わが国の農業経済学分野における多属性型表明選好法とコンジョイント分析の応用－ 1990 年代後半から2005 年まで－

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Application of Multi-attribute Stated Preference Methods and Conjoint Analysis in Agricultural Economics in Japan

– From the Latter Half of the 1990s to 2005 –

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Contents

I Introduction

The purpose of this paper, which is the English version of Aizaki (2005b, chap.3), is to assemble topics related to agriculture and rural areas that were treated using multi-attribute stated preference methods and conjoint analysis in Japan and to elucidate the features of these studies and further relevant issues in Japan. In this paper, multi-attribute stated preference methods include choice experiments, contingent ranking, contingent rating, and paired comparisons (Bateman et al., 2002) that are based on discrete choice models. On the other hand, conjoint analysis implies traditional conjoint analysis (e.g., Louviere, 1988). The following three research areas are reviewed in this paper: (1) consumer research including consumers' valuation of agricultural product characteristics and food safety; (2) farm management research including farmers' valuation of new technologies, inputs and farmer support services, and farmers' decision-making related to farmland use; and (3) rural planning research including environmental valuation related to agriculture and rural areas, and the valuation of a plan for constructing facilities.

In order to be able to review various studies, previous studies were gathered using the following policy. First, studies applying conjoint analysis were included in this review since conjoint analysis has been used in some areas before introducing multi-attribute stated preference methods. Although multi-attribute stated preference methods and conjoint

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analysis differ from the viewpoint of designing choice sets and analyzing responses statistically, the topics to which each of these methods is applicable are almost similar. It is possible to present more wide-range studies by including conjoint analysis studies as the objective of this review.

Second, national and local agricultural research institute publications were also included in this review along with references of academic journals and books. Multi-attribute stated preference methods and conjoint analysis have been used in various research projects in the institutes. They document interesting cases related to developing new agricultural technologies. However, these projects do not necessarily produce academic papers. Given that the objective of this review is limited to papers published in academic journals, a considerable number of research results using multi-attribute stated preference methods and conjoint analysis produced in the institutes are excluded. Therefore, publications from the institutes have also been included in the objective of this review.

On the other hand, the objective of this review is limited to agricultural economics. For example, applied studies related to the consumers' valuation of food might exist in the business and commerce fields. However, I am not very familiar with fields other than agricultural economics, and therefore, find it difficult to gather and systematically review publications. Moreover, abstracts of academic conferences have been excluded from the objective of this review. These abstracts are not easily available to non-participants of the conferences. It is also difficult to obtain detailed information of relevant researches using multi-attributes stated preference methods or conjoint analysis from these abstracts.

II Application in consumer research on agricultural and livestock products

Consumer research on agricultural and livestock products includes the following two topics: (1) consumers' valuation of commodity characteristics of agricultural and livestock products and (2) consumers' valuation of food safety with regard to agricultural and livestock products.

1 Consumers' valuation of commodity characteristics

First among this topic is the consumers' valuation of food labels. Hirao (1997) conducted a conjoint analysis to measure the relative importance of the content of the food labels of rice, such as the region of origin, variety, growing method, and price. Ooura et al. (2002) measured the region of origin indicating regional brand power and the growing method for each fruit and vegetable (mini tomato, Welsh onion, broccoli, onion, and kiwi fruit) using choice experiments. Kodama (2001) interpreted a regional product value as a brand power and measured the value of beef using contingent ranking. Kurihara (2002) implemented a conjoint analysis of measuring consumers' valuations of the form of package, country of origin, and growing method for green tea.

The second topic pertains to measuring the value of new technology and the effect of new marketing. Relevant studies tend to be examined in the national and local agricultural research institutes. Sugitani et al. (2002) set a hypothetical purchase situation of the Satsuma orange and conducted choice experiments that aimed to measure the consumers' valuation of the optical sensor technology that reduces the difference in the taste of the Satsuma orange. The introduction of the technology into a certain region relatively raised the brand power of the region compared with other regions wherein the technology was not introduced. Kono et al. (2005) divided the participants into two groups. One group of participants was informed that the merit of the optical sensor was that it nullified the difference in the taste of the Satsuma orange. The other group of participants was not informed about this merit. The informed participants placed high value on the Satsuma orange inspected by the sensor. In the case of the non-informed group, although the participants who were aware of the sensor highly valued the sensor-inspected Satsuma orange, the participants who were not aware of it evaluated the sensor-inspected Satsuma orange as lower than that of the non-inspected Satsuma orange. These results highlight the importance of the manner in which information is provided to the consumers, which in turn focuses on consumers' benefit from the new technology.

Isayama et al. (2003a) applied choice experiments to clarify the consumers' valuation of the summer spinach improved in the element (vitamin C, iron content, and nitric acid) by a new growing method compared with the conventionally grown spinach. From the result of these experiments comprising attributes of each element and the price, it was revealed that the aim of developing the new growing method was sufficient to increase the iron content in the summer

spinach by twice that in the conventionally grown spinach.

Hiramatsu (1999), Okubo (2000), Yutthana and Monma (2004), and Hoshino (2002) conducted studies related to new marketing. Hiramatsu (1999) analyzed the consumers' valuation of the quality factor of Shizuoka melon grown in the greenhouse for a family exchange gift by conducting conjoint analysis. Okubo (2000) evaluated the commodity characteristics of the Yamanashi grape considered by consumers when purchasing it from a mail-order sale. Yutthana and Monma (2004) conducted a conjoint analysis to clarify consumer requirements for organic food (kale) in Thailand; price, quality, freshness, the reliability of producer, and the reliability of shop were set as attributes and evaluated. Hoshino (2002) used conjoint analysis as the one measure of the agricultural product development techniques corresponding to consumer needs. Conjoint analysis was also used to clarify what kind of green soybean was most requested by consumers based on the commodity concept drawn from the examination of consumer requirements.

