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On the gap between payment card and closed-ended CVM-answers

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The paper presents contingent valuation (CV) estimates of benefits provided by a proposed 'Kalkalpen' National Park in Austria. Although descriptive results of welfare measures are presented, the focus of the paper is on methodological questions concerning the analysis of CV answers. Evidence is given regarding the difference between payment card (PC) answers and closed-ended question formats. Based on different estimation models for CV questions substantial differences are found between closed-ended and payment card welfare measures. On average PC-willingness to pay (WTP) measures are below the closed-ended figures. Since the evaluation models are based on different premises in the calculation of WTP figures a more precise disclosure of the underlying evaluation methods is required if different question formats are compared to one another. Identical assumptions on the probability distributions have to be assumed whenever open- and closed-ended CV welfare measures are compared. Taking theoretical arguments into account the application of the closedended double-bounded Spike model that provides an average welfare measure is recommended.

I. THE 'KALKALPEN' NATIONAL PARK STUDY

The Upper Austrian government is planning a national park on the north rim of the Alps. The mountain landscape, which contains large coniferous woodlands, enclosed approximately 21 500 ha and is partly used for agricultural and forestry purposes. The aim of the national park is preserving biodiversity in the typical limestone mountains (Kalkalpen). Moreover, the area is designated for recreational purposes of tourists, day-users, and local residents. These goals require the existing economic activities (agriculture, forestry) to be substantially reduced through the realization of the national park plans. Two different national park areas (southwest and northeast region) have to be distinguished because of both different economic characteristics and the level of persuasive efforts undertaken by the national park planning office. For estimating benefits from recreation and the preservation of species, a contingent valuation (CV) study was conducted.

The analysis of this paper is based on 604 on-site interviews of local residents[1] who were asked their annual WTP for the proposed national park. This sample was divided into two groups: the first group was asked closed-ended double-bounded questions with bids between 50 and 1100 ATS per year and the second group was confronted with open-ended formats using payment cards (PC) from 0 to 1500 ATS a year (see appendix). The values of the bid vector were chosen in accordance with the bid distribution of open-ended CV answers in a pretest study among 200 Upper Austrian residents. This pilot study was part of a multi-topic survey three weeks ahead of the actual CV study. The process of selecting the bid values follows Carson *et al.* (1992). In all cases the payment vehicle was an earmarked 'Kalkalpen' National Park fund into which the amounts had to be paid. The actual survey closely adhered to the guidelines proposed by the NOAA-panel on CV.[2]

The paper, which focuses on the parametric approach of calculating WTP welfare measures, is structured as follows. Section II covers different variants of closed-ended

[1] Apart from local residents 301 on-site interviews of tourists in the national park region and 505 off-site interviews in the capital of Upper Austria (Linz) were conducted. The complete questionnaires can be obtained from the authors on request.
[2] No interviewer pretests were conducted to check for potential biases.

estimation models: the 'conventional closed-ended double-bounded model', the 'spike model' and the calculation of 'closed-ended minimal legal WTP'. In Section III five evaluation methods for PC CV questions are illustrated: a so-called 'PC minimal legal WTP', the 'WTP using interval midpoints', the 'PC double-bounded model', the 'PC ordered logit/probit' and the 'PC spike model'. The results of these estimation methods show in Section IV that in general the gap between closed-ended and PC answers depends substantially on the underlying evaluation methods.

II. THE ANALYSIS OF CLOSED-ENDED CV QUESTIONS

Since two of the proposed PC evaluation methods are similar to the conventional closed-ended double-bounded model we briefly describe the procedure of evaluating closed-ended questions which follows Hanemann (1984) and Hanemann *et al.* (1991).

