# Comparing Dichotomous Choice Models UsingTruncated Welfare Estimates

**Carmelo J. León***

*Abstract*

*The purpose of this paper is to compare general and truncated welfare measures for single and double bounded dichotomous choice contingent valuation using data from an empirical example. The case study involves the benefits resulting from preservation of the landscape of a group of natural parks located in the higher areas of Gran Canaria (Canary Islands). Results show that double bounded leads to more conservative estimates than single bounded for general welfare measures. However, normalized truncated welfare measures for the mean and the median reduce the divergences between single and double bounded welfare estimates and tend to produce more efficient results, especially if the distribution assumption for willingness to pay is lognormal.*

*Keywords: Contingent valuation, dichotomous choice, double bounded, single bounded, truncation, welfare measures.*

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## Introduction

Dichotomous choice (DC) has become a popular elicitation method in implementing the contingent valuation method (CVM). DC was first utilized in valuing environmental goods by Bishop & Heberlein (1979). The idea is as follows. Each individual in the sample is randomly assigned a given bid taken from a set of prices which he or she either accepts or rejects to trade for the environmental good presented. By using the binary answers, a probability function for consumer surplus is estimated from which mean and median values can be calculated. This idea originated with survival experiments with drugs which are commonly performed in medical and biological sciences.[1] The formal theoretical model for the DC method was put forward by Hanemann (1984), thereby establishing a link between the

* Carmelo J. León, Department of Applied Economics, University of Las Palmas de Gran Canaria, Saulo Toron 4, Las Palmas de Gran Canaria, Spain 35017. E-mail: Carmelo@empresariales.ulpgc.es.

[1] See Collet (1991).

empirical models and economic theory. Further applications include Sellar *et al*. (1985) and Bowker & Stoll (1988). In addition, Hoehn & Randall (1987) argued that the DC elicitation method is incentive compatible. The comparison with other methods such as open ended questions or bidding games show that DC tends to produce somewhat larger estimates, but the differences do not appear to be significant (Sellar *et al*., 1985; Kealy *et al*., 1988; Kriström, 1993). A more recent development within the DC method is called the double bounded DC. This method was first proposed by Hanemann (1985) as a device that would conduce to more efficient estimates than the single DC method. It consists of adding a second DC question following the responses to the initial DC question. As a result of the sequence of binary answers, the individual's subjective value becomes bounded by an ending interval. Hanemann *et al*. (1991) proved both theoretically and empirically the higher efficiency of the double bounded DC welfare estimates.

Even though there are clear advantages of DC as an elicitation procedure, the final welfare estimates may be sensitive to the empirical approach adopted by the researcher. For instance, Bowker & Stoll (1988) used several empirical models to show the disparities that may result from using different concepts of welfare measure for the single bounded DC method. Cameron & Huppert (1991) and Cooper & Loomis (1992) studied the sensitivity of welfare estimates to the bid vector design. A discussion of the influence of the bid vector design using simulated data can be found in Kanninen & Kriström (1993) and Cooper & Loomis (1993). A further question raised by the development of double bounded DC is how different welfare estimates are when compared with those which would have been obtained using the single bounded DC method. Hanemann *et al*. (1991) detected significant disparities between single and double bounded DC for some of the goods valued in their CV survey. In particular, the single bounded DC tended to produce larger estimates than the double. These authors attributed the divergences both to the inadequate design of the bid vector chosen for the empirical application and to the higher efficiency of the double bounded method. It is suggested that the divergences might be avoided with an optimal bid vector design.

The persistence of significant differences between single and double bounded runs counter to the construct validity of DC CVM (Mitchell & Carson, 1989). Thus, an interesting question is whether these divergences are also present for the normalized welfare measures suggested by Boyle *et al*. (1988). These measures are based on theory and have the advantage of taking into account only the empirical data. Past theoretical work by Boyle *et al*. (1988) and Hanemann (1989) rejected the use of truncation in favour of an optimal bid design which would make truncation unnecessary. Nevertheless, there are several reasons for which further exploration of truncated welfare measures may be convenient. First, as Arrow *et al*. (1993) emphasized, from a theoretical point of view, it is clear that willingness to pay for environmental goods is bounded by the individual's budget constraint. This bound implies that the subject should consider not only her disposable income, but also the expenditure on other goods or other groups of commodities. Thus, one could conjecture that there is some theoretical threshold to the expenditure on the set of environmental goods.

