Auctioning Conservation Contracts and Evaluating the Risk Attitudes of Farmers: Economic Experiments in Japan

Hiroki Sasaki[1], Takeshi Fujie[2], Kentaro Kawasaki[3], Norikazu Inoue[4], Kentaro Koito[5]

[1] OECD Trade and Agriculture Directorate, France, e-mail: hiroki.sasaki@oecd.org
[2] Shiga University, Japan
[3] Policy Research Institute, Ministry of Agriculture, Forestry and Fisheries, Japan/University of Maryland, USA
[4] Shimane University, Japan
[5] Rakuno Gakuen University, Japan

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Hiroki SASAKI
OECD Trade and Agriculture Directorate, France
E- mail: hiroki.sasaki@oecd.org

Takeshi FUJIE
Shiga University, Japan

Kentaro KAWASAKI
Policy Research Institute, Ministry of Agriculture, Forestry and Fisheries, Japan/
University of Maryland, USA

Norikazu INOUE
Shimane University, Japan

and Kentaro KOITO
Rakuno Gakuen University, Japan

Abstract: Agri-environmental programs in Japan have generally been promoted through the provision of fixed payments for certain environment-friendly farming and management practices. However, the auctioning of agri-environmental contracts is a noteworthy alternative for the furtherance of such programs. Conservation auctions are used to enhance the cost-effectiveness of public expenses and have been employed in practice as well as tested in various pilot projects in some countries. This study uses an experimental economics method to factor the risk attitude of participants into a comparison of uniform price (UP) auctions and discriminatory price (DP) auctions. Although some studies have compared fixed payments, UP auctions, and DP auctions, the superiority or inferiority of these strategies depends on the settings of an experiment. Consequently, experiments reflecting the Japanese situation could provide further insight into the advantages of each of these methods, and be used to guide policy design. In addition, the study also examines the effects of participants' risk attitudes on auction performance. Its principal conclusion is that DP auctions outperform UP auctions; this is in line with the findings of previous studies. This empirical research furthers our understanding of environmental auctions in a first step toward the design of such auctions, but field experiments using real farmers should be conducted in order to help corroborate research conclusions before these are applied to the real world.

Keywords: conservation auction, experimental economics, risk attitude, environment-friendly farming

1. Introduction

The Japanese government has recently begun to encourage environment-friendly farming. The *Agricultural Environmental Code*, which was enacted in 2005, provides a list of production practices that farmers should adopt for environmental conservation. This code initiated the implementation of cross-compliance measures targeted at promoting environmentally beneficial practices. In addition, the government provides support to encourage farmers to take up environment-friendly farming practices that must go beyond the "reference level." For example, it awards concessionary loans to "eco-farmers" who adopt sustainable agricultural practices. Moreover, it is in the process of finalizing direct payments for environmentally pioneering farming and the promotion of organic farming as defined in the *Law for Promoting Organic Farming,* which was enacted in 2006. Furthermore, the marginal environmental benefits of agricultural production are now considered as important as those of agricultural products are. Table 1 summarizes existing forms of support and incentives for agri-environmental farming practices.

Table 1: Current Agri-environmental Policy Measures[1]

	Details	Policy r
ance with the *mental Code*	This policy promotes the adoption of and compliance with the code of Agricultural Practice in Harmony with the Environment (the Agricultural Environmental Code).	Implementing envir compliance
ers	This policy is based on the *Law for Promoting the Introduction of Sustainable Agricultural Practices*. It promotes the certification of "eco-farmers" who practice sustainable farming and provides financial and technical support for their activities. There were 167,995 eco-farmers at the end of March 2008.	Concessionary loan
ng farming	*Measures to Conserve and Improve Land, Water and Environment* were introduced in 2007. These support progressive farming activity, which helps conserve local environments by using less than 50% of the quantity of chemical fertilizers and synthetic agricultural chemicals that is applied in conventional practice.*	Direct payments (ag payments)
arming	In accordance with the *Law for Promoting Organic Farming*, which was established in 2006, this policy promotes the elimination of chemical fertilizer and pesticide from farming practice.	Concessionary loan tax relief, and the pr payments for pionee

me exists to help maintain and promote the natural circulation function of the agricultural ecosystem (e.g., by enriching biodiversity and creating sust
Agriculture, Forestry and Fisheries of Japan (MAFF 2008)

As shown in Table 1, agri-environmental programs in Japan have generally been promoted through the provision of fixed payments and concessionary loans for certain environment-friendly farming or management practices. However, the location and quality of farming land, and the production systems used by Japanese farmers, vary enormously, especially for small farming households in hilly and mountainous regions. Consequently, fixed payments that are uniformly distributed across the entire nation cannot correspond to the individual heterogeneity.

Under these circumstances, conservation auctions are a noteworthy alternative. Agri-environmental contracts have been auctioned to enhance the cost-effectiveness of public expenses in general practice as well as in various pilot projects in some countries. For example, the United States of America (US), Australia, and selected European countries have recently auctioned environmental contracts. The United States Department of Agriculture's (USDA) Conservation Reserve Program (CRP) uses a sealed-bid discriminative auction to obtain information about the opportunity costs for private landholders of diverting land from agricultural production and increasing the provision of conservation goods. Although Japan has not implemented a policy of auctioning contracts for agri-environmental conservation, a survey of farmers in hilly and mountainous regions that we conducted in 2008 shows that over 60% of the respondents are interested in such a policy (unpublished).

