BENEFIT ESTIMATES FROM FOREST RECREATION: FLEXIBLE FUNCTIONAL FORMS FOR *WTP* DISTRIBUTIONS

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ABSTRACT

Data from a large scale discrete choice contingent valuation study are used to estimate the recreational benefits from forest parks in the Republic of Ireland. In particular, we focus on the precision and differences in welfare estimates arising from linear and logarithmic bid transformations vis-à-vis *the intermediate Box-Cox transformation. We estimate these models on both site-specific and pooled data from referendum contingent valuation responses with one follow-up. We find that flexible forms such as the Box-Cox transformation may considerably improve the fit in terms of parameters estimates, but their benefit in terms of more precise welfare estimates require large samples.*

Keywords: Flexible functional forms, forest recreation, non-market valuation, referendum contingent valuation.

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INTRODUCTION

The notion of "multi-purpose management" of public forests e.g. for timber production, recreation and biodiversity preservation, is becoming an increasingly established practice in many countries. While the measurement of the value of timber produced is straightforward, less is known about the economic magnitude of the benefits from recreation and biodiversity preservation. At least in some forests, these are potentially substantial. In this paper we focus exclusively on the measurement of outdoor recreation benefits. The data used were collected in public forests in the Republic of Ireland (ROI) in 1992. As outdoor recreation is a "non-market" good and revealed preference analysis based on travel costs is hindered by the problem of joint destination trips, contingent valuation is the non-market valuation method of choice here.

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In particular, we estimate the magnitude of the per-visit recreational value of 13 forests which account for approximately fifty percent of all estimated forest visits. The survey applies the well-known referendum contingent valuation method (R-CV). In this context we investigate the effects of linear-in-the-bid and log-in-the-bid specifications of the indirect utility function on expected *WTP*. We then relax these two extreme assumptions by using a Box-Cox flexible form. This form nests each of the other two as special cases. We then discuss the effects of using such a flexible functional form on the estimates of expected *WTP* at the different sites and on the estimates of the structural parameters of the indirect utility function underlying the *WTP* distributions. We also pool the site-specific data and similarly estimate the linear, log and Box-Cox models with and without site specific dummies for the intercept. We discuss the effect of these dummies and the performance of the pooled model *vis-à-vis* the parameters and welfare estimates of the site specific ones. The ultimate aim of the study is to explore the effects on precision of the various truncated mean estimates of the *WTP* distribution, since this is of germane importance in deriving aggregate measures of benefits from forest recreation.

The remainder of this research note is organised as follows. Next we recall the well known theory and method employed for the estimation of the *WTP* distribution from R-CV data with a follow-up. Then we present the survey design, and estimates for the models' coefficients and respective truncated means at forest-specific level. This is followed by a discussion of their comparison with analogous results from the pooled models. Finally, conclusions are drawn and implications for an econometric specification strategy are highlighted.

Method

R-CV has established itself as one of the most widely used tools to estimate non-market benefits from public goods. Since the seminal paper by Bishop and Heberlein, (1979) the referendum format, which simply asks people whether they would or would not be *WTP* a specific amount for the good in question, has gradually grown in acceptance and sophistication (Arrow *et al.*, 1993). The NOAA Panel prescribes a full protocol for the conduction of R-CV surveys to which this forest recreation study in the Republic of Ireland largely complies.

A major drawback of the R-CV format is its sample inefficiency. Some researchers (Hanemann *et al.*, 1991) have proposed to add a "follow-up" question to the first value elicitation question. Under the assumption that both first and second response were driven by the same stochastic process (Cameron & Quiggin, 1994; Alberini, 1995), the sample efficiency of the welfare estimates can be increased at the cost of a low expected bias. A second reiteration of the elicitation question does not seem to produce further worthwhile efficiency improvements. Both Scarpa & Bateman (1999) and Garrod *et al.* (1999) show that expected efficiency gains from a second reiteration are relatively small and may introduce further iteration bias.