Secondly, looking at past applications of DC CVM, it is possible to interpret the empirical distribution as a truncated distribution (Maddala, 1983). The reason is that the data generation process usually does not produce reliable information for prices beyond the bounds of the empirical bid vector. Some strategies for designing the bid vector involve the expectation that the probability of answering yes to the lowest price goes to one, and the probability of accepting the highest price approaches zero. The researcher conveniently chooses the range of prices for which she wants to have information from the sample. If the empirical distribution turns out to have fat tails for the expected bounds, then it could be that only a section of the distribution has been investigated. Even if the offered bids are kept out of the tails of the assessed distribution (Kanninen, 1995), the researcher may not want to consider prices on the negative side and/or beyond the theoretical threshold.

Thirdly, a practical problem with DC welfare measures is the potential bias due to misspecification errors in the estimated probability function — either due to the wrong functional form or to the wrong parameters (Kanninen, 1995). The influence of this bias may be even more important when there is need to consider predicted probability estimates for the tails of the chosen distribution. The empirical estimates may be biased as the result of two related factors:

a) because the bid vector design is inappropriate, and

b) because the estimated probability function fails to reflect the empirical data.

Therefore, by considering only the range of feasible observations, normalized truncated measures may reduce the biases in welfare estimates which are due both to misspecification errors and to the limitations of the empirical bid vector. These sources of bias lead to prediction errors for prices outside the feasible range. In this sense, truncation may avoid the prediction errors for unreliable prices or prices outside the empirical bid vector. Thus, even if the researcher fails to get the right bid vector design, she is not misled by projecting the estimated probability function for unfeasible prices. However, the dependence of the results on the choice of the truncation point introduces a caveat in the use of truncated measures.

This paper explores the divergences between single and double bounded results for general and truncated welfare measures using data from an empirical example. The case study aims at estimating the benefits deriving from preservation of the landscape of a group of natural parks in the island of Gran Canaria (Canary Islands). In the following sections, we first outline general and truncated welfare measures using DC CVM. We then present the design of empirical application. Finally, we report the comparison between welfare estimates and close with a discussion of the main results and some concluding remarks.

## Dichotomous Choice Welfare Measures

In a dichotomous choice model individuals are asked a binary question regarding a monetary transaction for a given environmental good at a given price. Let us presume that the environmental good is the preservation of the landscape of some specified natural parks. It is suggested that there is to be a potential reduction in the quality of the landscape and the individual is asked whether he or she would pay a given amount of money in order to avoid this change through an efficient environmental policy. Following Hanemann (1984), $F_\tau(\Delta V)$ is the cumulative distribution function representing the probability of an affirmative answer to the option of buying the policy protecting the landscape assuming payment of a specific quantity $B$, where $\Delta V$ is the deterministic utility difference dependent on $B$, and $\tau$ is a random variable.

Although $F_\tau(\cdot)$ is an increasing function of $\Delta V$, it must be a decreasing function of the bid price. Therefore $F_\tau(\cdot)$ may be interpreted as a survival function over the offered price. If negative prices are ruled out then should $F_\tau(\Delta V(0))$ approach one, and $F_\tau(\Delta V(B))$ should approach zero as $B$ increases substantially. Welfare measures for the proposed environmental policy may be obtained by defining the mean and the median of the bid price. For instance, for the median, the researcher is interested in knowing the price at which 50% of the sample would accept the offered environmental policy. In general, the welfare measure depends both on the empirical specification of $\Delta V$ and on the truncation of the distribution function. Johansson *et al*. (1989) noted that the mean for a distribution function defined in $R$ can be written as follows

$$M = E[B] = \int_0^\infty F_\tau(\Delta V(B))dB - \int_{-\infty}^0 \left[1 - F_\tau(\Delta V(B))\right] dB \qquad (1)$$

For instance, for a linear specification of $\Delta V$, i.e. $\Delta V = \alpha - \beta B$, Kriström (1990) shows that the mean coincides with the median and takes the expression $\alpha/\beta$. For a loglinear specification of $\Delta V$, i.e. $\Delta V = \gamma - \theta \ln B$, the mean can be obtained from expression (1) by dropping the negative part. The median $B^d$ is $\exp(\gamma/\theta)$.[2]

[2] An alternative definition of the mean for the linear model is given by Hanemann (1989) under the assumption of no negative prices. This involves integrating the positive side of the estimated probability function for probit or logit models assuming a linear utility difference. This way of truncating the normal or logistic distributions at zero does not lead to an appropriate definition of the truncated mean if $F_\tau(\Delta V(0)) < 1$ because it does not consider normalization.