This paper reports on a test-bed laboratory auction that compares uniform price (UP) auctions and discriminatory price (DP) auctions to determine which auction policy works best in the Japanese situation. Although some previous studies have compared fixed payments, UP auctions, and DP auctions (see e.g., Cason et al. 2003, Cason and Gangadharan 2005), the superiority or inferiority of these strategies depends on the settings of the experiment. Consequently, experiments that reflect the Japanese situation could provide further insight into the advantages of each of these methods, and be used for the purposes of policy design. These approaches follow the idea of "*design economics*" (Roth 2002), which not only calls upon economists to analyze markets, but also urges them to *design* these using experimental economics and computer simulation.

[1] Although direct payments to farmers in hilly and mountainous areas aim to prevent the abandonment of farming and maintain a range of ecosystem services, these payments are not considered part of *agri-environmental* policy in this study.

Early work on auctions stems from Friedman's (1956) seminal paper on the single strategic bidder and Vickrey's treatise (1961) on deriving auction equilibrium using a game-theoretic approach. Latacz-Lohmann and Hamsvoort (1997) present the advantages of auctioning conservation management contracts. Several recent studies have reviewed major findings in the field and investigated the experimental economics approach as it applied to auctions (see e.g., Ferraro 2008, Rousseau and Moons 2008, Romstad 2009). Ferraro (2008) contends that more theoretical work and field and laboratory experimentation are needed before definitive conclusions about the superiority of one or more of these approaches can be drawn.

UP auctions require winning bidders to pay a price that may be based on either the highest accepted or the lowest rejected bid, while DP auction winners pay a price based on their own bid (for auction vocabulary, see Ferraro [2008]; for a longer review, see Latacz-Lohmann and Schillizi [2005]). DP auctions are more popular among sellers because these earn payments equal to the sellers' offer price. However, they also give sellers an incentive to inflate their offer price because sellers cannot earn any surplus by submitting an offer equal to their opportunity cost. In both types of auctions, sellers submit sealed offers and in UP auctions, successful sellers receive a uniform price (per unit of environmental benefit) equal to the highest accepted or lowest rejected offer. In DP auctions, each successful seller receives the actual price offered. In UP auctions, all successful sellers receive market-clearing prices that exceed their offers and that are set by a seller who does not trade. Thus, sellers have an incentive to reveal their true costs. In contrast, DP auctions encourage sellers to misrepresent their costs and to submit offers that are higher than their true costs. This paper studies auctions that employ multiple offer rounds per period and multiple potential management contracts per seller. In these auctions, only the final offer round determines the purchased management contract; hence, theoretical auctions research cannot directly be applied. In other words, this research is deliberately policy-oriented and does not aim to test any specific auction theory. Consequently, the Revenue Equivalence Theorem does not apply to this study.

Aside from focusing on policy relevance, this study aims to consider how risk attitudes influence individual bidding behavior. Since theoretical research cannot be directly applied to the auctions, it is safe to suggest that overbidding in common-value first price auctions may be a result of risk aversion (Lind and Plott 1991): the value of the item is unknown, so winners bid in excess of this value and thereby lose money. Called the winner's curse, this phenomenon occurs if auction winners systematically bid above the actual value of the objects, thereby systematically incurring losses. Otherwise, risk aversion does not affect incentives in UP auctions (Ferraro 2008).

Theoretical analyses of conservation auctions (see e.g., Latacz-Lohmann and Hamsvoort 1997) assume a risk-neutral seller. In addition, previous experimental analyses do not consider the effect of individual risk attitudes on bidding behavior and overall market performance. Herein, this point is examined using Japanese environmental parameters and risk preference data elicited in the laboratory. While risk preferences have historically been estimated through historical data, experimental risk-preference elicitation has the advantage of being conducted in a context involving the making of real financial decisions (Lusk and Coble 2005). In this study, participants in the conservation auctions experiment also took part in lottery choice experiments aimed at assessing their individual risk preferences. This empirical research could contribute to our understanding of how conservation contracts might perform in Japan.

The outline of this paper is as follows. Section 2 introduces the design of the experiments for elicit risk attitudes and test auction type suitability. Section 3 discusses the results of the experiment. Finally, Section 4 presents the study's conclusions and policy implications.

2. Experimental Design

2.1 Eliciting individual risk preferences from a questionnaire

This study uses Holt and Laury's (2002) method of eliciting individual risk attitudes, where a menu of paired lottery choices is structured so that the crossover points to the high-risk lottery. We utilize this method because it has several advantages over previously used techniques (Lusk and Coble 2005) and has been widely implemented in recent experiments (see e.g., Harrison et al. 2007, Andersen et al. 2008). This method requires individuals to make a series of ten choices between lotteries A and B, where lottery A is the safe lottery and lottery B is the risky lottery. Table 2 reports the series of decisions subjects were asked to make in all treatments. For each decision, a subject chose either option A or option B. The expected payoff difference between each paired choice was not shown to individuals and one decision was randomly selected in order to decide payment won by individuals. A risk-neutral individual would choose option A for the first four decisions listed in Table 2 because the expected value of option B for those decisions is less.

Table 2: The Ten Paired Lottery-choice Decisions

Option A	Option B	Expected payoff difference
1/10 of 1,000 JPY, 9/10 of 800 JPY	1/10 of 1,900 JPY, 9/10 of 100 JPY	540JPY
2/10 of 1,000 JPY, 8/10 of 800 JPY	2/10 of 1,900 JPY, 8/10 of 100 JPY	380JPY
3/10 of 1,000 JPY, 7/10 of 800 JPY	3/10 of 1,900 JPY, 7/10 of 100 JPY	220JPY
4/10 of 1,000 JPY, 6/10 of 800 JPY	4/10 of 1,900 JPY, 6/10 of 100 JPY	60JPY
5/10 of 1,000 JPY, 5/10 of 800 JPY	5/10 of 1,900 JPY, 5/10 of 100 JPY	-100JPY
6/10 of 1,000 JPY, 4/10 of 800 JPY	6/10 of 1,900 JPY, 4/10 of 100 JPY	-260JPY
7/10 of 1,000 JPY, 3/10 of 800 JPY	7/10 of 1,900 JPY, 3/10 of 100 JPY	-420JPY
8/10 of 1,000 JPY, 2/10 of 800 JPY	8/10 of 1,900 JPY, 2/10 of 100 JPY	-480JPY
9/10 of 1,000 JPY, 1/10 of 800 JPY	9/10 of 1,900 JPY,1/10 of 100 JPY	-640JPY
10/10 of 1,000 JPY, 0/10 of 800 JPY	10/10 of 1,900 JPY, 0/10 of 100 JPY	-900JPY