Consider the problem of valuing a visit to the forest. An adequate measure from the viewpoint of the consumer's utility maximisation exercise, is the compensating surplus[1]. That is, the amount E that implicitly solves the following equation

$$u(m,\mathbf{s}) = u(m-E,\mathbf{q},\mathbf{s})$$

where $\mathbf{s}$ is a generic vector of socio-economic characteristics of the visitor's, $\mathbf{q}$ is the vector of site quality attributes associated with the visit to the forest and m is income. In this context, the maximum *WTP* for the visit clearly corresponds to E. This quantity will be distributed across the population of visitors and its distribution can be identified by posing take-it-or-leave-it *WTP* questions at different amounts, so that each set of respondents facing the same amounts can be partitioned into two groups i.e. a group *WTP* the amount and a group not *WTP* the amount. Resulting frequencies allow the analyst to derive estimates of the population probabilities of *WTP* each proposed amount.

This probabilistic interpretation falls short of being a satisfactory one from the viewpoint of microeconomic theory as it is not directly linked to any construct in con-

[1] A reviewer suggested that compensating variation, rather than surplus, be the correct welfare measure in this context. However, we feel that the choice is made under rationing and hence compensating surplus should be the right one, either way this theoretical subtlety is irrelevant from the empirical econometric aspects that we wish to examine here.

sumer's choice theory. In this study we do not invoke the variation function proposed by Cameron & James (1987) and Cameron (1988), but the utility difference (Dv) paradigm proposed by Hanemann (1984, 1989) following the seminal papers by McFadden (1973) on random utility theory and Deacon & Shapiro (1975) on referenda as markets for public goods[2].

To estimate the relative probabilities we invoke distributional assumptions for the unobservable stochastic component Δu as well as a specification for Δv. Consider a logistically distributed Δu. The logistic distribution spans all reals, while *WTP* for recreation for visitors interviewed at the forest site is unlikely to be negative. For this reason, in many recreation studies, the distribution is often defined over a log transformation of the bid amount t. Furthermore, monotonicity of the log function preserves percentile estimates, such as the median, $M(WTP)$. This property is useful to estimate the values of *WTP* for given percentiles of the population of visitors.

However, depending on the choice of bid-vector and on the nature of the underlying random variable, once the distribution is fitted to the observed data, it is sometime observed that the linear specification has a significantly superior fit than the log. For this reason, in those cases one can employ the estimated relationship over the non-negative orthant, neglecting the component in the negative part of the real line. Consider now the Box-Cox transformation $l(t) = (t^l - 1)/l$, this transformation nests the linear (l=1) and logarithmic (l=0) cases. It is therefore a useful flexible form to adopt which may allow a better fit and a formal hypothesis test for the linear and logarithmic specification (see also Boman & Bostedt, 1999). However, it introduces a new parameter that must be estimated, l. This makes the log-likelihood function $\ln L_N$ no longer globally concave in the parameter space and poses some problems in the maximisation algorithm which is used to converge to the parameter values that maximise $\ln L_N$. For this reason we adopted the expedient of searching over the space [–1 , +1] by means of a grid search to find the value for l that maximised $\ln L_N$.

[2] These two approaches were later shown to be dual solutions to the same optimisation problem (McConnell, 1990). In fact, in some econometric specifications they are simple reparametrisations one of the other.

So, in our case Δv is always specified as a linear index in the $\ln L_N$. For the flexible form we have that $\Delta v = a + b\lambda(t)$ and we maximise $\ln L_N$ for the various samples by means of non-linear maximisation algorithms[3], hence obtaining the maximum likelihood (ML) parameter estimates a_{ML}, b_{ML} and l_{ML}. From these one can derive the various features of the *WTP* distribution (expectation, median and other percentiles). Under the correct specification, thanks to the invariance properties of estimates (Goldberger, 1993), these will be the ML estimates of the population parameters, with the usual properties of asymptotic consistency and minimum variance.

