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## ENVIRONMENTAL MANAGEMENT AND DEVELOPMENT OCCASIONAL PAPERS

# A Comparison of Contingent Valuation and Choice Modelling: estimating the environmental values of Catalonian Forests

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## Abstract

In this study, welfare measures estimated using two different stated choice methods, the contingent valuation method (CVM) and choice modelling (CM), are compared. The application involves the estimation of non-market values from alternative afforestation programs in the northeast of Spain. The two techniques are found to yield equivalent estimates of welfare change for identical afforestation programs when the fully specified utility functions are used as the basis for the calculations. When elements of the utility functions – for instance the alternative specific constants and the sociodemographic variables - are omitted from the value estimation procedure, significant differences do occur between estimates derived using the two valuation techniques.



*Key words:* Choice modelling; Contingent valuation; Welfare measures; Forest externalities.

## 1. Introduction

Forests produce a number of goods and services. In addition to timber products, forests assist in controlling soil erosion, regulate stream flow, provide shelter, sequester carbon and are sites for recreational activities. Many of the benefits provided by forests do not have a market where values can be observed directly. Improved knowledge of the value of all forest goods and services should allow more informed decisions to be made in the public and private sectors. The full economic implications of managing forests in alternative ways, including the transformation of degraded land, can then be taken into account.

Methods available to estimate the non-market values of forest can be categorised as revealed and stated preference methods depending on whether they are based on existing markets or constructed hypothetical markets (Mitchell and Carson 1989). Among the stated preferences methods, the contingent valuation method (CVM) is most widely used. Other stated preferences methods, notably choice modelling (CM), are rising in popularity amongst environmental economists (Bennett and Blamey 2001).

The objective of this paper is to compare welfare measures estimated from different valuation methods, CVM and CM. The paper tests the convergent validity of the results derived from the two techniques where different elements of the utility functions are used to derive the welfare change estimates. The empirical study focuses on two specific afforestation programs in the same region of northeastern Spain that have different biophysical characteristics.

The structure of the paper is as follows. In the next section, a brief outline of the CVM and CM is provided. The case study used in this project and the design of the research are described in Section 3. The results are presented in Section 4 and the last section contains the conclusions and some suggestions for further research.

## 2. Contingent Valuation and Choice Modelling in environmental valuation

CVM is a stated preference method where respondents are asked their maximum willingness to pay (or minimum willingness to accept in compensation) for a predetermined increase or decrease in environmental quality. In the dichotomous choice version of CVM, respondents are offered a change in the quantity or quality of a good at a given cost, and the respondent either accepts or refuses the payment of the suggested cost. CVM has been used to estimate the value of a wide variety of environmental resources. However, its use has been subject to criticism in terms of its ability to deliver reliable and accurate estimates of the willingness to pay (Diamond and Hausman 1994).

CM is also a stated preference valuation method that has its origin in conjoint analysis and was initially developed in the marketing and transport literature by Louviere and Hensher (1982) and Louviere and Woodworth (1983). There have been numerous applications to estimate the value of recreational and environmental goods in recent years (for example, Opaluch *et al.* 1993; Adamowicz *et al*. 1994; Rolfe and Bennett 1996; Boxall *et al.* 1996; Adamowicz *et al.* 1998; Hanley *et al*. 1998a; Morrison and Bennett 2000).

In a CM application, respondents are presented with a series of choice sets, each containing usually three or more alternative goods. An alternative is a combination of several attributes, with each attribute taking on a value, usually called a level. For instance, an alternative could be described as *h* hectares of additional forest with *p* percentage of tree species *s*, that would cost *c* monetary units. One of the alternatives in each choice set describes the current or future 'business-as-usual' situation, and remains constant across the choice sets. From each choice set, respondents are asked to choose their preferred alternative. The attributes used are common across all alternatives. Their levels vary from one alternative to another according to an experimental design (for a review, see Bennett and Blamey 2001).

## 2.1 Model specification and estimation

The CVM and CM share a common theoretical framework: the random utility model (RUM) (Thurstone 1927; McFadden 1973). Under the RUM framework, the indirect utility function for each respondent can be expressed as:

$$U_{ij} = V_{ij} + \varepsilon_{ij}\,, \qquad (1)$$

where $U_{ij}$ is person *i*'s utility of choosing alternative *j*, $V_{ij}$ is the deterministic component of utility and $\varepsilon_{ij}$ is a stochastic element that represents unobservable influences on individual choice.

In the dichotomous choice form of the CVM, respondents are asked to choose between an improved state, *j*, and the 'business-as-usual', *k*. Utilising utility functions for two alternatives from (1), the probabilities of an individual choosing alternatives *j* or *k* are:

$$P_{ij} = P(\varepsilon_{ij} - \varepsilon_{ik} < V_{ik} - V_{ij})$$

$$P_{ik} = P(\varepsilon_{ik} - \varepsilon_{ij} < V_{ij} - V_{ik}) \qquad (2)$$

In order to derive an explicit expression for these probabilities, an assumption is made about the distribution of the error terms. Assuming that each of the random terms is Type I Extreme Value distributed and the difference between random terms is logistically distributed, the probability that a respondent chooses alternative *j* is given by:

$$P_{ij} = \frac{e^{(Vij - Vik)}}{1 + e^{(Vij - Vik)}} \qquad (3)$$

This formulation can be estimated using the binary logit model (Hanemann 1984).