The conventional closed-ended double-bounded model (CEDB–conventional)

The theoretical model is based on a stochastic utility function $v(h, y; s) + \varepsilon_h$, with $h = 1$ if the national park is realized and $h = 0$ if it is not. Further arguments in this utility function are individual income y and a vector of socio-economic variables s expected to affect preferences. The stochastic term ε_h is assumed to be i.i.d. Confronting an individual with an offer B to be paid for the realization of the proposed national park gives the following probability that this amount is accepted

$$P_y \equiv \Pr\{v(1, y - B; s) - v(0, y; s) > \varepsilon_0 - \varepsilon_1\}$$
$$= \tilde{F}(-\Delta v) = F(B; \theta)$$

with the utility difference $\Delta v = v(1, y - B; s) - v(0, y; s)$ and the cumulative distribution function $F(B; \theta)$ which is usually assumed as logistic or cumulated standard normal. The parameters θ of this cumulative density function can be estimated for the double-bounded model by maximizing the following log-likelihood function:

$$\ln L^{CC}(\theta) = \sum_{i=1}^{N} \left\{ \begin{aligned} & d_i^{yy} \ln[F(B_i^u; \theta)] + d_i^{nn} \ln[1 - F(B_i^l; \theta)] \\ & + d_i^{yn} \ln[F(B_i^i; \theta) - F(B_i^u, \theta)] \\ & + d_i^{ny} \ln[F(B_i^l; \theta) - F(B_i^i, \theta)] \end{aligned} \right\}$$

The individual i is confronted with the initial offer B_i^i. If B_i^i is accepted, the respondent is subsequently asked whether she would be willing to pay a higher amount B_i^u, as well. However, the follow-up is some lower amount B_i^l if the individual does not respond positively to the first bid. The variable d_i^{yy} is 1 if the answer is 'yes' to both questions and 0 otherwise. The variables d_i^{nn} ('no' and 'no'), d_i^{yn} ('yes' and 'no') and d_i^{ny} ('no' and 'yes') are decoded in an analogous way depending on both answers. The variable N denotes the number of respondents.

Based on this model we specified different functional forms of the utility difference Δv and the respective coefficients were estimated both for probit and logit variants. According to summary statistics the best specification has been chosen (*Model* 2) and the estimated coefficients have been compared with the restricted base model (*Model* 1) including only a constant and the bid variable B. Expressed mathematically, the utility differences can be formulated as follows:

Model 1: $\Delta v = a_0 + a_1 \ln(B)$
Model 2: $\Delta v = a_0 + a_1 \ln(B) + a_2 \ln(Y) + a_3 D + a_4 \Delta Y + a_5 educ + a_6 age + a_7 club$

with

B	WTP-offer
Y	per capita net income of households,
D	regional dummy (1 = southwest region, 0 = northeast region)
ΔY	*expected* change in income due to the realization of the national park (1 = increasing income, − 1 = decreasing income, 0 = no income change)
educ	last grade of formal education
age	age of the respondent
club	wildlife club membership

As far as the treatment of non-respondents is concerned all empirical results in this paper refer to an optimistic scenario. This means that respondents were excluded from the sample whenever they answered 'do not know' either to the first WTP question or to the follow-up. Thereby assuming that non-respondents do not significantly deviate from those who answered the WTP questions, this variant can be criticized that it generates systematic overestimation of benefits in aggregating individual welfare measures. In support of this reasoning Loomis (1987) argues that the disapproving behaviour of non-respondents alone speaks for their WTP below-average.[3] The coefficients of the maximum-likelihood estimation of the closed-ended double-bounded model are provided in Table 1.

[3] In that sense we have calculated a pessimistic scenario, as well. Under this scenario those who answered 'do not know' to the WTP-question were treated like they had responded 'no'. This guarantees that the calculated welfare measures are indeed conservative what might result in downward biased benefits. A similar procedure was applied for the 'protest zero category' to which a zero WTP was assigned. Although the results of this pessimistic scenario are not presented, all methodological results being made in this paper remain unchanged.

Table 1. *Estimated coefficients for dichotomous choice contingent valuation models*

	Closed-ended double-bounded					
	Conventional				Spike	
	Model 1		Model 2		Model 3	
Variables	Logit	Probit	Logit	Probit	Logit	Probit
Intercept	2.82**[a] (7.60)[b]	1.72** (7.79)	5.22** (6.10)	3.10** (6.13)	1.02 (1.50)	0.64 (1.52)
ln *offer*	−6.89** (−8.68)	−4.25** (−9.29)	−8.71** (−9.27)	−5.14** (−10.0)		
Offer					−4.06** (−12.28)	−2.22* (−13.99)
ln *income*			0.27 (1.17)	0.15 (1.10)	0.25 (1.14)	0.15 (1.11)
Regional dummy			−0.96** (−3.50)	−0.57** (−3.50)	−0.88** (−3.40)	−0.52** (−3.37)
Expected income change			1.31** (3.02)	0.72** (3.18)	1.49** (3.77)	0.83** (4.01)
Education			0.26* (1.76)	0.16* (1.80)	0.34* (2.27)	0.20* (2.25)
Age			−3.00** (−3.59)	−1.80** (−3.66)	−1.85** (−2.36)	1.22** (−2.65)
Club membership			1.38** (4.39)	0.82** (4.41)	1.21** (4.14)	0.70** (3.98)
AIC[c]	324.53	322.47	288.21	287.37	349.99	353.06
N	287	287	287	287	287	287

