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Summary

Utilizing the random utility and random profit difference approaches, we develop a theoretical model that explains why farmers may require a premium in excess of the decrease in profits to adopt a conservation plan. Identification of this risk premium can aid the government in addressing approaches to lowering the costs of encouraging farmers to adopt the conservation programs. Previous work done in this area has not successfully identified this premium We estimate this premium using survey of farmers in conjunction with predictions of changes in production costs. To increase the efficiency of the econometric analysis of survey responses, we use the so-called "one-and-one-half-bound" (OOHB) elicitation format. Furthermore, to test the sensitivity of our estimation results to functional form and distributional specifications, we compare the results utilizing parametric, nonparametric, and semi-nonparametric econometric approaches.

Key Words: Risk premium, contingent valuation, willingness to accept, one-and-one-half-bound discrete choice elicitation format, agri-environmental practices

JEL: Q14, Q25

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Introduction

Agri-environmental payment programs can accomplish the task of improving the environmental performance of agriculture (Claassen and Horan; Batie; Lynch and Smith; Smith; Feather and Cooper). In the US, the USDA's Environmental Quality Incentives Program (EQIP) provides farmers incentive payments to adopt conservation plans that include environmentally benign management practices. In the European Union, "Agenda 2000" sets general guidelines and goals under which member countries can compose agri-environmental programs that include incentive, or stewardship, payments to farmers in return for adopting environmentally friendly management practices or for providing various environmental amenities. Member countries and sub-country level administrative units are free to compose their own plans under these rules[1].

For policymaking purposes, in order to predict the extent of farmer adoption of conservation plans and the associated budgetary costs, it is useful to know the sensitivity of the producer's decision to adopt a conservation plan to a schedule of potential incentive payments. One might initially consider that data on a farmer's cost of production is all that is needed to estimate a function relating the farmers' acceptance of a conservation plan to the incentive payment. However, cost of production data does not consider the potentially different variance in yields under a conservation plan versus that under the traditional management practices, nor does it tell us anything about the farmer's potential nonprofit-related preferences for acting in environmentally sound manner. Hence, the former suggests that the incentive payment needed to encourage the farmer to adopt the conservation plan may actually require a premium exceeding the reduction in profits associated with certain conservation plans, or that an incentive payment may be required even in cases in which the conservation plan is associated with an increase in profits. On the other hand, if a farmer desires to act in an environmentally sound manner, this premium associated with risk may be offset by an environmental premium that lowers the necessary incentive payment relative to the case where adoption decision is strictly business-related. Existing published research (e.g., Cooper; Cooper and Keim) estimates the incentive payments needed to achieve adoption of conservation practices utilizing data obtained from surveys of farmers, in which farmers are asked whether or not they would adopt a conservation practice at various offered incentive payments. The adoption functions estimated in these papers are sufficient for predicting farmer adoption of conservation plans as a function of the offered incentive payments, but they do not separately identify the premiums mentioned above.

In this paper, we examine the farmer's premium for adoption of conservation plans. Utilizing the random utility difference approach as well as the random profit difference approach, we develop the theoretical model that explains why the farmer may not choose to accept the conservation plan even when the decrease in profits associated with adoption of the plan is less than the incentive payment. Namely, the model demonstrates why the farmer may require a premium in excess of the decrease in profits associated with adoption of the conservation plan. Identification of this risk premium may potentially aide the government in addressing approaches to lowering the costs of encouraging farmers to adopt the conservation programs, e.g., using technical assistance and education to lower the farmers' perception of risk associated with conservation practices. Previous work done in this area has not successfully identified this premium. The same model is also used to explain cases in which the risk premium is offset by a premium association associated with farmer's preferences towards the environment, as well as why an incentive payment may still be required in cases where expected profits with the conservation plan are higher than without adoption of the plan. In the course of providing this model in the theoretical section of the paper, we analytically demonstrate the relationship of this random utility difference approach to the random profit difference approach, and establish the implications of the choice of approach for applied work.

The theoretical approaches discussed here can be used as basis for empirical analysis using either observed data or a combination of cost of production data and survey data, with the latter approach being most useful for conservation programs not yet implemented. In this paper's empirical application, we examine the farmer's adoption premium for a new hypothetical agri-environmental program in Sicily that falls under the general purview of the the "Agenda 2000". We use in-person surveys of farmers to elicit their willing to accept an incentive payment in return for their adoption of the proposed program in conjunction with predictions of production costs under the conservation plan that drawn from agronomic data.

As has become the preferred approach in survey questions that elicit the respondent's reaction to a payment offer, the conservation adoption question asked to the Sicilian farmers uses a discrete "take it or leave it" format. In this case, the farmer is asked to accept or reject an offered incentive payment, a value which is varied across respondents. Econometric analysis of the responses is to estimate the farmers' minimum willingness to accept (WTA) for the adoption of the conservation plan. To increase the efficiency of the econometric analysis of these responses, a new approach for asking follow-up questions is used to narrow the bounds on the farmers' minimum WTA. This approach, called the one-and-one-half-bound (OOHB) approach (Cooper, Hanemann, Signorello), reduces the potential for response bias to the follow-up bidding questions while maintaining much of the efficiency gains of the older multiple-bound approaches such as the double bound approach. Furthermore, to test the sensitivity of our estimation results to functional form and distributional specifications, we compare the results utilizing parametric, nonparametric, and semi-nonparametric econometric approaches.

