A GENERALISED TEST FOR VAGUENESS IN HYPOTHETICAL MARKETS

ERKKI MÄNTYMAA AND RAULI SVENTO*

ABSTRACT

A model of discrete choice valuation is developed to study possible vagueness in target specificity in hypothetical markets. A general test is formulated for testing the hypothesis that different forces affect "yes" and "no" answers. It is shown how this test generalises the double bounded and ordered probit models. It is also shown how willingness to pay can be modelled as a bivariate system. We also show how differences in target specificity affect the results of the survey.

Keywords: contingent valuation, right of common access, test for vagueness, trichotomous choice question.

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INTRODUCTION

Recent literature has suggested various ways of identifying and measuring possible vagueness in environment related willingness to pay studies. Using the responses from two questions, Hanemann *et al.* (1991) and Cameron & Quiggin (1994) e.g. have shown how the expected value of willingness to pay can be identified as situated in different regions. Based on their empirical results Cameron & Quiggin (1994, p. 233) find the following implication

"...respondents seem not to hold in their heads a single immutable 'true' point valuation for an environmental resource. At best, they may hold a distribution of values — amounts they would be willing to pay with some associated probability density. This might be interpreted as 'uncertainty'. Whenever they are asked to produce value for the resource, they make a draw from this distribution and use it as a basis for their response to the current discrete-choice CV question".

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Hanemann & Kriström (1995) and Li & Mattsson (1995) have analyzed the role of preference related uncertainty in valuation frameworks. The basic result from these studies also seems to be that the survey results are quite sensitive to methods where the respondents are given the opportunity to express preference certainty related attitudes.

Johansson (1989) and Svento (1993, 1999) have analyzed uncertainties related to the outcome of a project. Svento (ibid.) has shown how possible vagueness in the commodity definition can be estimated using a trichotomous choice discrete technique.

In this paper we also work with the project outcome question and generalise the previous studies to the case where the whole process of no-saying and yes-saying can be driven by completely different forces and show how this generalised setup can be used in testing the target specificity. We hypothesise that willingness to pay itself, when non-zero, has an upper and a lower bound. We show how these bounds can be estimated, how it can be tested whether they differ in a statistical sense, how it can be tested whether there is a linear dependency between the bounds and how it can be tested whether the bounds are, in fact, drawings from two independent distributions. It is important to estimate and explain the vagueness zone since a large and unexplained zone casts doubt on the usefulness of the stated values for public policy. In addition, if we can control for poorly defined goods in a survey through statistical methods, we can increase our understanding on people's behaviour in a hypothetical context.

In order to succeed in the empirical testing we need a commodity to be valued such that it can easily be thought of as including vagueness related to its attributes. We have chosen the commodity to be valued in this study to be the *right of common access* (RCA) or *everyman's right* to the countryside. It denotes the right of any citizen in Finland, Norway and Sweden to make use of areas that are in a natural state, especially forests, irrespective of who the owner is. These rights are the result of a long historical process, and are, in Finland, characteristically not regulated precisely by law, so that compliance is rather based on tradition and common sense. The right has been part of the Nordic culture for centuries (for the content and history of the RCA, see e.g. Bergfors, 1990 and Mäntymaa, 1997).

From the forestry point of view, the significance of the RCA is that it lets people enjoy commercial forests for multiple uses. It is, however, a secondary right: a forest owner is allowed, for example, to cut a forest area and spoil or deteriorate the possibilities of making use of the RCA without any obligation to compensate potential users.

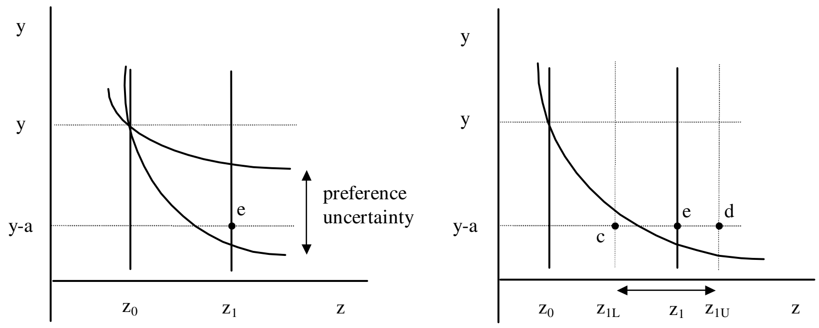
The paper is structured as follows: Next we discuss the question of preference vs. outcome related uncertainty and introduces the answering format. Thereafter we present the model formulation and its estimation possibilities. The generalised tests for testing WTP vagueness are formulated. Then we describe the main features of the surveys, and finally the main results are presented. The paper ends with our conclusions.