In CM, the probability that any particular respondent prefers option *j* in the choice set to any alternative option *k*, can be expressed as the probability that the utility associated with option *j* exceeds that associated with all other options. Formally,

$$P_{ij} = P\{V_{ij} + \varepsilon_{ij} > V_{ik} + \varepsilon_{ik}\,;\ \forall\ k \in C\} \qquad (4)$$

where C is the set of all possible alternatives. Assuming a Type I Extreme Value distribution for the error terms, the probability of choosing alternative *j* is:

$$P_{ij} = \frac{e^{\omega V_{ij}}}{\sum_{k \in C} e^{\omega V_{ik}}} \qquad (5)$$

This specification is known as the conditional logit model (McFadden 1973) where ω is a scale parameter, inversely proportional to the standard deviation of the error distribution, and typically assumed to be one. An important implication of this specification that follows from the independence of the error terms across the different options contained in the choice set, is the property of the independence of irrelevant alternatives (IIA). This property requires that the probability of an option being chosen should be unaffected by the inclusion or omission of other alternatives. This condition is normally tested using the test devised by Hausman and McFadden (1984). If a violation of the IIA assumption is observed, then more complex models of choice are required.

There has been some discussion regarding the advantage of CM relative to CVM (Hanley *et al*. 1998b; Bennett 1996; Swait and Adamowicz 2001). CM allows the identification of the trade-offs that each individual makes between attributes. If one of the attributes is the money that a person would have to pay to secure the change, it is possible to generate estimates of the marginal value of changes in each attribute. Moreover a single CM application can be used to generate estimates of compensating surpluses for an array of specific environmental qualitative or quantitative changes relative to the 'business-as-usual' situation. However there are some issues related to the use of CM, including the presence of strategic behaviour in respondent choice, the design of the experiments, fatigue, learning and complexity, that still require significant research effort (Adamowicz and Boxal 2001).

## 2.2 Comparison between the Contingent Valuation Method and Choice Modelling

A number of studies have compared welfare estimates derived from CVM and CM. The results of these studies are summarised in Table 1. Given that CM may offer some advantages over CVM, the question remains if the two methods yield estimates of compensating surpluses that are consistent.

The results reported in Table 1 provide mixed evidence of the convergent validity of the welfare measures (that is, the two methods yield the same welfare estimate). The results are sensitive to the assumptions made regarding the specification of the form taken by individual preferences. In Adamowicz *et al.* 1998, a linear functional form of the indirect utility function produced welfare measures for the CM that were lower than the CVM estimates, while a quadratic CM model produced measures that were higher than those generated by CVM. Convergent validity also appears dependent on the measure of central tendency chosen (that is, median or mean in Lockwood and Carberry 1998). With such mixed evidence, the objective of this paper is to explore further the consistency of CVM and CM welfare changes estimates. The context used for this comparison is the estimation of the environmental benefits associated with afforestation projects in Catalonia, Spain.

## 3. Afforestation in Catalonia and the research design

The valuation exercise presented in this paper involves the estimation of the impact of alternative afforestation programs on non-market forest values. The afforestation program concerned is in Catalonia, a region in the northeast of Spain, which has 1.3 million ha of forests, or about 40 per cent of its total area. Although the composition of the forest varies from the coastal areas to the Pyrenees and the inland plains, most are composed of Mediterranean species. The pine (*pinus halepensis* and *pinus sylvestris*) is the dominant species, covering 50 per cent of the forested area, followed by the holm oak (*quercus ilex*) with some 10 per cent (Ministerio de Medio Ambiente 1996). The majority (77 per cent) of forests are privately owned.

The program being proposed involves an increase in forest coverage from the current 40 per cent of the Catalonian area to 50 per cent. The additional 10 per cent of forest area would be at the expense of marginal agricultural land.

The questionnaire designed to estimate the non-market forest values of afforestation included four parts. The first part described some positive and negative effects of the afforestation program to the respondent. The second was the CM part. The next part was a CVM question. The final part of the questionnaire was devoted to the collection of some socio-demographic characteristics of the respondent.

*TABLE 1* ***COMPARISON OF WELFARE MEASURES OBTAINED BY CVM AND CM***

| Reference | Application | CVM | CM |
|---|---|---|---|
| Boxall *et al.* (1996)# | Impact of alternative Wildlife Management Units (WMU) | US$85.59<br>(Mean CS; DC for 1 WMU) | US$56.69<br>( Mean CS for 1 WMU) |
| Hanley *et al.* (1998a)## | Conservation of environmentally sensitive areas | £31.43 (Mean OE)<br>£98 (Mean DC) | £182.84<br>(Mean CS Linear model)<br>£107.55<br>(Mean CS. Quadratic model) |
| Hanley *et al.* (1998b)# | Alternative forest landscapes | £29.16<br>(Mean OE for the 'ideal forest') | £38.15<br>(Sum of the marginal WTP of the forest attributes for the 'ideal forest') |
| Adamowicz *et al.* (1998)# | Preservation of the Caribou habitat | US$142.82 (Median CS; DC. Linear model)<br>US$140.86 (Median CS; DC. Quadratic model) | US$91.84<br>(Median CS. Linear model. Intercept excluded)<br>-US$116.29<br>(Median CS. Linear model. Intercept included)<br>US$217.83<br>(Median CS. Quadratic Model. Intercept excluded)<br>US$76.70<br>(Median CS Quadratic Model. Intercept included) |
| Lockwood and Carberry (1998)# | Remnant native vegetation Conservation | A$80.69<br>(Mean CS;<br>DC. New South Wales)<br>A$77.35<br>(Mean CS;<br>DC. Northeast Victoria)<br>A$25.20<br>(Median CS;<br>DC. New South Wales)<br>A$3.71<br>(Median CS;<br>DC. Northeast Victoria) | A$51.97<br>(Mean CS.<br>New South Wales)<br>A$43.15<br>(Mean CS.<br>Northeast Victoria) |
| Christie and Azevedo (2002)## | 3 programs to preserve and improve the quality of the lake's water. | -US$658<br>(Mean CS; DC. Plan A)<br>US$540<br>(Mean CS; DC. Plan B)<br>US$821<br>(Mean CS; DC. Plan C) | -US$2122<br>(Mean CS. Plan A)<br>US$616<br>(Mean CS. Plan B)<br>US$2921<br>(Mean CS. Plan C) |