Shimoyama applied conjoint analysis and choice experiments for the consumers' valuation of various agricultural and livestock products in order to clarify the kind of commodity characteristics that were given a high value by the consumers, such as spinach (Shimoyama, 2000a, 2001), strawberry (Shimoyama et al., 2002), apple (Shimoyama, 2002), ice cream (Shimoyama, 2003), and bread (Shimoyama and Taniguchi, 2003). Moreover, Shimoyama (2000b) examined consumers' needs for mango, which is an important cash crop for farmers in the Mekong delta region in Vietnam by using conjoint analysis.[*1]

2 Consumers' valuation of food safety

Consumers' valuation studies of food safety would be classified into the following three categories: rice, fruits and vegetables, and livestock products.

Sato et al. (2001) and Yoshida and Peterson (2003) conducted researches with regard to the theme of food safety to which rice belongs. Sato et al. (2001) implemented choice experiments for Sapporo citizens to measure the market power of Hokkaido rice with regard to whether it could be considered a food safety attribute (growing method) such as organic or low-chemical. Rice has four attributes—the growing method, the variety and prefecture of origin, the presence of the name of the city of origin and farmer, and the price. A conditional logit model was used to analyze the responses to the choice experiment questions; individual characteristics were also included in the model in order to examine the effects of the individual characteristics of the valuation of food safety. By means of the simulation based on the estimated results, the market power of Hokkaido rice with the food safety attribute was clarified. Yoshida and Peterson (2003) executed choice experiments for the consumers' valuations of domestic rice and foreign rice (United States rice, Australian rice, and Chinese rice). It was clarified that consumers with a negative impression of the food safety and taste of foreign rice placed a relatively low valuation on foreign rice.

Kamioka (2002), Aizaki and Iwamoto (2004), and Ohtani and Yabe (2004) analyzed the food safety of vegetables and fruits. Kamioka (2002) examined the influence of the form of package, price, county of origin of raw material, and growing method on the university students' valuation of orange juice by using conjoint analysis. Aizaki and Iwamoto (2004) conducted choice experiments of the consumers' valuation of the mini tomato with four attributes—price, country (region) of origin, growing method, and traceability. As a result of a statistical analysis of the responses to the choice experiment questions with the help of a latent class logit model, it was discovered that the consumers' valuation of the traceability tended to be lower than that of organic farming, no-chemical farming, or low-chemical farming. Ohtani and Yabe (2004) conducted choice experiments for the consumers' valuation of the traceability system and the second generation genetically modifying technology aiming at increasing consumers' benefits. They also analyzed the responses using the latent class logit model. It was revealed that a portion of consumers might accept the second-generation genetically modifying technology if it made way for no-chemical farming.

In the research conducted to evaluate food safety with regard to livestock products, noteworthy researchers were Sawada et al. (2002), Iwamoto (2004), Iwamoto et al. (2004), and Hosono (2003, 2004) for milk, Yabe et al. (2002, 2003) for egg, and Aizaki et al. (2004bde) for beef. Sawada et al. (2002), Iwamoto (2004), and Iwamoto et al. (2004) conducted

*1 Shimoyama et al. (2004) developed a Web system for supporting agricultural marketing and integrated conjoint analysis into one of the functions of the system.

choice experiments for the consumers' valuation of milk with four attributes—the HACCP label ensuring the food safety of milk at the processed stage, an ecolabel certifying environmental protection at the fresh milk production stage, the days before the expiry date, and the price. Hosono (2003, 2004) distinguished three groups—a group informed about calcium, a group informed about HACCP, and a group not informed about calcium and HACCP, and examined the effect of information on the valuations of the food safety attribute (HACCP) and nutrition attributes (fortifying with calcium, and milk fat rate control). Yabe et al. (2002, 2003) applied choice experiments of consumers' choice behavior of egg in order to value the living conditions of hens, the use of agrochemicals and fertilizers in the production of chicken feed, the certification of health standards and quality of eggs, and the genetically modified content in chicken feed. Aizaki et al. (2004b) applied contingent ranking for valuing products (beef) derived from bovine embryo clones. Structural equation modeling was conducted for analyzing the relationship between knowledge and attitudes concerning bovine embryo cloning technology. By introducing forecasted attitudes into independent variables of the contingent ranking analysis, the effects of knowledge and attitudes on beef valuation were examined. Aizaki et al. (2004de) analyzed the relationship between consumers' choice behavior among beef (domestic Wagyu beef, domestic dairy beef, US beef, and Australian beef) and the consumers' valuation of food safety of beef after the Bovine spongiform encephalopathy (BSE) outbreak in Japan by using choice experiments and structural equation modeling.

Although the above-mentioned studies assumed the situation of purchasing agricultural and livestock products in daily life, Kurihara et al. (1999) tried to value food safety pertaining to school lunch. After the mass food poisoning caused by the school lunch in 1996 in order to clarify the feasibility of the ideal content of the school lunch requested by the students' parents, Kurihara et al. (1999) asked families with elementary or junior high school student(s) in Chiba city to answer choice experiment questions. These questions comprised six alternatives (hypothetical school lunches) with four attributes such as the cooking method, the school lunch expense, the food safety measures, and the nutritional balance.

3 Features and further issues of application in consumer research on agricultural and livestock products

a Features

The features of consumer research on agricultural and livestock products are summarized in the following five points. The first feature is the difference of the analysis technique; conjoint analysis is mainly applied in the valuation of commodity characteristics, whereas choice experiments are used in almost all food safety valuation studies. Empirically estimated value of food safety is frequently expected to be interpreted based on economics. Although choice experiments based on the random utility theory generally satisfy this requirement, the same does not apply to conjoint analysis. Moreover, several researchers among those who evaluate food safety have been working on environmental valuation research. Contingent valuation method (CVM) has been applied in the environmental valuation research and is similar to choice experiments from the viewpoint of theoretical background; therefore, choice experiments may be frequently used in food safety valuation studies. Learning conjoint analysis may be relatively easy with the advent of the Japanese version software for conjoint analysis (creating profiles and analyzing the responses) and Japanese books on conjoint analysis in the marketing research area. Therefore, it seems that conjoint analysis has been widely applied to commodity characteristics valuation studies.

