Preferences for result-based agri-environmental measures: a choice experiment study with Japanese farmers

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Abstract

The agri-environmental payment, which is rewarded to farmers who adopt environmentally friendly techniques, is one of the main policy tools for improvement for or maintenance of the environmental quality. Despite of its long history, its effectiveness and efficiency have been discussed. Result-based payment scheme has been drawing an attention as a cost-effective agri-environment measure and eleven countries have implemented this scheme mainly for biodiversity conservation in Europe. Empirical studies on result-based payment scheme have conducted survey or interview to farmers, but none of them use stated-preference approach. This paper is to reveal farmers' willingness to accept (WTA) for participating result-based payment scheme by choice experiments in hypothetical setting in Japan. We set up a hypothetical payment scheme for conserving red dragonflies, *Sympetrum spp*. These are the most common species that use paddy fields as reproductive sites, but the population is rapidly and severely declining since 1990s. Respondents of the choice experiment prefer result-based scheme to one action-based scheme, the nonuse of certain insecticides, but do not to another action-based scheme, the change in the draining paddy fields.

Keywords: agri-environmental schemes, biodiversity, choice experiment, payment-by-result.

1. Introduction

The agri-environmental payment, which is rewarded to farmers who adopt environmentally friendly techniques, is one of the main policy tools for improvement for or maintenance of the environmental quality. Europe has nearly three decades of experience in agri-environmental payment. The European Union (EU) introduced the agri-environmental scheme within a specific area into the Common Agriculture Policy (CAP) in the mid-1980s, and made it mandatory in 1992 (Jack, 2009). Agenda 2000, the CAP reform in 1999, placed Rural Development Policy (RDP) as the second pillar of CAP, and agri-environment scheme is the most important measure in RDP (Hill, 2012). In the current multiannual financial framework (2014-2020), almost half of the expenditure for RDP is related to the environment[1]. Specifically, the share of the agri-environment-climate measure in RDP funding is 16.8% (European Parliament, 2016).

Despite of its long history, its effectiveness and efficiency have been discussed. Kleijn and Sutherland (2003) reviewed published papers and reports which studies the effectiveness of agri-environmental schemes for biodiversity and concluded that there were not enough studies for general judgement of their effectiveness. Recent studies to test the effectiveness of agri-environmental schemes show mixed results (Ansell et al., 2016). Batáry et al. (2015) found that the effectiveness of agri-environmental schemes implemented after 2007 did not improve. The need for the cost-effective agri-environmental schemes have also been debated (Ansell et al., 2016).

Result-based payment scheme has been drawing an attention as a cost-effective agri-environment measure in European countries. Ordinary agri-environmental payment is action-based, i.e., farmers receive payments on the condition that they adopt prespecified practices good for the environment. On the other hand, result-based payment is rewarded to farmers if some outcome realized. Therefore, result-based payment is more cost-effective than action-based payment. Researchers argue that result-based payment may deliver better ecological outcomes than action-based payment. In addition, Burton and Schwartz (2013) maintained that result-based schemes are likely to promote long-term positive behavioural changes.

Eleven countries in Europe implemented result-based payment schemes and most of them are either small scale or trial practice (Herzon et al., 2018). Result-based payments were implemented in the mid-1990s as pilot projects in Germany, the Netherlands, and United Kingdom, and included in agri-environment measures of CAP since 2000 as options (Allen et al., 2014). Although result-based approach is applied to mainly biodiversity conservation, there are some examples in the field of water quality (Wezel et al., 2016).

Empirical studies on result-based payment scheme have conducted survey or interview to farmers (Matzdorf and Lorenz, 2010; Schroeder et al., 2013; Ravier et al., 2015; Russi et al., 2016; Wezel et al., 2018), but none of them use stated-preference approach. Recent studies aiming to solicit farmers' willingness to accept (WTA) for enrolling agri-environment scheme adopt choice experiment approach (for example, Ruto and Garrod, 2009; Espinosa-Goded, Barreiro-Hurlé and Ruto, 2010; Christensen et al., 2011; Broch and Vedel, 2012; Villamayor-Tomas, Sagebiel and Olschewski, 2019).

The objective of this paper is to reveal farmers' WTA for participating result-based payment

scheme by choice experiments in hypothetical setting in Japan. We first describe current situation on Japanese agri-environmental policy and challenges for biodiversity conservation in agriculture. Then the choice experiments of this study are explained. Results and discussions follow.