THE TRICHOTOMOUS CHOICE APPROACH

A key question related to the Cameron-Quiggin founding is whether the uncertainty is related to preferences or to the outcome of the project. Figure 1 clarifies the difference between preference uncertainty and outcome uncertainty. Here y denotes income, a the bid, z_0 the original environmental quality and z_1 the outcome of the project. Thus the proposed project would take the respondent to point e in Figure 1 a) and b).

In part a) of the figure the lower indifference curve at z_1 would imply a "yes" answer to the project (y–a, z_1) while the upper indifference curve would imply a "no" answer. Consequently, if the respondent is uncertain which one of the proposed curves describes his/her preferences he/she could give a "don't know" answer.

If there is uncertainty related to the outcome of the project while the preferences are well identified we have the situation as in part b) of the figure. If the respondent has to him/her certain downward going doubts (down to z_{1L}) about the outcome he/she would answer "no". If he/she has certain positive feelings about the outcome — up to z_{1U} — he/she answers "yes". But should he/she be uncertain of the outcome between z_{1L} and z_{1U} he/she might in principle answer "don't know". In particular, if, whenever the indifference curve cuts the y–a line between points c and d, the respondent adjusts his/her perception of the outcome to the level — between z_{1L} and z_{1U} — where the indifference curve cuts the y-a line the answer is "I am in-



a) Preference uncertainty b) Outcome uncertainty

FIGURE 1. PREFERENCE UNCERTAINTY AND OUTCOME UNCERTAINTY.

different between keeping the money versus paying and having the project". This is our hypothesis for estimating the width of the vagueness band z_{1U}–z_{1L}.

The basic idea is rather simple. In a discrete valuation situation the offered bid should not hit into the true optimum WTP too often. The true optimum is the situation where the respondent is indifferent between accepting the bid and having the project versus turning the bid down and continuing without the project. In many cases in dichotomous discrete choice situation the offered bid can be expected to be far away from the true WTP. Consequently there is not any kind of uncertainty related to the answer. One possibility to detect uncertainty in answering is to identify those respondents for whom the offer is very close to the true optimum. These respondents and the corresponding uncertainty can be found using the trichotomous answering format.

To accomplish the aim we have used the following type of questioning:

*Are you willing to pay **a** FIM if this sum would be used for the described project?*

- *Yes, I am willing to pay.*
- *I value equally the possibility of paying and having the project versus keeping the money for my personal use and not having the project.*
- *No, I am not willing to pay.*
- *I do not know.*

An interesting option for this format would be the open-ended format with questions related to the upper and lower bounds of the willingness to pay[1]. The problem then is of course that we face all the well-known difficulties of open-ended formats, i.e. many protest zeros, non-responses and unrealistic large amounts.

THE MODEL AND ITS ESTIMATION

Due to outcome uncertainty, peoples' maximum willingness to pay may have a vagueness band as described before. Assume that possible vagueness in the hypothetical market causes those respondents who have genuinely positive willingness to pay to compare the bid to what they would be *at most* or *at least* willing to pay. The assumption then is that the respondents can make a distinction between an upper bound for the willingness to pay $\overline{WTP}$, and a lower bound for the willingness to pay $\underline{WTP}$, with $\overline{WTP} > \underline{WTP}$, of course. Then it is, of course, assumed that the zero willingness to pay's are included among the "no" answers. We shall not analyse this spike in this context.

One possibility to model this situation is to follow Svento (1993, 1999) and assume that

$$E\left[\overline{WTP}\right] = WTP + \gamma \tag{1}$$

$$E\left[\underline{WTP}\right] = WTP - \gamma \tag{2}$$

where *WTP* is the true optimum willingness to pay with exact information content of the project, *E* is expectations operator, and γ is the symmetric deviation upwards or downwards depending on the doubts the respondents have about the outcome. Alternatively, we can let the vagueness be asymmetric with $\gamma^u \neq \gamma^d$, with γ^u indicating upwards and γ^d downwards vagueness.

The defect in this approach is that it is not the most general one because we end up explaining the true *WTP* with one set of factors while the vagueness shall be explained by another set of variables, i.e.

[1] This could be done by asking each respondent two separate willingness to pay questions: "How much would you *at least* be willing to pay for..." and "How much would you *at most* be willing to pay for...".

$$E\left[\overline{WTP}\right] = \beta' x + \gamma_1' z_1 \tag{3}$$

$$E\left[\underline{WTP}\right] = \beta' x - \gamma_2' z_2\,, \tag{4}$$

where x is a vector of variables explaining *WTP* and z a vector of variables explaining vagueness. Typically, we would have things like income, age, education, and sex in x and things like the amount of information or warm glow in z. In Svento (1999) it was shown how this model can be specified and estimated using both the Hanemann (1984) and the Cameron (Cameron & James, 1987; Cameron 1988) approaches.