The second feature is to create profiles using photos or the technical details of the agricultural products when the survey is conducted by researchers in national or local agricultural research institutes. In the research institutes, projects together with natural science researchers have been frequently carried out. In such cases, profiles can be created based on the technical information about the target product. Therefore, a more realistic situation is usable in questionnaires.

The third feature is the characteristics of participants. Although many studies have used a telephone directory database or list of voters as the population list, others construct original consumer panels. Since the size of the monitor is limited, one must be careful in the generalization of the result. However, the monitor survey has advantages in that all the participants can be gathered in one place and asked to answer questions after foretasting actual samples of food (Shimoyama, 2003).

The fourth feature is the use of a variety of discrete choice models. In addition to the conditional logit model, several studies used a random parameters logit model (Yabe et al., 2003; Yoshida and Peterson, 2003), a latent class logit model

(Yabe et al., 2002; Aizaki and Iwamoto, 2004; Ohtani and Yabe, 2004), and a nested logit model (Hosono, 2003; Yoshida and Peterson, 2003). Even when the conditional logit model was used, Sato et al. (2001) and Aizaki et al. (2004bde) examined the effects of individual characteristics (including attitudes) on the consumers' valuation of attributes. The use of various such models can be interpreted as the subjective reflection of wide differences in food safety valuation.

The last feature is to examine the reliability of the responses or the method of designing the choice sets. Hosono (2003, 2004) confirmed the reliability of the responses toward choice experiment questions by presenting the same choice set to participants in the first question and the eighth question and by checking the consistency of the responses in the two questions. Yabe et al. (2003) investigated the effect of an opt-out option on participants' response behavior toward choice experiment questions by comparing the responses in two types of questionnaires—"I would not buy any eggs" as the opt-out option, while the other set was "I would buy my usual brand of eggs."

b Further issues

Further issues related to consumer research on agricultural and livestock products are summarized in the following three points. The first issue pertains to the use of actual purchasing (revealed preference) data. In the consumers' valuation study related to agricultural and livestock products, completely virtual situations do not exist. In any case, one or few hypothetical elements (attributes and/or their levels) are simply introduced into the decision-making situation in real. Therefore, it is important to use revealed preference data when multi-attribute stated preference methods were applied in the consumers' valuation studies. However, excepting a few studies such as Yabe et al. (2003), no multi-attribute studies have revealed preference data. It is recommended that information related to real purchase behaviors should be asked in the multi-attribute stated preference questionnaires. An alternative is to conduct test-marketing of sample food jointly with the multi-attribute stated preference questionnaire.

The second issue is with regard to an examination of the utility function type. When participants were asked to evaluate each characteristic of the commodity, some of them answered, "Never purchase it if it has a certain characteristic." Similarly, it has been observed that some of the participants never select an alternative (product) with a certain characteristic (e.g., genetically modified food) from among choice sets. Such participants might have the tendency to not select a product with a certain characteristic that they dislike. In other words, there is a possibility that they have a non-compensatory utility function. Almost all studies have assumed a compensatory utility function by accepting the trade off between each attribute (e.g., I would purchase the product if its price is reasonable even if it is produced by using genetically modifying technology). If an individual characteristic can be assumed to be the factor that decides whether the individual has a compensatory or non-compensatory utility function, the behavior of the participant with a non-compensatory utility function might be traced by the compensatory utility function including the individual characteristic as an independent variable. However, it might be difficult to assume observable individual characteristics as the only factors that decide the type of utility function. Therefore, statistically selecting the function type seems to be suitable in this issue.

The third issue is to clarify a latent factor that influences the choice behavior of the agricultural and livestock products. In multi-attribute stated preference methods, the individual choice behavior of agricultural and livestock products is assumed to be determined by the attribute of the products. When the individual characteristics also seem to affect choice behavior, these can be included in the analysis of the multi-attribute stated preference data. However, the individual characteristics that can directly be observed are limited. According to previous research concerning food safety (e.g., Nakashima, 2004), the latent individual characteristics that cannot directly be observed also influence the evaluation of food safety. The existence of the latent factor can be clarified by using factor analysis, principal component analysis, or structural equation modeling (e.g., Aizaki et al., 2004bde). If it is able to handle the latent factor, findings of consumer research on food safety in various fields such as social psychology (e.g., Kikkawa, 1999; Takeda et al., 2003) can be reflected in the analysis of multi-attribute stated preference data without limiting oneself to the observable individual characteristic variables.

III Application in farm management research

The application of multi-attribute stated preference methods and conjoint analysis in farm management research

could be divided into three topics, namely, farmers' valuation of new technology, farmers' valuation of inputs and farmer support services, and farmers' decision-making related to farmland use.

1 Farmers' valuation of new technology

Multi-attribute stated preference and conjoint analysis studies aimed at the farmers' valuation of a new agricultural technology have been executed by Naka and Fujimoto (2002), Konya et al. (2002), Isayama et al. (2003b), Fujii et al. (2003), Kudo et al. (2003), Kato (2000), and Kitabatake et al. (2001).

Naka and Fujimoto (2002) conducted choice experiments for the farmers' valuation of strawberry cultivation with high bench culture system that has the effect of comfortable working. The system was expressed according to four attributes—income decrease depending on the extent of the target when failing, facilities introduction cost, change in the profit from which the direct cost is extracted, and form of work. The relationships between farmers' characteristics and their valuations of each attribute were analyzed. Konya et al. (2002) used conjoint analysis for the farmers' valuation of an environment-friendly rice farming method. According to the result of the microeconomic model analysis of farmers' decision-making with regard to selecting technology, the environment-friendly rice farming method was assumed to be composed of the price of rice, fixed costs, fertilizers and agrochemicals costs, working hours, and the presence of technical assistance. Conjoint analysis based on these attributes was conducted for rice farmers in Hokkaido, and the condition of spreading the method was simulated based on the results of the conjoint analysis. Isayama et al. (2003b) applied choice experiments for the farmers' valuation of a new large-scale paddy field's levee management technology—multi coating and moss phlox planting—that replaces conventional levee technology (weeding). The new management technology was assumed to consist of four attributes—transplant materials costs, transplant working hours, planting maintenance years, and the presence of weeds after transplanting. The condition of planting maintenance years for accepting the new management technology was examined based on the results of choice experiments conducted for farmers who had the experience of testing the technology with an intention to introduce it into their own paddy fields. Fujii et al. (2003) proposed the use of conjoint analysis in order to obtain information that was used for the development and improvement of agricultural machinery from farmers. They conducted a study of the onion harvest machine. The machine was assumed to be composed of four attributes, namely the size of the machine and efficiency of work, the presence of new storage mechanisms corresponding to the dry work after harvesting the onion, the presence of new washing mechanism improving the efficiency of brushing soil down from the harvested onion, and the price of the machine. They examined the attribute that was evaluated as being higher by farmers. Kudo et al. (2003) analyzed farmers' decision-making with regard to purchasing a field map service by using choice experiments in order to examine the effects of introducing a precision farming system from the viewpoint of farm management research. The field map service was assumed to consist of information for the farmers (the kind of soil element information and the presence of slope information of paddy field) and the price of the service. From the results in the case of rice farmers in Ishikawa prefecture, the farmers' willingness to pay for the contents of the service was measured.

