although empirical research on outcomes-based payments has been limited, the gap has recently been filled quickly. For example, Vainio et al. (2019) analyse the perceptions of the legitimacy of the existing action- and the proposed outcome-based agri-environmental schemes using farmers' and citizens' survey data in Finland. They find that citizens perceive the outcome-based scheme as more legitimate, whereas farmers attribute greater legitimacy to the action-oriented scheme. They also find that in order to move AEP to the outcomes-based approach, both groups must recognize the need for the change and base it on the values they consider important. Kelemen, Megyesi, and Andersen (2020) conduct a cross-country comparative analysis of the actual policy context of novel contractual solutions including the outcome-based payment scheme to improve the understanding of contract governance.

Many researchers have employed stated preference approaches to investigate farmers' responses to PES-type contracts regarding uptake determinants in payment for action-based schemes (Ruto and Garrod, 2009; Espinosa-Goded, Barreiro-Hurle and Ruto, 2010; Broch and Vedel, 2011; Christensen et al., 2011; Broch et al., 2013; Villanueva et al., 2015; Kuhfuss et al., 2016; Villaneuva et al., 2017; Villamayor-Tomas et al., 2019). According to a survey paper by Tyllianakis and Martin-Ortega (2021), 26 studies have attempted to measure farmers' willingness to accept (WTA) in agri-environment schemes, even if limited to the EU region only. Of these, 25 studies use a choice experiment[3]. Thus far, however, there has been quite limited use of this approach to predict payment uptake in an outcomes scheme. To our knowledge, one of few examples is the work by Niskanen et al. (2021), showing heterogeneous preferences for outcome-based payment schemes. Their empirical work with farmers in Finland has identified potential barriers to uptake and acceptability of outcome-based contracts. Although there exists a large body of literature related to outcome-based payments, it has been largely qualitative in nature (Birge et al., 2017). Our paper addresses this gap in the literature.

[3] See Table 1 in Tyllianakis and Martin-Ortega (2021) for details of each choice experiment study.

We use a WTA format, since (i) we assume that farmers need to be offered positive payments to agree to accept restrictions on their production activities and (ii) since all PES-type contracts that we are familiar with consist of the offer of payments to land owners/managers in return for an agreement to change management in a way which increases biodiversity or ecosystem service provision (farmers are not asked their willingness to pay for a contact). Moreover, as stated above, a very large body of stated preference studies now exists which uses stated preference methods to estimate farmers' willingness to participate in PES-type programmes. However, economists have worried about the incentive compatibility of WTA formats in stated preferences (Lloyd-Smith and Adamowicz, 2018).

As Vossler et al. (2012) have shown, in WTP formats we know that stated bids can closely approximate true WTP for public goods when 4 conditions are met: (i) participants care about the outcome (ii) a single binary choice is offered on which participants vote yes or no (iii) the payment mechanism is coercive and (iv) the probability that the proposed project is implemented is weakly monotonically increasing with the proportion of yes votes. Conditions (iii) and (iv) have been addressed in terms of perceptions about the outcome and payment consequentiality. However, despite encouraging empirical work by Lloyd-Smith and Adamowicz (2018) showing that for public goods, these conditions can also predict incentive compatibility for WTA formats, no such result was found for private goods. Since PES contracts are private goods, we cannot tell whether stated bids will under- or over-value farmer's true minimum WTA due to potential strategic bias in the hypothetical market in two opposing directions.

We employ a two-stage stated preference choice experiment to understand how rice farmers in Shiga Prefecture, Japan (see next section for details), would respond to a new type of PES scheme, where payments received would depend on environmental outcomes realized through farm-management changes. The first stage estimates farmers' decisions on the adoption of outcome-based contracts. We incorporate several contract attributes into our experiment: the number of waterfowl (bird) species counted on a farmer's paddy fields; whether a farmer or an external expert monitors the environmental outcomes; whether technical assistance is provided to the farmer to improve the expected conservation outcome; and whether rice grown under the designated scheme earns an "eco-label" to signify a high level of environmental friendliness to consumers, and annual per-hectare payment. These contract attributes reflect a set of important policy parameters identified by Herzon et al. (2018) in their comprehensive review of payment for outcome schemes in Europe: the selection of biodiversity indicators on which payments are based; who is responsible for monitoring outcomes; and the selection of appropriate payment levels.

Based on the results from the first stage, the second stage estimates the acreage allocation decisions (how much of his/her farmland to enrol in outcome-based payment) of adopting farmers who wish to enrol in contracts in the first stage. We expect that farmers' preferences on contract attributes and their impact on allocation decisions differ. Because farmers' allocation decisions can be observed only when he or she chooses one of the outcome-based contracts rather than the status quo in the first stage, we employ a sample selection multinomial logit model developed by Bourguignon et al. (2007). The next section describes our empirical procedures in detail.