However, in practice willingness to pay is bounded by the individual's budget constraint.[3] This implies that consumer choice is restricted not only by disposable money income but also by the prices of other goods and necessary expenses. Well designed constructed markets often put emphasis on presenting all the elements which are conditioning consumer choice. The introduction of a new good in the choice set is expected to produce readjustments in the optimal solutions. Following Deaton & Muellbauer (1981), it may be speculated that there is a given expenditure that the subject allocates to the group of environmental goods. It may be unreasonable to presume that the subject would spend all his/her income on the particular environmental good presented in the contingent market. That is, there must be some threshold below income which sets a limit to the highest price that the subject would pay. This threshold would define the point at which the probability of an affirmative answer to the policy approaches zero. On the other hand, although negative prices are theoretically feasible, most empirical applications do not obtain responses to the prices on the negative side of a general distribution.

The latter considerations have important implications for the empirical estimation of welfare measures. When dealing with fat tails in the empirical distribution one should place limits on the process of integration in order to reduce the bias which would follow from considering prices which are high in excess or negative. Thus, truncation of the distribution function may provide more accurate results when facing wide tails in the estimated distribution leading to unrealistic mean values of willingness to pay. Wide tails can follow as a result of both a suboptimal bid design and the incidence of misspecification errors. Obviously truncation would not be needed if the probability function were to approach zero for the theoretical threshold and one for the zero bid price.

[3] The essential variable limiting willingness to pay for an environmental policy is disposable income. This does not apply to the concept of willingness to accept because it may diverge substantially from willingness to pay (Hanemann, 1991) and is far more difficult to be measured empirically.

A controversial aspect of the empirical use of truncated measures is the choice of the truncation point. Boyle & Bishop (1988) suggest choosing the maximum between the highest offered bid and the 90th estimated percentile. The choice of the truncation point is also relevant for Ayer's nonparametric estimator (Kriström, 1990). With this approach, an empirical distribution is constructed using the binary responses to the prices randomly distributed in the sample. There is no need to assume a given parametric distribution. However, the definition of mean willingness to pay involves integrating the distribution until some threshold. Clearly, truncation will not affect the results if the empirical distribution contains the point at which the probability of acceptance reaches zero. In general, it seems obvious that the choice of the truncation point may involve a value judgement. Nevertheless, it could be argued that one should not consider values that individuals would never pay. For these prices the probability of acceptance will be nil. They will not count for the definition of mean willingness to pay. Thus, a rule of thumb may be the maximum price that could ever be paid for the good in question. An open ended question may certainly help to determine the truncation point.

The possible arbitrary decision as to choice of the truncation point has led to the theoretical rejection of truncated welfare measures (Boyle *et al.*, 1988; Hanemann, 1989). The underlying argument is that optimal bid design would make it unnecessary to rely on truncation. Nonetheless, the practice of applied welfare economics may find the theory of optimal bid design difficult to implement because of the information needed as to the true distribution (Kanninen, 1993; Alberini, 1995). Further, information about the relevant bid vector design seems to be important for an accurate estimation of welfare benefits. A suboptimal bid design may not only influence the parameter estimates but also the choice of the parametric distribution. That is, the bid vector design clearly defines the values for which actual responses are observed. An inappropriate design may lead to a parametric model which does not fully represent the true distribution.

Considering the integrated distribution only up to the highest offered price leads to the following definition of the *threshold* mean:

$$M^t = E\left[B^t\right] = \int_0^{B^m} \left[F_\tau\left(\Delta V(B)\right)\right] dB \qquad (2)$$

where $B^m$ is the maximum bid price offered. Similar definitions have been utilized in some empirical studies (Bishop & Heberlein, 1979; Seller *et al.*, 1985; and Bowker & Stoll, 1988). We will consider (2) in the empirical application only for the purposes of comparison.

The fact that we have defined the highest bid price for the truncation point does not mean that this should be used in practice. The appropriate truncation point is the theoretical threshold price. This threshold is related to income. The highest bid may be considered only if the answers to this price would all reject payment, and any positive response can be attributed to strategic behaviour or yea saying. In other cases we must determine the level of expenditure on environmental goods which must be bounding individual's choice. We can offer two strategies which are feasible: a) the researcher might ask this bound directly to the subject, and b) the researcher might rely on statistical evidence from general expenditure surveys as to proportion of income allocated to related groups of goods — not necessarily environmental expenses.