[a]Single asterisk indicates significance at 5% level, double asterisks indicate significance at 1% level.
[b]Asymptotic *t*-values in parentheses.
[c]Akaike's information criterion.

The results for *Model* 1 and *Model* 2 shown in Table 1 indicate expected signs of the coefficients with respondents' age determining the utility difference negatively. The regional dummy variable, expected income change, age, and club membership are highly significant. The differences between probit and logit models are relatively small both in terms of the summary statistics AIC and parameter significance. Subsequently, equivalent surplus measures were calculated based on these coefficients. Table 2 shows mean and median values for *Model* 2 contingent on the chosen probability distribution and different values of the independent variables for the northeastern national park region.[4] The means were computed by numerically integrating the willingness to pay function over the range of the offer bids up to the truncation limit of 2200 ATS. This is twice the highest offer with which respondents had been confronted in the survey.[5]

The figures for *Model* 2 in Table 2 make clear that the means are (considerably) higher than the medians in all cases even though the cumulative density function is truncated at 2200 ATS. This result of an asymmetric distribution function reflects the high WTP of a few people and the low WTP of a high number of respondents. Whereas the figures being rather invariant to either the logit or probit estimation approach, the estimated welfare measures are sensitive to the chosen truncation limit. The mean is decreasing (increasing) by approximately 30 (15)% if the distribution function is truncated at the WTP offer of 1100 (3300) ATS instead of 2200 ATS. This result is in line with other empirical evidence (for example, see Bowker and Stoll, 1988). Mean WTP in the northeast varies over a range between 243 ATS and 623 ATS depending on the age of the respondent and the last grade of formal education. The medians lie between 53 ATS and 246 ATS.

For comparison reasons the welfare measures of *Model* 2 are calculated again using the means of all independent variables. These results are summarized in Table 5.

[4]The structures of mean and median values for the southwestern national park region are very similar although the figures are lower compared to the northeastern region.
[5]Only four respondents were willing to pay a higher amount than the highest bid of 1100 ATS.

Table 2. '*Kalkalpen*' *National Park annual benefits for local residents in the northeastern region given different model specifications, estimation methods, and independent variables; in ATS*

Calculation model	Variable[a]	Method of estimation	Median	Mean WTP (2200 ATS)
Model 2	*age* = 20 years	Logit	209	562
		Probit	215	578
Model 2	*age* = 60 years	Logit	53	243
		Probit	53	233
Model 2	*education* = statutory school	Logit	69	289
		Probit	69	282
Model 2	*education* = university degree	Logit	232	594
		Probit	246	623
Model 3	*age* = 20 years	Logit	230	230
		Probit	260	260
Model 3	*age* = 60 years	Logit	48	48
		Probit	40	40
Model 3	*education* = statutory school	Logit	36	36
		Probit	35	35
Model 3	*education* = university degree	Logit	366	366
		Probit	399	399

[a]The remaining independent variables in the northeastern national park region were set at the following values: mean income: 20 277.29 ATS; mean of household members: 3.3; average age of respondents in years: 42.31; median education level: 2 corresponding to intermediate vocational school; median wildlife club membership 0.12 ATS are equivalent to 1 US$.