2. Methods

2.1 Geographical context

This study focuses on farmers who manage rice paddy fields in Shiga Prefecture, Japan (Figure A1, online Appendix). Paddy fields, which account for 54.4 % of the total agricultural area in Shiga (MAFF, 2018). Lake Biwa in this Prefecture, which is adjacent to our research site, is a Ramsar Convention designated lake and is the largest wintering ground for migratory birds in Japan. A wide variety of waterfowl inhabit the lake throughout the year. Of the 633 species of birds living in Japan, 340 species have been confirmed in this region. According to a population survey conducted in 2021, 141,990 Anatidae seabirds were observed in and around Lake Biwa (Shiga Prefecture, n.d.).

Paddy fields around the lake serve as essential habitats for a wide variety of species, acting as a substitute for natural wetlands (Amano et al., 2008; Natuhara, 2013). Some waterfowl such as egrets, spot-billed duck, and grey-headed lapwing, use the nearby rice paddies as their feeding grounds. Since these waterfowl are top predators at the top of the rice paddy food web, paddies frequented by these birds are considered to have a high diversity and level of habitat integrity. In addition, egrets feed on harmful species such as crayfish, ungulates, horseflies, and locusts, and also supply nutrients to rice through their excrement. However, the number of egrets in rice paddies has been decreasing due to the use of agricultural chemicals and the resulting decrease in the prey species living in the paddy fields, leading to them being designated as a near-threatened species.

When the fields are managed via sound conservation practices, paddy fields can serve as important aquatic ecosystems, sustaining insects, amphibians, and fish (Kiritani 2000). For this reason, Shiga Prefecture has been implementing a range of conservation programmes that encourage farmers to adopt fish-friendly conservation practices.[4] In Shiga, more than 90 % of the total agricultural area is dedicated to paddy fields. About 35 % of the total farmland in Shiga is dedicated to a currently implemented action-based agri-environmental scheme[5].

To design the outcome-based PES, the choice of environmental indicator used to determine payments to participating farmers is crucial. Across the EU, different payment programmes use

[4] Since 2001, the Shiga Prefecture has been implementing the "Fish Cradle Rice Paddies Project." Farmers enroling in this project must comply with several conditions including the use of pesticides that results in the lowest level of fish toxicity and specific water management to maintain fish habitats (Ministry of the Environment 2020).

[5] In Japan, the first national agricultural PES (“conservation payment for farmland, water, and environment”) was implemented during 2007–2011. The current and second generations of programme (“direct payments for environmentally friendly agriculture”) have been in use since 2012, and the programme was enhanced to become permanent law in 2015. Under these payments, farmers who voluntarily participate in the programme are required to reduce their use of chemical fertilizers and insecticides by 50 % and adopt a conservation practice known to be effective for biodiversity conservation and/or carbon sequestration. These practices include cover cropping, the use of compost, and organic farming and region-specific practices specified by each of the 47 prefectures in Japan. More specific information can be found at the official website (https://www.maff.go.jp/e/policies/env/sustainagri/directpay.html).

different species as indicators of outcomes, including mammals, birds, insects, and plants.[6] Based on the existing schemes, Herzon et al. (2018) suggest that a clear definition of environmental objectives, the identification of suitable indicators and a favourable socio-economic context are necessary for the effective design of outcome-based payments. After a series of discussions with local farmers and ecologists, waterfowl species were chosen as the indicator in Shiga because (1) birds are generally high in the food chain (Kuwae et al., 2012); (2) their ecology is well studied and understood, so that the driving forces 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 for farmers to monitor; and (5) they are publicly recognized as a flagship of biodiversity.

2.2 Empirical modelling

Our empirical models consist of two stages. Following Kuhfuss et al. (2016), a first stage analysis estimates farmers' decisions to adopt outcome-based AEP as a function of the contract characteristics and a number of farmer attributes. Then, in the second stage, the acreage allocation decisions of adopting farmers who choose to enrol in a contract in the first stage are modelled.

The first stage: Analysis of adoption decisions

In the first stage, the research task is to estimate how the probability of a farmer signing an outcome-based contract varies with the attributes of that contract. The N surveyed farmers were asked to choose their preferred contract from J options from T choice cards (Figure A2, online Appendix), their preferred alternative contract among J alternatives. A farmer's decision to adopt an outcome-based contract can be modeled as utility maximization from the choice of one contract among various alternatives (McFadden 1973). According to Lancaster's (1966) theory, this utility is a function of the

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

contract attributes. Following random utility theory, we assume that the utility of farmer n (n =1,…, *N*) when choosing alternative i ($i = 1, \ldots, J$) at the tth choice ($t = 1, \ldots, T$), U_{nit}, is defined by the following:

$$U_{nit} = \beta x_{nit} + \varepsilon_{nit} \quad (1)$$

where x_{nit} is 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 preference weight of each contract characteristic or attribute in the farmer's utility function. We assume that the random disturbances (ε_{nit}) are identically distributed among the alternatives and across the population. Assuming that the disturbances follow a Gumbel distribution, the probability that farmer n chooses alternative i in the t^{th} choice takes the conditional logit (CL) form:

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

The CL model assumes that irrelevant alternatives are independent (independence of irrelevant alternatives or IIA). IIA is a strong assumption and is often violated in reality. If the IIA assumption does not hold, the estimates from the CL model are biased and invalid. An alternative approach, 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 the following:

$$P(\text{choice}_{nt} = i|\beta_n) = \frac{\exp(\beta_n' x_{int})}{\sum_{k=1}^{J} \exp(\beta_n' x_{knt})} \quad (3)$$