The features of the distributions that we seek to compare across specifications and forest sites are truncated expectations derived as

$$E(WTP) = \int_0^{A^{\max}} \Pr(Yes\,|\,t; a, \; l, b)dA \qquad (1)$$

where t is the bid-amount, a is the constant, b is the slope and l is the Box-Cox coefficient. These integrals were computed numerically for the upper limit of A_{Max} = £7. Confidence intervals were obtained by parametric bootstrapping 10 thousand times the asymptotic distribution of the ML parameter estimates and using the pivotal statistics described in Krinsky & Robb (1986).

There are various empirical issues that are of interest in this comparisons. In the first place it would be interesting to verify whether there is a conventional specification that fits well the observed responses across different forests. If neither linear nor logarithmic specifications fit well in general, it is of interest to test formally, via a log-likelihood ratio test, the linear and logarithmic restrictions on l that is, l=1 and l=0 respectively.

The second issue is to investigate whether or not the linear, logarithmic and flexible form produce significantly different estimates of expected *WTP* at these sample sizes. This can be achieved by carrying out a pair-wise comparison of the 95 percent interval estimates. Poe *et al.* (1996) have demonstrated that this test is biased toward the re-

[3] We used the Newton-Raphson method with analytical gradient and Hessians coded in GAUSS© mathematical language (Aptech Systems, 1997).

jection of the null of no difference. Thus, if the confidence intervals overlap considerably this would be an indication that, although different specifications fit differently, choice of specification tends to have a small effect on the estimated benefits from forest recreation.

Thirdly, is there a common specification that fits the pooled responses from visitors to the 13 forests, or should each set of site specific responses be modelled independently? What bearing does this have on the pattern of welfare estimates across sites?

Finally, we test for site specific effects on the pooled model by using dummy intercepts for all sites except Lough Key, which was arbitrarily chosen as the baseline case. Testing the restriction for these to be jointly equal zero will test the hypothesis that site specific forestry features do not affect systematically the distribution of *WTP* of visitors to different sites.

SURVEY ADMINISTRATION AND SITE SPECIFIC ESTIMATES

In 1992 the Queen's University of Belfast conducted a recreation benefit study by administering on-site face-to-face CV interviews in 13 sites in the Republic of Ireland (Dhubhain *et al.,* 1994). Nearly 4500 visitors were interviewed in a period of a few weeks by trained interviewers who administered to all respondents the same survey. Respondents were intercepted at the end of their recreational visit and were posed the following value elicitation question:

"If it were necessary to raise funds through an entry charge to ensure this forest or woodland remained open to the public and with no charge being made for parking, would you pay an entry charge of £ t for each person in your party (including young people under 18) rather than go without the experience?"

We are therefore comparing two states, the first in the *presence* of the outdoor visit and the payment of the admission charge t which defines the state $u(m-WTP,f(\mathbf{q});\mathbf{s})$; the second, in the *absence* of the outdoor visit but intact income level m, which defines the state $u(m;\mathbf{s})$. This money measure of WTP is a Hicksian compensating measure as it includes an income effect.

TABLE 1. FOREST SPECIFIC LOGIT MODEL ESTIMATES.