In addition to the above-mentioned farmers' valuation studies, Kato (2000) used conjoint analysis for the non-farmers' valuation of a new agricultural technology. Kato (2000) pointed out that there was a possibility that the new technology affected the residents' comfort in their daily life; therefore, their valuation of the new technology by conjoint analysis was needed. Kato (2000) conducted a case study of a computer-controlled (unmanned) agricultural tractor with three attributes—type of operator, size of the tractor, and time zone of work. Kitabatake et al. (2001) examined the possibility of using conjoint analysis for measuring the relative importance of various influences of agriculture on the environment when evaluating the environmental impacts of the environment-friendly farming system from the viewpoint of the life-cycle assessment.

2 Farmers' valuation of inputs and farmer support services

This topic includes the farmers' valuation of compost and of a drying harvested rice service. Tarumoto (1997, 2001) highlighted that it was important to measure farmers' intentions to purchase compost in order to increase the amount of distribution of compost and then proposed the application of conjoint analysis for analyzing the farmers' purchase behavior toward compost. The compost consisted of five attributes, namely, the kind of domestic animal that produces the

raw material of the compost, the presence of sawdust, the degree of decomposition of raw material, the style of packing, and the price. Kumamoto farmers' valuation of the compost was extracted using conjoint analysis with these attributes. Uraya (2004) also proposed a way to improve the administration of a compost supply center, which made and supplied compost to farmers in a certain region, based on the conjoint analysis of farmers' valuations of compost. However, Aizaki (2004ab) pointed out that it was difficult for conjoint analysis to predict the demand for compost even if it is possible to forecast the share of each compost product in the compost market, since conjoint analysis has a limitation in that it does not distinguish between farmers who intend to purchase compost and those who do not. Prediction of the amount of demand for compost is required to plan the construction of the compost supply center; therefore, Aizaki (2004ab) proposed the application of choice experiments for predicting the amount of demand of the compost. Aizaki (2001) used choice experiments for building the farmers' decision-making model of the use of the rice center, which is a facility that accepts harvested rice from farmers and dries and processes the rice. Rice farmers were required to select the most preferred one from among the administration plans created based on the following three attributes: the fee of the facility, the time required until unloading the harvested rice after they arrive at the facility, and the time of closing the facility. Aizaki (2002) developed an administration simulator for the rice center by integrating the above-mentioned farmers' decision-making model, a waiting time function (Aizaki, 2000), and a fee (average cost) function calculated from the administration cost of the rice center.

Studies related to the farmers' valuation of farmer support services include those by Kurihara and Maruyama (1998) and Morishima and Tanaka (2001). Kurihara and Maruyama (1998) proposed an application of conjoint analysis on constructing the contents of programs supporting farmers who were approved by the local government as being self-motivated for improving their own management. In order to efficiently support approved farmers, it was essential to capture their preference for contents of the support program, to construct specific support programs based on the preference information, and to be able to simulate their degree of satisfaction toward the programs. Since conjoint analysis satisfied these requirements, Kurihara and Maruyama (1998) conducted it with the following five attributes: preferential treatment in the tax system; support for accumulation of farmland; preferential treatment in the financing; consultation and training related to farm management; and consultation and training related to agricultural technology. Morishima and Tanaka (2001) pointed out that the communication system between rice farmers and agricultural extension workers was important for spreading direct sowing in paddy field technology and conducted conjoint analysis for examining the kind of system required by rice farmers. As a result, it was revealed that a system combined with a personal computer and fax machine was preferred.

3 Farmers' decision-making related to farmland use

Studies related to the farmers' decision-making with regard to farmland use and the farmers' valuation of farmland conditions include Laboratory of Farm Management, Kyushu National Agricultural Experiment Station (1998), Endo et al. (2003), Endo (2004a), and Hirano et al. (2005).

Laboratory of Farm Management, Kyushu National Agricultural Experiment Station (1998) examined farmers' needs for farmland conditions by using conjoint analysis with five attributes: the scale of farmland division, the depth of effective soil strata, the type of farmland, the capacity of drain, and the time required from home to the farmland. A conjoint analysis was conducted for dairy farmers, vegetable farmers, indoor farmers, and industrial crop farmers and measured differences in farmland condition between these farmer types.

Endo et al. (2003) stated that the prediction of farmers' farmland use was essential to examine regional plans of farmland use and tried to predict it by using choice experiments. Factors that affect farmers' decisions to increase the growing area of Japanese pear or to discontinue their own management were assumed to have the following three attributes: the price of Japanese pear (Kousui) cultivated indoors, the price of Japanese pear (Kousui) cultivated outdoors, and the prices of other types of Japanese pear. With the help of the estimated results, both the number of farmers increasing the farmland area of cultivating Japanese pear and the number of farmers deciding to discontinue their own management were forecasted according to the change in these prices. Endo (2004a) constructed a farmers' decision-making model of renting farmland by using choice experiments in order to build a micro-simulation system for predicting farmland use in rural areas. The model was built by analyzing the responses toward choice behavior among farmland lease conditions

created from the combination of four attributes, the price of rice, the level of rent, the amount of direct payment received from the government, and the farmland condition.