The closed-ended double-bounded spike model (CEDB–spike)

Following Kriström (1995) and Hanemann and Kriström (1995) a spike model was estimated which makes a positive probability for zero WTP possible. The distribution of WTP takes the form,

$$H(B;\theta) = \begin{cases} 1 & \text{if } B < 0 \\ p & \text{if } B = 0 \\ F(B;\theta) & \text{if } B > 0 \end{cases}$$

where $F(B;\theta)$ is a logistic or cumulated standard normal distribution function, and $p \in (0,1)$ is a constant reflecting the probability for zero WTP. The parameters of $H(B;\theta)$ can be estimated with the following log-likelihood function for the double-bounded specification

$$\ln L^{CS}(\theta) = \sum_{i=1}^{N} \left\{ \begin{array}{c} S_i d_i^{yy} \ln[F(B_i^u;\theta)] + S_i d_i^{yn} \ln[F(B_i^i;\theta) - F(B_i^u;\theta)] \\ + S_i d_i^{ny} \ln[F(B_i^l;\theta) - F(B_i^i;\theta)] \\ + S_i d_i^{nn} \ln[F(0;\theta) - F(B_i^l;\theta)] \\ + (1 - S_i)\ln[1 - F(0;\theta)] \end{array} \right\}$$

where $S_i = 1$ if the individual is willing to pay a positive amount of money, and zero otherwise. All other variables correspond with the log-likelihood function in the conventional closed-ended double-bounded model. Since the introduction of a non-zero probability of zero WTP prevents the estimation of log-linear cumulative density functions we change Δv to the following linear form:

$$\textit{Model } 3\text{:}\ \Delta v = a_0 + a_1 B + a_2 \ln(Y) + a_3 D + a_4 \Delta Y + a_5\, educ + a_6\, age + a_7\, club$$

The coefficients for *Model* 3 are reported in Table 1, indicating expected signs and similar significance levels to *Model* 2. Since the Spike model allows explicitly zero and negative WTP as well, the resulting mean WTP is about 130% lower than in the conventional closed-ended double-bounded model (see Table 2). Furthermore, it should be noticed that the mean values are robust concerning the truncation value. Reducing (extending) the truncation value to 1100 ATS (3300 ATS) changes the means by less than 1%. Whereas the asymmetric distribution function of the conventional closed-ended double-bounded model yields different mean and median values, the symmetric distribution function of the Spike model results in identical mean and median figures. The median is either higher or lower as compared to the conventional closed-ended double-bounded model depending on the shape of the underlying distribution functions. Table 5 again includes estimated welfare measures using the means of all independent variables.

The minimal legal WTP-model (CEML–WTP)

Harrison and Kriström (1995) pointed out that a 'yes' in discrete WTP answers can be interpreted just as a commitment to pay a specified amount. In that legal sense it is not allowed to assume a positive probability for WTP higher than the accepted bid as was done in our previous models. Only those values on which the respondents definitely agreed in the first or the second closed-ended CV question can be used to calculate the 'minimal legal WTP' (CEML-WTP). For all those, who did not accept a positive amount, a zero WTP has to be assigned as the correct bid value to which they have committed themselves. Following this argumentation minimal legal WTP calculates as

$$CEML - WTP = \sum_i p_i x_i$$

where x_i is the accepted bid value and p_i is the relative frequency of respondents who were willing to pay x_i. Whereas the mean (median) in the southwest region of the national park amounts to ATS 92.64 (ATS 0), the mean (median) in the northeast region is ATS 152.80 (ATS 50) (see also Table 5).

III. THE ANALYSIS OF PC CV QUESTIONS

This section presents the analysis of PC questions. It is shown that, in general, PC welfare measures tend to be lower than their closed-ended counterparts. However, the difference varies with alternative model specifications.

The minimal legal WTP model (PCML–WTP)

Analysing PC answers by interpreting the chosen values on the payment card again as commitment to pay in a legal sense we get a mean (median) of ATS 81.29 (ATS 0) in the southwest region and ATS 65.20 (ATS 0) in the northeast region. Table 5 indicates that these figures are lower than the respective closed-ended values.

However, the respondents are asked to pick the appropriate WTP figure A^k from a list of potential WTP amounts arranged in ascending order between zero (A^0) and the highest amount (A^H). Assuming this figure to represent the individual's 'correct' WTP neglects that the given answers rather reflect the lower bound of an interval into which the true WTP is to lie. In other words, we may assume that choosing a certain value A^k from the payment card means that the individual's WTP lies within the range between this chosen WTP and the next higher amount A^{k+1} on the payment card.