The Theoretical Model

As the theory behind modeling farmer acceptance of incentives for the adoption of conservation practices is well known (Cooper and Keim; Cooper; Cooper and Osborn), this section gives a brief overview, with an extension of the theory to explicitly consider the risk premium. While Cooper and Osborn note that farmer participation in a conservation program may require that the incentive payment, B', may have to more than cover the mean loss in profits associated with adoption of the plan, no formal derivation is provided. Consider $ð_1$ to be profits with the conservation plan (excluding the incentive payment but including any fixed costs associated with adopting the plan) and $ð_0$ to be profits in the base state, and assume that profit under both states is stochastic. Considering the decision to accept the program strictly as a business decision, the farmer will accept the program if $B' \geq (ð_0.- ð_1) + P(ó^2(ð_1), ó^2(ð_0))$, where P(.) is a premium that accounts for the change in risk associated with moving from one state to the other, and is a function of the variance of profits in the two states and possible higher moments of the distributions as well, and may include transaction costs to the farmer seeking out information on the conservation approaches. If $ó^2(ð_1) > ó^2(ð_0)$, then P(.) is expected to be positive.

In Cooper and Cooper and Keim, the farmer's discrete decision to accept incentive payments in exchange for adopting the conservation practices is modeled using the random utility model (RUM) approach (e.g. Hanemann). Extending their approach with the addition of the risk premium concept above, from the utility theoretic standpoint, a farmer is willing to accept B’ to switch to a new production practice if the farmer's utility with the new practice and incentive payment is at least as great as at the initial state, i.e., if $U_1(L_1,ð_1,ó(ð_1),\boldsymbol{s}, B') \geq U_0(L_0,ð_0, ó(ð_0), \boldsymbol{s})$, where 0 is the base state; 1 is the state with the green practice adopted and L1 is the farm land under the conservation plan and L0 is the farm land under the conventional practices. The farmer's utility function is unknown because some components are unobservable to the researcher, and thus, can be considered a random variable from the researcher's standpoint. The observable portion is *V*, the mean of the random variable *U*. With the addition of an error *å*, where *å* is an independently and identically distributed random variable with zero mean, the farmer's decision to adopt the practice can be re-expressed as $V_1(L_1,ð_1, ó(ð_1), \boldsymbol{s}, B') + å_1$ $V_0(L_0,ð_0, ó(ð_0), \boldsymbol{s}) + å_0$.

In practice, V_1 and V_0 are generally not separably identifiable, but their difference (ΔV) is. This is done by expressing the probability of adoption in a probability framework as $\Pr\{e_0 - e_1 \leq V_1 - V_0\}$, and hence, the parameters of which can be estimated through maximum likelihood. Assuming that the marginal utility of a dollar is independent of its source, ΔV = $f(ð_1 - ð_0 + B' + P(ó(ð_1),ó(ð_0)), \boldsymbol{s}, , L_1, L_0,) + å$. As is evident, the farmer’s business decision is explicitly embedded in the utility difference model that accounts for the risk premium. For practical purposes, the only difference between using a random profit approach versus the random utility approach is that the latter provides the motivation for including other than business related explanatory variables in the econometric analysis. If $ð_1$and $ð_0$ are known to the researcher, then P can be separably identified, else only the composite function $B = ð_1 - ð_0 + B' + P$ can be known to the researcher, as is the case in the existing literature..

Because ΔV is generated directly from the utility model given above, it is compatible with the theory of utility maximization. Many different specifications for ΔV are possible, including semi-nonparametric (e.g., Creel and Loomis). The probability of farmer adoption at *B* is $\mathrm{F}_e\left\lfloor \Delta V\left(g^{j}\right)\right\rfloor$, where *G* is a cumulative density function. The estimated CDF can be used both to calculate the farmer's probability of acceptance of the incentive payment across a range of incentive payments or to calculate the average minimum WTA.

Econometric Approaches

When measuring respondents' maximum willingness to pay (WTP) or minimum WTA, most survey designs have switched in recent years from using an open-ended format in which respondents are asked how much they would be willing to pay for the item to a closed-ended format in which they are asked whether or not they would be willing to pay or accept some specified price.[2] The closed-ended format was first introduced by Bishop and Heberlein, who used what is now known as the single-bounded (SB) version in which each subject is presented with a single monetary amount, the amount being varied across respondents. Hanemann, Loomis, and Kanninen – henceforth, HLK – introduced a variant, the double-bounded (DB) format, in which the subjects are presented with a price as in the SB approach, but after responding they presented with another price and asked whether they would also be willing to pay that amount. The second price is set on the basis of the subject's response to the first price. If the subject responds "yes" the first time, the second price is some amount higher than the first price; if the initial response is "no," the second price is some amount lower. HLK showed analytically that the extra information gained from the follow-up question makes the DB estimates more efficient than the SB estimates, and they presented an empirical application in which this efficiency gain was quite large – for virtually no extra survey cost there was a significant improvement in the precision of the estimated WTP distribution. Given the estimated distribution, it was apparent ex post that the initial prices in that survey had been chosen poorly and were quite far from optimal; but HLK found that the second prices counteracted this and provided an effective insurance against the poor selection of an initial price.

Because of its statistical efficiency, the DB approach has gained in popularity and is now often favored over the SB approach. At the same time, however, it has aroused controversy because of evidence that responses to the first price may sometimes be inconsistent with the responses to the second, with the latter revealing a lower WTP (Hanemann, McFadden and Leonard, Cameron and Quiggin, Kanninen, Herriges and Shogren, DeShazo), Several explanations have been proposed for the anomaly. Carson et al. suggest an explanation based on cost expectations: a respondent who said "yes" to the initial price sees the second price as a price increase, which he rejects; a respondent who said "no" and is then offered a lower price may suspect that an inferior version of the item will be provided, which he also is disposed to reject. Altaf and DeShazo suggest that the second bid converts what had seemed to be a straight forward posted-price market into a situation involving bargaining; if this is bargaining, the respondent should say no in order to drive the price down. DeShazo offers a prospect theory explanation involving loss-aversion and framing on the first price.