# The CVM and the CM were administered to the same sample
## The CVM and the CM were administered to different samples
DC: Dichotomous Choice CVM, OE: Open-Ended CVM, CS: Compensation surplus
The CM models were computed using the conditional logit models

## 3.1 Design of the Choice Modelling questions

The non-market attributes of afforestation are numerous and include soil erosion control, water quality maintenance, biodiversity protection, carbon sequestration, and the provision of attractive sites for recreational activities. One of the first steps in implementing the CM method is to select the attributes to be used to describe each afforestation alternative. A choice is necessary because the use of a large number of attributes is likely to lead to lower data reliability due to the excessive cognitive burden it would place on respondents. The selection of the non-market attributes is based on what is relevant to society. For this study, this was undertaken through consultation with experts working in forestry research and focus groups of potential respondents. The pre-selection was then tested and refined in a pilot survey. The attributes chosen through this process were the availability of recreational activities (picnicking, picking mushrooms, and driving motor vehicles on forest ways), $CO_2$ sequestration and erosion control. A payment vehicle of an annual contribution that the Catalan citizens would make to a fund exclusively dedicated to the afforestation program, was also used as an attribute. Payment values were originally expressed in Spanish pesetas, although in this paper they are reported in Euros. The description of the attributes and their levels are shown in Table 2.

***TABLE 2** ATTRIBUTES AND LEVELS USED IN THE CM EXERCISE*

| Attribute | Description | Levels |
|---|---|---|
| Picnic | Picnicking allowed in the new forests<br>(BAU[#] = No) | Yes<br>No |
| Drive | Driving by car allowed through the new forests would be allowed<br>(BAU = No) | Yes<br>No |
| Mushrooms | Picking mushrooms allowed in the new forests<br>(BAU = No) | Yes<br>No |
| $CO_2$ | $CO_2$ sequestered annually by the new forests. Equivalent to the pollution produced annually by a city of...<br>(BAU = 0) | 300.000 people<br>400.000 people<br>500.000 people<br>600.000 people |
| Erosion | Number of years that the new forest will increase the productivity of the soil.<br>(BAU = 0) | 300 years<br>500 years<br>700 years<br>900 years |
| Cost | The afforestation cost per person and year<br>(BAU = 0) | 6 Euros<br>12 Euros<br>18 Euros<br>24 Euros |

[#]BAU: Business-as-usual alternative

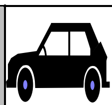
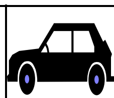
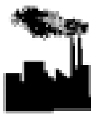
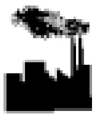
An experimental design[1] was used to structure choice sets with two afforestation alternatives (Louviere, 1988). The six attributes and their levels form a universe of $(2^3 \times 4^3) \times (2^3 \times 4^3)$ possible combinations for the afforestation alternatives. The final experimental design consisted of 64 pairs of afforestation alternatives chosen following an orthogonal fractional factorial design. This design permits the

[1] We are grateful to Professor Jordan Louviere for his assistance in the development of an experimental design for this application.

estimation of all two-way interactions in addition to main effects[2]. Figure 1 displays one of the resulting choice sets.

The 64 pairs were blocked into 16 blocks of 4 choice sets of two afforestation alternatives. Blocking was used because it is unrealistic to assume that each individual can respond to all 64 choice sets in an interview. The pre-test showed that respondents could cope with 4-5 choice sets in each questionnaire. The option of the 'Business-as-Usual' situation (no afforestation and no payment required) was included with each pair of alternatives to form the choice sets. Hence, in each choice set, respondents were asked for their preferred choice between the 'Business-as-Usual' situation and two afforestation alternatives scenarios.

*FIGURE 1. **EXAMPLE OF A PAIR OF AFFORESTATION ALTERNATIVES USED IN THE CM EXERCISE***

| FOREST UTILITY | AFFORESTATION A | AFFORESTATION B |
|---|---|---|
| **RECREATIONAL ACTIVITIES** |  • DRIVE IN FOREST WAYS |  • DRIVE IN FOREST WAYS  • PICNIC |
| **$CO_2$ SEQUESTERED PER YEAR** |  CITY OF 400.000 INHABITANTS |  CITY OF 500.000 INHABITANTS |
| **INCREASE IN SOIL PRODUCTIVITY** | 500 YEARS | 500 YEARS |
| **ECONOMIC COST** | | |
| **ANNUAL CONTRIBUTION** | **18** Euros/year | **24** Euros/year |

## 3.2 Design of the Contingent Valuation question

A CVM question was also presented to the respondents. The objective of the CVM was to estimate the maximum willingness to pay (WTP) for two specific afforestation projects: FOREST A and FOREST B. In order to facilitate the comparison between the two methods, the afforestation projects had the same basic form as those described in the CM exercise, that is, covering an additional 10 per cent of the surface of Catalonia, using marginal agricultural land. The quantity and quality levels of the new forests were described using the same attributes and levels as in the CM (Table 2). The two afforestation programs involved a change from the 'Business-as-Usual' situation to the afforestation programs described in Table 3. The attributes levels of the 'Business-as-Usual' were the same as in the CM. It was assumed, from the physical attribute levels, that FOREST B was preferred to FOREST A.

[2] An experimental design that permitted the estimation of all two-way interactions, is a wise design strategy because main effects and two-way interactions account for virtually all the reliably explained variance in choices (Louviere *et al*., 2000).