2. Agri-environmental payments and challenges for biodiversity in Japan

2.1. Agri-environmental payment scheme in Japan

The "Measure to Conserve and Improve Land, Water and Environment", the first national agri-environment payment program in Japan, started in 2007 as a five-year program (Nishizawa, 2015). Under this program, action groups received grants for collaborative action aimed at maintaining and improving farmland and irrigation and drainage facilities and farming action reducing chemical inputs. The latter part of the program, that is, grants for reduction in chemical inputs, is the agri-environment payments. This was called the "Assistance for Advanced Farming Practices". Farmers who halved inputs of chemical fertilizers and agricultural chemicals from conventional farming received a grant. Payment rates depend on crops. For example, it was 60,000yen/ha for rice, and 30,000yen/ha for wheat and barley.

The Measure to Conserve and Improve Land, Water and Environment was modified and the Assistance for Advanced Farming Practices was revised to the "Direct Assistance for Environmentally Friendly Agriculture" in 2011. This program requires farmers a higher level of conservation practices. Farmers have to adopt any practice which should contribute to mitigating climate change or conserving biodiversity in addition to halving the application of chemical inputs. The current program basically remains unchanged. The program covers only 4% of farmland, partly due to the small budget size (4.6 billion yen/year).

2.2. Challenges for biodiversity in agro-ecosystem

Agriculture originally plays an important role for biodiversity and provides exquisite breeding environment and habitat (MAFF, 2012). As much as 5,600 species are recorded in Japanese paddy field. Modern farming, however, unintentionally caused degradation of breeding environment and habitat for wild flora and fauna, and resulted in loss of biodiversity. Extensive use of agrichemicals, conversion of paddy fields into dry fields through field adjustment, and the increase in concrete-finished channels resulted in the decrease in the number of organisms commonly found in these environments for many generations.

In the choice experiment, we set up a hypothetical payment scheme for conserving red dragonflies, *Sympetrum spp*. These are the most common species that use paddy fields as reproductive sites (Nakanishi, Yokomizo, Hayashi, 2018). Among them, *Sympetrum frequens* has a wide distribution in Japan, and is considered to be important (Jinguji, 2015). The species is one of the most effective predators of rice insect pests, and S. frequens is symbolic of the Japanese countryside. Unfortunately, beginning in the 1990s, populations of *S. frequens* and other *Sympetrum* species were rapidly and severely declining in Japan (Nakanishi Yokomizo, Hayashi, 2018). The use of fipronil and the neonicotinoid imidacloprid is suspected as the main cause of these population declines. Mid-summer drainage of paddy fields has also adverse effect on dragonflies if it happens

before the emergence, because larvae cannot survive in drained field (Aoda et al., 2013).

3. Choice experiment

3.1. Experiment design

Table 1 shows attributes and attribute levels in profiles. Attributes consists of the payment condition, the confirmation procedure and the payment level. We set three payment conditions: (1) no certain insecticides[2], (2) to postpone to drain paddy field untill late June or do not drain, and (3) to find out at least four exuviae of Sympetrum per 10 ares. The first and second conditions, which are supposed to contribute to conservation of dragonflies (Aoda et al., 2013), correspond to the action-based payment and the third one applies to the result-based payment. The confirmation procedure is either self-check or inspection by authority. The payment levels are three: 4,000 yen, 8,000 yen or 12,000 yen per 10 ares.

These attribute levels generated the first choice set with 18 profiles by orthogonal experimental design, and the second choice set with 18 profiles was set up from the first choice set by shift design method. Then, the random sampling without replacement from the first and the second choice sets resulted in 18 paired choice profiles. Each choice card consists of the paired profiles and opt-out alternative. These choice cards were divided into two blocks, which means that each questionnaire has 9 choice cards. An example choice card is shown in Figure 1.

3.2. Data collection

We collected data from groups of farmers who enrolled the Measure to Conserve and Improve Land, Water and Environment[3]. We distributed questionnaires to the group and explain how to answer them at a community center, and collected questionnaires on the day. They are familiar to the payment schemes and biodiversity conservation. Previous field research suggested that it was difficult for farmers who were not familiar the agri-environmental measures and interested in environmentally friendly farming to respond to the hypothetical situation of agri-environmental payment scheme. Therefore, we did not conduct a random sampling, which is a point of attention.

We conducted pretests three times to refine the questionnaire between June to October 2018, and main survey in December 2018 at three communities in Utsunomiya City, Tochigi Prefecture. 57 farmers' response resulted in 393 samples after excluding non-response and respondents answering "no interest in result-based payment scheme".

3.3. Model

The conditional logit model is used in this model. Due to the sample size, the estimation based on the random parameter logit model does not produce a competent result. The specification of the estimation model is the following.