Existing applications of the DB approach all use scenarios where the respondent is *not* told ahead of time that she will be confronted with a second price; the interview focuses mainly on the first price, and the second price comes as something of a surprise when introduced at the end. We suspect that this surprise may be the root cause of the discrepancy in the responses to the two prices. To remedy this, we propose an alternative survey design in which the respondent is given two prices up front and told that, while the exact cost of the item is not known for sure, it is known to lie within the range bounded by these two prices.[3] One of the two prices is selected at random, and the respondent is asked whether she would be willing to pay this amount; she is then asked about the other price only if doing so would be consistent with the stated price range. For example, if the lower of the two prices price was selected initially and she says “yes” to this, she is then asked whether she would be willing to pay the higher price; but, if she says “no” to the lower price, there is no follow-up question because that would go below the stated price range. We believe that eliminating the element of surprise has the potential to remove discrepancies in the responses to the two valuation questions, but it comes at the cost of not always being able to ask the second valuation question: the second question will be appropriate half the time, on average, but not the rest of the time. Hence, we refer to this as the one-and-one-half bound format (OOHB).

In the SB format, the i^{th} respondent is asked if she would be willing to pay some given amount B_i^* (henceforth we refer to this as the “bid”) to obtain, say, a given improvement in environmental quality. The probability of a “yes” response, or a “no” response, $p_i^Y\left(B_i^*\right)$, can be cast in terms of a random utility maximizing choice by the respondent. By virtue of the random utility framework the individual's WTP is a random variable from the point of view of the econometric observer, reflecting individual variation in preferences and unobserved variables or measurement error in the observed variables. Thus, while the individual knows her own WTP, C_j, to the observer it is a random variable with a given cumulative distribution function (cdf) denoted $G(C_i;\ \grave{e})$ where $\grave{e}$ represents the parameters of this distribution, which are to be estimated on the basis of the responses to the CV survey. The parameters will be functions of the variables in X_i, but this is left implicit in $G(C_i;\ \grave{e})$. For example, there can be a mean of the WTP distribution which depends on covariates, $\grave{\imath} = X\hat{a}$, and a variance, $\acute{o}^2$. In this case, $\grave{e} = (\hat{a},\ \acute{o}^2)$.

Then, as noted by Hanemann, the response probabilities are related to the underlying WTP distribution by

(1a) $$p_i^N \equiv \Pr\{No\ to\ B_i^*\} \equiv \Pr\{B_i^* > C_i\} = G(B_i^*;q)$$

(1b) $$p_i^Y \equiv \Pr\{Yes\ to\ B_i^*\} \equiv \Pr\{B_i^* \leq C_i\} = 1 - G(B_i^*;q)$$

The resulting log-likelihood function for the responses to a CV survey using the SB format is

(2) $$\ln L^{SB}(q) = \sum_{i=1}^{N} \left\{d_i^Y \ln\left[1 - G(B_i^*;q)\right] + d_i^N \ln G(B_i^*;q)\right\}$$

where $d_i^Y = 1$ if the ith response is Yes and 0 otherwise, while $d_i^N = 1$ if the ith response is No and 0 otherwise, The maximum likelihood estimator (MLE), denoted $\hat{q}^{SB}$, is the solution to the equation $\partial \ln L^{SB}\left(\hat{q}\right)^{SB} / \partial q = 0$.

The survey instrument used for this paper utilizes the one-and-one-half bound format (OOHB) in which the respondent is presented with a range, $\left[B_i^-, B_i^+\right]$, where $B_i^- < B_i^+$ (Cooper, Haneman, and Signorello). One of these two prices is selected at random and the respondent is asked whether she would be willing to pay that amount. She is asked about the second price only if that is compatible with her response to the first price. If the lower price, B_i^-, is randomly drawn as the starting bid, the three possible response outcomes are (No), (Yes, No) and (Yes, Yes); we denote the corresponding response probabilities $p_i^N, p_i^{YN}, p_i^{YY}$. If the higher price, B_i^+, is randomly drawn as the starting bid, the possible response outcomes are (Yes), (No, Yes) and (No, No). We denote the corresponding response probabilities $p_i^Y, p_i^{NY}, p_i^{NN}$[4] Observe that

(3a) $$p_i^N = p_i^{NN} = \Pr\{C_i \leq B_i^-\} = G(B_i^-;q)$$

(3b) $$p_i^{YN} = p_i^{NY} = \Pr\{B_i^- \leq C_i \leq B_i^+\} = G(B_i^+;q) - G(B_i^-;q)$$

(3c) $$p_i^{YY} = p_i^{Y} = \Pr\{C_i \geq B_i^+\} = 1 - G\left(B_i^+;q\right)$$

Let $d_i^N = 1$ if either the starting bid is B_i^- and the response is (No) or the starting bid is B_i^+ and the response is (No, No), and 0 otherwise; let $d_i^{YN} = 1$ if either the starting bid is B_i^- and the response is (Yes, No) or the starting bid is B_i^+ and the response is (No, Yes), and 0 otherwise; and let $d_i^{YY} = 1$ if either the starting bid is B_i^- and the response is (Yes, Yes) or the starting bid is B_i^+ and the response as (Yes), and 0 otherwise. Then, the log-likelihood function for the responses to a survey question using the OOHB format is (Cooper, Hanemann, and Signorello)

(4) $$\ln L^{OOHB}(q) = \sum_{i=1}^{N}\left\{d_i^Y \ln\left[1 - G\left(B_i^+;q\right)\right] + d_i^{YN} \ln\left[G\left(B_i^+;q\right) - G\left(B_i^-;q\right)\right] + d_i^N \ln\left[G\left(B_i^-;q\right)\right]\right\}$$

The specification above implicitly assumes that in the cases in which there is a follow-up response, the correlation, call it ñ, is equal to 1. However, because the researcher will never be able to fully model the respondent’s decision making process (i.e. the research has insufficient information to consistently predict the respondent’s response to the follow-up based on his response to the first bid), in practice this assumption may be too strong. Alternatively then, we can specify a hybrid likelihood function in which responses with a follow-up are distributed with a bivariate normal distribution, and those without a follow-up follow the univariate distribution. We use this approach for estimation.