*TABLE 3* ***ATTRIBUTES AND LEVELS USED IN THE CVM EXERCISE***

| Attribute | FOREST A | FOREST B |
|---|---|---|
| Picnic | Yes | Yes |
| Drive | Yes | Yes |
| Mushrooms | Yes | Yes |
| $CO_2$ | 400,000 people | 600,000 people |
| Erosion | 500 years | 900 years |
| Cost | 6 Euros<br>12 Euros<br>18 Euros<br>36 Euros<br>48 Euros<br>72 Euros | 6 Euros<br>12 Euros<br>18 Euros<br>36 Euros<br>48 Euros<br>72 Euros |

A dichotomous choice CVM question was employed. After describing the particular forest composition, the respondents were given the option of choosing to pay a cost (annual payment) and accepting the afforestation program, not paying the cost amount and not accepting the program ('Business-as-Usual' option) or responding 'I don't know'. The costs (bids) were 6, 12, 18, 36, 48, and 72 Euros, and one amount was assigned to each questionnaire version, making a total of six versions per type of afforestation.

## 3.3 The sample

The CM and the CVM questionnaire were administered to a sample of the Catalan population. Personal interviews were conducted in respondents' houses. The 16 versions of the CM questionnaire were assigned to sub-samples of the total sample of 1200 individuals. This sample was chosen so as to be representative in terms of location, age and gender[3]. The CVM was presented to a sub-sample of 1000 respondents of the total sample used in the CM. This sub-sample was split into two approximately equal sub-samples also representative of the Catalan population in terms of location, gender and age[4]. Each sub-sample was assigned a given afforestation project (FOREST A or FOREST B), and one of the six CVM questionnaire versions was randomly allocated to respondents within each sub-sample. The surveys were collected during the second half of 1999.

The average response rate in the CM was 95 per cent across all subsamples, while in the CVM 93 per cent of the sample responded to the FOREST A versions, and 75 per cent responded for the FOREST B versions. The same questionnaire was used for the CVM and CM, although the larger number of individuals who did not provide any answer or said 'no', because of a protest reason in the CVM, explains the lower response rate in the CVM. The most common motives for protesting were disagreement with the payment vehicle, distrust in the use of the money and that the government should be the one to pay for the proposed afforestation. The usual practice in CV studies is to exclude protest answers from the calculation of the welfare measure (Mitchell and Carson, 1989; Jorgensen *et al.*, 1999). In this particular exercise, the deviation in the welfare estimates from including all 'no' responses is not statistically significant.

[3] The 16 questionnaire versions were randomly distributed in 25 locations, proportionally to the population of each location. In each location, the questionnaires were distributed using random survey routes, with the sample being stratified to include ten respondents selected in terms of gender and age.
[4]The rest of the sample (200 respondents) were asked questions irrelevant to the current study

The sociodemographics of the respondents who completed the CM surveys and who completed the CVM questions with valid responses for each one of the afforestation programs are summarized in Table 4.

*TABLE 4* ***SOCIODEMOGRAPHICS OF THE RESPONDENTS IN THE CM AND CVM SURVEY***

| Variable | CM Sample | CVM Sample FOREST A | CVM Sample FOREST B | Catalonia Average |
|---|---|---|---|---|
| Respondent Age (>18 years) | | | | |
| 18-29 | 21% | 22% | 24% | 20% |
| 30-44 | 31% | 29% | 28% | 31% |
| 45-64 | 30% | 27% | 30% | 27% |
| 65 or over | 18% | 22% | 18% | 22% |
| Gender (% Male) | 50% | 48% | 52% | 49% |
| Education (% with primary school finished) | 64% | 62% | 68% | 82.30% |
| Income (net average monthly income, Euros) | 552.25 | 392 | 305 | 705 |
| Visitation (% of respondents that have gone to the forest in the last year) | 57% | 61% | 63% | Not available |
| Village size (< 10.000 inhabitants) | 21% | 14% | 36% | 20% |

**Source:** Institut d'Estadistica de Catalunya (2002) and Instituto Nacional de Estadística (2002)

The age and gender of the survey sample are not statistically different from the Catalonian average. However, respondents' incomes and educational qualifications are lower than the average population[5]. In the CVM, the subsample corresponding to FOREST A tends to be representative of the urban areas whereas for FOREST B it tends to be self-selected toward rural areas.

# 4. Results

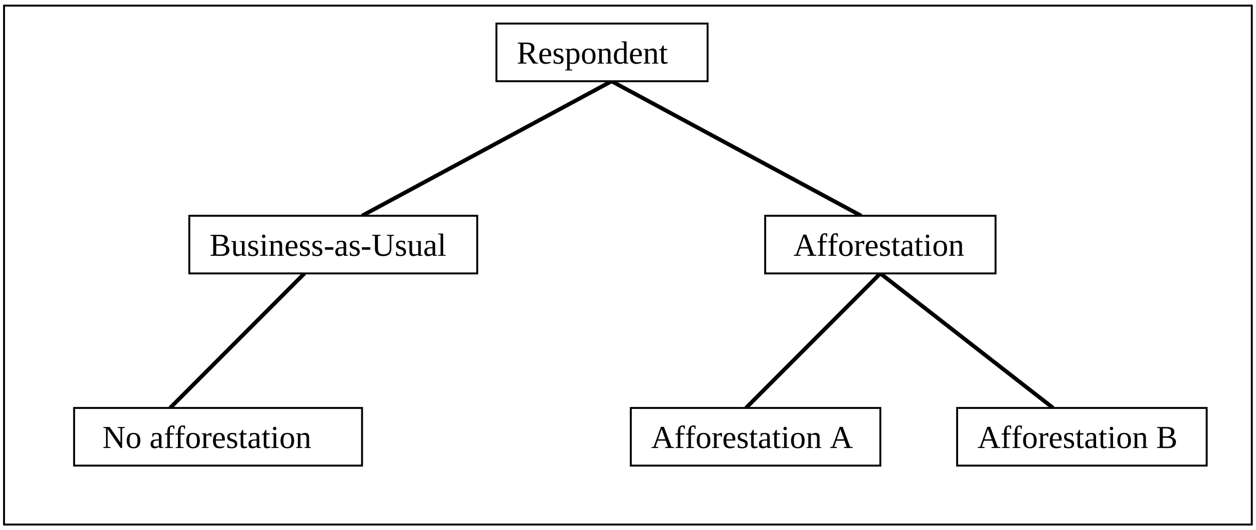
## 4.1 The models

The choice data collected from the CM in the surveys were analysed statistically to detect relationships between the levels of the forest attributes, the sociodemographic characteristics of the respondents and the probability of respondents choosing particular alternatives. A multinomial logit model (MNL) was initially used. Using the test developed by Hausman and McFadden (1984), the assumption of the independence of irrelevant alternatives was tested and found to be violated. Hence a nested logit model (NL) was constructed.