PC with interval midpoints (PCIM–WTP)

In accordance with the interpretation that the chosen value represents the lower bound for WTP, we provide alternative PC welfare measures. Suppose the individual WTP is symmetrically distributed within the given interval, a mean value (PCIM–WTP) can alternatively be computed as

$$PCIM\text{–}WTP = \sum_{k=0}^{H-1} \frac{A^k + A^{k+1}}{2} p_k + \frac{A^H + A^T}{2} p_H$$

with p_k and A^T representing the relative frequency of the kth interval and the truncation value, respectively. The median can be calculated by analogy. However, this calculation of mean and median rests on the unreasonable assumption of symmetric WTP functions within all intervals. Empirical results based on this formula are presented in Table 5 in row PCIM–WTP.

Payment card double-bounded model (PCDB–conventional)

Referring to more realistic cases we abandon the restriction of symmetric 'within-distributions' and provide an alternative calculation which we call the PC, double-bounded (PCDB) model. For this estimation model see also Cameron and Huppert (1989).

By analogy to the closed-ended model the probability P_k that WTP lies within the interval $[A^k \ldots A^{k+1})$ can be written as

$$P_k \equiv \Pr\{v(1, y - A^k; s) - v(0, y; s) > \varepsilon_0 - \varepsilon_1\}$$
$$- \Pr\{v(1, y - A^{k+1}; s) - v(0, y; s) > \varepsilon_0 - \varepsilon_1\}$$

or

$$P_k = F(A^k; \theta) - F(A^{k+1}; \theta)$$

For the cumulative density function $F(A; \theta)$ we obtain the parameters by maximizing the following log-likelihood function

$$\ln L^{PD}(\theta) = \sum_{i=1}^{N} \begin{Bmatrix} I_i^0 \ln[1 - F(A_i^l; \theta)] + I_i^H \ln[F(A_i^H; \theta)] \\ + \sum_{k=2}^{H-1} I_i^k \ln[F(A_i^k; \theta) - F(A_i^{k+1}; \theta)] \end{Bmatrix}$$

The dummy variable I_i^k is 1 if the individual chooses A_i^k on the payment card and zero otherwise.

For comparison reasons we used identical functional forms of the utility difference Δv (see *Model* 1 and *Model* 2). The results of the maximum likelihood estimation are shown in Table 3.

In comparison with the closed-ended approach (Table 1) it should be mentioned that all variables again show expected signs but the significance levels are generally lower than in the dichotomous choice model.[6] There is an

[6] Alternative specifications of Δv might provide a better statistical fit and higher significance levels of parameters.

Table 3. *Estimated coefficients for the PC double-bounded contingent valuation method*

	Payment cards double-bounded					
	Conventional				Spike	
	Model 1		Model 2		Model 3	
Variables	Logit	Probit	Logit	Probit	Logit	Probit
Intercept	1.78**[a] (4.29)[b]	1.05** (4.73)	2.76** (3.42)	1.61** (3.33)	0.21 (0.29)	0.08 (0.18)
ln *offer*	− 6.82** (− 5.84)	− 4.09** (− 7.95)	− 7.71** (− 6.24)	− 4.60** (− 7.04)		
Offer					− 5.44** (− 11.22)	− 2.86** (− 15.31)
ln *income*			0.36 (1.45)	0.20 (1.33)	0.33 (1.28)	0.17 (1.03)
Regional dummy			− 0.37 (− 1.33)	− 0.18 (− 1.06)	− 0.33 (− 1.14)	− 0.12 (− 0.68)
Expected income change			0.77* (2.11)	0.44* (2.15)	0.69* (1.84)	0.48* (2.25)
Education			0.15 (1.08)	0.09 (1.10)	0.15 (1.08)	0.10 (1.08)
Age			− 1.45* (− 1.83)	− 0.88* (− 1.85)	− 1.54* (− 1.86)	− 0.86* (− 1.68)
Club membership			1.20** (4.37)	0.67** (3.89)	1.16** (4.00)	0.71** (3.82)
AIC[c]	354.61	349.40	341.06	336.87	322.55	325.22
N	249	249	249	249	249	249

[a]Single asterisk indicates significance at 5% level, double asterisks indicate significance at 1% level.
[b]Asymptotic *t*-values in parentheses.
[c]Akaike's information criterion.

important argument which favours the PCDB approach: it overcomes the unconvincing assumption of symmetric WTP distributions within the intervals on the payment card. By assuming WTP functions identical to closed-ended models, the welfare measures derived from the PCDB model best represent the figures to be compared with benefit estimates from the conventional closed-ended double-bounded models (CEDB-conventional).