Here we shall generalise these models by asking the question of why could not the x variables as well influence possible vagueness. Abandoning the assumption of specific factors giving rise to vagueness, we can formulate the most general hypothesis

$$\overline{WTP} = \beta_1' x_1 + \varepsilon_1 \tag{5}$$

$$\underline{WTP} = \beta_2' x_2 + \varepsilon_2 \tag{6}$$

with x_1 and x_2 being two vectors with either the same or different content and ε_1 and ε_2 identically distributed error terms absorbing all unmeasured non-systematic determinants of the value of the resource to the respondent.

Several things in this model are worth commenting. Notice firstly how this model is a general formulation of the situation from which Cameron and Quiggin's (1994) findings could have been drawn. It must be stressed, however, that we do not want to claim that the indifference sets would be belts, i.e. that people would be willing to pay the same amount for different amounts of the commodity. We relate the belt in willingness to pay to unawareness with respect to the commodity amenities, i.e. we deal with the case b) of Figure 1.

A central question relates to the correlation of the error terms in the above general presentation. If there is perfect linear dependency between the errors, then the upper and lower bounds of *WTP* are also perfectly correlated, i.e.

$$\overline{WTP} = E\left[\overline{WTP}\right] + \frac{\sigma_2}{\sigma_1}\left\{\underline{WTP} - E\left[\underline{WTP}\right]\right\}, \tag{7}$$

where σ_1 and σ_2 are standard deviations of the corresponding error terms. This obviously is identical to

$$\overline{WTP} = \beta_1' x_1 + \frac{\sigma_2}{\sigma_1}\left(\underline{WTP} - \beta_2' x_2\right). \tag{8}$$

Now we can clearly see how, if $x_1 = x_2$, the necessary condition for no vagueness in willingness to pay is equal to: $\beta_1 = \beta_2$ and $\sigma_1 = \sigma_2$. If this hypothesis is rejected we have two possibilities; either the vagueness zone can be modelled as above with a linear dependency between the boundaries, or there exists a more fundamental vagueness with completely different forces driving the boundaries. If the latter is true then the boundaries can come from two independent distributions and the model must be estimated as a system with some cross equation correlation. We shall assume a bivariate normal distribution $BVN\left(\beta_1' x_1, \beta_2' x_2, \sigma_1^2, \sigma_2^2, \rho\right)$, where ρ is the correlation coefficient between the error terms. If ρ equals one the bivariate model cannot be estimated and we are back in the situation above where the boundaries come from the same distribution and there exists a linear dependency between them. If, however, the hypothesis $\rho = 1$ is rejected we have a genuine two-dimensional situation with different forces driving the boundaries.

We shall show how all these situations can be modelled and hypotheses tested using our trichotomous data. We shall start with the simpler case and assume perfect correlation between the boundaries. After we have shown how this case can be estimated we drop this assumption and formulate the more general bivariate model.

Case 1: Perfect Linear Correlation between ε_1 and ε_2

Let a now be the bid offered to the respondent. We can state that the probability of answering "yes" is

$$\Pr\{yes\} = \Pr\{\beta_2' x_2 + \varepsilon_2 > a\} = 1 - F_{\varepsilon_2}\left(a - \beta_2' x_2\right), \tag{9}$$

where F_{ε_2} is the cumulative distribution function of the error term ε_2. Accordingly the probability of answering "no" is

$$\Pr\{no\} = \Pr\{\beta_1' x_1 + \varepsilon_1 < a\} = 1 - F_{\varepsilon_1}(a - \beta_1' x_1). \tag{10}$$

The probability of stating indifference in answering is

$$\begin{aligned}\Pr\{ind\} &= \Pr\{\beta_2' x_2 + \varepsilon_2 < a < \beta_1' x_1 + \varepsilon_1\} \\ &= F_{\varepsilon_2}(a - \beta_2' x_2) - F_{\varepsilon_1}(a - \beta_1' x_1).\end{aligned} \tag{11}$$

This model can be estimated with the maximum likelihood method. Define the following indicator variables:

$d_0 = 1$ if respondent answered "no", 0 otherwise,

$d_1 = 1$ if respondent answered indifferent, 0 otherwise,

$d_2 = 1$ if respondent answered "yes", 0 otherwise.