Nested logit models are appropriate when modelling a number of discrete alternatives and when similarities exist across the unobserved attributes of utility over particular choices (Schwabe *et al.*, 2001). In this application, a two level nested choice model was estimated. The tree structure has two branches. In the first level, respondents were assumed to make a choice about whether they would support an increase in the forest area (afforestation) against continuation of the current situation ('Business-as-Usual'). In the second level, if respondents chose to support the afforestation, then they were assumed to choose between the two afforestation alternatives presented in each choice set. This hierarchical structure is pictured in Figure 2.

[5] Chi-squared tests of independence were conducted to determine whether the CVM and CM samples had the same sociodemographics as the Catalonia population.

*F*IGURE *2* ***H*IERARCHICAL MODEL STRUCTURE**




The NL model includes additional parameters to explain the choices made by respondents. These are the inclusive value parameters ($\alpha_i$), which are associated with the inclusive value indices ($IV_i$). Each inclusive value index can be interpreted as the expected maximum utility from the set of alternative options associated with a given branch. Hence the inclusive value parameter measures the degree of substitutability between the various branches at the 'upper level' of the model (Louviere *et at.*, 2000). The utility associated with each specific afforestation alternative (the 'lower level') was assumed to be a function of each alternative's characteristics, the sociodemographic characteristics of the respondents, the interactions of choice attributes with the individual sociodemographic characteristics, and the two-way interactions between attributes. Hence the nested logit model estimated was:

*Upper level*

$V_{afforestation} = \alpha_1 IV_{afforestation}$
$V_{BAU} = \alpha_2 IV_{BAU}$

Where $V_{afforestation}$ is the utility associated with the afforestation options and $V_{BAU}$ is the utility obtained from selecting the 'Business-as-Usual' option. The inclusive value parameter associated with the 'Business-as-Usual' branch ($\alpha_2$) was fixed to one.

*Lower level*

Alternative A:

$$V_A = \alpha_1 * (ASC + \sum_r \beta_r X_r + \sum_p \theta_p Z_p + \sum_{rp} \phi_{rp} X_r Z_p + \sum_{rr} \varphi_{rr} X_r X_r)$$

Alternative B:

$$V_B = \alpha_1 * (\sum_r \beta_r X_r + \sum_p \theta_p Z_p + \sum_{rp} \phi_{rp} X_r Z_p + \sum_{rr} \varphi_{rr} X_r X_r)$$

Alternative BAU:

$$V_{BAU} = \sum_r \beta_r X_r + \sum_p \theta_p Z_p + \sum_{rp} \phi_{rp} X_r Z_p + \sum_{rr} \varphi_{rr} X_r X_r$$

The ASC is an alternative specific constant equal to 1 for alternative A and B and 0 otherwise. $\beta_r$, $\theta_p$, $\phi_{rp}$, $\varphi_{rr}$, are parameter vectors conditional on, respectively,

(a) a matrix of $r = 1, ..., R$ attributes of the alternative options, $X_r$;

(a) a matrix of $p = 1, ..., P$ socio-demographic characteristics of the respondents, $Z_p$;

(b) a matrix of interaction of choice option attributes with the sociodemographic characteristics, $X_rZ_p$; and,

(c) a matrix of two-way interactions between the choice option attributes, $X_rX_r$.

$V_A$ and $V_B$ represent the indirect conditional utility of the two afforestation alternatives, and $V_{BAU}$ represents the utility of the ‘Business-as-Usual’ situation. The sociodemographic variables were included through interactions with the alternative specific constant.

The results of the NL model that yielded the best goodness-of-fit and greatest statistical efficiency, are presented in Table 5. The explanatory power of the model, measured by the pseudo-$R^2$ (Ben Akiva and Lerman, 1985) is satisfactory by the conventional standards (Hensher and Johnson, 1981). The signs of the parameters are consistent with *a priori* expectations, and all attributes except Drive are statistically significant at 95 per cent level. The positive coefficients of picnicking, picking mushrooms, $CO_2$ sequestered and erosion decrease, suggest that afforestation programs were more likely to be chosen when picnicking and picking mushrooms were permitted, the amount of $CO_2$ sequestered was high, and erosion was postponed longer. However, afforestation programs with higher cost contribute negatively to utility and are therefore less likely to be selected. The *Drive* attribute was found to be not statistically significant as a stand-alone variable and was not included in the model. The importance of *Drive* as an explanatory variable arises from its interaction with other attributes and the sociodemographic characteristics of the respondents. The two statistically significant second order interactions with drive are picking mushrooms and erosion. The first one could be interpreted as if the use of cars in forests, other things being equal, tended to decrease the utility of the respondent who significantly values picking mushrooms – it suggests some degree of social incompatibility. The interaction between drive and erosion suggests that utility from free car access is also reduced, maybe due to a perception amongst respondents that a greater rate of erosion may be caused by the use of cars. However there was no debriefing question dealing with the motives for the choices made by respondents. The cross-products of the attributes with the sociodemographic characteristics, suggest that the negative impact on utility of using cars is higher for respondents who use the forest for recreational activities and live in urban areas[6]. The positive sign of the variable *Price*Visitation*, means that the probability of a respondent agreeing to pay for the afforestation program is higher for respondents who use the forest for recreational activities.