As Boyle *et al.* (1988) argued, the definition in (2) is incorrect because it is not consistent with the properties of a cumulative distribution function. A statistically appropriate definition of the truncated mean should consider the normalization of the cumulative distribution function, i.e. a truncated or conditional distribution. In general, truncating a given survival distribution between $B^1$ and $B^2$ leads to the following definition of the truncated mean:[4]

$$M^c = E\left[B \mid B^1 \le B \le B^2\right] = \int_{B^1}^{B^2} \frac{B f_\tau\left[\Delta V(B)\right]}{F_\tau\left[\Delta V\left(B^1\right)\right] - F_\tau\left[\Delta V\left(B^2\right)\right]}\, dB \qquad (3)$$

where $f_\tau\left(\Delta V(B)\right)$ is the density function.

[4] See Nelson (1982) for a presentation of truncated distributions and their moments.

Assuming $F_\tau\left(\Delta V(0)\right)=1$, the conditional or normalized mean can be defined by

$$M^n = E\left[B \mid 0 \le B \le B^m\right] = \int_0^{B^m} \frac{F_\tau\left[\Delta V(B)\right] - F_\tau\left[\Delta V\left(B^m\right)\right]}{1 - F_\tau\left[\Delta V\left(B^m\right)\right]}\, dB \quad (4)$$

If $B^m$ takes a value such that $F_\tau\left(B^m\right)=0$ then expression (4) results in (2). Expression (2) overestimates willingness to pay with respect to (4). Since $F_\tau(B)$ is less than one and decreasing with respect to $B$, it can be shown that normalization implies a downward shift of the survival distribution, therefore reducing the area corresponding to the mean value. This relationship can also be derived by rearranging equation (4) as follows

$$M^t = M^n + F\left[\Delta V\left(B^m\right)\right]\left[B^m - M^n\right] \quad (5)$$

Another of the consequences of truncation is the consideration of the truncated or normalized median. We can define the median of the truncated distribution as the bid price for which the conditional cumulative probability is 0.5. That is, for a rightward truncated distribution at $B^m$, the median $B^n$ satisfies the following expression

$$\Pr\left[\Delta V\left(B^n\right) \ge \tau \mid \Delta V(B) \ge \Delta V\left(B^m\right)\right] = \frac{F_\tau\left(\Delta V\left(B^n\right)\right)}{\left[1 - F_\tau\left(\Delta V\left(B^m\right)\right)\right]} = 0.5 \quad (6)$$

For a linear specification, the normalized median is $(t-\alpha)/\beta$, where $t$ is the value of $\Delta V$ for which the cumulative probability is $0.5[1-F_\tau(B^m)]$. For a loglinear specification the result is $\exp((t-\gamma)/\theta)$.

Finally, several strategies of data generation have been utilized in the literature to estimate the distribution $F_\tau(\cdot\,)$. The most common are single and double bounded DC question formats. A potential problem of using empirical data is that significant disparities between both estimation processes have previously been detected (Hanemann *et al.*, 1991). Both approaches should in theory produce the same welfare estimates, with double bounded producing more efficient results than single bounded. Thus, we can consider whether the possible disparities between single and double bounded would be reduced by using the concept of normalized truncated mean. Let $M_1^t$ and $M_2^t$ be the *threshold* means for single and double bounded respectively, and $M_1^n$ and $M_2^n$ the corresponding normalized truncated means. Define $d^t = M_1^t - M_2^t$ and $d^n = M_1^n - M_2^n$. Then it follows

$$d^n = d^t - \left[F_1\left[\Delta V\left(B^m\right)\right]\left(B^m - M_1^n\right) - F_2\left[\Delta V\left(B^m\right)\right]\left(B^m - M_2^n\right)\right] \quad (7)$$

Therefore, if $d^t > 0$ and if

$$\frac{F_1\left[\Delta V\left(B^m\right)\right]}{F_2\left[\Delta V\left(B^m\right)\right]} > \frac{B^m - M_2^n}{B^m - M_1^n} \quad (8)$$

then $d^t > d^n$. It can be seen that if $F_i(\Delta V(B^m))$ tends to zero then $M_i^n = M_i^t$ ($i$ =1,2) and therefore $d^t = d^n$. That is, the choice of a truncation point so high that the accepting probability is zero for both estimated distributions will make no difference in the estimated mean by normalization. In other words, assuming $d^t > 0$, the divergence between single and double bounded welfare estimates may be reduced by normalization only if the truncation point is effective for the single bounded estimated distribution.