Next, the probability of a particular sequence of *T* choices is given by the following:

$$P(A_{jn1} = 1, \ldots, A_{jnT} = 1) = \int \prod_{t=1}^{T} \prod_{j=1}^{J} \left[\frac{\exp(\beta_n' x_{jnt})}{\sum_{k=1}^{J} \exp(\beta_n' x_{knt})}\right]^{A_{jnt}} f(\beta|\theta) d\beta \quad (4)$$

where $A_{jnt} = 1$ if farmer n chooses alternative j in the t^{th} choice and is 0 otherwise. θ are the parameters of the distribution of β over the population. The preference distribution $f(\beta|\theta)$ is typically 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, the maximum simulated likelihood is commonly used to find the solution (Train, 2009).

The second stage: Analysis of acreage allocation decisions

The research question in the second stage is how much farmland farmers choose to enrol in the contract from the first stage, conditional on a decision to sign an outcome-based contract. In the choice experiment, for any chosen outcome-based contract in a choice card, respondent *n* is asked what acreage of their land they would be willing to enrol in the contract. The acreage enroled, 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 the contract alternatives selected in the first stage, there is a risk of selection bias in estimating the parameters of (5). This is because unobserved factors affecting a farmer's choice of contract, ε_{int}, are likely to be correlated with the unobserved factors that also influence his choice of acreage, u_{int}. Following Kuhfuss et al. (2016), we use the procedure developed by Bourguignon et al. (2007) to address this issue. In the regression, we include the terms that 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 the following:

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

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 the alternative contract A_{int} of choice card C_t and the individual characteristics of farmer n and his or her farm. For identification purposes, at least one of the variables included in X_{int} in the first stage equation (the choice of a contract) is not included in W_{int}.

2.3 Design and implementation of the Choice experiment

As already mentioned, the data were collected through a choice experiment survey in which farmers were asked to select the best option among two different contracts and a status quo alternative. Figure A2 shows an example of a choice card used in our survey[7].

Table 1 lists the five attributes of the outcome-based contract and their levels. A key attribute is an ecological metric used to determine payments to farmers. This is SPECIES, the minimum number of waterfowl (bird) species necessary for receiving the payment; this attribute takes a value of 1, 2, or 3 waterfowl species counted on the farmer's land. We speculated that a farmer's willingness to engage in the contract would also depend on a number of perceived benefits and costs to the farmer of enroling, determined by the contract design. These consist of (a) MONITOR, referring to who is in charge of monitoring bird populations on farms and reporting this information to the regulator; this is a dummy variable that takes a value of 1 if the participating farmer performs these tasks and 0 if an external expert performs them; (b) TA is the availability of technical assistance and advice provided to enroling farmers on land management practices which are viewed as being effective for achieving the ecological outcomes determining payment; this is also a dummy variable, taking a value of 1 if assistance is available and 0 otherwise (see, for example, Cortes-Capano et al., 2021), and (c) CERTI is

[7] Before presenting the choice cards, we conversed with farmers about some management techniques they could implement to attract more birds to their farms. We also stressed that it was their responsibility to decide how best to "produce" birds on their own farm. Farmers could choose to enrol less than 100 % of their farm in any contract selected if they wished so.

the availability of eco-certification for outcome-achieved farming products; it takes a value of 1 if eco-certification is available and 0 otherwise. In this hypothetical certification scheme, only participating farmers who achieve the outcome can use the eco-label, which allows them to earn a price premium on their crops. Finally, PAY is the payment per hectare farmers can receive when the specified ecological outcome is achieved. Based on the pilot survey, we set payments to range from JPY 60,000 to 120,000 per hectare per year (about 451 to 902 Euro).[8,9]

[Insert Table 1 here]

Of these five attributes, technical assistance, eco-certification, and payment level are common determinants of uptake of action-based contracts. On the other hand, the number of waterfowl species is an attribute specific to the outcome-based scheme. Niskanen (2021) use water quality effects (nutrient runoff reduction) as the outcome indicator, which is to be reported by an installed automatic measuring device. Therefore, no monitoring effort is required for participants. Since the outcome indicator in this study is the number of waterfowl species, human observation is necessary for monitoring the outcome[10].

[8] Prior to the survey, we performed several pilot surveys in December of 2018 and January of 2019. In these surveys, we conducted a total of six in-person interviews with local farmers who have adopted conservation practices near Lake Biwa. We questioned farmers on various topics including preferences regarding current action-based agricultural PES, their basic understanding of outcome-based payment, possible outcome indicators, acceptable payment ranges, and potential barriers and issues related to implementing the outcome-based payments. Through these surveys, we developed our payment variations and the number of waterfowl species as feasible outcome indicators in our study region.

[9] 1 Euro is equivalent to about JPY 133 (as of June 2021).