Focusing on the socio-demographic characteristics, being female, living in a rural area, having higher income and using forest for recreation, increase significantly the probability of choosing the afforestation program alternatives. Age was found to have a parabolic influence, where the probability of choosing the afforestation program increases in the groups between 25 and 65 years old.

[6] The irony of this finding is that most urban residents would have used cars to travel to the forest.

*TABLE 5* ***RESULTS OF THE NESTED LOGIT MODEL***

| Variable | Coefficient | Variable | Coefficient |
|---|---|---|---|
| Attributes | | Interactions attributes-sociodemographics | |
| Constant | 0.172*** | Drive*Visitation | -0.193*** |
| Picnic | 0.138*** | Drive*Rural | 0.326*** |
| Mushroom | 0.699*** | Price*Visitation | 0.011* |
| $CO_2$ | 1.131E-6*** | Interactions between attributes | |
| Erosion | 0.873E-3*** | Mushroom*Drive | -0.282*** |
| Cost | -0.026*** | Mushroom*Erosion | -0.722E-3*** |
| Interactions with ASC | | Inclusive Value parameter | |
| Age | -0.023*** | Afforestation ($\alpha_1$) | 0.621*** |
| Age2 | 0.109E-2*** | Status quo (Fixed Parameter) | 1 |
| Gender | -0.591*** | Model Statistics | |
| Income | 0.148E-2*** | Maximum Log. Likelihood | -4,470.540 |
| Visitation | 0.744*** | Pseudo-$R^2$ | 0.24 |
| Rural | 1.055*** | $\chi^2$ | 2,746.812 |
| | | Observations | 4,476 |

***Significant at 1% level, * Significant at 10% level

**Variable definitions:**

Age = individual's age minus mean age of sample (45.64)
Age2 = age squared = $(Age – 45.64)^2$
Gender = gender of the respondent (1 for male, 0 for female)
Income = income of the respondent in Euros
Visitation = Use of the forest for recreation (1 if the respondent had used the forest during the last year, 0 otherwise)
Rural = village size (1 if <10,000 inhabitants, 0 if >10,000 inhabitants)

Results of the analysis of CVM responses for FOREST A and FOREST B are provided in Table 6. The two CVM models were estimated using binary logit models where the dependent variable takes the value one if the respondent accepted to pay, and zero otherwise (Hanemann, 1984; and Hanemann and Kanninen, 1999). The independent variables are the monetary payment (cost) and the sociodemographic characteristics of the respondents.

The coefficient of cost is negative and significant in both models. This indicates that the probability for people agreeing to pay the proposed amount decreases as the cost increases. In both CVM models, those who have more income, those who used the forest for recreation during the last year and those who live in a rural area are more likely to pay. The chi-square statistic indicates that each model is significant at the 99 per cent level.

*TABLE 6* ***LOGIT MODEL ESTIMATION FOR FORESTS A AND B***

| Variable | FOREST A Coefficient | FOREST B Coefficient |
|---|---|---|
| Constant | 0.577 *** | 0.760** |
| Cost | -0.033*** | -0.018*** |
| Gender | -0.215E-02 | -0.464** |
| Income | 4.261E-4*** | 5.017E-4** |
| Visitation | 0.581*** | 0.461** |
| Rural | 1.091*** | 0.448* |
| Maximum Log. Likelihood | -289.469 | -237.815 |
| % of correct predictions | 68% | 63% |
| $\chi^2$ | 64.856 | 22.586 |
| Pseudo-$R^2$ | 0.1 | 0.06 |
| Number of valid observations | 464 | 371 |

*** Significant at 1% level
** Significant at 5% level
* Significant at 10% level
**Note:** Age is not significant in the logit estimation
**Variable definitions:**

Cost = bid amount (possible values in Euros)
Gender = gender of the respondent (1 for male, 0 for female)
Income = income of the respondent in Euros
Rural = village size (1 if <10.000 inhabitants, 0 if >10.000 inhabitants)
Visitation = Use of the forest for recreation (1 if the respondent had used the forest during the last year, 0 otherwise)

The CM model is superior to the CVM estimation in terms of the goodness-of-fit (Pseudo-$R^2$). This result suggests that CM has a greater capacity to explain the choices made by respondents. One possible reason for this is that CM choices are explained in terms of variations in multiple attributes, respondents' socio-demographic characteristics and the interactions between these variables, whilst CVM responses can only be explained in terms of one attribute (cost) and the socio-economic characteristics.

## 4.2 Welfare estimates

Since both CVM and CM are based on RUM theory, the welfare estimates associated with the afforestation programs obtained using these methods in this study can be compared. In the CVM case, two changes were examined - the changes from the 'Business-as-Usual' situation to FOREST A and from the 'Business-as-Usual' situation to FOREST B. Using the welfare measures outlined by Hanemann (1984) for discrete CVM responses, the mean WTP for the FOREST A (WTPA) and FOREST B (WTPB) were estimated. The mean WTP was determined using the formula[7]:

[7] The formula corresponds to the unrestricted mean WTP that implies that mean WTP can assume positive and negative values. Since it is possible that individuals would rather maintain the 'business-as-usual' situation, the possibility of negative WTP measures in the CVM exists and the unrestricted mean WTP is appropriate. The median is not calculated separately because if the utility function is linear in parameters, as in this study, then the mean and the median of the distribution of WTP coincide (Hanneman, 1989)

$$MeanWTP = -\frac{\delta}{\beta} \qquad (6)$$

where β is the value of the coefficient of the cost variable in the estimated logit equation, and δ is the sum of all other terms in the equation evaluated at the mean values of the explanatory variables.

