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REVIEW
Choice Experiment Approaches to Measure the Economic Value of the Multifunctionality of Agriculture and Rural Areas

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Abstract
Many studies related to the multifunctionality of agriculture and rural areas have been conducted in both the natural and social sciences. One of the research topics dealt with in agricultural economics was the economic valuation of multifunctionality. This paper reviewed three research results of the economic valuation of multifunctionality by using a choice experiment. The first study analyzed the environmental benefits of promoting ecologically friendly paddy fields. The second study measured the environmental benefits of improving agricultural canals to make them habitable for fireflies. The third study examined a way of conducting choice experiments with six or more function attributes based on a questionnaire (pencil and paper) survey. Finally, it was pointed out that collaboration with other research fields, including natural sciences, was one of the important issues for appropriately applying choice experiments to the economic valuation of multifunctionality.

Discipline: Agricultural economics
Additional key words: conjoint analysis, environmental benefit, Japan, paddy field, stated preference

Introduction

Many studies related to the multifunctionality of agriculture and rural areas (MFA) have been conducted in both the natural and social sciences. One of the research topics dealt with in agricultural economics is the economic valuation of MFA. MFA includes various individual functions such as flood prevention, wildlife protection or landscape management. Measuring the economic value of MFA is essential for deciding which agro-environmental policies for managing comprehensively these functions are appropriate. Although some statistical methods−such as the travel cost method, the hedonic pricing method, or the replacement cost method −have been applied to measure it, one of the most widely applied methods is a contingent valuation method (CVM). In CVM, a change in the environment is explained to respondents and then the economic valuation of the environmental change is measured in terms of money. CVM is one of the stated preference methods and is more suitable for measuring various environmental values economically than any other method. Therefore, CVM has been applied by many empirical studies, including previous studies considering the whole country of Japan[5, 11, 13]. However, the number of attributes is limited to one in CVM. That is, a monetary term attribute varies between respondents while other conditions such as environmental qualities are fixed to all respondents. If CVM is used to evaluate two or more environmental quality changes, questionnaire surveys according to the number of evaluation scenarios must be conducted. In order to recover this limitation, in the last decade a choice experiment (CE) has been applied to the measurement of the economic valuation of MFA in Japan, since CE can easily assess various conditions of the environment in a questionnaire survey.

In order to take the advantage of CE, the following subjects should be examined. First, we determine which type of indicator should be used for expressing the condition of MFA. Although some functions of MFA are assumed to be defined numerically from the viewpoint of natural sciences, these measures are not necessarily able to be used for the questionnaire of CE. Second, we determine how to simultaneously measure each function

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of MFA in a questionnaire of CE. CE is able to measure the economic value of each function of MFA by considering each function to be an attribute of CE[12]. However, we cannot evaluate seven (plus or minus two) or more pieces of information simultaneously, since our information processing ability is limited to that amount[10]. Under this limitation, the design of the CE question and analysis of responses toward the CE question should be modified so as to measure the economic value of all functions. Third, we determine how to explain an evaluation scenario of CE. By using CE, various conditions of MFA can be measured economically. However, this advantage induces a complicated explanation about evaluation scenarios and definitions of attributes and their levels. Copious information sometimes burdens respondents with a heavy cognitive load; therefore the respondents might provide inaccurate answers to CE questions or refuse to respond to the questionnaire. We should seek to find a balance between providing information and reducing cognitive burden. Finally, we determine how to design the combination of attributes levels in the CE questionnaire. Since it is not usual for respondents to value MFA economically, their decision-making on valuing MFA might be more burdensome than their decision-making about purchasing daily necessities. From the viewpoint of the tradeoff between respondents' burdens and statistical efficiency, the number of choice-set alternatives presented and the number of CE questions posed to each respondent should be considered.

This review paper aims to investigate mainly the first and second of the aforementioned four subjects, based on our three previous studies. The first and second studies examined the usability of knowledge about the ecological condition of paddy fields on CE questions. The third study developed one of the ways of measuring each function of MFA simultaneously in a CE questionnaire. Then, in the last section, it shows the remaining issues to promote the application of CE to the assessment of MFA. The general method of conducting CE is referred to in previous books and papers[2, 6, 8, 9].