[10] It is technically possible to measure the number of waterfowl species automatically. We have actually tested the effectiveness of AI-based automatic waterfowl observation in the pilot paddy fields in collaboration with a domestic telecommunications company (NTT DoCoMo). However, considering the cost per unit of equipment, we conclude that it is not a realistic solution at this time.

There are a total of 72 combinations of attribute levels for the outcome-based contract, but we narrowed them down to 24 using orthogonal design. From these 24 combinations, we randomly created 12 pairs, and added a "No Participation" option to each of the pairs. Out of these 12 choices, 3 groups of 4 cards were randomly selected, and these were designated as versions A, B, and C. We printed 300 copies of each version and then enclosed them in the mail packages.

In addition to the choice experiment, the questionnaire includes questions about the demographic characteristics of the respondents (e.g., farming experience, family members, presence of a successor), farming practices (e.g., type of farming, acreage of parcels, number of employees, major buyers), and perceptions of farming and environment. The questionnaire translated into English is available online[11]. Table 2 summarizes the descriptive statistics of some important questions included in the questionnaire.

The survey was jointly conducted with the Shiga Prefectural government. GIS experts in the government office identified agricultural districts suitable for implementing a future outcome-based payment scheme. A total of 90 districts were chosen based on spatial and agronomic factors, including distance to the lake, the condition of irrigation canals, and current conservation farming practices. We sent ten copies of the survey questionnaires to the heads of each district and asked them to distribute the questionnaires to local district farmers. A total of 900 questionnaires were distributed in this manner. We chose this approach after discussion with local policymakers who supported this survey. This method has advantages in terms of both feasibility and ensuring a reasonable response rate.

The survey was conducted in February and March of 2019. 418 out of 900 farmers returned the questionnaires (a response rate of 46.4 %). Among them, 85 farmers had incomplete responses to choice experiment questions (20.3% of total respondents). This incompletion rate was somewhat expected, as most farmers are not familiar with outcome-based payments and had never participated

[11] Available online at: https://is.gd/tanaka_hanley_kuhfuss_2022.

in a choice experiment survey. We use the remaining 333 responses for our analysis. The left half of Table 2 presents descriptive statistics of our sample.

[Insert Table 2 here]

To ensure that the sample we collected adequately reflects the population, we compared our sample with statistics reported from 90 communities in the study region. The right half of Table 2 shows descriptive statistics of these communities, based on community-level statistics from the 2015 World Census of Agriculture and Forestry in Japan (MAFF, n.d.). Checking several indicators, including farm size, the number of people employed, and participation in conservation agriculture, we confirmed that the averages for the sample and the region are similar. Therefore, we believe that our sample reasonably represents the population of the study area.

3. Results

3.1 The first stage: Analysis of adoption decisions

Table 3 reports the estimated results of the first stage of the analysis of contract selection. The CL model provides the average effect of contract attributes on farmers' decisions. We conduct the Hausman test and find that the independence of irrelevant alternatives (IIA) assumption did not hold in our data. The 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 set as fixed.

[Insert Table 3 here]

The first ML model (ML1) includes only the contract attributes and the alternative specific constant (ASC)[12] as a comparison with the CL model. The second model (ML2) includes three individual characteristics of responding farmers as an interaction with the ASC. The first characteristic is farmer's

[12] The ASC is coded 1 when the alternative is the no-contract (status quo) option and 0 for the 2 outcome-based contract alternatives.

perceptions of pollution from farming (POLL). This dummy variable takes a value of 1 if the respondent believes that intensive application of chemical fertilizers and pesticides is polluting the environment (0 otherwise). The second characteristic is related to farmers' attitudes (PROF). This is also a dummy variable that is 1 if the farmer agrees with the statement that profit maximization is the most crucial aspect of his or her farming (0 otherwise). The last variable relates to farmers’ experience in participating in AEP. This variable (AEP) is dummy coded and takes the value 1 if a farmer has participated in the nation-wide agri-environmental schemes, zero otherwise. We include these three farmer-level variables since the analysis of farmer participation in PES schemes has highlighted the potential importance of attitudes and beliefs regarding the goals of farming as being important in helping to determine their participation decisions (Dessart et al., 2019). As specified, these interaction terms indicate how these three individual characteristics affect farmers' willingness to participate in the scheme.

In both ML1 and ML2 models, the parameters of all independent variables except TA are highly significant and match our expectations. The coefficient of the ASC is negative and significant in both models, indicating that farmers generally prefer one of the outcome-based contracts to the no-contract option. The negative coefficient of SPECIES suggests that farmers' utility tends to decrease as this variable becomes larger, as expected. The negative value of MONITOR indicates that farmers prefer an external expert rather than having to monitor and report themselves. If the outcome-based scheme is implemented, monitoring waterfowl species will be conducted during the rice-growing season (the paddy fields are dry during the rest of the year, and waterfowl do not fly in). During this period, however, most farmers are busy with farming and would not want to spend time for non-farming operations. In general, farmers’ paddy fields consist of many small parcels, so when many parcels participate in a payment contract, the monitoring effort is even greater.