Forest		Linear			Logarithmic			Box-Cox			
Site	N	Mean ln$L$	a	b	Mean ln$L$	a	b	Mean ln$L$	λ	a	b
1	318	–1.044	3.049	–0.021	–1.020	15.066	–3.085	–1.016	0.27	8.348	–0.817
2	160	–0.971	1.619	–0.022	–0.966	9.835	–2.326	–0.955	0.45	3.788	–0.294
3	498	–1.185	2.709	–0.017	–1.133	13.702	–2.751	–1.131	0.17	9.249	–1.175
4	273	–1.055	2.978	–0.021	–1.052	14.315	–2.950	–1.040	0.46	5.756	–0.312
5	196	–1.065	2.132	–0.018	–1.089	10.896	–2.325	–1.060	0.69	3.058	–0.082
6	249	–0.935	3.119	–0.020	–0.987	14.527	–2.923	–0.935	0.99	3.128	–0.021
7	491	–1.151	2.087	–0.016	–1.162	10.347	–2.164	–1.138	0.56	3.554	–0.141
8	496	–1.126	2.346	–0.011	–1.143	11.048	–2.101	–1.115	0.59	3.667	–0.098
9	136	–1.146	2.579	–0.014	–1.125	12.504	–2.443	–1.117	0.34	6.055	–0.432
10	493	–1.033	1.590	–0.016	–1.068	8.984	–1.998	–1.031	0.79	2.067	–0.045
11	498	–0.996	3.497	–0.015	–0.972	16.858	–3.122	–0.969	0.26	9.348	–0.786
12	199	–1.188	2.018	–0.014	–1.195	10.106	–2.084	–1.172	0.53	3.593	–0.152
13	483	–0.957	3.661	–0.019	–0.970	17.073	–3.297	–0.951	0.62	5.460	–0.139

For ease of exposition the asymptotic standard errors are omitted, but all the estmates were significant at conventional statistical levels.

Forest sites are: 1=Avondale, 2=Cratloe, 3=Currachase, 4=Douneraile, 5=Dun a Dee, 6=Dun a Ree, 7= Farran, 8=Glendalough, 9=Guaghan Barra, 10=Hazelwood, 11=J. F. Kennedy, 12=Killykeen, 13= Lough Key.

The initial (first bound) bid amounts t used were: {50, 100, 150, 250, 400} (in Irish pence). The follow-up question used a higher bid vector t^h: {100, 150, 250, 400, 700} and a lower one t^l: {30, 60, 80, 150, 250}. Bid amounts were chosen on the basis of initial parameter estimates of the *WTP* distribution obtained from extensive pilot studies.

In Table 1 we present the site specific estimates for the slope and intercept parameters of the linear indices for Δv in the various models. All the samples show values of estimated l between 0 and 1. A formal likelihood test of linearity (l=1) at 10 % significance fails to be rejected by the samples collected in Dun a Ree and Hazelwood. The logarithmic transformation, (l=0), fails to be rejected by the samples collected in Avondale, Currachase and Guaghan Barra forests. The remaining seven samples reject both linear and logarithmic specification, indicating that the flexible functional form fits these sets of responses significantly better. However, most R-CV studies are conducted to estimate the parameters of the *WTP* distributions. Do these statistical differences in fit translate into significantly different welfare estimates? To answer this question we have

TABLE 2. ESTIMATES OF EXPECTED WTP.

Forest	Linear			Logarithmic			Box-Cox		
Site	Lower	Point	Upper	Lower	Point	Upper	Lower	Point	Upper
1	134	144	156	142	156	174	140	152	168
2	68	81	98	78	93	118	73	87	105
3	152	163	175	163	177	196	161	174	191
4	129	141	154	139	154	175	134	146	162
5	111	126	144	124	143	174	115	130	149
6	144	157	172	155	173	199	143	157	171
7	129	140	153	146	162	183	135	147	161
8	204	220	239	226	247	274	211	229	249
9	165	189	219	178	210	256	173	201	242
10	100	110	122	116	130	148	102	113	125
11	225	239	254	237	255	276	234	250	269
12	133	152	175	149	174	213	139	160	187
13	180	190	201	190	204	222	183	194	207

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estimated the truncated expectations of *WTP* for all three distributions and 13 forests, with the associated limits of 95% confidence intervals are presented in Table 2.

The lowest mean *WTP* is estimated for Cratloe, with a value of less than £1 in all three specifications. Lough Key, Glendalough and J. F. Kennedy forests are the three top sites in this respect with an expected *WTP* of around £2 .

Because of the higher density on the upper tail typical of the logarithmic specification, the estimates for these expectations are higher than for the linear counterparts, while the flexible functional form produces intermediate values. For the same reason the values for the median, which we do not report here, show an opposite pattern. However, all 95% confidence intervals for expected *WTP* across specifications overlap, showing that at this sample size (n<500), estimates of welfare measures are not sensitive to choice of specification.