Overview of the choice experiment and its application to studies of the economic valuation of multifunctionality

The choice experiment (CE), which is related to conjoint analysis methods developed in the marketing research field, has been applied in order to statistically and numerically examine what kind of attributes affect the decision-making of individuals in various research fields. In order to make the merits of CE clear, consider the situation where CE is applied to examine the characteristics of the most preferred personal computer. The chassis type of the computer, the type of CPU, the hard drive capacity, the memory capacity, price and so on are included in the characteristics of the personal computer (characteristics of goods or services are known as "attributes" in CE) and each attribute has two or more levels. For example, the chassis type of the computer may have "desktop" and "laptop" levels, and the price may have "$1,000" or "$1,500" levels. A specific personal computer can be expressed based on a combination of the levels of each attribute. The list of attributes and their levels are decided, combinations of the levels of each attribute (choice sets) are created by using the design of experiments (usually, fractional factorial designs), consumers are asked to select their preferred alternative from each choice set, and then consumers' valuations of each attribute and each level are measured by statistically analyzing the relationship between their responses and the combinations of the levels of each attribute in each choice set. Since CE has valuable features that are able to numerically evaluate the attribute level and are also based on economic theory, it has been applied in economics.

When using CE to measure the economic value of the multifunctionality of agriculture and rural areas (MFA), the details of which are described later, the environment-related factors such as farmland area, number of facilities for environmental conservation, or number of animals, as well as cost (the monetary factor), are set as the attributes in CE. Various environmental conditions are created as alternatives and respondents are requested to select their preferred one in each choice set. Finally, the economic valuations of attribute and level−for example, the environmental benefit of farmland per unit area−are measured by considering the trade-off between monetary and non-monetary attributes.

For example, consider a measurement of the environmental benefits of a plan for promoting ecologically friendly paddy fields in an area. For the purposes of simplicity, only two attributes are assumed, that is, the target area of the ecologically friendly paddy field (target area) and tax used to conduct the plan (Fig. 1). If respondents agree with the plan, they pay B yen per household per year for spreading A ha of the ecologically friendly paddy field in the area. Otherwise, they do not have to pay additional tax (Tax = 0 yen) and the ecologically friendly paddy field is not spread in the area (Target area = 0 ha), and hence they cannot receive any environmental benefit from it. The respondent is assumed to agree with the plan if the utility of the plan is

Do you agree with the following plan?

	Plan	Future situation without the plan
Target area	A ha	0 ha
Tax per household per year	B yen	0 yen

1. Agree 2. Disagree

Fig. 1. A hypothetical example of the choice experiment question for the economic valuation of multifunctionality

Which plan do you agree with?

	Plan 1	Plan 2	Future situation if any plans would not be implemented
Number of intermediate egrets per 10 ha	1.4 egrets	1.7 egrets	0.9 egrets
Bird-watching field	Constructed	Not constructed	Not constructed
Eco field	Not constructed	Constructed	Not constructed
Contribution per household per year	2,500 yen	5,000 yen	0 yen

1. Agree with plan 1 2. Agree with plan 2 3. Neither

Fig. 2. An example of the choice experiment question for measuring environmental benefits of promoting ecologically friendly paddy fields[1]

higher than that of the future situation if the plan was not implemented. The utility function is assumed to be of the form

$$U_j = b0 + b1\ AREA_j + b2\ TAX_j + e_j\,, \quad (1)$$

where U_j is the utility of alternative j (including the future situation), b0 is the alternative specific constant, $AREA_j$ is the target area of alternative j, TAX_j is the tax of alternative j, b1 and b2 is the coefficient for $AREA_j$ and TAX_j respectively, and e_j is the error component of alternative j. $AREA_j$ and TAX_j are assumed to take various values (levels). The combinations of $AREA_j$ and TAX_j, which show plans presented to respondents, are assumed to be generated by using a fractional factorial design. Coefficients (b0, b1, b2) are estimated by statistically analyzing the relationship between the plans presented to respondents and their responses to them. Following the equation (1), the environmental benefit of promoting the ecologically friendly paddy field is calculated as −b1/b2 yen per hectare per household per year.