The coefficient of TA is not statistically significant in both ML1 and ML2 models. However, it should be noted that the SD parameter of TA is highly significant and much greater than the mean effect parameter. This implies that some farmers emphasize receiving technical assistance and advice on environmentally effective farming practices designed to make the target ecological outcomes more likely. The coefficient of PAY is positive and highly significant, indicating that the proposed contract becomes more and more appealing to farmers as the annual per-hectare payment becomes greater.

In ML2 model, the three variables of farmers' characteristics that interacted with the ASC are estimated to be significant determinants of participation. The negative value of ASC×POLL indicates that farmers believing that intensive application of chemical fertilizers and pesticides pollute the environment are more likely to choose one of the proposed contracts rather than the no-contract option. Similarly, the negative coefficient of ASC×PROF indicates that farmers placing the most importance on maximizing their profits are more likely to choose one of the contracts offered rather than no contract. This implies that outcome-based payment schemes are likely to be consistent with their profit-maximizing behaviours. This result is consistent with a choice experiment of an outcome-based contract by Niskanen (2021). In their analysis, nearly half of the farmers were willing to implement the proposed outcome-based policies if the compensation was high enough. They interpreted this class as entrepreneurial.

In Japan, profit-seeking farmers tend to view agri-environmental contracts as an additional source of income and actively consider participating in them (Kyoi and Tanaka 2019). In the case of existing action-based contracts, farmers who participate tend to be larger-scale and more efficiency-oriented. We therefore expect that they also consider outcome-based contracts as an additional income opportunity.

Finally, the negative sign of ASCxAEP suggests that farmers who have experience in participating in AEP are more likely to choose one of the 2 alternative contracts than no contract. It should be noted, however, that this group may also register for other action-based contracts.

3.2 Marginal willingness to accept (MWTA)

Table 4 summarizes the estimated marginal willingness to accept (MWTA) of farmers for three contract attributes of the outcome-based payment (SPECIES, MONITOR, and CERTI) based on the results from the first-stage analysis (ML2 presented in Table 3). The confidence intervals are calculated using the bias-corrected bootstrapping[13]. The MWTA of TA is not reported, as the estimated parameter is not significant at any statistical level in all three models. The MWTA of SPECIES is estimated to be JPY 24,643 per hectare per year (about 185 Euros). For example, if the necessary outcome is two species, the amount of payment to farmers would be 24,643*2 = JPY 49,286 (about 370 Euro). If the payment condition is three species rather than two, then an extra JPY 24,643 would be needed, and the payment per hectare would be JPY 73,929 (about 555 Euros).

[Insert Table 4 here]

The MWTA of MONITOR indicates that if monitoring and reporting are conducted by farmers rather than by external experts, the payment to farmers would need to increase by JPY 44,554 per hectare per year (about 335 Euros). Although this is not a negligible extra payment, checking ecological outcomes besides regular farming activities during the crop growing season is a significant additional burden, confirming prior focus group discussions with farmers in the region.

The MWTA of CERTI is minus JPY 33,220 (about minus 250 Euros). The value is negative because eco-certification provides an extra value for crops produced from outcome-achieving farmland. For consumers, a label indicating the achievement of outcome-based payment conditions can clearly signal that the crop (rice) was produced in an environmentally friendly manner, for which consumers may be willing to pay a premium. This implies that farmers would be willing to choose the contract with a lower payment from the government when higher crop prices are made possible via eco-certification.

[13] We used Stata 16's default bootstrap command. Please refer to the Stata manual for technical details (https://www.stata.com/manuals/rbootstrap.pdf).

3.3 The second stage: Analysis of acreage allocation decisions

Table 5 summarizes the estimated results from the two-step sample selection models, building on ML2 (Table 3) as the selection model in the first step. As explained in Section 2, one of the variables included in the selection equation (ML2 in Table 3) cannot be included in the acreage equation for identification. We thus use a dummy variable for past participation in the AEP as an instrumental variable in the selection equation.

[Insert Table 5 here]

Table 5 shows that the variable POLL has a positive and significant impact on acreage decisions. This implies that farmers with environmental concerns about chemical-intensive agriculture are more likely to devote a greater portion of their farmland under a given contract. Similarly, the coefficient of PROF is negative and significant, implying that farmers tend to allocate less land to the outcome-based scheme if they place a greater emphasis on maximizing profit. These results highlight the importance of farmers' individual characteristics in their acreage decisions as well as contract participation decisions regarding outcome-based payment schemes.

As expected, PAY is positive and highly significant in all models. This clearly indicates that farmers allocate a greater portion of their farmland when the payment levels are higher. On the other hand, the coefficients of other contract attributes (SPECIES, MONITOR, TA, CERTI) were found not to be statistically significant. Interestingly, SPECIES, MONITOR, and CERTI were highly significant in the first-stage analysis but not in the second stage. As our results indicate, a variety of contract attributes influence farmers' decisions on participation. However, once a farmer decides to participate, his or her decisions on how much farmland to allocated is more likely to be influenced by the level of the payment and her/his attitudes and beliefs. Therefore, to encourage more farmers to participate and provide more farmland, policymakers' decisions on the level of payment offered seem to be critically important.