With the OOHB survey format, since the respondent is told about the possible range of costs at the beginning of the survey we believe she is less likely to form false cost expectations, enter into bargaining mindset, or experience loss-aversion when responding to the follow-up bid. (Cooper, Hanemann, and Signorello) find that there is less likely to be a discrepancy between the responses to the first and second bids with the OOHB format than with the DB format. Note that we can derive an SB data set from the OOHB data set. In the case of WTA, for example, the SB response is ‘yes’ when the OOHB answer is ‘yes’ when B- is drawn first, and ‘yes’ when the OOHB answers are (Yes, No) and (Yes, Yes) when B+ is drawn first.

To analyze the OOHB survey responses, we use both a parametric approach, based on the normal WTP distributions, and a semi- nonparametric distribution-free (SNPDF) approach, first applied to SB data by Creel and Loomis and extended here to OOHB data[5]. The reason for the SNPDF approach is to reduce the sensitivity of our econometric analysis to specific parametric assumptions regarding the form of the WTP distribution. In the event, both approaches produced similar results. A simple way to motivate the SNPDF approach is to observe that, with the normal WTP distribution, the CV response probabilities corresponding to, say, (1a), (3b) take the form

$$p_i^N = G\left(B_i^*;q\right) \equiv F\left[\Delta V\left(B_i^*\right)\right] \tag{1a'}$$

$$p_i^{YN} = G\left(B_i^+;q\right) - G\left(B_i^-;q\right) \equiv F\left[\Delta V\left(B_i^+\right)\right] - F\left[\Delta V\left(B_i^-\right)\right] \tag{3b'}$$

where F(.) is the standard normal cdf and

$$\Delta V\left(b\right) \equiv -a + bB \tag{5}$$

is what Hanemann calls a utility difference function, which is increasing in the bid price, *B*. The SNPDF approach retains the normal cdf in the response probabilities such as (1a'), (3b'), but replaces the linear utility difference with a Fourier flexible form (e.g. Gallant). where (omitting quadratic term as in Creel and Loomis)

$$\Delta V\left(\mathrm{x},q_k\right) = \mathrm{x}b + \sum_{a=1}^{A}\sum_{j=1}^{J}\left(v_{ja}\cos\left[j\mathrm{k}'_a s(\mathrm{x})\right] - w_{ja}\sin\left[j\mathrm{k}'_a s(\mathrm{x})\right]\right) \tag{6}$$

where the vector $\mathbf{x}$ contains all arguments of the utility difference model, A and J are positive integers, and $\boldsymbol{k}_\alpha$ are vectors of positive and negative integers that form indices in the conditioning variables, after shifting and scaling of $\mathbf{x}$ by $s(\mathbf{x})$[6]. There exists a coefficient vector such that, as the sample size becomes large, ÄV($\mathbf{x}$) in (20) can be made arbitrarily close to a continuous unknown utility difference function for any value of $\boldsymbol{x}$. In our particular specification, the bid price is the only explanatory variable, so that $\boldsymbol{k}_\alpha$ is a (lxl) unit vector and max(A) equals 1. We choose the same value for integer J as do Creel and Loomis, leading to

$$\Delta V(B) = g + dB + d_v \cos\ s(B) + d_w \sin\ s(B) \qquad (7)$$

where s(B) prevents periodicity in the model and is a function that shifts and scales the variable to lie in an interval less than 2ð (Gallant)[7]. Specifically, the variable is scaled by subtracting its minimum value, then dividing by the maximum value, and then multiply the resulting value by 2ð - 0.00001, which produces a final scaled variable in the interval [0, 2 ð - 0.0001]. When d_v = d_w = 0, (21) reduces to (19) with d = $\hat{a}$ and $\tilde{a}$ = -$\acute{a}$: the normal WTP model is nested within the SPNDF model. The four coefficients in the utility difference function (22) are estimated by maximum likelihood, using the log-likelihood function in (7) for the OOHB data.

Survey and Data

A survey was designed and pre-test with a small group of farmers. After a few rounds of revisions, the survey was administered through in-person interviews during the period October 2000-July 2001 to five hundred farmers, selected at random, from three important cereal growing provinces in Sicily (Enna, Catania, and Ragusa). The interviews was carried out by eight trained interviewers. The training emphasized the need for neutrality, and the nature of the survey. The survey consisted of seven parts[8]: (1) general information about the firm, (2) detailed information on the agronomic aspects of crop production in the last four years, (3) data on costs and revenues of cereal crop production, (4) farmer attitudes toward general environmental issues, and towards agricultural practices environmentally friendly, (5) information on participation to others recent EU agricultural programs, (6) the contingent valuation scenario (a facsimile of the contingent valuation questions is reported in the Appendix II), (7) information on socio-economic characteristics of farmers. As discussed in the previous section, the OOHB dichotomous choice format was used to elicit WTA for the acceptance of the new agri-environmental cultivation protocol for cereal crop land. The OOHB bid pairs (in Lira) used in the survey are (300,000; 450,000), (600,000;750,000), (750,000; 900,000), and (900,000; 1,050,000)[9]. Approximately 10% of farmers refused to participate to contingent valuation exercise. The final usable sample was composed by 449 farmers. Tables 1 and 1A present the data set for the SB and OOHB formats respectively.