Hirano et al. (2005) analyzed the effects of change in a paddy field crop diversion policy on farmers' behavior by using choice experiments. Two scenarios were set—one analyzed factors affecting the acceptance of the control of rice production, while the other analyzed factors affecting the expansion area of the crop diversion. In the former scenario, based on an assumption that each farmer freely decides whether or not to accept the control of rice production, farmers were asked to select the most preferred option from among control of rice production plan alternatives created from a combination of three attributes—the price of rice when they sell rice through agricultural co-operation, the amount of compensation for income loss while accepting crop diversion, and the amount of subsidy for the establishment of high-productivity paddy field farming. In the latter scenario, farmers were asked to select the most preferred option from among crop diversion plan alternatives, which were created from the combination of four attributes—the amount of consignment charge, the prices of wheat and soybean, the yields of wheat and soybean per 10 a, the condition of paddy field where crops were diverted.

4 Features and further issues of application in farm management research

a Features

The features of farm management research are summarized in the following three points. Integration of the results of multi-attribute stated preference methods into a decision-making support system for regional agricultural planning (Aizaki, 2002; Endo, 2004b) is the first feature and makes it possible to evaluate more real scenarios compared with simulation based on only the results of multi-attribute stated preference methods. For example, Aizaki (2001) paid attention to the user fee and the time required until unloading the harvested rice after they arrived at the rice center as factors affecting the rice farmers' use behavior of the facility. Both factors can be changed by the number of farmers who use the facility, while the levels of the two factors are changed in the opposite direction. That is, if the number of user farmers increases, the congestion of the entrance to the facility becomes violent and the waiting time increases (since the capacity of accepting harvested rice is constant), while the user fee can be reduced (since the fee is equal to the average cost of the facility). It is difficult to predict the rice farmers' use behavior as setting the combination of appropriate waiting time and user fee merely based on the results of the choice experiments. Therefore, a simulator that includes the farmers' behavior, the waiting time, and the level of fee as endogenous variables can appropriately forecast their behavior.

The second feature is with regard to the farmers' valuations of support programs or policies as well as those of agricultural machinery or the growing method. One may consider multi-attributes stated preference methods as one of the marketing research methods, and its application would be on the agricultural machinery or agricultural materials and services that the farmers would avail of. However, with a perspective that multi-attribute stated preference methods are tools for analyzing individuals' decision-making with regard to characteristics of the decision-making process, one may understand that the methods are suitable for analyzing the farmers' valuation of various systems or policies. Particularly, when a policy will be largely changed, it may be difficult to predict the behaviors based on revealed preference data (data on recorded farmers' behavior in the past). In such a case, the farmers' valuation of the policy change by using multi-attribute stated preference methods would have a large advantage. For example, in order to examine the effects of rice policy reforms that have been implemented since 2004, Hirano et al. (2005) measured, in 2002, the effects of the price levels of rice, the amount of compensation for income loss when accepting control of rice production, and the amount of subsidy for establishing high-productivity paddy field farming on the farmers' behavior in accepting the control of rice production

The third feature is with regard to the qualitative characteristics of agricultural technology. If the agricultural technology can be valued only based on the quantitative attributes, mathematical programming based on data obtained from farm surveys or econometric analyses derived from revealed preference data can be applied for valuing agricultural technology. However, if qualitative factors play an important role when the technology is evaluated by farmers, the farmers' preference toward the technology must directly be extracted from the farmers. For example, Naka and Fujimoto (2002) applied choice experiments for the farmers' valuation of strawberry cultivated with a high bench culture system that has the effect of comfortable working, since it was difficult to value the effect by using quantitative data.

b Further issues

Further issues related to farm management research are summarized in the following four points. The first issue is with regard to the use of revealed preference data. Along with the consumers' valuation of the agricultural and livestock products, complete virtual situations do not exist in the farmers' valuation of agricultural technology; one or few hypothetical elements are introduced into the decision-making situation in real. Therefore, revealed preference data corresponding to the situation that is assumed in the multi-attribute stated preference method could be gathered. Moreover, accuracy of prediction or reliability of evaluation would increase by integrating the revealed preference data into the analysis of multi-attribute stated preference data. For example, as a result of modifying the estimated results of choice experiments of the farmers' use behavior of the rice center with the help of real data such as the demand for services from the facility, the accuracy of prediction of current (real) situations was improved (Aizaki, 2002). However, the result of multi-attribute stated preference methods cannot be necessarily corrected by using real data. For example, in the case where a new facility will be introduced into a certain region, real data according to the facility do not exist for the region. Therefore, it is necessary to measure the extent of differences between the actual value and predicted value derived from the estimated results of multi-attribute stated preference data and to examine the strategy that reflects the differences in the prediction by multi-attribute stated preference methods.

The second issue is to examine a method by which to inform farmers about agricultural technology especially by taking into consideration its qualitative characteristics. Although it was pointed out that one of the features of multi-attribute stated preference methods is its ability to measure the farmers' valuation of agricultural technology in consideration of its qualitative characteristics, an explanation of the qualitative characteristics of the agricultural technology might be more difficult than that of its quantitatively measurable characteristics. If the explanation of quantitative characteristics is invalid, farmers' understanding of the technology would differ subjectively and their valuation would be biased. This issue is not avoided by explaining the technology in detail. When a considerable amount of information is provided to participants in order to explain it in detail, they would tire of understanding the explanation; they might be negligent in answering relevant questions or might not respond at all. Moreover, the participants' degree of tiredness in understanding the information might differ according to the kind of media providing the information. It is necessary to examine the manner in which one may inform farmers and the extent of information provided to farmers from the viewpoint of both the degree of cognitive load in understanding the information as well as the degree of understanding the information.