3.4 Policy simulations

Using the results from the first-stage analysis (ML2 presented in Table 3), we conduct several policy simulations to examine how adoption rates and acreage entered would likely respond to changes in contract design. More specifically, we calculate farmers' adoption rates for outcome-based contracts for different contract specifications. We consider the following four cases: (a) monitoring done by experts with certification; (b) monitoring done by experts without certification; (c) monitoring done by farmers with certification; (d) monitoring done by farmers without certification. Simulated results are presented in figures 1a to 1d. In each table, the horizontal axis shows the level of payment offered and the vertical axis shows the probability of participation in the contract.

[Insert Figure 1a to 1d here]

These figures show that, as described in the analysis of adoption, outcome-based schemes requiring higher environmental results (3 bird species instead of 1) tend to have lower expected adoption rates for a given payment level. The figures also show the positive effect of offering crop certification alongside the outcome-based scheme. The model predicts higher participation rates for a given payment rate when the certification is included (3b and 3d) than not included (3a and 3c), everything else being equal.

Finally, the figures illustrate the negative impact of requiring farmers monitoring rather than experts. A lower participation rate is predicted for a given payment rate when asking farmers to monitor outcomes themselves rather than having it done by experts. Again, this effect tends to be higher for lower levels of payment.

4. Discussion and Conclusions

In principle, output-based payments are attractive to increase the effectiveness of PES schemes. They condition payments to farmers to achieve the environmental objectives that society values rather than on changes to farm management intended to produce these desired outcomes. Moreover, outcome-based schemes allow farmers to decide how best to produce the desired outcomes, partly based on private information (White and Hanley, 2016). From the policymaker/buyer's perspective, the drawback with the policy “standard” of action-based payments is that payments may be made to farmers without improvements in environmental conditions. Such a problem could result from farmers’ low conservation efforts (moral hazard) or heterogeneity in the environmental potential of management actions, and adverse selection of which farmers enrol due to hidden heterogeneity in opportunity costs of participation (Hanley et al., 2012; Ferraro, 2008).

On the other hand, under outcome-based payments, external factors could compromise the environmental impact of farmers’ management efforts. For example, if off-farm changes in land use lead to reductions in how many birds can be “produced” on-farm. The provision of technical outcome-based payments transfers risks from the buyer (the regulator) to the seller (the farmer).

Despite this higher uncertainty regarding payments from the farmer’s perspective, our results confirm that farmers in our study area show a willingness to participate in outcome-based PES schemes. However, they also demonstrate that participation rates decrease when payments are conditioned to higher environmental objectives per hectare payment. Maintaining constant participation rates in the face of increasing ambition in ecological objectives would therefore require higher contract payments, as illustrated by the substantially increased WTAs associated with the increased number of bird species necessary to achieve environmental objectives (Figures 1a-1d). These increased payments can be interpreted as compensation for higher conservation effort costs needed to achieve more ambitious ecological goals.

While outcome-based payment schemes reduce the risks of moral hazard from the buyer's perspective, they also transfer risk to farmers. Therefore, the increased WTA can also be viewed as a risk premium that must be paid to farmers to compensate for their increased uncertainty regarding payment, whether they undertake recommended management actions or not. This implies that farmers’ risk preferences, their knowledge about the uncertainty of environmental processes, and their perceptions of controllable risks determine levels of participation in outcome-based contracts (Liu 2013; Ambali et al. 2021). Where environmental outcomes are subject to relatively high uncertainty/stochasticity, payments under outcome-based contracts may need to be much higher to encourage a given level of participation than where such uncertainty is lower. The implication is that the relative efficiency of outcome-based contracts over action-based contracts will vary according to the environmental objective in focus (e.g., bird populations compared to nutrient levels in watercourses). It should be noted that how the way in which farmers' risk preferences are elicited may lead to different results, conclusions and recommendations regarding compensatory payments for risk and uncertainty (Jin et al. 2017).

In our study, we were not able to include a measure of farmer risk aversion. However, we show that profit-maximizing farmers seem to be more likely to adopt outcome-based schemes. This supports the expectation that farmers’ risk preferences play a key role in their participation decisions. This could imply that the idea of enhancing the environmental impact of PES schemes through the use of outcome-based payments might only be valid if a more extensive budget was allocated.

Additionally, the cost of monitoring relative to outcomes is a crucial factor in determining whether output-based schemes should be favoured over action-based ones. One way to reduce these costs is to ask farmers themselves to monitor the outcomes of the scheme. Again, our results show that this would come at a cost, as farmers would demand increased payments compared to the cost of hiring external experts to conduct monitoring.

Farmers’ have lower WTAs when schemes are associated with eco-certification. This demonstrates that by supplementing outcome-based PES schemes with an eco-certification scheme, operators can use the label-associated price premium to reduce monetary payments offered by the government to farmers, thereby transferring some conservation costs from taxpayers to consumers. However, this would add a layer of uncertainty to farmers’ incomes. An alternative interpretation is that from the policymaker's perspective, for the same level of payments, adding a certification scheme could increase farmers’ participation rates and their likelihood of achieving the environmental objectives. In both cases, the combination of eco-certification with outcome-based payment is likely to increase the cost-effectiveness of a PES scheme.