The likelihood of the sample is

$$\begin{aligned}L = \prod_{i=1}^{n} &\left[F_{\varepsilon_1}\left(\frac{a_i - \beta_1' x_{1i}}{\sigma_1}\right)\right]^{d_{0i}} \times \\ &\left[F_{\varepsilon_2}\left(\frac{a_i - \beta_2' x_{2i}}{\sigma_2}\right) - F_{\varepsilon_1}\left(\frac{a_i - \beta_1' x_{1i}}{\sigma_1}\right)\right]^{d_{1i}} \times \\ &\left[1 - F_{\varepsilon_2}\left(\frac{a_i - \beta_2' x_{2i}}{\sigma_2}\right)\right]^{d_{2i}}.\end{aligned} \tag{12}$$

This likelihood function of course is based on standardised error terms ε_1/σ_1 and ε_2/σ_2. All parameters β_1, β_2, σ_1, and σ_2 can be recovered by maximising logL with respect to them. Notice how the double bounded models of Hanemann *et al.* (1991) and Cameron & Quiggin (1994) are special cases of our model. They use the exogenous first and second offered values as thresholds in identifying the *WTP*. Instead we use only one threshold but let the *WTP* itself have boundary values. Further inspection of the likelihood function also reveals that if $x_1 = x_2$, $\beta_1 = \beta_2$ and $\sigma_1 = \sigma_2$ but there are different intercept terms, (12) reduces to the ordered probit model (see Svento, 1999, for details).

Case 2: Estimated Correlation between ε_1 and ε_2

If the boundaries of *WTP* are genuinely driven by different forces we have to estimate a bivariate model. Since the bivariate normal is the most well understood multivariate model it certainly is a good candidate. However, there is a serious drawback in our trichotomous data. In order to estimate a bivariate probit we need observations for two latent variables from the same respondent. Instead we have three possible alternatives for the response for each individual. But we can change back to the dichotomous situation by looking at a "yes"/"not yes" versus "not no"/"no" distribution. By so doing we have two (1,0) variables for each respondent as demanded by the bivariate probit.

However, we still face a problem. Let y_1 and y_2 be the observed response variables for the "yes"/"not yes" and "not no"/"no" responses. For someone who answered "yes" both variables are coded as a one. For someone who answered indifferent y_1 is coded as a zero and y_2 as a one. Someone who answered "no" has a zero in both variables. But this means that we have observations only for three quadrants, the fourth for a "yes"/"no" answer being empty (unless the "don't know" answers are first coded as a "yes" and then as a "no"[2]). This means that we have to scale by dividing by one minus the cumulative density in the indifference quadrant. Under the null hypothesis of no linear dependency this term is equal to 0.75.

Let $z_1 = (a - \beta_1' x_1)/\sigma_1$, $z_2 = (a - \beta_2' x_2)/\sigma_2$, and $g(z_1, z_2)$ be the bivariate standard normal density function. The log-likelihood function for the model then takes the following form

$$\begin{aligned}
\log L = \sum_i \Bigg\{ & (y_1 y_2) \log\left[\int_{(a-\beta_2' x_2)/\sigma_2}^{\infty} \int_{(a-\beta_1' x_1)/\sigma_1}^{\infty} g(z_1, z_2)\, dz_1 dz_2 \right] \\
& + (1-y_1) y_2 \log\left[\int_{-\infty}^{(a-\beta_2' x_2)/\sigma_2} \int_{(a-\beta_1' x_1)/\sigma_1}^{\infty} g(z_1, z_2)\, dz_1 dz_2 \right] \\
& (1-y_1)(1-y_2) \log\left[\int_{-\infty}^{(a-\beta_2' x_2)/\sigma_2} \int_{-\infty}^{(a-\beta_1' x_1)/\sigma_1} g(z_1, z_2)\, dz_1 dz_2 \right] \\
& - (1-y_1) y_2 \log\left[1 - \int_{-\infty}^{(a-\beta_2' x_2)/\sigma_2} \int_{(a-\beta_1' x_1)/\sigma_1}^{\infty} g(z_1, z_2)\, dz_1 dz_2 \right] \Bigg\}. \qquad (13)
\end{aligned}$$

[2] Carson *et al.* (1998) analyzed the effect of an opportunity to select a "don't know" option in a CV survey. They found that including "don't know" responses into the "no" category does not alter WTP estimates and the distribution of "yes" and "no" answers compared with results of a survey where such an option is not given.

This model cannot be estimated using standard routines. However, programs like Gauss or Limdep can easily take care of this kind of maximisation[3].

MAIN FEATURES OF THE SURVEYS

As described above, the RCA is very suitable for our research objective. First of all interest in this question has raised because, with Finland and Sweden joining the European Union, there is the possibility of aligning land use rights more closely to European standards. Secondly, this commodity is not — even though most people use it frequently — clearly defined in common vocabulary or even in legislation. It is not unambiguous exactly what this right allows one to do in the woods — can you camp wherever you want, can you make a campfire wherever you want, can you ride or bike everywhere? When it comes to exact norms related to these kinds of questions, there is a large degree of unawareness. Thus the RCA is a suitable target for a case analyzing outcome uncertainty.