Environmental benefits of promoting ecologically friendly paddy fields

The first study[1] examined the environmental benefits of a plan for promoting ecologically friendly paddy fields in the plain area of Ibaraki Prefecture by using CE. Respondents were asked to select their preferred alternative from among three options (Fig. 2). The plan offered to respondents consisted of four attributes. The first attribute was the number of intermediate egrets per paddy field of 10 ha, indicating the ecological condition of the paddy field as a wildlife habitat[7]. The second attribute was the presence of a paddy field used for bird-watching (bird-watching field). The third attribute was the presence of a paddy field where children could capture animals, such as loaches, crucians and aquatic insects, living in the paddy field (eco-field). The fourth attribute was a contribution to the plan. The cost necessary to implement the plan was assumed to be financed

Table 1. Levels of each attribute in case of measuring environmental benefits of promoting ecologically friendly paddy fields

Attribute	Levels
Number of intermediate egrets per 10 ha	1.1 egrets, 1.4 egrets, 1.7 egrets
Bird-watching field	Constructed, Not constructed
Eco field	Constructed, Not constructed
Contribution per household per year	500 yen, 1,000 yen, 2,500 yen, 5,000 yen, 10,000 yen

Table 2. Estimated WTP for each plan for promoting ecologically friendly paddy fields

Eco field	Bird-watching field	Number of intermediate egrets per 10 ha		
		1.1 egrets	1.4 egrets	1.7 egrets
Constructed	Constructed	3,016	4,130	5,245
	Not constructed	2,373	3,488	4,602
Not constructed	Constructed	1,385	2,500	3,614
	Not constructed	743	1,858	2,972

Source: Aizaki[2] (reanalysis of Aizaki[1]).
Note: Unit is yen per household per year. MWTP for ASC is not included in each WTP estimates.

by donations from each household. Each attribute has two, three or five levels as shown in Table 1. These levels were determined based on previous research results and the results of a preliminary survey.

One of the important points of this study was to explain to respondents that the population density of intermediate egrets in a paddy field area could be used as an indicator of the ecological condition of that paddy field. In a questionnaire, by using text, a picture and figures (including numerical data), we carefully explained the relationship between the population density of intermediate egrets in a paddy field and the number of aquatic prey animals in the paddy field area; we also explained the roles of the bird-watching field and the eco-field.

Each respondent was asked to select their preference from three options (Fig. 2), which consisted of two different plans and one option to choose neither of the two plans in each choice set. The none-of-these option showed the condition of paddy fields in the plan area in the near future when no plans were implemented. A total of 15 choice sets were created and grouped into five versions of three choice sets each. The questionnaire written in Japanese was included in Aizaki[2].

The survey was mailed in January 2003 to 1,500 households in Tsuchiura-city, in Ibaraki Prefecture. All of the households were selected randomly from a commercial phone directory database. Five hundred and eighty-four households returned the survey by mail. As households with a lexicographic preference and/or those protesting against the question were deleted, as were households that responded incompletely to questions, 422 usable surveys remained.

The environmental value (marginal willingness to pay: MWTP) of one intermediate egret per 10 ha, bird-watching paddy field, and eco field is 3,715 yen per household per year, 642 yen per household per year and 1,630 yen per household per year, respectively. Table 2 shows the environmental benefits of various plans calculated using the MWTPs, compared with the future situation option. Although the target of the number of intermediate egrets in the plans can be set continually, it includes only 1.1, 1.4 and 1.7 egrets per 10 ha. Among a total of 12 plans, the environmental benefit of the plan that constructed both an eco-field and a bird-watching field and targeted for 1.7 intermediate egret per 10 ha was the highest, at 5,245 yen per household per year (= 642 + 1630 + 3715 × (1.7 − 0.9)).

Environmental benefits of improving the agricultural canals to make them habitable for fireflies

The second study[3] measured the environmental benefit of a plan to improve the agricultural canals to make them habitable for fireflies. Since firefly-watching has been popular in Japan, such plans have been considered and implemented in various places. Under a hypothetical scenario in which some parts of the agricultural canals in a small village, Aomori Prefecture, were reconstructed to make them suitable for the habitat of the firefly, residents of the village were asked to evaluate the environmental benefit of the plan through CE questions.