Subjects may exhibit two types of risk aversion:

1. Constant Relative Risk Aversion (CRRA) $=U(x)=\frac{x^{1-rr}}{1-rr}$, where rr is a measure of the coefficient of relative risk aversion; or
2. Constant Absolute Risk Aversion (CARA) $=U(x)=-\mathrm{e}^{-ar*x}$, where ar is a measure of the coefficient of absolute risk aversion.

Coefficients corresponding to rr (ar) <0, rr (ar) =0, and rr (ar) >0 are associated with risk-loving, risk-neutral, and risk-averse behavior respectively. Given the preceding, rr and ar are calculated as follows:

$$rr=-\frac{xU''(x)}{U'(x)}$$

$$ar=-\frac{U''(z)}{U'(x)}$$

2.2 Auction settings

The second part of the study consists of the conservation auction experiment, which bears similarities to previous studies (see e.g., Cason and Gangadharan 2005), but has been modified to reflect the Japanese situation (see Table 3). The experiment employs multiple rounds of sealed-bid DP and UP auctions. Auction budgets are constrained but unknown to sellers. The pricing rules of DP and UP auctions are compared and consideration is given to the incentive of farmers (sellers) to reveal the opportunity cost of agri-environmental management practices that improve environmental quality. The environmental benefits of the sellers' proposed management contracts is concealed in order to better simulate real life, where farmers know the costs associated with conservation management and their impact on profits, but do not usually possess information about the environmental benefits associated with the conservation of farmland assets. Only final round bids are analyzed because sellers use the preceding rounds to gain an understanding of these environmental benefits. In order to control the potential for collusion between sellers, communications between sellers during auctions are prohibited. Specific environmental parameters are explained in the next section.

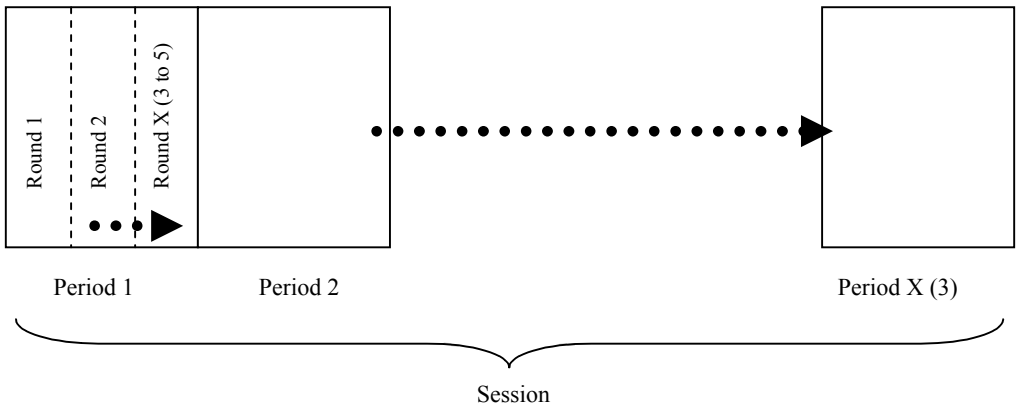
Table 3: A Comparison of the Auction Settings with those of Previous Studies

	Auction type		Rounds		Information available to seller?		Budget or environmental target constraints		Communication between subjects	
	UP	DP	Single round	Multiple rounds	Yes	No	Budget constraints	Environmental target constraints	Permitted	Not permitted
Cason et al. (2003)		√		√	√	√	√		√	
Cason and Gandagharan (2005)	√	√		√		√	√			√
Latacz-Lohman and Schilizzi (2007)		√		√		√	√	√		√
Sasaki *et al*. (2010)	√	√		√		√	√			√

2.3 Environment parameters and auction procedures

Six sessions of each type of auction were conducted, each with eight sellers. This called for a total of 96 participants. Each session consisted of three periods, which in turn consisted of three to five offer rounds. The number of periods and rounds in each session was unknown to sellers, who submitted sealed offers. In the UP auctions, successful sellers received a uniform price (per unit of environmental benefit) equal to the lowest rejected offer; in the DP auctions, successful sellers received the actual prices offered. Auction periods were declared final when a predetermined maximum number of rounds was reached, upon which the next period was started using different cost information. Sellers did not have knowledge of the buyers' budget, which was fixed at 50% of total opportunity cost. Figure 1 summarizes the timeline and steps of each session.

Figure 1: The Timeline and Steps of Each Round and Period



In each offer round, sellers submitted offer sheets that specified a desired sale price for each of three items that corresponded to different agri-environment-friendly management practices, although natural terminology was used to refer to these practices (see Table 4). The red, blue, and yellow items correspond to the agri-environment-friendly management practices of the application of manure at the ratio of one ton for every ten are (a) of land (1t/10a) (for carbon sequestration), a 50% reduction in the application of pesticide and chemical fertilizer (for water quality), and the maintenance of channels through weeding and mud-dredging (for biodiversity), respectively.