For a more general concept of welfare measure such as the nontruncated mean of a nonnegative random variable, let $M_1$ and $M_2$ be the results obtained with single and double bounded respectively. Then, it can be shown that

$$d^n = d - g - I, \quad (9)$$

where $d = M_1 - M_2$ ,

$$g = F_1\left[\Delta V\left(B^m\right)\right]\left(B^m - M_1^n\right) - F_2\left[\Delta V\left(B^m\right)\right]\left(B^m - M_2^n\right)$$

and

$$I = \int_{B^m}^{\infty} \left[ F_1\left(\Delta V(B)\right) - F_2\left(\Delta V(B)\right) \right] dB.$$

Thus, if $d > 0$ the following cases would lead to $d^n < d$:

i) $g > 0$, $I > 0$;

ii) $g > 0$, $I \leq 0$, $|I| < g$;

iii) $g \leq 0$, $I > 0$, $I > |g|$ . By definition, cases i) and ii) imply that condition (8) is satisfied.

## SURVEY DESIGN

### *Area of Study*

The area of study is a group of natural parks located in the higher hinterlands of Gran Canaria which are popularly known as the 'Cumbre'. Gran Canaria is one of the seven islands in the Canary Archipelago. The parks are Cuenca de Tejeda, Tamadaba, Cumbres, and Inagua. They cover a total of some 28,000 hectares of which 29% is pine forest, 58% thicket, 9% agricultural land and 4% unproductive. There is no productive use made of the forest resources. The total area represents about 18% of the extension of Gran Canaria. It represents the forest reserve of the island and is regularly visited by the local population and foreign tourists. The landscape of this area has been progressively transformed by the construction of houses and roads. At present, there is controversy as to the extent of further regulation designed to set limits on later private use of the land. A stronger and more effective regulation of the use of the land may benefit the local population and contribute to the sustainability of tourism. The measurement of the benefits to be derived from preservation may be used in cost-benefit analysis in order to decide upon the appropriate regulatory policy for private use of this land.

### *Data Sources*

A CV survey was carried out over an adult population of 506,230 individuals in Gran Canaria in the last quarter of 1993. The interviews were conducted by telephone. This method limits the extension of the interview and the description of the good to be valued. However, its choice is justified because of the high familiarity of the local population with the good to be valued. A pretest survey of 60 cases supported this conclusion and allowed us to introduce some changes in the final design. The final sample of 573 individuals was chosen by stratified random sampling according to the parameters of age, sex, and county population published in official statistics. The sample frame was the list of the national telephone company, Compañía Telefónica de España, published in 1993. The interviews were carried out by 6 professional interviewers who belonged to a specialized survey company. The number of phone calls which led to the final sample was 1,542, implying 37% participation. The reasons given for refusing to participate included lack of confidence in the possibility of an efficient interview over the phone (60%), and being too busy for the interview at any time (20%). Interviews lasted on average 6 minutes and varied between 3 and 15 minutes.

### *The Survey Instrument*

The survey instrument first presented the area in point then formulated some questions as to recreational activities at the site, e.g. number of visits and reasons for the same. The second set of questions were about monetary valuation. The final sections sought the subjects' opinions with respect to the policy of protecting the landscape of Gran Canaria, and further questions with respect to possible future visits and sociological profile.

The valuation scenario contained all the elements of the contingent market including the payment vehicle and the elicitation method. Individuals were informed as to the aim of the valuation in order to give them time to ponder their answers in monetary terms. The scenario presented a landscape subject which was being threatened by environmental deterioration due to the construction of houses, roads and stores in the surroundings. Subjects were told that everybody would have to pay for the protection of the landscape. This was expected to reduce strategic behaviour. The budget constraint was explicitly recalled in order to reduce hypothetical behaviour. Payment for the preservation policy was justified by the need to raise money to compensate the people affected. The payment vehicle was a contribution to a fund for preserving the landscape. This vehicle was preferred because it was viewed as least controversial by the general public. The exact wording of the valuation question was as follows:

> "The next question is about how much you value in money terms the landscape of this area of parks. Our aim is merely to ascertain the maximum amount you would pay in order to preserve this landscape. (Take into account that there may be other places in Gran Canaria, such as the beaches or the coasts, that you may also consider worthy of preservation and for which you may be willing to contribute money to the same purpose).
>
> With reference to the landscape in the area of the 'Cumbre', this may be transformed due to the construction of houses, commercial stores, and roads. Suppose that you were asked for a contribution to a fund designed at preserving the landscape in its present state. Think that everybody will have to pay and that the money will be well invested in compensating the people affected. Taking into account your personal and family income and your necessary expenses, would you be willing to contribute __ pesetas per year to preserve the landscape in its present state?"