In order to compare the welfare measures obtained from each method, the welfare changes for the same afforestation programs used in the CVM were also calculated from the CM results. The levels of the attributes used in the CVM exercises were within the range of the attribute levels used in the CM. The welfare measures were estimated as the compensating surplus for each afforestation program using the following equation (Kling and Thomson, 1996):

$$MeanWTP = -\frac{1}{\beta}\left\{ \ln\left[ \sum_{m=1}^{M} \left( \sum_{j=1}^{J_m} e^{\frac{V_{mj}^1}{\alpha_m}} \right)^{\alpha_m} \right] - \ln\left[ \sum_{m=1}^{M} \left( \sum_{j=1}^{J_m} e^{\frac{V_{mj}^0}{\alpha_m}} \right)^{\alpha_m} \right] \right\} \qquad (7)$$

where M is the number of branches of the nested model, $J_m$ is the number of alternatives in each branch, $V_{mj}$ is the utility associated with the alternative *j* contained in the branch *m*, and $\alpha_m$ is the inclusive value parameter that measures the degree of substitution between the various branches. $V^0$ represents the utility of the 'Business-as-Usual' state and $V^1$ represents the level of utility of the alternative state.

For both the CVM and CM, the attribute levels of 'Business-as-Usual' are set to zero. To estimate the utility of the afforestation FOREST A ($V_A$) and afforestation FOREST B ($V_B$), improvements were defined using the levels of the attributes outlined in each of the two CVM questions (Table 3). The sociodemographic characteristics were set at the population mean levels.

## 4.3 Specification of the welfare estimation process

Different model specifications of a utility function with the same parametric distribution can lead to widely different welfare estimates (Alberini and Cooper, 1995). Kling and Thomson (1996), in an analysis of the sensitivity of welfare measures to alternative nesting structures, noted the influence of the choice of variables included in the estimation of welfare measures. Similarly, the magnitude of welfare estimates can be influenced by the inclusion or omission of elements of the utility function in the estimation process. For instance, some studies that have compared welfare estimates obtained from CVM and CM have not included the sociodemographics variables and/or the alternative specific constants (ASCs) in the specification of the welfare estimation process (Boxall *et al.* 1996; Hanley *et al.* 1998a; Hanley *et al.* 1998b; and Christie and Azevedo, 2002). The omission of the ASCs has been justified on the grounds that, even though they may improve the model fit, they are not related to specific attributes and hence do not explain choice in terms of observable attributes (Adamowicz *et al.*, 1997). Alternatively, given that the ASCs reflect part of the explanation of respondents' choices, there is an argument for including them in the welfare estimation process (Morrison *et al.*, 2002).

In order to examine the influence of the specification of the welfare estimation process on the convergent validity of the welfare measures derived from CM and CVM, three alternative welfare estimation specifications were investigated. Each alternative specification is based on the form of the models with the most complete utility specification (Section 4.1). Welfare Specification A is based on the complete model. In Specification B, the intercept was excluded for the CVM estimate and the ASC was excluded for the CM estimate. In Specification C, the welfare measures were estimated without the interactive independent variables in the CM. In Specification D, sociodemographic variables in the

CVM and sociodemographic variables and interactions in the CM were excluded. The welfare measures and the confidence intervals for the two afforestation programs calculated using CVM and CM, under these different welfare estimation specifications, are reported in Table 7. The confidence intervals were calculated using the Krinsky and Robb (1986) bootstrapping procedure from 1000 draws. All estimates are significantly different from zero at the five per cent level.

*TABLE 7* **COMPARISON OF WILLINGNESS TO PAY FOR DIFFERENT UTILITY SPECIFICATIONS**

| Welfare specification | FOREST A (1999 Euros) | FOREST B (1999 Euros) |
|---|---|---|
| Specification A (section 4.1) | | |
| CVM | 37.5<br>(31.57, 45.97) | 61.53<br>(47.6, 104.75) |
| CM | 56.68<br>(33.18, 95.33) | 63.1<br>(37.55, 105.83) |
| Specification B (Intercept and ASC excluded) | | |
| CVM | 20.4<br>(10.83, 33.42) | 20.55<br>(1.16, 59.55) |
| CM | 52.67<br>(30.01, 87.81) | 59.17<br>(34.74, 98.25) |
| Specification C (Interactive variables excluded) | | |
| CVM | 37.5<br>(31.57, 45.97) | 61.53<br>(47.6, 104.75) |
| CM | 76.38<br>(45.93, 122.73) | 89.65<br>(54.56, 145.25) |
| Specification D (Sociodemographic and interactive variables excluded) | | |
| CVM | 17.22<br>(4.53, 28.51) | 41.44<br>(15.9, 77.33) |
| CM | 45.03<br>(27.98, 73.73) | 58.73<br>(36.5, 97.06) |

The results show that there is apparent variation across the willingness to pay estimates resulting from each of the different welfare estimation specifications. In all the specifications, the welfare measures obtained for the two forests are higher in the CM than in the CVM. The difference between the CVM and CM estimates is particularly marked for both FOREST A and FOREST B in the case of the welfare estimation specification which excludes the ASC and constant terms (Specification B). Differences across the methods for both forests are smallest for Specification A in which the full models are used.

## 4.4 Tests for equivalence between methods

To substantiate these observed differences between CVM and CM welfare estimates, the relevant null and alternative hypotheses to be tested are:

$H_0$: $WTPA_{CVM} = WTPA_{CM}$
$H_1$: $WTPA_{CVM} \neq WTPA_{CM}$
and

$H_0$: $WTPB_{CVM} = WTPB_{CM}$
$H_1$: $WTPB_{CVM} \neq WTPB_{CM}$

Following the convolution test proposed by Poe *et al.* (1997), the confidence intervals of the difference between the two random variables of interest ($WTP_{CVM}$ and $WTP_{CM}$) were calculated. The null hypothesis of equality can thus be reformulated as the difference between $WTP_{CVM}$ and $WTP_{CM}$ being equal to zero.