Payment card double-bounded spike model (PCDB–spike)

The spike model can be applied to the PC double-bounded approach by estimating the following log-likelihood function

$$\ln L^{PS}(\theta) = \sum_{i=1}^{N} \left\{ \begin{array}{l} (1 - S_i) I_i^0 \ln[1 - F(0, \theta)] \\ + S_i I_i^0 \ln[F(0, \theta) - F(A_i^1; \theta)] \\ + \sum_{k=2}^{H-1} S_i I_i^k \ln[F(A_i^k; \theta) - F(A_i^{k+1}; \theta)] \\ + S_i I_i^H \ln[F(A_i^H; \theta)] \end{array} \right\}$$

Estimated coefficients of this log-likelihood function (*Model* 3) are shown in Table 3, the welfare measures using the means of all independent variables are included in Table 5.

Ordered probit and ordered logit model (OPOL)

There is one more alternative to the conventional PCDB model. Using 'ordered probit' and 'ordered logit' models, which represent standard tools in most econometric packages, we subsequently demonstrate another variant of estimating demand functions from PC answers.

To make the results again comparable to other estimation techniques, we still apply identical functional forms with the exception that the WTP offer is omitted (compare *Model* 2 and *Model* 3). The results of this standard estimation are presented in Table 4.

Again the coefficients indicate expected signs. The variables *club membership*, *age* and the *expected income change* are significant. The means and medians in

Table 4. *Estimated coefficients for ordered probit and ordered logit models*

Variable	Open ended ordered logit/probit Logit		Probit	
Intercept 1	−0.20	(−0.27)[a]	−0.11	(−0.23)
Intercept 2	0.02	(0.03)	0.03	(0.06)
Intercept 3	0.23	(0.32)	0.16	(0.34)
Intercept 4	1.21*[b]	(1.65)	0.73	(1.60)
Intercept 5	2.18***	(2.82)	1.26***	(2.66)
Intercept 6	3.09***	(3.63)	1.70***	(3.41)
Intercept 7	3.67***	(4.05)	1.97***	(3.83)
Intercept 8	5.08***	(3.88)	2.52***	(4.08)
ln *income*	0.34	(1.26)	0.20	(1.19)
Regional dummy	−0.31	(−1.02)	−0.13	(−0.72)
Expected income change	0.70*	(1.75)	0.42*	(1.88)
Education	0.16	(1.08)	0.11	(1.17)
Age	−0.02*	(−1.80)	−0.01*	(−1.89)
Club membership	1.17***	(3.97)	0.71***	(3.97)
N	249		249	
AIC restricted model[c]	322.38		322.38	
AIC full model	316.86		315.61	
Likelihood ratio chi square	37.04		39.53	

[a]Asymptotic *t*-values in parentheses.
[b]Single asterisk indicates significance at 10% level (double asterisks = 5%, and triple asterisks = 1%).
[c]Akaike's information criterion.

Table 5 are calculated in analogy to the PCIM-WTP model with *estimated probabilities* from the ordered probit and ordered logit model.

IV. COMPARISON OF EVALUATION METHODS

There is extensive literature on the reasons for the differences between closed-ended and open-ended CV answers. One theoretical argument as to why disparities between open-ended and closed-ended WTP figures occur, refers to the notion that closed-ended formats seem more realistic. People may find it hard to state a maximum amount of money which they would be willing to pay for a certain item. However, it seems an easier task to reveal whether or not an individual would be willing to buy a specific good at a given price. Hanemann (1994) argues that the maximum WTP represents an extremum, and therefore, errors of cognition tend to fall on the low side. He draws the conclusion that open-ended responses may therefore understate maximum WTP. Other arguments in favour of an application of closed-ended question formats refer to higher non-response rates in open-ended questions and to the higher percentage of protest-zeros again generating a downward bias in the answers (Mitchell and Carson, 1989). Reviewing these arguments it seems obvious that they are valid for the explanation of differences between closed-ended question formats and payment card answers as well.