However, direct valuation of the RCA itself is problematic. The RCA is, after all, a tradition with a long and unquestioned history and it may well be that it is very difficult for people to imagine or accept it being restricted or even taken away. It may be even more difficult for people to try to find their willingness to pay for the right not to be taken away — they own it in the first place![4]

New ways of using the RCA — different kinds of motorised travel as the most important example — have caused damage to nature in some areas. Thus, respondents were informed that the money hypothetically collected in the study would be used for preventing and repairing damages from abuse of the RCA.

In this paper, we report WTP results from two samples (1000 households conducted in each). Respondents in one sample were given a basic definition (BDS) of the target to be valued. After a general description of the rights included

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[3] We have used Limdep in all estimations, programs can be received from us on request.

[4] We have also conducted several "willingness to accept" studies since the RCA seems to be a very suitable commodity for WTP/WTA comparisons. Results of these studies are reported in Mäntymaa, 1999a and 1999b.

in the RCA, respondents were told that the European standard would mean free access only into specific restricted recreation areas.

In the other sample, respondents were given the opportunity of revealing their perception about the broadness of the RCA. They were presented with 28 statements about the RCA, and asked to indicate whether they believed the statement was true or untrue (a "don't know" possibility was also offered). The statements were planned in such a way that ten of them included rights not really included in the RCA, ten of them excluded rights that in reality are included in the RCA and eight of them were correct (a detailed description of the statements can be found in Mäntymaa & Svento, 1995 and Mäntymaa, 1997). In this statement based definition sample (SDS) respondents were then given the same scenario as the other sample regarding abandonment of the RCA in favour of the European system with restricted recreational areas.

Based on previous studies (see e.g. Mäntymaa, 1997) it is well-known that Scandinavian people respect the right and know their preferences on this principle but are not familiar with the exact rights of the RCA and European principles in detail. Based on this research result we can conclude that the uncertainty related to the RCA arise from the definition of the commodity and not from respondents' preferences.

The WTP question in both samples was: *Are you willing to pay **a** FIM on a yearly basis if the RCA would be maintained?* The respondents were also told that the money hypothetically collected would be used for preventing and repairing damages caused by improper use of the RCA. The answering format was the one shown previously. The indifference possibility was stated subsequently: *I value equally the possibility to pay **a** FIM on a yearly basis if the RCA is maintained and the possibility to keep the money in my own personal use and change into the system of restricted recreational areas.*

The Results

The pilots and main surveys were mailed during the summer 1995. In the pilot studies (100 each) a yearly payment — compared to a once and for all payment — proved to work better. All the samples — 1000 contacted households

TABLE 1. DESCRIPTIVE STATISTICS.

	Basic Definition Sample (BDS)		Statement Based Definition Sample (SDS)	
	Abs.	%	Abs.	%
Sample size	1 000		1 000	
Received	503	100	539	100
Number of "No"	178	35.5	171	31.7
Number of "Indifferent"	71	14.1	66	12.2
Number of "Yes"	194	38.6	204	37.8
Number of "Don't know"	59	11.8	98	18.2
Median WTP	150		150	
Mean WTP	226		247	

in each main sample — were randomly selected from adult (18–75) Finns. The samples were randomly divided between ten bid groups which varied from 20 FIM to 1 000 FIM.

Outliers of the data set were detected by boxplot technique. The variable on which the outlier analysis was based is the bid's share of the respondent's income. All those who accepted the bid while the bid's income share was more than two standard deviations above the expected level were deleted. This was almost identical to abandoning accepted bids whose income share was five percent or more.

In Table 1, some main statistics are presented. Notice how the amount of indifference answers in fact does not increase in the definition based sample — instead the answers in the "don't know" group increase by over 65%. The mean WTP was calculated from dichotomous data (i.e. indifference and "don't know" answers excluded) by logit regression of the WTP (yes/no) variable on a constant and the bid. Mean WTP is then calculated by dividing the constant coefficient by the estimated bid coefficient.

Figure 2 shows the survival curves for the basic definition sample (BDS) and the statement based definition sample (SDS). These survival curves are based on Ayres interpolated data.