The utility that respondent n derives from choosing alternative i among the choice set C is given by

$$U_{in} = V_{in} + \varepsilon_{in} \quad (1)$$

where V_{in} is the observed component and ε is unobserved random term that is assumed to be independent and identically distributed according to an extreme value distribution. The probability the respondent chooses alternative i is

$$P(i \mid C) = P[(V_{in} + \varepsilon_{in}) > (V_{jn} + \varepsilon_{jn})] = \exp(V_{in}) / \sum_j \exp(V_{jn}) \quad \text{for } i \neq j, \quad i, j \in C \quad (2).$$

Assuming that utility increases lineally with improvements in attributes, the observed component of the utility is expressed as

$$V_{in} = \sum_k \beta_{ki} X_{kin} \quad (3)$$

where X_{kin} is the vector of attributes and β_{ki} is the vector of coefficients to be estimated. The list of variables used in the analysis is presented in Table 2. We applied the effect coding to variables on the payment condition. Non-use of certain pesticides is set to the baseline (i.e., -1). According to Vaissière et al. (2018), the willingness to accept (WTA) for attribute k is calculated as

$$WTA_k = -\beta_k / \beta_{PAYMENT} \quad (4).$$

However, when the effect coding is used, the WTA must be multiplied by 2 (Le Coënt, Préget, Thoyer, 2017).

4. Result and Discussion

The estimation result is shown in Table 3. Among payment conditions, the coefficient on DRAINAGE and that on EXUVIAE are both positive and significant. This means that farmers prefer the change in draining paddy fields to nonuse of certain insecticides, and also prefer finding out of exuviae to nonuse of certain insecticides. Concerning confirmation procedure, coefficient on self-check is negative but insignificant, which implies that respondents prefer inspection by the authority to self-check. Coefficient on payment level is positive and significant, which means that the higher the payment, the more likely farmers to enroll the agri-environmental payment program.

The estimation result of marginal willingness to accept is shown in Table 4. Farmers would adopt the change in draining even if they receive 7,672 yen less than the amount they get when they do not use certain insecticides. They would also enroll result-based payment scheme even if they receive 4,212 yen less than the amount they get when they do not use certain insecticides. Therefore, as for the payment condition, farmers prefer the change in draining the most, and the result-based payment scheme is the second. In addition, although the estimator is insignificant, farmers would accept self-check if they receive 787 yen more than the amount they get when the authority conducts the confirmation.

5. Concluding remarks

This paper investigated farmers' preference for agri-environmental payment measures, including explicitly a result-based scheme as an option. Respondents prefer result-based scheme to one action-based scheme, i.e., the nonuse of certain insecticides, but do not to another action-based scheme,

i.e., the change in the draining paddy fields.

One of the future research issues is to increase in the sample, so that random parameter logit model and latent class model can be applied.

Notes

1. Measures related the environment corresponds to the fourth (restoring, preserving and enhancing ecosystems related to agriculture and forestry) and the fifth (promoting resource efficiency and supporting the shift towards a low carbon and climate resilient economy in agriculture, food and forestry sectors) priorities of RDP.
2. Fipronil, imidacloprid and dinotefuran.
3. This program is now called the Multifunctionality Payment Grant.

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Figure 1. Example of a choice card

	Option A	Option B	Option C
Condition	Postpone to drain paddy field untill late June or do not drain	Find out at least four exuviae of Sympetrum per 10 ares	Neither Option A nor Option B
Checking	Inspection	Self-check	
Payment	8,000yen/10ares/year	12,000yen/10ares/year	

Table 1. Attributes and attribute levels in choice experiments

Attributes	Descriptions	Attribute levels
Condition	Requirements for the payment	Non-use of certain insecticides (action-based) Change in draining pady field, e.g. suspention of draining until late June or no-drainig (action-based) Find out at least four exuviae of Sympetrum per 10 ares (result-based)
Checking	Procedure to confirm whether the farmer meets the requirement	Self-check: farmers submit reports Inspection: authorities visit to check
Payment	Amount of remuneration	4,000yen/10ares/year, 8,000yen/10ares/year, 12,000yen/10ares/year

Table 2. Description of variables used in the analysis

Variable	Description
DRAINAGE	Effect coding 1 = if the condition is the change in draining 0 = if the condition is the result-based -1 = if the condition is the non-use of certain pesticides
EXUVIAE	Effect coding 1 = if the condition is the result-based 0 = if the condition is the change in draining -1 = if the condition is the non-use of certain pesticides
SELFCHCK	Dummy coding Checking procedure is self-check (1=yes, 0 otherwise)
PAYMENT	Amount of remuneration per 10 ares per year

Table 3. Estimation result

Variable	Coefficient	S. E.	p-value
DRAINAGE	0.4473	0.1185	0.0002
EXUVIAE	0.2456	0.1199	0.0405
SELFCHCK	-0.0918	0.0634	0.1480
PAYMNT	0.0001	0.0000	0.0000
Log-likelihood	175.6		2.20E-16
Adjusted pseudo R^2	0.194		
AIC	695.873		
No. of observations	393		

Table 4. WTA for payment condition and checking procedure

Variable	WTA (yen/10ares/year)
DRAINAGE	-7,672
EXUVIAE	-4,212
SELFCHCK	787