In addition, discrete environmental benefits can be obtained from each of the management practices because the practices are relatively independent. Consequently, the instructions explained that each seller would buy more than

two items in different colors. This rule setting differs from that of Cason et al. (2003) and Cason and Gangadharan (2005).

In their instructions, Cason et al. (2003) and Cason and Gangadharan (2005) use the term "quality" to refer to the environmental benefits of each item. However, our instructions describe these benefits as the "gold content" of the items desired by the buyer in order to improve the seller's understanding of the auction rule. This is based on the feedback we obtained from pre-experiments.

Sellers knew only their costs and had no information about the costs and environmental benefits (gold content) of other sellers. Neither did they know the government's budget, which was fixed at 50% of total project cost (opportunity cost) in all periods.

Table 4: Natural Terminology and Corresponding Management Practices

Natural terminology	Corresponding management practice and cost
Colored item Red Blue Yellow	Environment-friendly farm management • Application of manure at 1t/10a (for carbon sequestration) • 50% reduction in the application of pesticide and chemical fertilizer (for water quality) • Maintenance of channels through weeding and mud-dredging (for biodiversity)
Sale of item	Implementation of environment-friendly farm management
Item offer	Cost offered by individual farmers
Commission for sale of item	Real cost (opportunity cost) of individual farmers
The item's gold content	Environmental benefits (to be evaluated by indicator or in monetary terms)

2.4 Cost and environmental benefit parameters

We selected cost and benefit parameters that approximate the opportunities for environmental improvement through agri-environmental management in Japan. Table 5 presents the cost and environmental quality parameters used in the experiments. The exact cost and environmental benefit parameter of each practice was drawn independently from a uniform distribution with the indicated range. Consequently, sellers had different cost and environmental quality parameters that represented the heterogeneity of cost and environmental benefits among and within the practices.

2.4.1 Carbon sequestration through the application of manure at 1t/10a

Soil carbon stock is heavily affected by fertilizer management. Therefore, appropriate amounts of organic fertilizer could increase the carbon content of soil and reduce total greenhouse gas (GHG) emissions.[2] In addition, Japanese weather conditions make organic input well suited to the foregoing tasks. This is in contrast to no-tillage, which is unlikely to be a promising technique of suppressing carbon release from arable soil because Japan's high-humidity and high-temperature climate has made vigorous weed growth a serious bottleneck.

It is assumed that organic fertilizer (manure) will be spread at 1t/10a. Cost data consists of manure price, transportation costs, and application costs. The average cost of manure application per ton is 7,950 Japanese yen (JPY), according to field survey data by the Ministry of Agriculture, Forestry and Fisheries of Japan (MAFF, 2008). The benefit of this practice is the increase in the amount of soil carbon through the application of manure, and is estimated at 0.0584C-t/10a (0.214 tons of carbon dioxide [CO_2]/10a) by MAFF. In 2009, the price of one ton of CO_2

[2] Organic fertilizer applications help maintain soil fertility and create an environmental trade-off between methane (CH_4) emissions and soil carbon sequestration. Studies on comprehensive carbon dynamics are limited to paddy fields. Although this study does not cover the effects of manure application on CH_4 emissions, Sasaki (2010) shows that manure application (1–1.5t/10a) has a positive net effect on Japanese paddy and cropland (it decreases greenhouse gas [GHG] emissions).

was ten to fifteen Euros (EUR) per CO_2-t (approximately 1,100–1,650JPY per CO_2-t) under the European Union Emissions Trading Scheme (EU ETS). Therefore, the benefit of carbon sequestration per ten acres is estimated at 298JPY.

2.4.2 The improvement of water quality through a 50% reduction in the application of pesticide and chemical fertilizer

The next environmental issue is the improvement of water quality. The government currently makes fixed payments to farmers who use less than 50% of the amount of chemical fertilizers and synthetic agricultural chemicals than is consumed in conventional application (see Table 1). This is to support progressive farming activity and conserve local environments, and is assumed to cost 6,000JPY/10a (MAFF). Its benefits are calculated at 857JPY/10a by the Contingent Valuation Method (CVM) survey in Shiga prefecture, Japan[3].

2.4.3 The enhancement of biodiversity through the maintenance of channels via weeding and mud-dredging

The Japanese government supports cooperative conservation action by local farmers, such as the maintenance of channels through weeding and mud-dredging, by making direct payments for such action at a rate of 4,400 JPY/10a. This support is targeted at more than simply improving biodiversity, but has been used to represent the cost of the foregoing because no other precise data is available. Its benefits are estimated at 858JPY/10a (the CVM survey, cited in Aizaki et al. 2006).

All costs and benefits were assumed to have a range of ±20% from their average value for individual farmers.

Table 5: Cost and Benefit Data for Conservation Auctions

Activities	Application of manure at 1t/10a (for carbon sequestration)	50% reduction of pesticide and chemical fertilizer application (for water quality)	Maintenance of channel through weeding and dredging up mud (for biodiversity)
Cost (JPY/10a)	6625–9540	5000–7000	3667–5280
Average	7950	6000	4400
Benefit (JPY/10a)	248–358	714–1028	715–1030
Average	298	857	858

2.5 Choosing winners

In both auction formats, once the auctioneer received the sellers' submissions, calculated the ratio of their offer price to their benefit, and then prioritized projects according to this ratio from the lowest to the highest in each period. In the DP auctions, each successful seller received the actual price that they had offered. In the UP auctions, all the successful sellers received market-clearing prices that exceeded their offers.