The results of the hypothesis tests for the welfare measures estimated using the different welfare estimation specifications are shown in Table 8. The mean WTP estimates derived using CM and CVM are equivalent at the five per cent significance level for both FOREST A and FOREST B only when Specification A is used. When the specification of the welfare estimate is simplified, the two techniques no longer provide consistently equivalent estimates at the five per cent level for both afforestation programs.

It is useful to observe that for FOREST A, equivalence at the ten per cent significance level is not achieved for any specification of the welfare estimate. In contrast, for FOREST B, equivalence is achieved (at the five per cent level) for all specifications other than Specification B (ASC and constant omitted).

***TABLE 8 RESULTS OF HYPOTHESIS TESTS FOR EQUIVALENCE BETWEEN CVM AND CM***

| | 95 per cent Confidence Intervals ($WTP_{CM}$-$WTP_{CV}$) | | Significance Level ($WTP_{CM}$-$WTP_{CV}$) | |
|---|---|---|---|---|
| | FOREST A | FOREST B | FOREST A | FOREST B |
| Spec A | (-5.09, 58.90) | (-46.45, 47.31) | 0.080 | 0.475 |
| Spec B | (5.00, 70.26) | (-7.49, 86.11) | 0.000 | 0.004 |
| Spec C | (6.42, 85.57) | (-24.85, 84.10) | 0.000 | 0.150 |
| Spec D | (6.67, 59.30) | (-24.72, 64.91) | 0.000 | 0.195 |

The above results provide a mixed picture. For FOREST A, only for Specification A do the CVM and CM yield equivalent estimates of compensating surplus. However, this equivalence is weak as the hypothesis that the two methods yield equal estimates is rejected at the 10 per cent level. For the other specifications, the CM welfare estimates were found to be greater than those obtained from the CVM. This outcome is consistent with those found in other studies (Hanley *et al*., 1998a; Lockwood and Carberry, 1998; Christie and Azevedo, 2002). Lockwood and Carberry (1998) suggested that the larger WTP obtained by CM may be explained by the lower recognition of the WTP attribute compared to CVM. The monetary attribute in CM is only one of the several attributes that defines the alternatives, and, hence, is de-emphasized in importance relative to its central role in the CVM. However this remains conjectural. In contrast, the only specification that yielded a significant difference (at the five per cent level) between CVM and CM derived estimates for FOREST B was Specification B.

The inconsistency in equivalence between CVM and CM derived estimates for the two scales of afforestation represented by the FOREST A and FOREST B scenarios is further confounded by the apparent presence of embedding effects in the CM estimates[8]. Whilst the CVM estimates for the two forests are significantly different at the five per cent level for Specifications A and C, none of the CM

[8] The embedding effect implies that people's valuation of a good is basically independent of the quantity or quality of the good (Kahneman and Knetsch , 1992).

welfare estimation specifications yield significant differences. Hence, there is evidence to suggest that the CM results are more prone to embedding problems than the CVM results.

Notwithstanding the embedding effect potential, there is a degree of consistency across the CM results for both forests using the alternative specifications for welfare estimation. In other words, no matter what specification is used, the CM estimates are not significantly different from each other. Even in the case of the CVM results, where divergence across specifications is more apparent, the confidence intervals are sufficiently broad to ensure that the differences are not significant for each of the forest types.

## 5. Conclusions

This paper provides a comparison between welfare measures estimates determined using two different stated choice methods: the contingent valuation method (CVM) and choice modelling (CM). The application involved the values of alternative afforestation programs in the northeast of Spain.

First, the results show that the models estimated from both methods are significant overall, all the independent variables have the *a priori* expected signs and the majority are significant. This gives support to the theoretical validity of the models. However, the superior estimation efficiency and the greater explanatory power provided by CM indicates its greater capacity to allow an understanding of the choices of respondents.

The estimates of welfare change associated with two different afforestation projects were found to be positive when estimated by both CVM and CM. Variation across welfare estimates was found to result from the use of alternative specifications of the welfare estimation process. Initial observation indicated that the CM derived estimates were generally greater than those generated through the use of CVM, particularly when welfare estimates were calculated without including the effects of constant terms. This outcome is broadly consistent with the findings from other studies. Statistical testing of these observations revealed that the evidence of equivalence is mixed. Only when welfare was estimated on the basis of the complete utility functions were the CM and CVM estimates found to be equivalent for both afforestation scenarios.

Further complexity is apparent in this result because of the potential for embedding in the CM results and the observation that a change in the welfare estimation specification yields a larger difference in the CVM estimates than in the CM estimates. The large confidence intervals around the estimates driven by both techniques also makes the drawing of firm conclusions tenuous.

The dilemma that is posed by the results of this study is that whilst the CM derived explanation of respondents' stated preferences appears statistically stronger than that provided by the CVM, the welfare estimates drawn from the CVM are appealing because they appear to be more resilient to embedding problems. On the other hand, the CVM results are more sensitive to the specification of the welfare estimation process. It is clear from the results that omitting the constant term from the CVM welfare estimation process is inadvisable. By omitting the constant term, the ability of CVM to avoid the embedding effect is lost. In contrast, the omission of the ASC for the CM estimates has a less marked effect. The preference information captured by the constant in the CVM formulation of choice is clearly an important contributor to value whilst the richer model specification offered by CM appears to reduce the importance of the constant (ASC) term. The importance of the ASC in this case is in contrast to the model used by Adamowicz *et al* (1998) where the inclusion of the intercept had a marked effect on the CM based estimates of value. This contrast demonstrates the importance of selecting attributes that are able to explain most choice variation, leaving little to be explained through the operation of the ASC. The results of the research reported in this paper shows that the attributes selected were effective in explaining respondent choice and that heterogeneity of preferences was not a key factor.

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