The third issue is to modify the method in order to be able to directly predict a continuous variable. Although the dependent variable of discrete choice models comprises the qualitative variable indicating alternative that is selected, the prediction of a quantity is required in some cases. For example, Aizaki (2002) required predicting the amount of harvested rice loaded into the rice center. However, the farmers' use behavior model was constructed with the help of a discrete choice model. Moreover, farmers' behaviors with regard to some amount of their harvested rice being loaded into the rice center and the other amount being dried by their own dryer facility were also observed. In Aizaki (2002), the farmers' use behavior model was modified with the help of the average number of farmers who used the rice center that was calculated by using real data. In order to specify the model in a more concrete manner, it is necessary to construct both the discrete choice model that predicts the farmers' use behavior toward the rice center and the continuous variable model that predicts the amount of rice that is loaded into the rice center on the condition that farmers use the rice center.

The fourth issue is to develop and apply a multi-attribute stated preference method considering the social interactions between farmers. According to previous researches on the diffusion of agricultural technology (e.g., Fujita, 1987; Sajiki, 2000), a farmer's decision with regard to introducing a new technology is affected by other farmers' previous introductions of it. Konya et al. (2002) set an attribute about technical support of a new technology from other farmers (it has three levels; "advices from farmers who are experts at the new technology," "exchange information related to the new technology with farmers who have same ability," and "no support") and examined the effects of each level of technical support on farmers' decisions with regard to introducing the new technology.[*2] In order to treat a situation where farmers make decisions by taking into consideration other farmers' decision-making, it is necessary to introduce social interaction

*2 For example, Aizaki and Nagaki (1998), who used a contingent valuation method, included mutual dependent relationships between farmers as a factor of their willingness-to-pay for decreasing congestion of common use facility. Partial farm work trust in a village was defined as a mutual dependent relationship and measured by using social network analysis.

into the attribute of multi-attribute stated preference methods and to examine the use of the discrete choice model with social interaction (Brock and Durlauf, 2001; Fukuda et al., 2004).

IV Application in Rural Planning Research

The application of multi-attribute stated preference methods and conjoint analysis in rural planning research can be classified into two topics—environmental valuation related to agriculture and rural areas (e.g., multifunctional roles of agriculture and rural areas) and valuation of plans for constructing facilities.

1 Environmental valuation

Environmental valuation studies related to agriculture and rural areas[*3] include those by Sasaki et al. (2000), Yoshida et al. (2002), Yoshida (2003a), Fujimoto (2002), Isayama et al. (2003b), Aizaki (2003a), and Aizaki et al. (2004c).[*4]

Sasaki et al. (2000) applied choice experiments for the environmental valuation of a park in Kumamoto prefecture that was constructed by a rural improvement project. On the basis of a hypothetical situation where “If residents were unwilling to pay some money to construct the park, some portion of the park would not be built,” they tried to value construction components such as the planting of trees, the presence of a stroll road, the presence of a belvedere, and the presence of other components. Yoshida et al. (2002) and Yoshida (2003a) applied choice experiments for evaluating the effects of preservation plans of terrace paddy fields from the viewpoint of both environmental benefits (“rural landscape and wildlife protection,” and “the preservation of disaster and land protection”) and environmental burden (“pollution of surface and ground water”). Yoshida et al. (2002) verified the possibility of benefit transfers of the estimated results among four regions. Yoshida (2003a) examined the influences of respondents’ individual characteristics on their responses toward the choice experiment questions in one region.

Fujimoto (2002) and Isayama et al. (2003b) analyzed the relationship between the maintenance method of levee and slope of paddy fields and environmental valuation of the method. Fujimoto (2002) used choice experiments for valuing the countermeasures for abandoned farmland in hilly and mountainous areas, such as land improvement and coating the levee and the slope, from the viewpoint of the multifunctional role of agriculture (landscape preservation). In the choice experiments, respondents were requested to select the most preferred option from among alternatives that were created from the combination of three attributes, the condition of farmland, the maintenance methods of the levee and the slope, and the monetary burden. Isayama et al. (2003b) also valued the environmental benefits of a large scale paddy field’s levee management technology by using choice experiments with three attributes—the condition of paddy field, the condition of levee, and the monetary burden.

Aizaki (2003a) applied choice experiments for valuing environmental benefits of plans for promoting ecologically-friendly paddy fields. In order to make participants understand that a number of intermediate egrets per paddy field of 10 ha was usable as an indicator of the ecological condition of paddy field as a wildlife habitat, relationships between the population density of intermediate egrets in a paddy field area and the number of aquatic prey animals in the paddy field area (Fujioka and Yoshida, 2001) were explained using text and figures in the questionnaire. Then, the participants were required to select the most preferred option from among alternative plans for promoting ecologically-friendly paddy fields that created using four attributes, the population density of intermediate egrets in a paddy field area, the presence

*3 Studies related to environmental valuation included the following. Kuriyama (1998) examined the relationship between the environmental benefit of the conservation plan of the Kushiro marsh and the amount of targeted area of the plan by using choice experiments. Takeuchi et al. (1999) valued the effect of decreasing damage of oil spills by using paired comparisons and contingent ranking. Kuriyama (1999) used contingent ranking for citizens’ valuation of forest management. Saito et al. (2002) applied conjoint analysis to countermeasures for damage by great cormorants in Lake Biwa. Tsuge (2001) conducted choice experiments for measuring the environmental benefits of forests. Kuriyama et al. (2002) used paired comparisons to value the company’s environment-conscious behavior from the viewpoint of investors. Yoshida (2003b) analyzed the environmentally-improved effects of fountainhead protection policies by using choice experiments. Itsubo et al. (2003) applied choice experiments to develop the weighting factor for life-cycle impact assessments.

*4 See Aizaki (in press) for a detailed review of choice experiment studies related to economic valuation of multifunctional roles of agriculture and rural areas by the author.

of a bird-watching field, which was a paddy field used for bird-watching, the presence of an eco-field that was used for a paddy field where children could capture animals living in the paddy field, and the monetary burden. Aizaki et al. (2004c) used choice experiments for valuing each role of multifunctional roles of agriculture and rural areas. Eight functions were evaluated, namely, flood prevention, groundwater conservation, soil erosion prevention, health and rest, wildlife protection, landscape management, water environment conservation, and organic waste disposal.