Econometric Results

Table 2 presents the maximum likelihood results for the SB and OOHB models, both for the parametric and SNPDF cases. For the purposes of this paper, as we are interested in only estimating mean minimum WTA, the incentive payment is the only explanatory variable. By survey design, the incentive payment offered to the respondent is uncorrelated with other possible explanatory variables. Hence, for the estimation of the mean compensation measure for the sample, other explanatory variables are irrelevant (McFadden). Additional explanatory variables become useful when there is some policy interest in stratifying the compensation measure according to these variables, a process which should be of interest to policy makers, but is extraneous to the topic of interest in this paper.

For this survey the untransformed bid offers are highly collinear with the constant term, which is quite common in discrete choice surveys as the variation in the bid variable tends to be fairly small (researchers tend not to check for, or report this, condition). The SNPDF OOHB model is rejected outright as the estimated probability function for this model is not monotonic with respect to bids between the maximum observed incentive payment and the incentive that drives the probability of acceptance to near 100%. As such, it is dropped from further consideration here. Perhaps the SNPDF OOHB version is particularly sensitive to this collinearity discussed above.

Table 3 present WTA estimates. We calculate the E(WTA) values by integrating the density function between $B = 0$ and $\propto$.[10] For comparison, nonparametric results using both the Turnbull (Turnbull; Kriström) and kernel (Kappenman) approaches are presented in Table 3 as well. As the response probabilities in Table 1 demonstrate, the responses to the first bid alone encompass a wide probability range. Hence, it is not surprisingly that the coefficient of variation of WTA is not much smaller in the OOHB approach than for the SB approach. Furthermore, WTA for the SB SNPDF model is little different from the parametric SB model, which is not surprising given the small and statistically insignificant difference in the likelihood values. Of course, this collinearity is not an issue in the two nonparametric models, and represents another trait in their favor.

With regards to the nonparametric results, the Kernel model yields a mean WTA value quite similar to the parametric and SNPDF value. The Turnbull based value is lower, but this is not surprising as the density function must be truncated at the maximum offered incentive payment given that it cannot predict the probability of acceptance outside the range of the data.

Discussion and Conclusion

We address the policy-relevant concept of the farmer's risk premium for adoption of the conservation plan. Namely, we provide the theoretical model explaining why the farmer may not choose to accept the conservation plan even when the decrease in profits associated with adoption of the plan is less than the incentive payment, i.e., why the farmer may require a premium in excess of the decrease in profits associated with adoption of the conservation plan. We utilize information from outside the farm survey to estimate this premium.

The net minimum WTA for the farmers is presented in Table 3. In order to estimate the risk premium, we need to know the difference in profits with and without the conservation plan. Current average return per hectare is estimated to be 1,454,875 Lira. The estimated returns per hectare under the conservation program is 1,007,484 Lira, for a loss of 447,391 per hectare[11]. If we can assume that the farmer has made roughly the same calculation on his own, and recalling that the risk premium equals WTA – ($ð_0$ –$ð_1$), then the farmer's risk premium associated with entry into this program is around 300,000.

In addition to this policy-relevant consideration of the risk premium, we examine econometric considerations in estimating WTA. To increase the efficiency of the econometric analysis of discrete choice questions, follow-up questions can be used to narrow the bounds on the farmers' minimum WTA. For example, for the case of estimating willingness to pay (WTP), Hanemann, Loomis, and Kanninen (1989) developed a double bound approach, where the respondent is requested to accept or reject a follow-up bid that is a function of the response to the first bid offer. To reduce the potential for response bias on the follow-up bid in multiple-bound discrete choice questions while maintaining much of the efficiency gains of the multiple-bound approach, we utilize a new one-and-one-half-bound (OOHB) approach. Despite the fact that the

OOHB model uses less information than the double-bound (DB) approach., efficiency gains in moving from single-bound to OOHB capture a large portion of the gain associated with moving from single-bound to DB (Cooper, Hanemann, and Signorello). Furthermore, to test the sensitivity of our estimation results to functional form and distributional specifications, we compare the results utilizing parametric, nonparametric, and semi-nonparametric econometric approaches. For this data set, which basically covered the full range of WTA even with just the responses to the first question, we found that using the multiple bound approach to be of value largely as a form of insurance.

Table 1. Data Set for the First Bound (449 observations)

Bid (Lira)	Sample Size	No. of 'Yes' Responses	Percent of 'Yes' Responses
300,000	44	2	4.55
450,000	87	11	12.64
600,000	91	33	36.26
750,000	95	47	49.47
900,000	89	61	68.54
1,050,000	43	41	95.35

Table 1A. Data Set for the OOH Bound (449 observations)

Bid (Lira*1,000)	Lower Bound			Upper Bound			Sample Size
	No. of Yes Responses	No. of No-Yes Responses	No. of No-No Responses	No. of No Responses	No. of Yes-No Responses	No. of Yes-Yes Responses	
300-450	2	8	34	37	3	3	87
450-600	5	8	31	28	12	7	91
600-750	14	11	19	23	13	9	9
750-900	23	14	11	11	14	21	91
900-1,050	26	11	6	2	12	29	94