Table 6 presents an example of one period of a UP auction. The column "ratio rank" shows the sellers' ranking. Sellers 1, 6, and 7 can sell their red items, but seller 3 (ranked fourth) cannot because no additional item can be purchased with the remaining the auction budget. All the red items are sold at the offer/benefit ratio of seller 1, who submitted the highest ratio (27.07) of all the accepted bids. Consequently, seller 6 receives 27.07 times their environmental benefit of 357JPY (i.e., 9,664JPY) instead of their red item offer of 7,700JPY; similarly, seller 7 receives 27.07 times their environmental benefit of 277JPY (i.e., 7,498JPY), and seller 1 receives their own offer of 8,500JPY. This rule was applied to the blue and yellow items in the same manner. Finally, sellers' benefits were calculated based on the winners' project cost and sale price.

[3] Estimated over all benefit in the Shiga prefecture was 7,879 million JPY (PRIMAFF and Shiga, 2003) and total agricultural land was 44,180ha. Consequently, 857JPY/10a is obtained.

Table 6: Example Cost, Benefit, Offer, and Winner Decision (UP)

	Project cost			Project benefit			Cost/benefit			Offer			Offer/benefit ratio			Ratio rank		
Seller ID	R	B	Y	R	B	Y	R	B	R	R	B	Y	R	B	Y	R	B	Y
1	8456	6929	4698	314	993	868	27	7	5	8500	6930	4700	**27**	7	5	3	6	4
2	7333	5914	5182	289	973	738	25	6	7	8243	6349	5183	29	7	7	5	4	8
3	7151	5325	4437	249	797	757	29	7	6	7000	5200	4300	28	**7**	6	4	3	7
4	8798	6645	4496	275	838	809	32	8	6	8850	6700	4400	32	8	5	8	8	5
5	7749	6421	4411	295	1025	1013	26	6	4	8500	6700	5100	29	7	**5**	7	5	3
6	6649	5528	4020	357	969	798	19	6	5	7700	5300	3200	**22**	**5**	**4**	1	1	1
7	7284	5924	4481	277	956	1016	26	6	4	7400	6200	4580	**27**	**6**	**5**	2	2	2
8	8812	5100	4297	348	797	771	25	6	6	10000	6000	4300	29	8	6	6	7	6

	Project sold?			Sale price (UP)			Benefit of seller		
Seller ID	R	B	Y	R	B	Y	R	B	Y
1	1	0	0	8500	0	0	44	0	0
2	0	0	0	0	0	0	0	0	0
3	0	1	0	0	5200	0	0	-125	0
4	0	0	0	0	0	0	0	0	0
5	0	0	1	0	0	5100	0	0	689
6	1	1	1	9664	6322	4018	3015	794	-2
7	1	1	1	7498	6237	5115	214	313	634
8	0	0	0	0	0	0	0	0	0

3. Results

3.1 Preliminaries

Ninety-six university students at Japan's Shiga University took part in these experiments, which were conducted from November 2008 to June 2009. At the beginning of each session, the subjects were organized into a group of eight persons. Each session consisted of a lottery choice experiment and an auction experiment, and each type of auction was conducted six times. There were three periods in each session and each period consisted of three to five rounds, but subjects were told that each session would last an unknown number of periods and rounds.

At the completion of the experiment, each subject was paid earnings equal to the conversion of their laboratory market earnings to Japanese yen. The conversion rate was not announced until all the sessions had ended. Sessions typically lasted 90 minutes, including instruction time. Average subject earnings were about US$40 (4,320JPY), depending upon individual performances during the experiments.

3.2 Risk attitudes

Before the data was analyzed, portions of data that were inconsistent with the lottery choices were excluded. Table 7 reports the distributions of the number of safe choices made by each included subject and Figure 2 plots the percentage of safe choices in each of the ten decision tasks shown in Table 7. First, it is apparent that the majority of subjects in the sample are risk averse, and this is consistent with previous studies (see e.g., Lusk and Coble 2008). A risk-averse individual would choose option A for the first four decision tasks; the majority of respondents chose option A five or more times.[4] However, risk-loving and risk-neutral individuals also exist, making up 39% of the sample. Second, there are no significant differences between subjects in UP sessions and subjects in DP sessions.

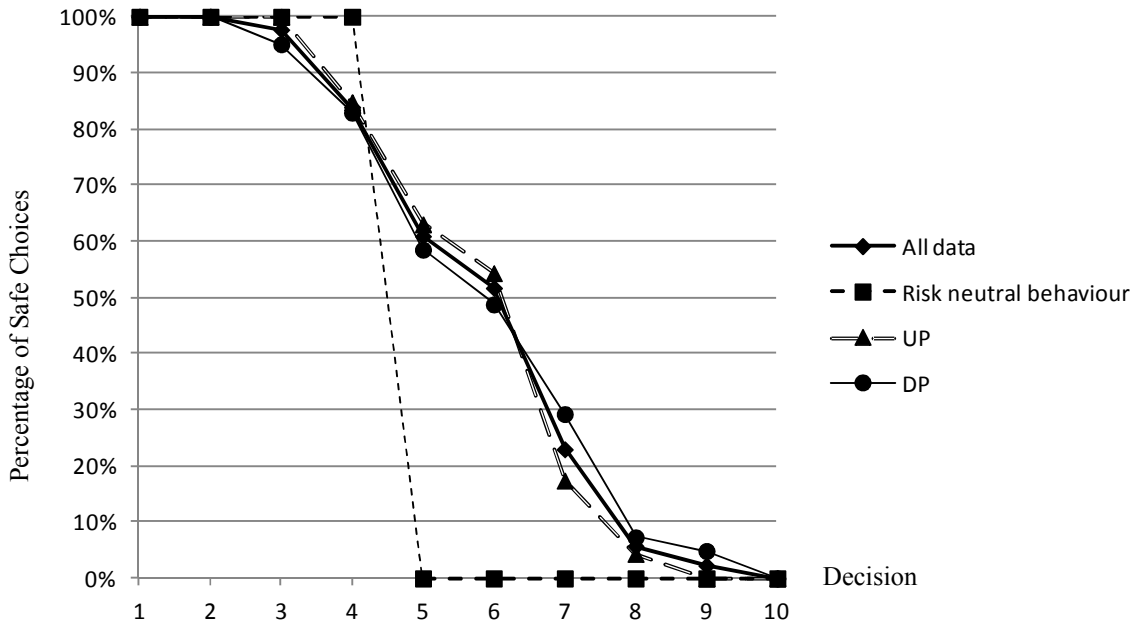
[4] We also conducted a mail survey of Japanese farmers in hilly and mountainous regions in 2008. Three thousand and forty-three questionnaires were circulated to fifteen randomly selected regions and overall response rate was 14.4%. No significant differences are observed in risk preference