A research area related to the environmental valuation of agriculture and rural areas measures the consumers' valuation of products produced with consideration of the environment (eco-products). Itohara and Ooba (2003) used conjoint analysis for the non-farmers' valuation of attributes of compost. In the study, the attributes of compost were assumed to consist of the producer, the price, the recognition of recycling product, the weight, and the kind of domestic animal that produce raw material of compost. Aizaki (2005a) tried the consumers' valuation of rice produced with consideration of harmony with the ecosystem (eco-rice) by using choice experiments. Eco-rice was defined as "rice produced considering that various animals can easily live in the paddy field" and consisted of three attributes—the distance from home to farmer producing the eco-rice, the ticket for using eco-field where children can directly capture animals living in the paddy field, and the price. Oizumi (2004) conducted conjoint analysis for examining the kind of terrace paddy fields owner system that was preferable. Three types of participants, that is, customers of the owner system, the village office staff who was the provider of the owner system, and the prefecture office staff who was a supporter or conductor of the owner system, were set, and the differences in evaluation of the owner system depending on the three types were examined. In addition to the above-mentioned studies, Sawada et al. (2002), Iwamoto (2004), and Iwamoto et al. (2004), whose studies have been reviewed in the section of the consumers' valuation of food safety, also featured the valuing of the benefits in consideration with the environment at the stage of producing raw milk.[*5]

2 Valuation of plan for constructing facilities

Studies related to valuing plans for constructing facilities include those by Ooura et al. (1999), Aizaki (2003b), Kobayashi et al. (2003), Laboratory of Rural Life, National Agricultural Research Center (2001), and Aizaki et al. (2004a).[*6]

In order to manage the direct sale store of agricultural products, Ooura et al. (1999) pointed out that it was necessary to understand the conditions of residents' choice behavior toward the store for purchasing vegetables and fruits and to reflect the conditions in the store design, and conducted conjoint analysis for measuring the residents' valuation of the direct sale store of agricultural products. The store profiles in conjoint analysis consisted of five attributes, namely, the parking lot size, the variety of goods in stock compared with a super market, the rate of products produced in the local area, the type of growing methods, and the range of price compared with a supermarket. The relationship between respondents' characteristics and valuation of the store was examined using the partial utilities of the attributes calculated from the results of conjoint analysis.

Aizaki (2003b) analyzed the effects of the content of the agriculture and rural park on the residents' visit behavior toward the park by using choice experiments. The park consisted of four squares—flower-watching, bird-watching, experience of agriculture, and wildlife-catching. In addition to each square, the distance from home to the park and the fee of the park were set as attributes of the park. Kobayashi et al. (2003) used conjoint analysis to clarify the relationship between landscape evaluation of an agricultural canal and the condition of the agricultural canal. Agricultural canal landscape profiles were created from five attributes, the angle, the materials of the canal, the depth of the canal, the hedge along with the canal, and the conditions of location.

Laboratory of Rural Life, National Agricultural Research Center (2001) applied conjoint analysis for the residents' valuation of allotment gardens considering four attributes, the presence of selling agricultural products, the presence

*5 Other studies related to eco-products are as follows. Kuriyama and Ishii (1999) applied choice experiments to measure the consumers' environmental value of recycled products in the case of water cleaning purifiers. Kuriyama (2000) used choice experiments for valuing a wooden house and an eco label. Taguchi and Sakagami (2000) applied choice experiments to measure consumers' valuation of paper made from non-wood pulp. Sakagami (2000) evaluated recycled fiber by using choice experiments.

*6 One of the related studies was by Akazawa et al. (2003) who analyzed the relationship between the characteristics of forest recreation sites and visit behaviors toward the site by using choice experiments.

of guidance of growing, the contents of facilities, and the size of division of the garden. Aizaki et al. (2004a) applied choice experiments for modeling the residents' use behavior of the allotment garden and integrated the model into a decision support system for regionally planning the allotment garden based on a Geographical Information System. In the questionnaire, respondents were requested to select one of two alternatives: "I would use the allotment garden," and "I would not use the allotment garden." Allotment garden alternatives consisted of five attributes—the distance from home to the allotment garden, the fee per year, the type of guidance of growing method, the presence of facility for rest, and the presence of a small warehouse for agricultural machines and implements.

3 Features and further issues of application in rural planning research

a Features

The features of rural planning research are summarized in the following three points. The first feature is to examine the method of analyzing several attributes in the application of multi-attributes stated preference methods. When the numbers of attributes and/or their levels increase, the size of choice set and/or the number of trials increase; consequently, it would be difficult to efficiently conduct the survey. Moreover, it is pointed out that there is an upper bound in the number of attributes that can be presented to participants simultaneously because our information processing ability is limited (Miller, 1956). If the number of attributes exceeds the upper bound, there is a possibility that a problem is caused in the reliability of the responses toward the questionnaire. Aizaki et al. (2004c) examined the method of measuring several attributes by choice experiments based on a pencil and paper questionnaire survey. The reason why the paper and pencil questionnaire survey was targeted was that the survey method has been used generally for measuring the valuation of multifunctional roles of agriculture and rural areas in Japan. This method was as follows, first, eight functions contained in the multifunctional roles of agriculture and rural areas were explained to the respondents; second, the respondents were requested to rank each function in terms of subjective importance and to respond up to the 3rd function; third, they were asked to answer the choice experiment questions for valuing the functions that each respondent selected as the first, second, and third most important at the above-mentioned second step; finally, a data set was created by integrating responses to ranking questions with responses to the choice experiment questions, and valuation of the eight functions was measured by conducting a discrete choice model analysis base on the data set.[*7]

The second feature is that there are two ways of expressing the attribute. One is a way of expressing the attribute by each physical unit. For example, Aizaki (2003a) used the population density of the intermediate egret as an index showing the ecological condition of the paddy field. Another is a way of expressing the difference rate from the current state (percent display). In particular, the second way was frequently used in studies that valued the multifunctional roles of agriculture and rural areas or forests because there were some functions that were difficult to express in physical units (Tsuge, 2001; Yoshida et al., 2002; Yoshida, 2003a; Aizaki et al., 2004c). For example, Yoshida et al. (2002) valued environmental benefits and environmental load of plans for preserving terrace paddy fields by using three attributes—rural landscape and wildlife protection, disaster prevention and land conservation, and water pollution. These attributes were expressed by the difference rate from the current situation such as "60% improved" or "50% deterioration."