Table 2. Regression Results

	Coefficient (*t*-stat)			
	Single Bound		**OOHB**	
Variable	**Parametric**	**SNPDF**	**Parametric**	**SNPDF**
Constant	-2.797	-4.087	-2.613	-0.2413
	(-11.12)	(-4.897)	(-11.97)	(-2.757)
BID	3.809e-006	5.7235e-006	3.5222e-006	1.914e-007
	(11.02)	(4.767)	(11.69)	(1.498)
BIDu	--	0.2071	--	-0.26406
		(1.716)		(-6.334)
BIDv	--	0.1642	--	-0.2967
		(1.384)		(-6.764)
ñ	--	--	0.57478	0.34164
			(4.593)	(3.199)
Log-L.	-232.844	-231.19	-405.37	-418.79
Efron's R^2	0.29085	0.29616	--	--
Chi-sq.	148.98	152.29	--	--

Table 3. WTA Estimates (Lira, Italian)

		WTA Estimates ($)			
Bounds	**Approach**	**Mean**	**Coefficient of Variation**[b]	**90% Confidence Intervals (BCa)**	
Single	Parametric	735612.07	0.0243	(706632.55,	765479.62)
	SNPDF	715302.45	0.0323	(678007.39,	753741.15)
	Turnbull	642959.74	0.0272	(614555.70,	672234.38)
	Kernel[a]	719693.74	0.0229	(692996.87,	747208.62)
OOH	Parametric	743160.26	0.0221	(716574.02,	770561.08)
	SNPDF	1029953.20	0.0603	(927417.90,	1134320.16)

[a] Computer programs for Turnbull and kernel estimation are also available from the author.

[b] The coefficient of variable is generated from the standard error of the empirical confidence interval.

Appendix I. Nonparametric Methods

A. Turnbull Estimation

A traditionally popular nonparametric technique is the histogram, in which the data are divided into partitions on the basis of some smoothing parameter and cell frequencies estimated based on these partitions (see e.g., Delgado and Robinson for a survey of nonparametric techniques). The model in this section falls into the general category of variable partition histogram approaches (VPHA), which allow a locally adaptive smoothing (Van Ryzin). The Pool Adjacent Violators Approach (PAVA) approach to generating empirical Bernoulli trials has been around a relatively long time (e.g., Ayer, Brunk, Ewing, Reid and Silverman; Turnbull). The specific PAVA used here is the Turnbull estimator, which can be considered a variation on a VPHA approach in which each partition is of different width. The Turnbull version was first applied to CVM by Carson et al, and is also presented in Haab and McConnell, while a similar nonparametric estimator for CVM is that of Kristom. Another nonparametric CVM application using empirical probabilities is that of Duffield and Patterson.

For discrete choice data, the goal of the Turnbull is to insure that the estimated cumulative densities are strictly increasing in the bid offer, that is, F_j = prob($WTP \leq A_j$) = $N_j/(N_j+Y_j)$, where N_j = the number of no responses to the bid offer A_j and Y_j the number of yes responses to that bid. Given the initial J empirical properties, the PAVA algorithm takes cases where $F_{j+1} \leq F_j$ and pools F_{j+1} and F_j as $(N_j + N_{j+1})/(Y_j + N_j + Y_{j+1} + N_{j+1})$, where this pooled value is associated with A_j , i.e., cell boundaries are A_j and A_{j+2}. The pooling is continued until the F's are strictly increasing in the bids. Given that without great loss of generality the density in most binary choice cases can be represented nonparametrically by sets of Bernoulli trials, PAVA for binary choice yields maximum likelihood estimates (Ayer, Brunk, Ewing, Reid and Silverman).

The Turnbull procedure is simple and does not require sophisticated programming, although a fast compiler is useful in bootstrap applications:

1) Sort $\{F_j, A_j\}$, $j = 1,\dots,k$ in ascending order with respect to A_i, where A_1 = minimum observed bid and A_k = maximum observed bid..

2) Starting with $j = 1$, compare F_j and F_{j+1}.

3) If $F_{j+1} > F_j$, continue.

4) If $F_{j+1} \leq F_j$, then pool F_j and F_{j+1} into a cell whose boundaries are F_j and F_{j+2}, i.e., for pooled frequency cell $F_j + F_{j+1}$, the pooled bid value is the upper end of the boundary, or A_{j+1}. The required assumption is that users who are not willing to pay A_j will not be willing to pay A_{j+1}.

5) The pooling loop is continued until the F_j's are strictly increasing in F_j. The pooled data pairs are denoted $\{F^*_j, A^*_j\}$, $j = 1,\dots m$, where m k. The stronger the relationship between ***F*** and ***A***, and the lower the influence of other variables on ***F***, the greater the number of cells, or histograms, in the set $\{\boldsymbol{F^*}, \boldsymbol{A^*}\}$.

Given the set of points $\{F^*_j, A^*_j\}$, $j = 1,\dots, m$, the approximation of the integral WTP = $\int_{A_1}^{A_{mm}} f(A)dA$ is estimated using the trapezoidal rule as:

$$\textbf{(1)} \qquad E(WTP_{Turnbull}) = \sum_{j=2}^{m}\left(A_j - A_{j-1}\right)F_j + 0.5\sum_{j=2}^{m}\left(A_j - A_{j-1}\right)\left(F_{j-1} - F_j\right) \quad .$$

where, to simplify the notation, $T = T^*$ and $C = C^*$ for the rest of this section. If it is desired to make no assumptions of how the empirical density is shaped between points, then the lower bound estimator (Haab and McConnell), which deletes the triangles from the above equation, can be used, yielding $E(WTP^L_{Turnbull}) = \sum_{j=2}^{m}\left(A_j - A_{j-1}\right)F_j$. The upper bound WTP estimator includes the upper triangle and is thus $E(WTP^{U}_{Turnbull}) = \sum_{j=2}^{m}\left(A_j - A_{j-1}\right)F_j + \sum_{j=2}^{m}\left(A_j - A_{j-1}\right)\left(F_{j-1} - F_j\right)$. Since ÄF converges on 1 in the limit, the limit in the difference between $E\left(WTP_{Turnbull}\right)$ on either bound is $\left|0.5\sum_{j=2}^{m}\left(A_j - A_{j-1}\right)\right|$.