Empirical evidence is provided in support of different WTP depending on the question format. Exploring a large number of CV studies, Walsh *et al*. (1989) in their meta analysis proposed the hypothesis that a dichotomous valuation design tends to give higher WTP mean values. Moreover, Kealy and Turner (1993) found for public goods that, irrespective of the specification of WTP functions, the different ways of asking the questions had generated significantly different results with the closed-ended answers (mean and median) being always higher than open-ended welfare measures. Using statistical survival functions for discrete response data Kriström (1993) provided further evidence that dichotomous choice questions produce both a higher mean and a higher estimate of the median. For more recent studies comparing continuous and discrete CV estimates, see Ready *et al*. (1996).

As can be seen from Table 5 our welfare measures depend strongly on the chosen estimation model. In accordance with the empirical evidence in the literature we obtained PC–WTP measures that are on average below the closed-ended figures. According to *a priori* expectations the benefit estimates of techniques that allow for a positive probability of WTP beyond the chosen value on the payment card or in the closed-ended question format are higher than the minimal legal WTP figures.[7] The PCDB-Spike model generates

[7] However, it may occur that the PCDB mean is lower than the minimal legal WTP estimate if the WTP function shows a broad tail and a relatively low truncation limit has been chosen. See the OEDB-Spike mean for the southwest region in Table 5.

Table 5. *Calculated medians and means of different evaluation methods*

			Southwest			Northeast		
			Median	Mean	*N*	Median	Mean	*N*
Closed-ended	CEDB – Conv.	Logit	29.36[a]	166.93	278	97.23	357.98	278
		Probit	30.93	153.75	278	98.74	359.52	278
	CEDB – Spike	Logit	0	124.39	278	128.24	242.89	278
		Pobit	0	129.81	278	137.05	256.31	278
	CEML – WTP		0	92.64	141	50	152.8	137
Payment card	PCML – WTP		0	81.29	124	0	65.2	125
	PCIM – WTP		12.5	114.3	124	12.5	97.2	125
	PCDB – Conv.	Logit	11.72	111.47	249	18.08	147.73	249
		Probit	11.88	92.51	249	16.79	121.61	249
	PCDB – Spike	Logit	0	75.91	249	0	96.18	249
		Probit	0	79.37	249	0	93.85	249
	OPOL	Logit	0	90.20	249	0	109.12	249
		Probit	0	87.83	249	0	101.87	249

[a]The means of independent variables in the southwest (northeast) national park region are as follows: income: ATS 24477.39 (ATS 20277.29); number of household members: 3.02 (3.3); age of respondents in years: 43.66 (42.31); education level: 2.15 (2.12); wildlife club membership: 0.72 (0.73); expected income change: −0.1 (−0.01). All methods apply to a truncation limit of ATS 2200.

the lowest mean WTP of ATS 77.6 in the southwest region.[8] Compared with this the highest mean of ATS 160.3 results from the conventional CEDB estimation model. A similar picture can be shown for the northeast region. Whereas the lowest mean welfare measure, the payment card minimal legal WTP, amounts to ATS 65.2 in the northeast region the highest mean for this region turns up to ATS 358.75 again under the conventional CEDB model.

Referring to empirical CV work on the comparison between open- and closed-ended CV questions it both remains often unclear whether appropriate models for PC and closed-ended question formats are compared to each other. It seems obvious that a conventional CEDB figure (ATS 160.3 in the southwest region) does not validly compare with PCML–WTP (ATS 81.29 in the south west region) or PCIM–WTP (ATS 114.3 in the southwest region) since different assumptions on the probability distributions have been made in the models.

Moreover, even if adequate model specifications are compared to each other, variations in the difference between PC figures and closed-ended measures can be observed. For example, looking at the southwest region, the comparison between PC and closed-ended formats results in a difference of approximately 45% if it is based on the conventional double-bounded model. The respective difference, however, increases to 50% if the PC and closed-ended spike models are compared to each other. On the other hand, based on the minimal legal WTP approach we obtain the smallest difference of only 13%. In that sense the minimal legal WTP figures turn out to be the most robust welfare measures with the smallest gap between the closed-ended and the PC question format.[9]

V. CONCLUSIONS

Based on the empirical results of this paper the following conclusions can be drawn:

- Given the result that empirical welfare measures depend on the assumed probability distribution we plead for a more precise disclosure of the underlying evaluation methods whenever open- and closed-ended CV answers are compared. As an example, the mean of conventional closed-ended double-bounded CV answers (CEDB–Conv.) needs to be compared with its double-bounded payment card counterpart (PCDB–Conv.) instead of the simple interval mean variant (PCIM–WTP). In any comparison of different question formats equal needs to be compared to equal.
- Even if correct model specifications are used for comparison purposes a broad range of differences between PC figures and closed-ended welfare measures can be observed. For the practical use of CV studies in cost–benefit analysis sensitivity tests seem indispensable to gain an impression on the span of possible empirical outcomes.

[8] All figures on the comparison of different valuation techniques refer to an average between the logit and probit values.

[9] The problem that different CV models generate a broad range of welfare measures for the same environmental goods is aggravated by the consequences of selecting the truncation limit. We have presented figures by truncating the distribution function at ATS 2200. If this limit is changed all welfare measures from the different models are either shifted upwards or downwards.

Thereby, it can be made obvious how sensitive policy-relevant empirical results are with respect to changes in the underlying model structure.

- Even though the true value cannot be identified among the different figures we argue for the use of spike-models. Almost all empirical CV studies that have been conducted in the field of the environment show a significant number of respondents who are decidedly not prepared to pay some positive amount. Since spike-models explicitly take these zero answers into account and allow for non-symmetric probability beyond the chosen value they may be interpreted as a method that provides average welfare measures. Its WTP figures lie on average between the results of the conventional double-bounded model and the minimal legal WTP. Yet from a practical point of view, assigning some positive probability to zero WTP requires more effort to be undertaken in CV surveys to identify people with zero WTP, respondents who have some positive but low WTP, and protest bidders.
- As far as the choice between closed-ended and payment card question formats is concerned we refer to the above mentioned theoretical arguments in Section IV and therefore plead for the closed-ended variant. However, if one is in particular interested in conservative WTP measures the PCDB-Spike model should be applied.

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APPENDIX

Closed-ended double-bounded WTP question

Even though the subsequent questions cannot be answered easily, I kindly ask you to answer honestly and well-conceived. Realize that the ‘Kalkalpen National Park’ is associated with financial cost. The following questions try to highlight how residents would vote on this project if they had to pay a specific amount of money for it. Those who vote ‘for’ say this environmental project is worth the money to them. Some say that they would rather spend the money for other things that are more important to them. And some say the money they would have to pay for the ‘Kalkalpen National Park’ is more than they can afford. Of course whether you would vote ‘for’ or ‘against’ this project depends on how much the National Park will cost your household. Cost estimations say that the ‘Kalkalpen National Park’ will cost your household ATS 50/150/350/700 a year to be paid in an earmarked National Park fund. If this project cost your household ATS 50/150/350/700 a year would you vote for the project or against it?

FOR
AGAINST
DO NOT KNOW
DO NOT ANSWER QUESTIONS LIKE THIS IN GENERAL

What if the cost estimates showed that the project would cost your household ATS 150/350/700/1100 (ATS 25/50/150/350) a year? Would you vote ‘for’ or ‘against’ the ‘Kalkalpen National Park’ project?

FOR
AGAINST
DO NOT KNOW

Payment card WTP question

Even though the subsequent questions cannot be answered easily, I kindly ask you to answer honestly and well-conceived. Realize that the 'Kalkalpen National Park' is associated with financial cost. The following questions try to highlight how residents would vote on this project if they had to pay a specific amount of money for it. Those who vote 'for' say this environmental project is worth the money to them. Some say that they would rather spend the money for other things that are more important to them. And some say the money they would have to pay for the 'Kalkalpen National Park' is more than they can afford. Of course whether you would vote 'for' or 'against' this project depends on how much the National Park will cost your household. What is your maximum willingness to pay for your household per year into an earmarked 'Kalkalpen National Park' fund? Please, choose the appropriate amount on the list.

ATS 0
ATS 25
ATS 50
ATS 100
ATS 250
ATS 400
ATS 550
ATS 700
ATS 900
ATS 1100
ATS 1500
DO NOT KNOW
DO NOT ANSWER QUESTIONS LIKE THIS IN GENERAL