In Figure 3, the corresponding indifference reply curves are presented (i.e. the shares of the indifference answers in different bids). Neither curve looks like a proper density function of a normal distribution which is what we would expect if the indifference answers were only the ones close

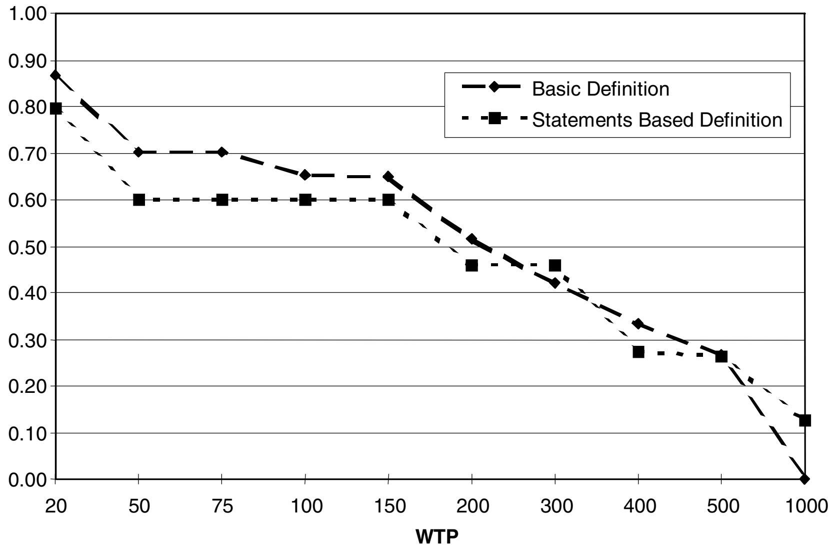

FIGURE 2. EMPIRICAL SURVIVAL CURVES FOR THE BASIC AND STATEMENTS BASED DEFINITION DATA.

to maximum WTP. Especially the left hand tail in the basic sample and the right hand tail in the definitions based sample as well as the strange and strong focal point effect in 300 FIM are against the presupposition of the shape of the normal distribution.

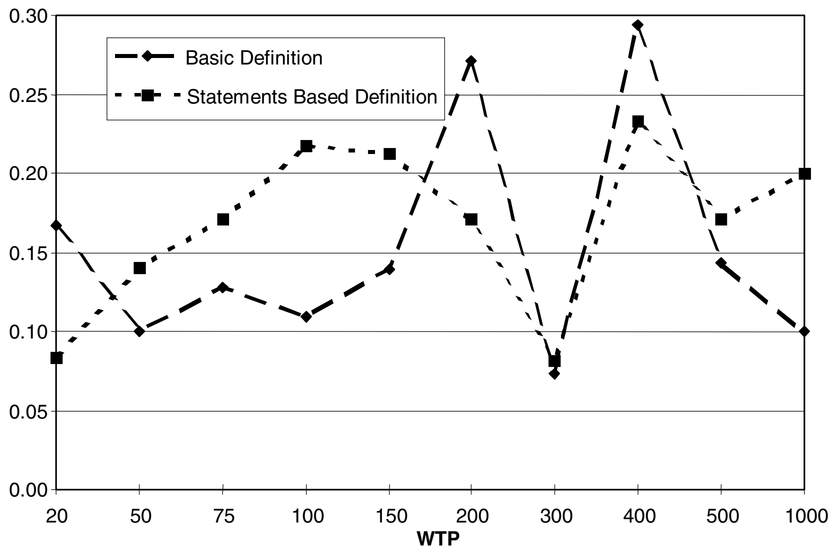

FIGURE 3. EMPIRICAL INDIFFERENCE REPLY CURVES FOR THE BASIC AND STATEMENTS BASED DEFINITION DATA.

TABLE 2. THE WTP AREAS.

	Basic Definition Sample (BDS)	Statements Based Definition Sample (SDS)
$E\left[\overline{WTP}\right]^a$	394.8 (8.78)	404.5 (9.38)
$E\left[\underline{WTP}\right]^a$	121.6 (3.94)	179.8 (6.56)
σ_1	397.2 (6.64)	313.9 (6.43)
σ_2	276.9 (7.17)	253.4 (5.51)
Wald[b]	41.3	35.1
Wald[c]	41.8	35.8
LogL	–408.8	–379.4

[a] See Equations (5) and (6).

[b] H_0: $\beta_1 = \beta_2$, i.e. $E\left[\overline{WTP}\right] = E\left[\underline{WTP}\right]$

[c] H_0: $\beta_1 = \beta_2$, i.e. $E\left[\overline{WTP}\right] = E\left[\underline{WTP}\right]$, and $\sigma_1 = \sigma_2$

In Table 2 the maximum likelihood estimates for model (12) are presented without any covariates. In other words we have included only the constant term in the vectors x_1 and x_2. These constants can then be interpreted as expected values for the boundaries (see Equations (5) and (6)). We have included the bid in FIM so that the estimates of the constants are money values for the WTP bounds[5]. The hypothesis of no vagueness (i.e. $\beta_1 = \beta_2$, $\sigma_1 = \sigma_2$) can clearly be rejected. Notice how the vagueness zone seems to be narrower in the statement based definition sample. It could be that answering the statements is actually a process which makes people concentrate harder in answering. We still, however, have to be careful in the interpretation since we do not know whether these bounds are drawings from the same distribution.