Table 7: Risk Aversion Classification Based on Lottery Choices

Number of safe choices	Range of relative risk aversion(1)	Range of absolute risk aversion(2)	Risk preference classification	Number of subjects	Proportion of subjects
0–1	rr<-0.97	ar<-0.11	Highly risk-loving	0	0%
2	-0.97<rr<-0.49	-0.11<ar<-0.06	Very risk-loving	2	2%
3	-0.49<rr<-0.12	-0.06<ar<-0.02	Risk-loving	12	14%
4	-0.12<rr<0.19	-0.02<ar<0.03	Risk-neutral	20	23%
5	0.19<rr<0.49	0.03<ar<0.07	Slightly risk-averse	8	9%
6	0.49<rr<0.79	0.07<ar<0.11	Risk-averse	25	29%
7	0.79<rr<1.12	0.11<ar<0.17	Very risk-averse	15	17%
8	1.13<rr<1.61	0.17<ar<0.25	Highly risk-averse	3	3%
9–10	1.61<rr	0.25<ar	Stay in bed	2	2%
SUM				87	100%

(1)Assuming $U(x) = x^{(1-rr)}/1-rr$
(2)Assuming $U(x) = -exp(-ar*x)$

Figure 2: Percentage of Safe Choices



3.3. Auctions

3.3.1 Overall market performance

Figures 3 and 4 summarize the offer data with scatter plots that display the final round offers of auction sellers against their cost draws for the three types of environmental externalities (carbon sequestration, water quality, and biodiversity). In DP auctions, 93.3% of offers exceed costs, as expected. On the contrary, the scatter plot of offers for UP auctions is more centered on the "offer = cost" line, with 80.6% of offers exceeding costs. Table 8 shows that the percentage of offers above cost does not differ significantly between project types.

between Japanese farmer and students in classroom experiments of this paper.

Figure 3: Individual Offers in the Final Round (DP)

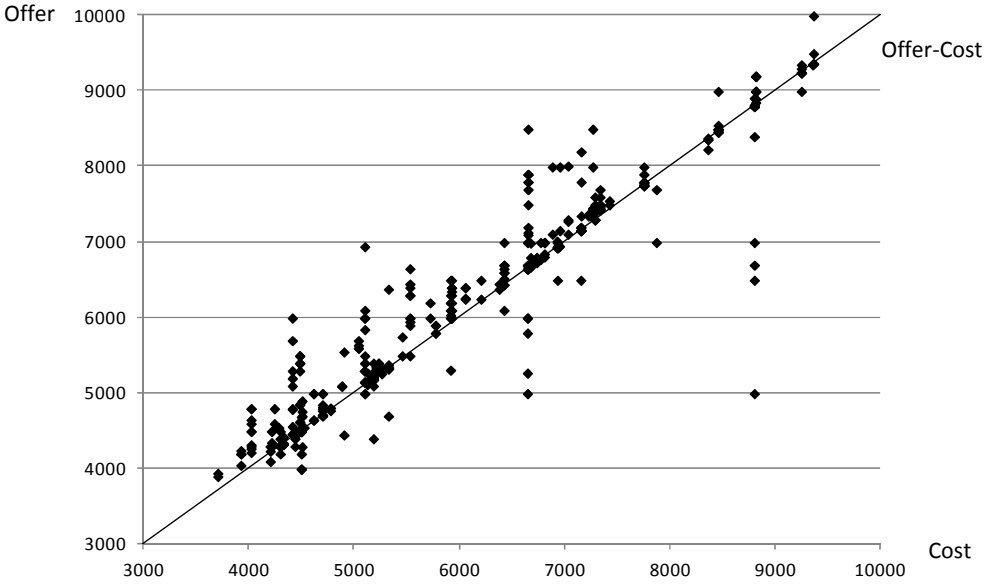


Figure 4: Individual Offers in the Final Round (UP)

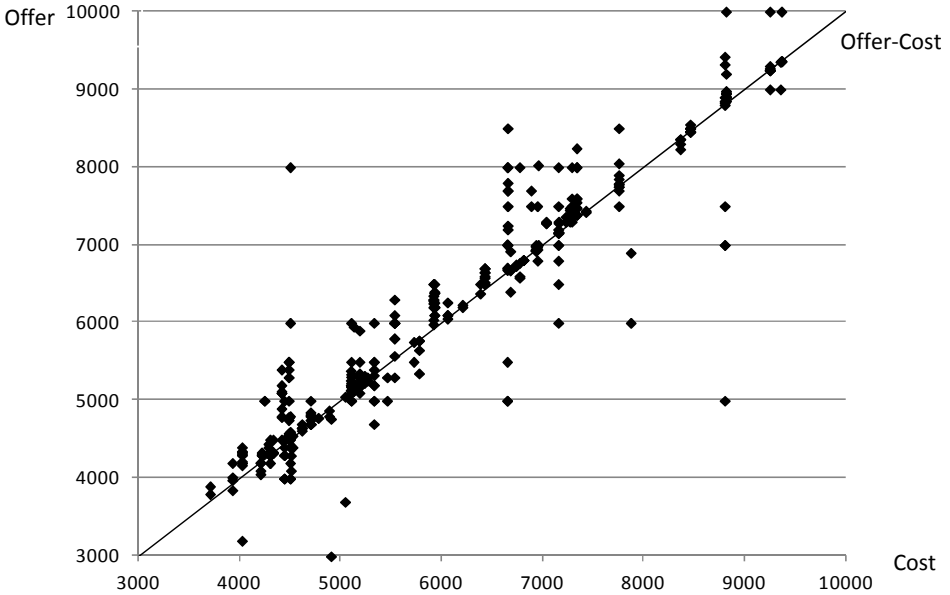


Table 8: The Percentage of Above-cost Offers for Different Auction and Project Types