ESTIMATES FROM THE POOLED SAMPLE

Since the same survey instrument was administered at all sites using the same design it is possible to pool the samples into one. From such a sample we have estimated the

TABLE 3. ESTIMARES FROM THE POOLED SAMPLE.

N = 4490		Par. Estimates			Expected *WTP*		
Specification	Mean ln$L$	a	b	λ	Lower	Point	Upper
Linear	−1.1377	2.377	−0.0151	—	159	163	168
Logarithmic	−1.1411	11.588	−2.3354	—	179	185	191
Box-Cox	−1.1217	4.2796	−0.1835	0.51	167	171	176

three basic linear, log-linear and Box-Cox models. Estimates are reported in Table 3. Notice how the confidence intervals of the expected *WTP* estimates from this large sample are much tighter than those estimated for the individual sites. The linear and logarithmic specification confidence intervals do not overlap. The flexible specification also produces welfare estimates which do not overlap with those of the logarithmic specification, while they only overlap by one penny with linear estimates. This shows how, in samples of this size ($n \approx 4{,}500$) the choice of specification may matter. However, we do note that most empirical studies in the literature have sample sizes far below the one for this pooled model.

The suitability of the estimates from the pooled sample to represent the samples of responses collected at each single forest site can be formally tested. To test this, we use the likelihood ratio test where the restriction applied is $\theta^i_{ML} = \theta^p_{ML}$ where the superscripts i and p refer to the i^{th} forest sample and to the pooled sample, respectively. The results of these tests show that these restrictions are always rejected at 10% significance with the exception of the sample in Killykeen forest which fails to reject the null for both the linear and logarithmic models. If one takes the 5% significance, the responses from Guaghan Barra and Currachase forests also do not reject the restriction, except for the linear models. We conclude that, under the correct specifications, pooling may not be corroborated by the observed responses.

In Table 4 we present the estimates from models with forest specific dummies. These are meant to measure forest-specific effects from the baseline forest of Lough Key. These can reflect two effects. The first one relates to differences in the socio-economic characteristics of the population of visitors to the individual forest. Forests may be vis-

TABLE 4. POOLED SAMPLE ESTIMATES WITH FOREST DUMMIES.

$N = 4490$	Linear		Logarithmic		Box–Cox $\lambda = 0.49$	
$\ln L$ value	–4845		–4846		–4762	
Parameter	Estimate	Asy.St.Er.	Estimate	Asy.St.Er.	Estimate	Asy.St.Er.
a	3.115	0.1151	13.1722	0.3452	5.3591	0.1538
Avondale	–0.7811	0.1578	–0.7887	0.1593	–0.7966	0.1583
Cratloe	–2.0477	0.2027	–2.3796	0.2306	–2.2194	0.2247
Currachase	–0.5100	0.1397	–0.5239	0.1403	–0.525	0.1399
Douneraile	–0.8528	0.1651	–0.8686	0.1675	–0.8733	0.1661
Dun a Dee	–1.1681	0.1864	–1.2365	0.1919	–1.2172	0.1893
Dun a Ree	–0.5805	0.1701	–0.5571	0.1711	–0.5771	0.1702
Farran	–0.9385	0.1409	–0.9824	0.1429	–0.9737	0.1417
Glendalough(*)	0.2251	0.1412	0.1647	0.1403	0.2002	0.1409
Guaghan Barra(*)	–0.1442	0.2127	–0.1693	0.2122	–0.1587	0.2125
Hazelwood	–1.4983	0.143	–1.6236	0.1487	–1.5768	0.1464
John F Kennedy	0.7105	0.143	0.5922	0.1411	0.662	0.1423
Killykeen	–0.7772	0.1845	–0.8154	0.1869	–0.8078	0.1854
b	–0.0163	0.0003	–2.5404	0.0655	–0.2208	0.0052