[5] Notice again that we have estimated the model using the Cameron approach that uses the bids as thresholds in concluding that the respondent's true willingness to pay is either greater than of less than the bid. The Bishop-Heberlein-Hanemann approach, on the other hand, uses the bid as an explanatory variable in explaining the utility difference (see Svento, 1999).

Now knowing that there is vagueness in the data we can look for explanations for it using the covariates. Table 3 presents estimation results of the basic definition sample. The three left-hand columns describe the results for explanatory vector x_1 of the lower bound and the three right-hand columns the corresponding information for x_2 of the upper bound of the WTP. Shared factors are located in the middle column. The estimation starts with three basic explanatory variables, income, year of birth and gender, and continues by reducing the model by dropping out non-significant variables. Dashed lines separate different specifications from each other. We have used double logarithmic transformations and logistic distributions.

We start by maximising (12) with the same x_1 and x_2 vectors so that $x_1 = x_2 = Income_i, Year\ of\ birth_i, Gender_i$. The hypothesis of no vagueness (i.e. $\beta_{11} = \beta_{21}$, $\beta_{12} = \beta_{22}$, $\beta_{13} = \beta_{23}$, $\sigma_1 = \sigma_2$) can clearly again be rejected. This is no surprise since the RCA, after all, is not a well-definable commodity. The hypothesis of different variances in $\overline{WTP}$ and $\underline{WTP}$ distributions (i.e. $\sigma_1 = \sigma_2$) can be rejected as well as the hypothesis of different income elasticities (i.e. $\beta_{11} = \beta_{21}$). In the final specification, youth and being a female drive what the respondent would at most be willing to pay upwards while only income drives the lower bound.

Recall that in the SDS the respondents had to accept or reject 28 claims concerning the rights included or excluded in RCA. Every time a respondent accepted a statement saying a right is included while in reality it is not, he/she made an upwards error. Correspondingly, every time he/she accepted a statement excluding something that actually is included he/she made an error downwards. This scheme worked well at least in the respect that all respondents filled in their answers to all the claims.

In modelling the SDS we need to control for differences in answering these statements. In particular, we can estimate marginal valuations for the attributes in the statements by using dummy variables to indicate respondent errors. By so doing we have 28 dummies for each respondent. If a respondent got all claims right he/she has only zeros in these dummies and he/she would be valuing RCA as stated in orders of Finnish Ministry of the Environment (1995). We have used the information content of the an-

Table 3. Estimation Results for Basic Definition Sample (BDS).

	$\underline{WTP}$ [a]				$\overline{WTP}$ [b]	
Income	β_{11}	0.402		0.279	β_{21}	*Income*
		(2.55)		(1.41)		
Year of birth	β_{12}	0.174		0.641	β_{22}	*Year of birth*
		(0.466)		(1.36)		
Gender	β_{13}	0.358		1.23	β_{23}	*Gender*
		(1.25)		(3.16)		
	σ_1	1.23		1.59	σ_2	
		(6.55)		(5.82)		
	logL		−334.7			
	Wald[c]		34.7			
Income	β_{11}	0.496		0.394	β_{21}	*Income*
		(31.4)		(3.77)		
				0.414	β_{22}	*Year of birth*
				(1.64)		
				0.895	β_{23}	*Gender*
				(3.32)		
	σ_1	1.23		1.53	σ_2	
		(6.55)		(6.15)		
	logL		−335.8			
	Wald[d]		2.53			
Income	β_{11}	0.492		0.343	β_{21}	*Income*
		(26.1)		(3.11)		
				0.542	β_{22}	*Year of birth*
				(2.04)		
				0.871	β_{23}	*Gender*
				(3.42)		
	σ		1.45		σ	
			(6.69)			
	logL		−337.6			
	Wald[e]		1.95			
Income	β_{11}		0.492		β_{21}	*Income*
			(25.8)			
				0.191	β_{22}	*Year of birth*
				(4.08)		
				0.889	β_{23}	*Gender*
				(3.46)		
	σ		1.47		σ	
			(6.65)			
	logL		−338.5			

[a] x_{11} = log(*Income*), x_{12} = log(*Year of birth*), x_{13} = 1 if female, 0 if male
[b] x_{21} = log(*Income*), x_{22} = log(*Year of birth*), x_{23} = 1 if female, 0 if male
[c] H_0: $\beta_{11} = \beta_{21}$, $\beta_{12} = \beta_{22}$, $\beta_{13} = \beta_{23}$, $\sigma_1 = \sigma_2$
[d] H_0: $\sigma_1 = \sigma_2$
[e] H_0: $\beta_{11} = \beta_{21}$

Table 4. Frequencies from Zero to Five Mistakes up and down in Statement Based Definition Sample (SBS).