The sentence in brackets in the introductory paragraph was randomly omitted for approximately half of the sample in order to ascertain whether a reminder of potential substitutes influenced willingness to pay. In implementing the DC question format, we have used an initial five bid or price vector. These prices were chosen following the method of equal loglinear intervals which arose as the result of the empirical distribution of the open ended answers in the pre-test survey. We intended that the probability of payment of the highest bid offered should tend towards zero, whereas for the lowest bid this probability should approach one.[5] In order to obtain double bounded estimates of willingness to pay, a second DC question was put to individuals conditional on the answer to the first DC question. If the answers to the initial price were affirmative (negative), then the second price was substantially higher (lower). Table 1 shows the five versions of questionnaires which resulted from the initial five bid vector and their follow up.

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[5] The purpose is to cover approximately the entire range of willingness to pay. This is expected to nail down the tails of the distribution. Results based on the theory of optimal bid design suggest that there is no need to obtain information from the tails (Alberini, 1995; Kanninen, 1995).

Table 1. Models of Questionnaires Based on the Bids (Pesetas) for Double Bounded DC Format.

| Model | First Bid | Second Bid/Yes First Bid | Second Bid/No First Bid |
|---|---|---|---|
| A | 1000 | 5000 | 500 |
| B | 5000 | 10000 | 1000 |
| C | 10000 | 20000 | 5000 |
| D | 20000 | 40000 | 10000 |
| E | 40000 | 60000 | 20000 |

## Results

Subjects were not informed previously that there would be a second DC question following the first DC question. Thus, we can assume that the responses to the latter satisfy the exogeneity condition for a single bounded DC approach. The answers to the prices in the first bid vector are used to estimate the single bounded model. Model development and estimation methods for both single and double bounded models follow the maximum likelihood procedures in Hanemann *et al*. (1991).[6] A normal distribution assumption has been chosen for the error component of the utility function. If the specification of $\Delta V$ is loglinear, this leads to a lognormal distribution of willingness to pay. These distributions were found to be the best representation of the empirical data for both single and double bounded models when compared within the context of a more general distribution such as generalized gamma.[7] In this section, results are presented for the computations of welfare measures using the estimated models without covariates. The introduction of sociological and opinion variables produced slight changes in both welfare estimates and their confidence intervals.[8]

[6] The alternative parameterisations by Cameron & James (1987) and Cameron & Quiggins (1994) for single bounded and restricted double bounded models respectively are known to lead to the same welfare estimates (See Patterson & Duffield, 1991).

[7] See León (1995) for double bounded results involving fully specified models with covariates.

[8] According to McFadden & Leonard (1992) pp. 18, this would validate the implicit assumptions of the CV method, since "the unconditional average of WTP over a representative sample takes the effects of covariates into account, and is a consistent estimate of mean WTP in the population".

TABLE 2. ESTIMATION OF $\Delta V$. (STANDARD ERRORS IN PARENTHESIS)

| VARIABLE | LINEAR SINGLE | LINEAR DOUBLE | LOGLINEAR SINGLE | LOGLINEAR DOUBLE |
|---|---|---|---|---|
| *Intercept* | 0.32671<br>(0.0742) | 0.3461<br>(0.0164) | 2.9272<br>(0.4035) | 4.240<br>(0.2269) |
| *Bid* | −0.270E−04<br>(−0.400E−05) | −0.439E−04<br>(−0.188E−05) | −0.33231<br>(−0.04420) | −0.50326<br>(−0.02655) |
| LogL | −372.25 | −797.17 | −366.4 | −763.64 |

Table 2 presents the estimation results for the linear and for loglinear specifications using both single and double bounded DC models. Both the intercept and the bid variable are significant at the 0.01 level. The negative sign of the bid variable indicates that the probability of an affirmative answer for willingness to pay decreases as the bid offered raises across the sample. Looking at the maximum loglikelihood, it would seem that the loglinear specification fits the data better, since this statistic is higher in the aforementioned assumption. An appropriate way of comparing both functional forms in $R^+$ is by utilizing a Box-Cox transformation for the bid price variable (Cameron & Huppert, 1989). This is done by redefining the bid price as $((B)^\lambda-1)/\lambda$. The parameter $\lambda$ takes the value 0.083 for single bounded and 0.354 for double bounded, with respective standard errors 0.221 and 0.057. Thus, the linear specification implied by $\lambda = 1$ is rejected for both models whereas the loglinear specification ($\lambda = 0$) is rejected only for the double bounded model. Therefore, the single bounded data is represented better by the loglinear functional form, i.e. a lognormal distribution for willingness to pay. However, both specifications are rejected after use of double bounded data. As expected by definition, the double bounded model leads to more efficient and more significant parameter estimates than the single bounded for both specifications.