A variance measure for $E\left(WTP_{Turnbull}\right)$ can be constructed analytically as in Haab and McConnell or estimated using bootstrap approaches. The latter is used here for uniformity with the other approaches.

Although not covered in the existing literature, it is equally valid to pool bids until Prob(yes to BID_i) > Prob(yes to BID_{i+1}), i = 1,...,*m* bids, where hence, the pooled bid value is from lower end of the cell boundaries. However, as a different starting point is used, the results will not necessarily be symmetric to those obtained by pooling bids until Prob(No to BID_i) < Prob(No to BID_{i+1}). What can differ are not the number of pooled bids or the empirical probabilities, but the boundaries of the cells (see table A.2). With the dataset analyzed here, the mean lower bound estimate is 391.97 pooling by Prob(No to BID_i) < Prob(No to BID_{i+1}) and 306.81 pooling by until Prob(yes to BID_i) > Prob(yes to BID_{i+1}). Hence, the Turnbull-based WTP value can be sensitive to the arbitrary choice between these two pooling criteria.

B. Kernel Approach

While the Turnbull approach in the previous section is simple to compute, the discontinuities inherent in the histograms do not allow estimation of derivatives (a minor concern here). In addition, asymptotic convergence of the Turnbull to the true density may be slower than for the kernel approach, at least for smooth densities. The kernel is a continuous function that describes the shape of a weight function, or local averaging procedure, that is used to represent a density function. The kernel imposes greater form on the demand function than does the Turnbull approach through the selection of a bandwidth, which controls the level of smoothing of the function. The higher the bandwidth, the higher the amount of smoothing. The density function $F(z \le A_j)$ can be estimated in kernel form (Kappenman) as

$$\textbf{(2)} \qquad \hat{F}(z_i) = \frac{\sum_{j=1}^{m} r_j \exp\left(-\frac{z_i - A_j}{2h}\right)}{\sum_{j=1}^{m} n_j \exp\left(-\frac{z_i - A_j}{2h}\right)}, \qquad i = 1,\ldots,V$$

where $\{A_j, n_j, r_j\}$, $j = 1,\ldots, m$, represents the j^{th} distinct bid value, the number of observations at that bid value, and the number of yes responses to that bid value , respectively. The variable $\boldsymbol{z}$ is an $(V\text{x}1)$ sequence of distinct values, say from A_1 to A_m in an ascending sequence of small increments, and h is the bandwidth.

Many possible methods can be used to find the bandwidth h. Härdle and Silverman provide a review of methods. For instance, cross-validation (e.g., Härdle; Nason; Kappenman) can be used to find the optimal value of h. Alternatively, a grid search can be used to find the smallest h for which $F(z)$ in increasing in the bid value. If one is interested in obtaining the median, then if $F(z)$ is monotone as long as $h \ge h_o > 0$, the value assigned to h should be h_o (Kappenman). In other words, the goal is not too choose too large an h, which causes over-smoothing of the data, while insuring that $F(z)$ is monotone. The grid search approach is fast enough with relatively small data sets and is the approach used here. For the data set used here, the optimal value of h was 0.175, where $\boldsymbol{A}$ was transformed to logarithmic form $\ln(A)$ to insure a smoother function.[12] Mean benefits can then be estimated under the function $\{F(\boldsymbol{z}), \boldsymbol{z}\}$using the trapezoidal rule discussed in the Turnbull section.[13]

Appendix II. Hypothetical Scenario

Appendix II. Facsimile of the Contingent valuation Scenario

The progressive degradation of the natural environment (e.g, soil erosion, groundwater contamination, alteration of rural landscape, reduction or definitive loss of agro-biodiversity) due to the modern agriculture has stimulated the European Union to change the content of its agricultural policy to pursue more environmental protection goals. In the last ten years, numerous agro-environmental policies have been set up. Many of programs that have been yet implemented will provide direct economic incentives to farmers adopting environmentally sound practices.

Suppose that one of these programs, offer a monetary compensation only to farmers practicing for **five years** on all arable farmland the following production protocol:

- **Crop rotation**
  1rst year: seed leguminous plants;
  2nd year: durum wheat;
  3rd year: forage crop;
  4th year: forage crop;
  5th year: durum wheat

- **Soil Tillage**
  The farmer must execute only one deep ploughing (>35 cm) once every three years, and harrowing the soil in the other years. If the slope of the arable land is more than 5%, tillage must to be done according the contour lines. The farmer is also under obligation to execute cross furrows every 25 m to better control rain water downstream.

- **Fertilizing**
  The farmer is authorized to only use organic manure.

- **Weeding**
  The farmer is authorized to only use mechanical weeding. He can use chemical components only in extreme circumstances, and in any case, only under preventive authorization.

The total annual payment to farmer signing this agri-environmental contracts will be given by **two instalments**, after half-year field inspections of the observance of the contracts.

It would be desirable that a **large number of farmers** endorse this program. However, its implementation should not require **a great deal of public financial resources**, as the assigned financial quota to agricultural sector is progressively decreasing. In fact, **if the expected cost of this program is high, almost surely, it will be not approved by the policy makers.**

At moment, we do not know the exact annual level of payment per hectare to give to farmer signing the above contract. Consider for a moment that the payment will be somewhere in the range of (BIDL) to (BIDU) lira.