The third feature is to use an efficient way of making profiles based on the photographs. In the same case, reality of alternatives (profile) can be improved by using the photograph compared with using only text. The photograph has been used sometimes in studies of the consumers' valuation of the agricultural and livestock products. However, it is difficult to efficiently create profiles by using general image processing software because many photographs have to be processed. In order to overcome this problem, Kobayashi et al. (2003), who clarified the evaluation structure of the agricultural canal landscape by using conjoint analysis, efficiently made photograph profiles by using a rural landscape simulation system based on the personal computer (Matsuo, 2000).

*7 Kuriyama (2000) gathered stated preference data with several attributes for wooden houses by using the Adaptive Conjoint Analysis (ACA) from Sawtooth Software Inc. ACA is personal computer software and is able to treat many attributes in the conjoint analysis by selecting attributes used in conjoint analysis depending on participants through some kind of questions. Kuriyama (2000) applied ACA only for gathering data. With the help of other software, marginal willingness-to-pays for the attributes that could not be calculated by using only ACA were estimated.

b Further issues

Further issues related to rural planning research are summarized in the following three points. The first issue is to examine the way of improving transferability of the result. Transferability is the possibility that a result obtained in a certain area for valuation or forecast is used also in a different area or at a different time. It is called “benefit transfer” in the environmental evaluation studies. Yoshida (2003c) pointed out that it was an important issue to examine the method of the benefit transfer because the survey cost could be reduced and the project valuation that guaranteed neutrality and objectivity became possible. Such advantages exist in valuing plans for constructing facilities. If residents’ visit behavior models obtained in a certain area could be transferred to other areas or the transfer could be feasible by the model modified using an additional small size survey, the total survey cost would decrease.

The second issue is to examine indicators for expressing the state of each function of the multifunctional roles of agriculture and rural areas. This issue consists of two parts. One is the examination of a concrete index. The reason why the percentage display has been used for valuing each function of the multifunctional role of agriculture and rural areas is that each concrete index corresponding to each function has not been decided (Yoshida, 2003a). The decision of a concrete index is not only demanded from the viewpoint of the respondents’ understandability of the index but is also related to the above-mentioned issue of benefit transfer. For example, in order to be feasible in the benefit transfer from area A to area B, it is necessary not only that the transfer would be supported statistically but also that the index can be used by both areas A and B or the rule that converts the index used in area A into the index used in area B is fixed. Statistical transferable presupposes fixing the index with common meanings from the viewpoint of substance sciences. Therefore, the index should be decided by not only economics and statistics but also other research areas such as ecology or engineering. The other is an examination of manner in which to inform participants about the meaning of the index. Even if the concrete and proper index is decided, it is difficult to correctly determine the meaning of the index to lay participants. If the information that is provided to participants in a questionnaire increases, the participants soon tire of understanding the information; they might provide inaccurate answers to the multi-attribute stated preference questions or refuse to respond to the questionnaire. Theoretical and empirical examinations are necessary for establishing the efficient and effective way of informing participants about the meaning of the index.

The third issue is to consider the environment-conscious behavior model that has been constructed in social psychology and consumer behavior research. Since environmental valuation studies in rural planning research were mainly concerned with the valuation results (i.e., willingness-to-pay), an individual decision-making process tended to be treated as a black box. Of course, there are some studies that used participants’ knowledge or attitudes related to the environment as part of independent variables included in the model; however, the selection of knowledge and attitudes has tended to be ad hoc. There were few studies aiming at analyzing the participants’ behavior based on the environment-conscious behavior model. If multi-attribute stated preference methods would be used for clarifying factors of consumers’ environmental behaviors such as purchasing eco-products, it is necessary to be based on the environmental-conscious behavior models such as that by Hirose (1995) and Sugiura (2003). Moreover, it is important to create a scenario considering others’ behaviors in studies for researching the condition of consensus building related to environment management, in view of the issue of social dilemma (e.g., Fujii, 2003). In this case, the reality of the scenario would be spoiled by setting the scenario such that there is no external influence. It is necessary to set an attribute showing others’ behaviors such as “rate of others agreement with a plan” when the environmental management issues would be analyzed by using multi-attribute stated preference methods.

V Concluding remarks

This paper assembled the application of multi-attribute stated preference methods and conjoint analysis in agriculture and rural areas in Japan, and clarified features of these studies and further issues. While other issues were pointed out for each research area—consumer research, farm management research, and rural planning research—some of them were common to the three research areas, such as integrating revealed and stated preference data. The common issues would be examined efficiently by referring to the research results of each area, mutually.

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わが国の農業経済学分野における多属性型表明選好法とコンジョイント分析の応用

－ 1990 年代後半から 2005 年まで－

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要　約

本資料では，わが国の農業経済学分野において，多属性型表明選好法とコンジョイント分析を利用して取り組まれてきた研究テーマを整理し，その特徴と今後の課題を明らかにした。本資料における多属性型表明選好法は，確率効用理論をベースとした離散選択モデルにより回答結果を分析するものであり，回答形式が選択実験，仮想順位付，仮想評定，および一対比較であるものを含む。コンジョイント分析とは，いわゆる伝統的コンジョイント分析に該当する。取り上げている研究領域は，消費者研究（農畜産物の特徴の消費者評価，食品安全性の消費者評価），農業経営研究（農業者による新技術，生産要素，および農家支援サービスの評価，農地利用に関する意思決定分析），および農村計画研究（農業・農村の多面的機能の経済評価，施設整備計画の住民・利用者評価）である。各研究領域には固有の特徴や課題が見られる一方，顕示選好データと表明選好データの統合による分析精度の向上などの共通する課題も見られた。共通する課題については，各研究領域での成果を相互に参照することで，効率的に対応することが可能となろう。

キーワード：選択実験，離散選択モデル，消費者研究，農業経営研究，農村計画研究