The estimated welfare measures of equivalent surplus for the preservation of the landscape of the natural parks are shown in Tables 3 and 4 both for the linear and for the loglinear specifications. The limit value of willingness to pay chosen for the truncated welfare measures is the high-

TABLE 3. MEAN AND MEDIAN VALUES OF WILLINGNESS TO PAY FOR THE LINEAR SPECIFICATION OF $\Delta V$.

| WELFARE MEASURE | SINGLE BOUNDED | 95% CONFIDENCE INTERVAL | DOUBLE BOUNDED | 95% CONFIDENCE INTERVAL |
|---|---|---|---|---|
| $M$ | 12100 | (7775,16266) | 7815 | (5252,10278) |
| $M^t$ | 16782 | (15252,18527) | 12741 | (11598,13920) |
| $M^n$ | 10013 | (8004,11658) | 10403 | (9344,11427) |
| $B^n$ | 1491 | (–9137,6729) | 5620 | (3038,7743) |

est bid offered in the first DC question, that is, 40,000 pesetas.[9] The confidence intervals for the welfare estimates were calculated employing the Monte Carlo approach suggested by Park *et al*. (1991), which is based on Krinsky & Robb (1986). This procedure consists in taking random samples for the parameter estimates based on a multi-variate normal distribution with the estimated mean and covariance matrix. For each welfare measure we have carried out 1000 draws. For each draw, the welfare measure is calculated and ranked in an ascending order. The intervals are obtained by using the method according to Efron (1981).

The results demonstrate the higher efficiency of double bounded estimates for all welfare measures, since their confidence intervals are shorter than those obtained with the single bounded model. On the other hand, the confidence intervals for the linear model are in general larger than those obtained for the loglinear specification, although the differences are not relevant for measure $M^t$. Furthermore, the normalized truncated welfare measures tend to produce more efficient estimates than the truncated welfare measures without normalization and the nontruncated welfare measures. For instance, whereas the 95% confidence interval for the loglinear specification using the double bounded procedure for the threshold mean $M^t$ is (10292,13038), the result for the normalized truncated mean $M^n$ is (6452,7533), which implies a reduction in the length of the interval of 60%.

[9] This choice has been influenced by the fact that for the single bounded model this is the upper limit of the sample observations. The conclusions that follow were found not to change by using a higher limit such as 60000 pts, which is above the 90th percentile for all models but for loglinear single. No attempt has been made in this study to determine the theoretical threshold for the bid price.

TABLE 4. MEAN AND MEDIAN VALUES OF WILLINGNESS TO PAY FOR THE LOGLINEAR SPECIFICATION OF $\Delta V$.

| WELFARE MEASURE | SINGLE BOUNDED | 95% CONFIDENCE INTERVAL | DOUBLE BOUNDED | 95% CONFIDENCE INTERVAL |
|---|---|---|---|---|
| $M^t$ | 16500 | (14409,17572) | 11580 | (10292,13038) |
| $M^n$ | 6748 | (5450,7860) | 7069 | (6452,7533) |
| $B^d$ | 6692 | (4735,9268) | 4561 | (3773,5414) |
| $B^n$ | 2310 | (1137,3438) | 3235 | (2683,3762) |

The estimated point of willingness to pay depends both on the specification of the utility difference model $\Delta V$ and on the particular welfare measure. For the linear specification, the mean/median $M$ using single bounded is 12100 pts, whereas for double bounded the result is 7815, i.e. 35% lower. This would suggest that the latter model leads to lower welfare estimates than the former. This conclusion also applies for welfare measure $M^t$ for both assumptions of $\Delta V$. For instance, for the linear (loglinear) specification, $M^t$ is 16782 (16500) for single bounded and 12741 (11580) for double bounded. Nevertheless, using the normalized truncated mean $M^n$ leads to similar results between single and double bounded for both specifications of the utility difference. In respect of the median value of willingness to pay for loglinear, the welfare measure $B^d$ is significantly higher for single bounded than for double bounded. The concept of normalized median $B^n$ produces similar results for the loglinear specification.