1. *IF THE LOWER BOUND PAYMENT IS CHOSEN AS STARTING BID*, would you accept it to sign the above contract?

YES ☐ (*If YES, go to question 3*)

NO ☐ (*If No, continue with question 1.1*)

1.1 Are you willing to sign the contract if the annual level of payment per hectare is the upper bound

YES ☐ (*If YES, go to question 3*)

NO ☐ (*If No again, continue with question 2*)

----

1. *IF THE UPPER BOUND PAYMENT IS CHOSEN AS THE STARTING BID*' would you accept it to sign the above contract?

YES ☐ (*If YES, go to question1.1*)

NO ☐ (*If No, continue with question 2*)

1.1 Are you still willing to sign the contract if the annual level of payment per hectare is the lower bound?

YES ☐ (*If YES, go to question 3*)

NO ☐ (*If No again, continue with question 2*)

----

2. Please, tell us why are you not interested in accepting this contract? (*mark only one reason*)*

A	I am not interested in the protection of the environment
B	The level of payment is inadeguate
C	I believe that this program will be not admitted by policy makers
D	If the program will be implemented, I believe it does not reach the expected goals
E	The program is not feasible in my firm
F	I consider inadeguate all of information you provided me

**Interviewer, If the marked reason is C, or D or , tell farmer to take out any perplexity, and ask again the previous questions on the Willingness to Accept (use red pencil to mark the new answers)*

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Endnotes

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[1] According to EEC Regulation 1257/99, agri-environmental payments in return adoption of the environmental plan are calculated according to the following guidelines: i) revenue loss due to adoption of the environmental plan; ii) increase in production costs due to adoption of the environmental plan; iii) an incentive payment to encourage adoption; iv) cost of investments that do not generate income. In any event, premiums cannot exceed the ceilings given in EEC Regulation 1257/99.

[2] For the convenience of the reader, since most researchers interested in the estimation of random utility models are interested in WTP applications, the discussion of the econometric models will focus on the WTP application, and will note where necessary the modifications needed for estimating WTA.

[3] This survey design was originally suggested to us by Paul Ruud.

[4] In a WTA application, if the lower price, B_i^-, is randomly drawn as the starting bid, the three possible response outcomes are (Yes), (No, Yes) and (No, No). We denote the corresponding response probabilities $p_i^Y, p_i^{NY}, p_i^{NN}$. If the higher price, B_i^+, is randomly drawn as the starting bid, the possible response outcomes are (Yes, No), (Yes, Yes) and (No). We denote the corresponding response probabilities as $p_i^N, p_i^{YN}, p_i^{YY}$.

[5] Chen and Randall present an alternative model for SB data similar to that of Creel and Loomis; their model could be extended to DB and OOHB data in the same manner.

---

[6] In addition to appending ***Xb*** to the Fourier series in equation (6), Gallant suggests appending quadratic terms when modeling nonperiodic functions, i.e.,

$$h_k(\mathbf{x}, q_k) = U_0 + b'\mathbf{x} + 0.5x'Cx + \sum_{a=1}^{A} \left\{ \sum_{j=1}^{J} \left(v_{ja} \cos\left[j\mathbf{k}'_a\, s(\mathbf{x}) \right] - w_{ja} \sin\left[j\mathbf{k}'_a\, s(\mathbf{x}) \right] \right) \right\}$$

where $U_0 = u_0 + \sum_{a=1}^{A} \{ u_{0a} \}$, and $C = \sum_{a=1}^{A} u_{0a}\, k_a{}'\, k_a$.

Our experiments generally suggest that inclusion of the quadratic terms as well in the regressions had little impact on the benefit estimates. Hence, we leave them out the regressions we use to estimate benefits for the sake of efficiency.

[7] With X unique bid values in our data set, our specification permits a max(*J*) = Y to avoid singularity in the regression. For our data, since increasing *J* to values above 1 yielded little change in the regression results, *J* = 1 appears to proved the best balance in the trade-off between bias and efficiency.

[8] A copy of the fully questionnaire (in Italian) is available from the authors.

[9] The maximum offer in the vector is less than the ceiling given in EEC 1257/99.

[10] For practical purposes, the upper limit of this numerical integration is some value that drives Prob{"yes"} to near zero. In our case, the highest bid value of 2,000,000 lira produced the desired effect with Prob{"yes" to 2,000,000 lira } < 0.001% for models in Table 2.

[11] Average gross revenues per hectare are estimated by considering the following five years cropping plans:

i) Current practice:

durum wheat, durum wheat , durum wheat, vetch, durum wheat.

ii) New practice (proposed in the questionnaire):

Vetch, durum wheat, forage crop, forage crop, durum wheat

For each crop, the output is equal to mean value coming up from field data; we used market information to estimate average prices. Finally, we included in the revenue the public supports to wheat durum and seed leguminous plants producers contemplated by the EEC Regulations 1765/92, 2309/97, 1251/99, 1577/96, 1644/96, and by specific national regulations.

[12] Note that Z should be created using the endpoints of the unlogged ***A*** and then transformed to log form.

[13] If desired, one can assume that $F(A_0 = \$0) = 0$ and add $\{n_0 = r_0, A_0 = 0\}$ as a data point to the dataset. However, doing so this can have a strong impact on the mean value. It is possible that respondents may hold a value of $F(A=\$0)>0$ due to nuisance values or to some biases in the survey design. It is less risky simply to define the boundaries of the density function over the observed data.

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