While the provision of technical assistance could have been expected to reduce WTAs through promoting improved conservation practices and reducing the uncertainty of environmental outcomes, this attribute of the PES scheme was not significant in our study. The importance of technical assistance in the adoption of action-based agri-environmental schemes has already been supported by a number of existing studies (e.g., Espinosa-Goded et al., 2010; Kuhfuss et al., 2016; Del Rossi et al., 2021), which is not the case in our study. This can be explained by the farming situation in this area rather than the difference between action-based and results-based payment. In Japan, Agri-environmental payment programme started in 2004 in Shiga Prefecture, which includes the study area, and then the scheme was extended to all over Japan. About one-third of all farmers in this Prefecture are participating in the existing scheme, which is the highest figure in the nation. The prefectural government has been conducting continuous campaigns to promote and educate local farmers about environmentally friendly farming practices since the beginning of the scheme, and it is likely that many farmers have already acquired the necessary knowledge. This may be the reason why technical assistance, which is an important attribute in the adoption of agri-environmental schemes, was not significant in this study.

However, the heterogeneity of preferences among farmers for this particular contract attribute could be related to differences in farmers' knowledge, awareness, and access to other sources of assistance. Therefore, free technical assistance could very well be a participation determinant for some farmers.

Several limitations of our work should be pointed out. First, as already mentioned, our empirical models do not include an explicit measure of risk preferences. Second, our study did not explicitly model the uncertainty attached to each environmental outcome. Because waterfowl migration is a natural phenomenon, their likelihood of visiting land parcels under the outcome-based contracts would partly depend on uncontrollable factors beyond the farm gate, such as climatic conditions or pressures in migration areas where birds over-winter[14].

Third, this study is based on a relatively small-scale analysis. We focus on only 90 districts in one prefecture in Japan, based on one specific outcome determining payments (the number of waterfowl species). Further analyses are much needed to generalize our findings to other settings for outcome-based PES schemes.

[14] The primary reason for not explicitly modeling this uncertainty is that we believe the risks associated with environmental outcomes are highly dependent on the respondent's farmland and farming practices and should not be given exogenously, even in hypothetical questions. Our experiment explicitly asked respondents to consider possible risks in his or her circumstance, but we did not receive any difficulty or confusion. As a result, we are confident that we were able to elicit realistic responses from the farmers.

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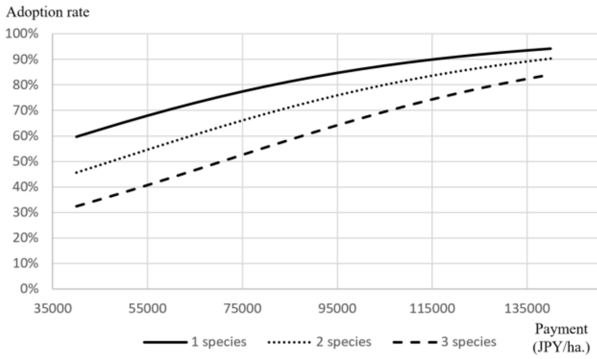
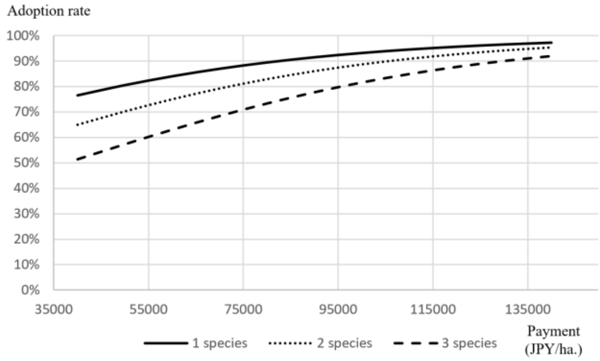
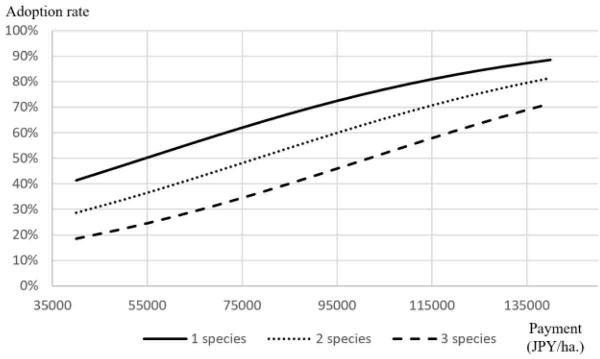


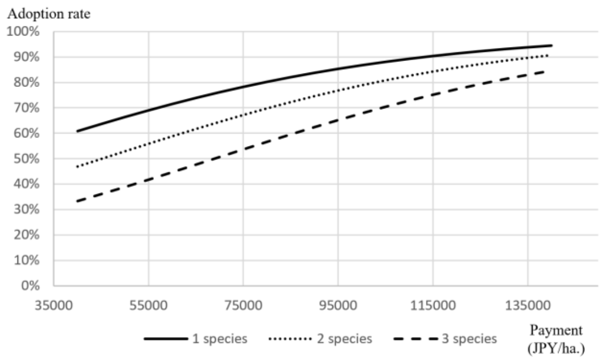
1a. Monitoring by expert + No certification



1b. Monitoring by expert + Certification



1c. Monitoring by farmers + No certification



1c. Monitoring by farmers + Certification

Figure 1: Simulated adoption rates of outcome-based contracts for different result requirements

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: 0 species, 1 species, 2 species, 3 species
MONITOR	Monitoring and reporting of the outcome	Dummy variable: 1 if done by the participating farmer; 0 if done by an external expert
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 (JPY/ha.)	Quantitative variable: JPY 0/ha.; JPY 6,000/ha.; JPY 8,000/ha.; JPY 10,000/ha.; JPY 12,000/ha.