	DP			UP		
	No. of observations	No. above cost	%	No. of observations	No. above cost	%
R (high-cost management)	144	135	93.8%	144	118	81.9%
B (medium-cost management)	144	133	92.4%	144	117	81.3%
Y (low-cost management)	144	135	93.8%	144	113	78.5%
SUM	432	403	93.3%	432	348	80.6%

In the next step, overall market performances are provided based on Cason et. al's (2003) method, which differ from the typical efficiency measure used in laboratory experiments because they need to evaluate the conservation auctions not only for cost efficiency, but also for environmental effectiveness. To assess these, the following market measures are introduced:

- ENV(environmental effectiveness: for the percentage of maximum environmental benefit realized)
- COST (cost efficiency: for the percentage of optimal cost effectiveness)

As one of the most important policy targets of the conservation auctions, high levels of environmental benefit need to have been achieved with the given budgets in order for the auctions to be adjudged environmentally effective. Therefore, the auctions need to have selected as many management practices as possible, or chosen those that give the highest amount of environmental benefit. In addition, the least costly projects should have been selected.

The overall performances of the three management practices in DP and UP auctions are reported in Table 9 and 10 respectively. Both ENV and COST are slightly greater in DP than in UP, although the Mann-Whitney test did not reject the hypothesis of equal efficiency across treatment for either measure. Nevertheless, results for high-cost management projects (represented by the red item—manure management for carbon sequestration) show that ENV scores a much lower value in UP than it does in DP (p-value = 0.031).

Under the auction settings, a sale of three to four practices per round is considered acceptable because the sellers' budgets are constrained at half their total opportunity cost. In rounds that resulted in the sale of four practices, ENV values of close to 100% represent successful contracts. (These values are underlined in Tables 9 and 10.) The number of successful contracts differs significantly across DP and UP auctions, coming in at 23% (23/108) in DP auctions and 12% (12/108) in UP auctions. It is conjectured that the inefficiency of UP auctions is caused by the UP pricing rule, which creates much greater levels of overcompensation than those produced by overbidding in DP.

Another measure of the efficiency of the two auction types is the comparison of seller profits, which represent government overspending relative to the actual cost of implementing agri-environment-friendly management practices. Tables 9 and 10 show seller profits in DP and UP auctions respectively. Seller profits achieve an average of 3,581JPY in DP auctions and 5,017 JPY in UP auctions. The Mann-Whitney test strongly rejects the hypothesis of equal seller profits across treatment (p-value = 0.0033). Seller profits are significantly higher in UP.

Thus, DP auctions outperform UP auctions as far as environmental effectiveness and government expenditure savings are concerned. However, relationship between average individual risk attitudes and overall market performance are not significant (see also the bottom line of Table 9 and 10), because market performance measures used here can not include the losers' attitudes. In order to study the foregoing, the next section considers individual bidding behavior and risk attitudes.

Table 9: Overall Session Performance and Individual Risk Attitudes (DP)

Session		DP1			DP2			DP3			DP4			DP5			DP6			Treatment
Period (round)		1 (4)	2 (4)	3 (3)	1 (4)	2 (4)	3 (3)	1 (5)	2 (3)	3 (4)	1 (5)	2 (3)	3 (4)	1 (5)	2 (3)	3 (4)	1 (5)	2 (3)	3 (4)	mean
Carbon	ENV	77%	77%	79%	72%	100%	79%	77%	100%	100%	98%	101%	100%	76%	100%	104%	72%	100%	100%	89.7%
	COST	98%	93%	94%	99%	98%	93%	97%	97%	97%	99%	95%	97%	93%	94%	91%	99%	96%	94%	95.7%
Water quality	ENV	71%	97%	76%	76%	100%	78%	70%	98%	99%	74%	76%	100%	76%	76%	100%	76%	100%	100%	85.7%
	COST	94%	94%	90%	96%	94%	91%	94%	94%	92%	98%	94%	96%	94%	93%	94%	96%	94%	92%	93.8%
Biodiversity	ENV	77%	100%	97%	77%	74%	76%	72%	74%	74%	100%	76%	100%	78%	100%	74%	84%	74%	74%	82.3%
	COST	90%	94%	93%	95%	95%	93%	91%	97%	96%	98%	94%	96%	89%	94%	94%	103%	96%	94%	94.6%
Seller profit (JPY)		3779	4592	4695	2891	2883	5979	3208	2140	3726	-724	3532	2569	5502	4218	4085	3272	3431	4680	3581
No. of safe choices			5.5			6.0			5.0			5.0			5.9			4.6		5.3

Table 10: Overall Session Performance and Individual Risk Attitudes (UP)