The plan consisted of four attributes. The first attribute was the number of reconstruction canals that was able to provide the habitat for snails which feed on firefly larvae and had three levels: “One canal,” “Two canals” or “Three canals.” The second attribute was the population density of the firefly per 100m^2 and had four levels: “5 fireflies,” “10 fireflies,” “25 fireflies,” or “50 fireflies.” The third attribute was the construction of a stroll road used for firefly-watching at night and had two levels: “Constructed,” or “Not constructed.” If the stroll road was not constructed, residents would have to walk along the green road in order to watch the fire-

Do you agree with the following plan?

	Plan
Number of reconstructed canals	One canal
Firefly population density per 100m^2	25 fireflies
Stroll road	Not constructed
Contribution per household per year	10,000 yen

1. Agree 2. Disagree

Fig. 3. An example of the choice experiment question for measuring the environmental benefit of improving agricultural canals to make them habitable for the firefly[3]

Table 3. Estimated WTPs of each plan for improving the agricultural canals to make them habitable for the firefly[3]

Stroll road	No of canals	Number of fireflies (Unit: fireflies per 100m^2)									
		5	10	15	20	25	30	35	40	45	50
Constructed	1	662	825	987	1,136	1,256	1,335	1,364	1,339	1,264	1,147
	2	699	871	1,042	1,199	1,326	1,409	1,440	1,414	1,335	1,211
	3	824	1,026	1,228	1,412	1,562	1,660	1,696	1,666	1,572	1,427
Not	1	859	1,069	1,280	1,472	1,628	1,731	1,768	1,737	1,639	1,488
constructed	2	907	1,129	1,351	1,555	1,719	1,828	1,867	1,834	1,731	1,571
	3	1,068	1,330	1,592	1,831	2,025	2,152	2,199	2,160	2,039	1,850

Note: Unit is yen per household per year.
These estimated WTPs are calculated for the representative respondent.

flies. The final attribute was a contribution per household per year to the plan and had five levels: "500 yen," "1,000 yen," "2,500 yen," "5,000 yen," or "10,000 yen."

A total of 25 reconstruction plans were created and grouped into five versions of five plans each. Each respondent was asked to agree or disagree with each of the five plans (Fig. 3). When respondents disagreed with the plan, they would not be able to enjoy watching the fireflies and they did not have to pay any money. A very important point of this study was to make respondents understand clearly the population density of the firefly. Therefore, four pictures−showing 5, 10, 25, and 50 fireflies flying above a paddy field area, respectively −were created and included in the questionnaire.

In February 2005, questionnaires were distributed to a total of 231 households in the survey area. The survey was returned by 168 households. Of these, 109 had been satisfactorily completed.

Table 3 shows the environmental benefits of several plans calculated from the estimation results. Although the relationship between the population density of intermediate egrets and the evaluation of it was assumed to be a linear function in the first study, a statistical model used in the firefly case was modified to be able to capture a quadratic relation between the population density of the firefly and its evaluation. Consequently, the MWTP of the population density of the firefly increased in proportion to the density increase and decreased when the density exceeded a certain level (approximately 35 fireflies per 100m^2). The preferred plan did not construct the stroll road, but it did reconstruct three parts of the agricultural canals, and targeted 35 fireflies per 100m^2, and its environmental benefit was calculated at 2,199 yen per household per year.

Economic valuation of each function in the multifunctionality

When each function contained in MFA is regarded as an attribute, the economic value of each function can be measured by using CE[12]. However, it is difficult for CE to increase the number of the functions to be measured. We cannot evaluate seven (±2) or more pieces of information simultaneously, as our information processing ability is limited[10]. On the other hand, it has been pointed out that MFA had more than seven functions.