Table 2: Descriptive statistics of farmers who responded

		Our sample					Study region[a]				
Variable	**Description**	***N***	**Mean**	**S.D.**	**Min.**	**Max.**	***N***	**Mean**	**S.D.**	**Min.**	**Max.**
FULL	1 if full-time farmer	333	0.32	0.47	0.00	1.00	90	0.26	0.15	0.00	0.60
EXP	Years in agriculture	325	33.61	15.28	0.00	77.00	—	—	—	—	—
AREA	Area of paddy fields	331	4.79	9.99	0.00	93.00	90	4.17	3.97	0.64	17.06
WORKER1	# of full-time workers	193	2.02	2.27	0.00	17.00	90	2.32	6.64	0.00	54.00
WORKER2	# of part-time workers	240	1.78	1.96	0.00	28.00	90	2.20	2.87	0.00	20.00
SUCCESSOR	1 if successor is available	333	0.29	0.46	0.00	1.00	90	0.31	0.16	0.00	0.70
AEP	1 if currently adopting the AEP	333	0.50	0.50	0.00	1.00	90	0.54	0.26	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	—	—	—	—	—

a: Calculated from the community-level statistics from the 2015 Census of Agriculture and Forestry.

Table 3: Results of the first-stage analysis (adoption decisions) using the conditional and mixed logit models

Dependent variable:		**Conditional logit (CL)**			**Mixed logit 1 (ML1)**			**Mixed logit 2 (ML2)**		
Choice		Coefficient		Std. error	Coefficient		Std. error	Coefficient		Std. error
Mean	ASC	0.336		0.209	-5.888	***	1.289	-0.881		0.996
parameters	ASC×POLL	-		-	-		-	-6.537	**	3.268
	ASC×PROF	-		-	-		-	-4.288	***	1.340
	ASC×AEP	-		-	-		-	-4.413	**	1.878
	SPECIES	-0.102	*	0.053	-0.373	***	0.122	-0.566	***	0.170
	MONITOR	-0.133	*	0.077	-0.612	**	0.239	-0.744	**	0.320
	TA	0.105		0.076	0.079		0.117	0.145		0.193
	CERTI	0.270	***	0.070	0.669	***	0.174	0.792	***	0.260
	PAY	8.75E-06	***	2.12E-06	2.10E-05	***	5.10E-06	2.41E-05	***	6.25E-06
S.D.	ASC	-		-	-10.780		1.608	7.654	***	1.264
parameters	ASC×POLL	-		-	-		-	6.733	**	2.691
	ASC×PROF	-		-	-		-	11.794	***	3.125
	ASC×AEP	-		-	-		-	10.497	***	1.740
	SPECIES	-		-	1.173	***	0.186	1.628	***	0.355
	MONITOR	-		-	2.918	***	0.397	3.683	***	0.800
	TA	-		-	1.192	***	0.341	1.529	***	0.499
	CERTI	-		-	1.099	***	0.306	1.376	***	0.404
	# of obs.	3,861			3,861			3,861		
	# of cases	1,287			1,287			1,287		
	Log-likelihood	-1,378			-965			-957		
	AIC	2,768			1,949			1,931		

a: *, **, *** indicate statistical significance at 10, 5, 1 percent respectively.

Table 4: The estimated marginal willingness to accept (MWTA)[a]

Attribute	*n*	Mean	Bootstrap std. dev.	Biass-corrected 95% confidence interval	
SPECIES	333	24,643	3,453	20,304	33,260
MONITOR	333	44,554	8,372	26,552	57,281
Tab	—	—	—	—	—
CERTI	333	-33,220	2,076	37,011	28,987

a: MWTA of TA is not reported due to statistical insignificance at the first-stage.

Table 5: Results of the second-stage analysis (acreage decisions) using the sample selection model (Dependent variable: % of farmland allocated)

	Coefficient		**Bootstrap std. error**
Intercept	0.167		-0.354
POLL	0.109	***	-0.036
PROF	-0.087	***	-0.022
AEP	—		—
SPECIES	0.021		-0.015
MONITOR	0.007		-0.023
TA	-0.008		-0.024
CERTI	-0.033		-0.028
PAY	1.7E-06	***	-5.4E-07
_m1	-0.135		-0.150
_m2	-0.333		-0.460
_m3	-0.455	***	-0.426
# of obs.	872		

a: *** indicates statistical significance at 1 percent.

b: The variable AEP is used as an instrument.