Session		UP1			UP2			UP3			UP4			UP5			UP6			Treatment
Period (Round)		1 (4)	2 (4)	3 (3)	1 (4)	2 (4)	3 (3)	1 (5)	2 (3)	3 (4)	1 (5)	2 (3)	3 (4)	1 (5)	2 (3)	3 (4)	1 (5)	2 (3)	3 (4)	mean
Carbon	ENV	74%	76%	79%	76%	77%	83%	73%	78%	79%	77%	76%	79%	78%	78%	79%	91%	78%	79%	78.4%
	COST	88%	104%	89%	90%	91%	95%	93%	89%	90%	90%	90%	91%	90%	96%	92%	91%	95%	92%	92.0%
Water quality	ENV	69%	100%	78%	69%	100%	97%	76%	100%	78%	90%	75%	78%	76%	76%	76%	90%	73%	78%	82.2%
	COST	93%	93%	94%	94%	97%	99%	94%	92%	91%	95%	93%	89%	94%	93%	93%	95%	89%	91%	93.4%
Biodiversity	ENV	77%	75%	100%	77%	74%	94%	70%	76%	100%	77%	74%	100%	78%	74%	74%	77%	74%	100%	81.6%
	COST	95%	93%	96%	91%	94%	91%	90%	92%	96%	91%	90%	95%	88%	93%	96%	90%	90%	95%	92.6%
Seller profit (JPY)		5577	808	6020	5929	4682	1961	3885	6282	6271	6073	6366	6836	6350	3475	4989	3301	5557	5936	5017
No. of safe choices			5.4			5.6			5.9			4.9			5.3			4.6		5.3

3.3.2 Offer behavior and risk attitudes

This section describes sellers' risk attitudes in detail. The experiment drew upon a set of eight sellers with three items each. Six sessions of each type of auction were conducted, with each session consisting of three periods. Thus, each auction type comprised 432 cost draws, of which only final round bids are analyzed here:
8 sellers × 3 items × 6 sessions × 3 periods = 432 cost draws

Ferraro (2008) have already mention about the role of risk attitude in auctioning conservation contracts from previous studies that under standard assumptions the DP and UP formats yield the same expenditures (Milgrom, 2004), however, the characteristics of conservation procurement auctions are unlikely to result in expenditure neutrality.

Risk-loving and risk-neutral are defined here as those who chose less than four safe choices at the lottery choice experiment, while the highly risk averse are those opted for more than eight safe choices. Data that were inconsistent with the lottery decision choices and negative bid in DP were excluded. The significant relationship between risk attitude and bidding behavior is shown by the difference in opportunity cost between individual sellers in DP (Table 11), however not for slightly risk averse individuals. Risk-averse individuals are aggressive to win the auction in comparison with risk-loving and risk-neutral sellers in the DP auctions. Therefore, in the conservation procurement auction, risk-averse landowners have an incentive to reduce their bid-prices below the bid-prices of risk neutral landowners. Otherwise, risk aversion does not affect incentives in UP auctions as predicted.

The bidding behavior in the DP auctions is consistent with conjecture by economists (see e.g., Lind and Plott 1991), who explain it as a form of risk aversion that drives bidders to spend more money (decrease benefit) so that they can be sure of a win, rather than risk losing. Another explanation is that the element of competition drives sellers to aggressive bid so that they can experience the joy of winning.[5]

Table 11: Bidding Behavior and Risk Attitudes

		DP		UP	
	No. of safe choice	Difference with Opportunity cost (mean)	No. of observations	Difference with Opportunity cost (mean)	No. of observations
Risk loving and neutral	less than 4	247	138	68	153
Highly risk averse	8	185	9	62	18
	9	74	17	n.a.	n.a.

4. Discussion and Conclusion

Auctions provide a noteworthy alternative for the promotion of agri-environmental programs in Japan, although the dominant practice of doing so thus far has been to offer fixed payments for certain environment-friendly farming and management practices. In fact, over 60% of farmers in hilly and mountainous regions are interested in supporting agri-environmental conservation through the auctioning of contracts.

The laboratory auctions conducted in this research compare the performance of DP and UP auctions in three different environmental applications tailored to the Japanese situation. In addition, the auctions also consider the effect of individual risk preferences on performance outcomes.

The results show that DP auctions outperform UP auctions in terms of environmental effectiveness and government expenditure savings, even though UP auctions have better cost revelation incentives. This is consistent with the principal results of Cason and Gangadharan (2005) and is despite the fact that sellers in DP auctions overbid.

Policymakers are beginning to understand that the effect of individual risk attitudes on policy outcome is an important element in the creation of appropriate agri-environmental policies. In fact, the United Kingdom's (UK) Department

[5] In addition to these economic explanations of overbidding, Delgado et al. (2008) combine neuroeconomic and behavioral economic techniques to argue that there may be yet another factor causing overbidding in normal auctions, namely loss contemplation in a social context (i.e., the fear of losing).

for Environment, Food and Rural Affairs (DEFRA) (2008) announced that internal factors need to be identified before policy interventions are made, and said that it was important to recognize and respond to individual characteristics by putting them at the forefront of policy development.

If DP auctions are chosen for field application, it will be necessary to develop an Environmental Benefit Index (EBI) based on scientific evidence so that farmers do not succumb to the winner's curse, although winners curse effect cannot be explained single element (Holt and Sherman, 2000). Conservation auctions are assumed to have independent private values if the environmental benefit is clearly known. But in practice conservation procurement auctions may have common-value elements. Currently, little is known of the relative costs and benefits of using agricultural land (especially rice paddy fields) instead of other land use types to provide ecosystem services (Organization for Economic Co-operation and Development [OECD] 2008). Concealing information about the environmental benefits of agri-environmental managements may improve regulatory efficiency.

The conclusion that DP auctions outperform UP auctions is in line with previous studies, but may not hold in all circumstances. However, as the first step toward designing conservation auctions, this empirical research deepens our understanding of the field potential of such auctions. The next step forward is to test the research findings by conducting field experiments using real farmers.

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