1) Flood prevention
Paddy fields and upper fields store water temporarily, decrease the drainage of excessive water to the river during heavy rainfall and prevent flooding or inundation around the fields and in the downstream.
2) Groundwater conservation
A lot of irrigation water becomes a part of underground water and is used as water for daily life use or industrial use downstream.
3) Soil erosion prevention
The outflow and the dispersion of the soil are controlled in farmland compared with the bare ground and the moorland.
4) Health and rest
People visit rural areas and enjoy the recreations that use agriculture or rural areas.
5) Wildlife protection
The habitat of the animal and the plant is offered.
6) Landscape management
Agricultural activities in rural areas maintain and conserve the favorable rural landscape.
7) Water environment conservation
The organism and the nitrogen included in water are purified.
8) Organic waste disposal
Organic waste such as garbage and livestock excretion is resolved by the activity of the microorganism in the soil.

Fig. 4. Explanation of each function included in the multifunctionality[4]

In the parentheses below, please rank each function shown in the first step in terms of importance to you from most important to third most important.

Most important (   )
Second most important (   )
Third most important (   )

Fig. 5. Question for ranking each function[4]

Therefore, in order to use CE for evaluating MFA by each function, the limitations of our ability should be overcome by modifying the way of applying CE.

The final study[4] examined a way of conducting CE with six or more function attributes (one additional attribute was needed for a tax or donation attribute) based on the questionnaire (that is, pencil and paper) survey. The method consisted of four steps, as follows.

The first step was an explanation to respondents of the functions contained in MFA. For example, the number of the functions (M) was assumed to be eight (M = 8) and each function was explained in the questionnaire survey (Fig. 4).

The second step was to assign a ranking for each function. Respondents were asked to rank each function in terms of importance to them and to answer up to the Rth function. Figure 5 presents the question in the case of M = 8 and R = 3. According to the limitations of the information processing ability, it may be possible to rank functions up to the sixth most important in this question. However, since the evaluation of MFA would be more burdensome to the respondents, only the top three functions were set to be the object of evaluation for this study.

The third step was to set the CE questions. A scenario that targeted the functions that each respondent selected as most, second and third most important was explained to respondents, as shown in Fig. 6. After explaining the scenario to the respondents, they were asked to choose the most desirable alternative from among the four options shown in Fig. 7. Each plan had three function attributes and a tax attribute. Attributes corresponding to the functions were expressed as the “most important function,” the “second most important function” and the “third most important function.” The functions filled in on the answer columns for ranking each function question varied depending on the respondent. For example, a respondent might feel that “flood prevention function” was the most important function, “groundwater conservation function” was second most

At present, due to the decrease in and aging of farmers, it has become more difficult to continue properly managed agricultural activity. If no proper management of agriculture is carried out, the eight functions mentioned above will weaken. Suppose the eight functions are expected to weaken by 20% as compared with the present level in the near future if no measure is taken. Also suppose the measure to prevent the weakening of the functions and to improve them is taken for three of the eight functions you think the most important on a national level. The plans of such a measure are shown in questions below. However, the funding needed for the measure should be borne by you in the form of a tax increase. Also, not all of the functions will be improved.

Fig. 6. Explanation of the scenario for the choice experiment question[4]

Which plan do you most prefer?

	Plan 1	Plan 2	Plan 3	Future situation if any plans would not be implemented
Most important function	10% improved	Present state	20% improved	20% decrease
Second most important function	Present state	Present state	20% improved	20% decrease
Third most important function	Present state	10% improved	30% improved	20% decrease
Tax per household per year	10,000 yen	500 yen	10,000 yen	0 yen

Fig. 7. An example of the choice experiment question for economic valuation of each function in the multifunctionality[4]

important and "water environment conservation function" was third. Another respondent might feel that "wildlife protection function" was the most important, followed by "health and rest function" and "flood prevention function." Therefore, even if the same CE question was asked, the functions to evaluate in the CE question could be different depending on the respondent.

The final step was to create the data set and conduct the statistical analysis. In order to create a data set for statistical analysis, each response to the ranking questions (up to the *R*th rank) was connected with the combinations of the levels of each attribute presented to each respondent. Through the connection, independent variables included in the statistical model were set to be "Improving *m* function" instead of "Improving *r*th function" (*m* is the function from the set of the functions explained to respondents).