The symbol (*) indicates lack of significance of the estimate across all models at conventional levels.

ited by self-selected groups of visitors with different socio-economic characteristics across forests, maybe simply because of their proximity to residential areas with a differing socio-economic fabric. The second relates to potential differences in forest quality as perceived by respondents during the course of their visit. Forests of different quality simply command different amounts of *WTP* for visits. All estimates for the dummies are concordant in sign across models. Most are significantly different from zero according to the asymptotic t-test, with the exception of Guaghan Barra and Glendalough forests. The samples from these two actually produced estimates of expected *WTP* very close to those of the baseline forest of Lough Key, and it is therefore not surprising that their dummies do not shift the utility difference from the baseline.

In all, though, the pooled estimation suggests that ten out of twelve forests shift the *WTP* distribution from the baseline, with the possible exception of Guaghan Barra and Glendalough. A joint likelihood ratio test of all dummies being equal to zero is strongly rejected across all specifications. Notice that the log-likelihood values at a maximum are very similar in both linear and logarithmic specifications, this means that either fit the pooled responses similarly well. However, the linear and logarithmic restrictions on the parameter *l* are strongly rejected. So, in the pooled sample the flexible form represents a significant improvement over the two nested alternatives.

CONCLUSIONS

This study investigates the improvements in terms of fit delivered by a flexible Box-Cox specification for the bid amount *vis-à-vis* its nested linear and logarithmic transformations in R-CV responses for the distributions of *WTP* for forest recreation. We focus our attention on the expectation of *WTP* truncated at the maximum bid amount. In sample sizes varying from 136 to 498 we find evidence that estimates of this welfare measure may not be sensitive to choice of linear versus logarithmic specification. Although the flexible specification systematically improves on both nested forms in terms of likelihood of the samples, the interval estimates it produces have confidence intervals that, at these commonly used sample sizes, widely overlap with those of the nested forms.

The estimates of expected *WTP* per visit, as estimated by the integral between zero and the maximum bid amount (£7), range from £.81 in Cratloe forest up to £2.55 in the sample of visitors surveyed at J. F. Kennedy forest. Conservative estimates from the lower limit of the 95% confidence interval range from £0.63 to £2.37 per visit (values are in Irish Pounds)

Parameter estimates of the indirect utility function obtained from the pooled sample are significantly different from those estimated from forest-specific samples. Forest-specific dummies for the intercept shift are generally significant, indicating that site effects matter in *WTP* distributions.

Welfare estimates from the pooled sample are much more precise, given the increase in sample size, and as a consequence the confidence intervals on the expected *WTP* from different pooled models do not overlap. This shows that at large sample sizes the welfare estimates are indeed sensitive to choice of specification.

The analyses conducted on these data show that utility difference estimates for forest recreation vary systematically across forest sites. This implies that a unique simplified specification for the indirect utility function of the type constant-slope fails to adequately fit the population of responses, even though they all deal with the same item — *WTP* for one visit to the forest — and they have been collected by administering the same survey instrument. This suggests that utility differences for recreation are sensitive to the forest in which the recreational experience is undertaken. More generally, it would appear that while a parsimonious structure of the utility difference of the type slope-constant may be warranted to derive welfare estimates for single sites, assuming that this structure can adequately fit across sites may be unwarranted (*cfr.* Downing and Ozuna, 1996).

Secondly, employing flexible functional forms such as the Box-Cox does not remedy the lack of overall fit in the pooled model as the same pattern of significance of site-specific effects detected with the two restricted linear and logarithmic models is still present in the pooled model of the flexible form.

In summary, the flexible form does not resolve the site-specificity of the underlying indirect utility function generated by the *WTP* responses, indicating that utility changes depend on the forest characteristics relevant for recreation. Despite using a double bound approach the sample size (n<500) of the forest specific estimates welfare estimates are not sufficiently precise to distinguish across forest sites, although they are probably precise enough to design site specific entrance charges schemes.

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