On the other hand, the divergences which may result from choosing some of the parametric distributions which can be fitted to the empirical answers can be ascertained by comparing the welfare measures obtained with the linear and the loglinear functional forms. For the single (double) bounded, the median for the linear model ($M$) is 80% (70%) higher than the median for the loglinear model ($B^d$). One reason for this disparity is that the normal distribution imposes symmetry on the empirical data whereas the lognormal distribution allows to model the asymmetry which results from a large mass probability concentrated in the lower bid prices. Using the normalized truncated median ($B^n$), the disparities are still present but become less emphasized since the linear model leads to a result which is 35% (42%) lower (higher) than the loglinear model estimates. However, this reduction in the divergences using the normalized concept does not apply to the truncated mean. That is, whereas $M^t$ leads to similar results for both specifications, the normalized truncated mean ($M^n$) implies that the estimated value is 47% higher for the linear than for the loglinear functional form.

## Discussion

The disparities between single and double bounded estimates for nontruncated and some truncated welfare measures have been detected in past work by Hanemann *et al*. (1991) for some of the goods valued in their CV survey. These authors argued that the disparities were due to the poor bid design and the higher efficiency of double bounded estimates. To this end, further research into the development of optimal bid design strategies, such as the methods proposed by Cooper (1993) and Kanninen (1995) may lead to a reduction of the disparities in welfare estimates.

A second related factor which might lead to empirical divergences between single and double bounded is the learning process which may be occurring in the double bounded dichotomous choice format. In theory, since the answers correspond to the same individuals there is no reason for the empirical divergences. However, double bounded gives more information about the behaviour of individuals facing alternative prices. Therefore, we may rightly expect more accurate estimates resulting from double bounded data. Cameron & Quiggins (1994) have interpreted the answers to the double bounded format as resulting from a bivariate distribution. A more coherent interpretation to be considered for further research could look at modelling the learning process which might be occurring through the first and second DC questions.

A third reason for the differences in the results is the incidence of model misspecification bias. The estimated parameters may be biased because of the omission of relevant covariates and/or because of the failure of the constant variance assumption for the disturbances across the sample (Ozuna, 1993). Further, if the estimated distribution function does not reflect the true distribution the result will be a misspecified functional form. The error as to estimated willingness to pay obtained using the estimated rather than the true distribution may be higher for general welfare measures than for truncated welfare measures. This might be the case if the estimated distribution were to predict large probabilities of willingness to pay for unfeasible prices. Truncated measures avoid the use of extreme price prediction errors which would result from the use of the wrong functional form and/or the wrong parameters. If the integral defining mean willingness to pay does not converge for the theoretical bounds or for the available data, then there would be a need for information for prices placed in the tails of the distribution. Since this information is not generally available, the common solution involves projecting the estimated results on prices for which actual responses have not been observed. In this respect, normalized truncated measures have the advantage of conditioning estimation to the feasible range actually investigated by the researcher.

A final remark must be made with respect to the possible difficulty encountered in empirical application of DC of a bid vector design which would allow estimated probability of acceptance of the highest bid offered or the threshold price to be nil for both single and double bounded. Relatively small departures from this zero probability may lead to unrealistic welfare estimates with no useful validity for policy purposes. Unexpected factors such as strategic behaviour and yea saying could result in wide tails with the need to predict the probability estimates for prices outside the feasible range of willingness to pay values. Finally, the introduction of a scaling factor with the normalized concepts may increase the statistical homogeneity of both estimated distributions, which may lead to a reduction of the disparities between single and double bounded.

## CONCLUSIONS

The empirical application presented in this paper aims at producing welfare estimates for the preservation of the landscape of a group of natural parks located in Gran Canaria (Canary Islands). In practical terms, the estimated benefits of preservation can be compared to the costs of the same to ascertain whether or not it is in the interest of society to accomplish a policy toward this end. The results have demonstrated that, in terms of benefits, the conclusions might have differed substantially if instead of a double bounded approach the researcher had decided to use a single bounded approach based on the same bid vector design. In support of the double bounded method, it can be argued that this allows individuals to participate in a learning process which leads to more accurate information. However, this may affect the principle of incentive compatibility, which is the most relevant advantage of the DC format.

Therefore, we consider it convenient to explore the disparities between single and double bounded DC CVM for the variety of welfare measures available to the researcher on non-market valuation. The comparison based on data from this specific case study shows that for the more common welfare measures used in the literature, double bounded estimates tend to be lesser than single bounded estimates. However, the use of normalized truncated welfare measures has led to a reduction of the disparities and to more efficient results. The latter measures have the advantage of being based on available empirical data. Therefore, the prediction errors for prices placed in the tails of the distribution which would result from model misspecification and poor bid design are not considered in the estimate of environmental benefits. If double bounded DC is to be useful for policy purposes, it needs to provide reliable welfare estimates to be consistent with single bounded DC. We conclude that further research is needed in developing design mechanisms which will lead to consistent results between single and double bounded models.

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