To examine the applicability of this way, a questionnaire survey was mailed to 300 households living in Tsuchiura-city in Ibaraki Prefecture in November of 2002 and was returned by 75 households. The questionnaire, which was written in Japanese, was included in Aizaki[2].

Table 4 shows the economic value of each function per one percent (MWTP), that is, the amount of money that respondents were willing to pay a year for a one percent improvement in each of the functions. The flood prevention, groundwater conservation and water environment conservation function was rated higher than other functions with 133 yen per household per year, 103 yen per household per year and 114 yen per household per year, respectively. This result indicates that respondents could recognize the relationship between agriculture and water, since there were a lot of paddy fields as well as Kasumigaura, which is the second largest lake in Japan, in and around the survey area. On the other hand, health and rest and landscape management did not have a sig-

Table 4. Estimated MWTP for each of the eight functions included in the multifunctionality[4]

Function	MWTP
Flood prevention	133
Groundwater conservation	103
Soil erosion prevention	86
Health and rest	10*
Wildlife protection	91
Landscape management	55*
Water environment conservation	114
Organic waste disposal	89

Note: Unit is yen per household per year.
* : Indicates the estimate is not significantly different from zero at the 5% level.

nificant MWTP, since these functions were evaluated lower in the question for ranking each function. It may be that respondents in our survey are not so interested in recreations in rural areas.

One of the reasons why the economic values shown in this study are relatively smaller than those in the first and second studies is that the values in this study display MWTP for each function. If a WTP for "a policy that increases or maintains the level of MFA" (such as that found in the first or second study) needs to be estimated in this study, both a baseline situation and a planned situation according to an agro-environmental policy must set, and the economic value of the differences between the two situations should be calculated. For example, consider that the baseline situation is assumed to be the present status and that the planned situation is assumed to be "each function is 10% improved" for all functions. For each attribute, a difference between the level of the planned situation and the level of the present status is calculated to be 10 (= 10 − 0). Except for the two functions that did not have significant MWTP, that is the health and rest function and the landscape management function, the WTP for the planned situation is 6,160 yen per household per year (= 133 × 10 + 103 × 10 + 86 × 10 + 91 × 10 + 114 × 10 + 89 × 10).

Concluding remarks

In order to develop an appropriate agro-environmental plan, it is necessary for stakeholders to examine various candidate plans. As compared with CVM, which evaluates only one plan, CE is able to draw evaluations of various plans efficiently. The studies introduced in this paper might accurately express the advantages of CE.

The first and second studies showed concrete examples of practical uses of knowledge about the ecological condition of agriculture in evaluating MFA by CE. If the economic valuation is conducted based on poor reality of the environmental condition, it will not bring us valuable information. Of course, if the natural scientific knowledge is used only to develop the scenario, then the combinations of the levels of each attribute, which are candidate plans, will be very limited and statistical valuation of them will be very difficult. In order to take advantage of CE such as multi-attribute valuation, it is important to consider the balance of natural scientific knowledge with the statistical requirements for conducting CE.

In addition, examining ways of explaining the scientific information to respondents based on humanities and social sciences is also needed for the assessment of MFA by using CE. Respondents, who are generally non-experts, may find it difficult to understand the scientific information. The first study explained through use of graphs how an increase in the aquatic prey animals living in the paddy field caused an increase in the population density of the intermediate egret, and tried to have respondents understand that the population density of the intermediate egret could be used as the index species of the ecological condition of the paddy field. As much as two A4-size sheets of paper were used for the explanation so that even respondents who might not have sufficient knowledge about the ecosystem of paddy fields were able to understand the explanation. However, some respondents may still have been overwhelmed by the explanation. The same issue can be pointed out to the third study. It provided one of the ways in which modifying CE for measuring the economic value of each function of the MFA based on the questionnaire survey. A current level of each function was assumed to be a reference point, and the unit of each attribute was expressed as a change rate (%) from it. Whereas it was understandable for respondents to assume the current level to be the reference point, the attribute and its unit might be not so easy to understand for them.

The four subjects explained in the introduction of this paper were partially examined in this paper. In addition, each of the three studies was based on limited samples. We once again emphasize the need for further investigations collaborated with other research fields in order to gain more general insights about the subjects.

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