Number of mistakes	Up	Down
0	128	54
1	128	124
2	107	143
3	84	99
4	37	57
5	33	33

swers to the statements in two different ways. The basic approach has been to estimate the marginal values of the attributes in the claims by including all 28 dummies in the estimations. The other approach is to calculate the total ″volume″ of the RCA by each respondent. This can be accomplished by switching a minus one on every time a respondent made an error downwards and a plus one on each time he/she made a mistake upwards. The total volume then can be calculated by assuming equal weights to all attributes and summing over the statements. If the net amount is less than zero the respondent thinks that the RCA is in fact smaller than stated by the law and vice versa. The frequencies from zero to five mistakes up and down are shown in Table 4.

The table shows that there were 128 respondents who did not make any errors up and 54 respondents that did not make any errors down. There were 84 respondents who made three mistakes up and 99 who made three errors down, etc.

Table 5, organized in the same way as Table 3, presents the estimation results of the SDS. For comparison, results using the same x_1 and x_2 vectors as those in the BDS (i.e. without the statement dummies) are presented in the first part of the table. The hypothesis of no vagueness (i.e. $\beta_{11} = \beta_{21}$, $\beta_{12} = \beta_{22}$, $\beta_{13} = \beta_{23}$, $\sigma_1 = \sigma_2$) can clearly be rejected. The next step was to include the 28 statement dummies. Due to high collinearities, individual marginal valuations turned out to be difficult to estimate robustly, i.e. the standard deviations of individual marginal valuations remained rather high. The result on the acceptance of the vagueness

TABLE 5. ESTIMATION RESULTS FOR STATEMENTS BASED DEFINITION SAMPLE (SDS).

	$\underline{WTP}$ [a]				$\overline{WTP}$ [b]	
Income	β_{11}	0.449 (2.81)		0.513 (3.07)	β_{21}	*Income*
Year of birth	β_{12}	0.234 (0.625)		0.227 (0.588)	β_{22}	*Year of birth*
Gender	β_{13}	−0.337 (−1.27)		0.299 (1.07)	β_{23}	*Gender*
	σ_1	1.16 (7.50)		1.21 (7.08)	σ_2	
	logL		−337.7			
	Wald[c]		42.5			
Income	β_{11}	0.583 (32.9)		0.611 (24.7)	β_{21}	*Income*
Gender	β_{13}	−0.420 (−1.30)				
Swimming not allowed	β_{14}	−0.952 (−4.10)				
	σ_1	1.08 (7.58)		1.25 (6.96)	σ_2	
	logL		−328.0			
	Wald[d]		48.8			
Income	β_{11}	0.559 (27.1)		0.625 (34.3)	β_{21}	*Income*
Gender	β_{13}	−0.367 (−1.79)				
Net mistakes	β_{15}	0.936 (2.23)				
	σ		1.20 (7.65)		σ	
	logL		−332.4			
	Wald[e]		11.8			
Income	β_{11}	0.535 (36.4)		0.629 (34.6)	β_{21}	*Income*
Net mistakes	β_{15}	1.33 (3.87)				
	σ		1.19		σ	
	logL		−336.3			
	Wald[f]		41.8			

[a] x_{11} = log(*Income*), x_{12} = log(*Year of birth*), x_{13} = 1 if female, 0 if male, x_{14} = *Swimming not allowed without permission*, x_{15} = *Net mistakes*
[b] x_{21} = log(*Income*), x_{22} = log(*Year of birth*), x_{23} = 1 if female, 0 if male
[c] H_0: $\beta_{11} = \beta_{21}$, $\beta_{12} = \beta_{22}$, $\beta_{13} = \beta_{23}$, $\sigma_1 = \sigma_2$
[d] H_0: $\beta_{11} = \beta_{21}$, $\sigma_1 = \sigma_2$
[e] H_0: $\beta_{11} = \beta_{21}$
[f] H_0: $\beta_{11} = \beta_{21}$

hypothesis remained clear also in this case. In the second part of Table 5, we present the results using the single most important statement, that ”swimming and washing are allowed without permission only on public beaches”. The statement is not true but 153 respondents out of 539 got it wrong, i.e. they made a mistake downwards. Thus, we include the variable only in estimating the lower boundary. Since downward mistakes are represented by the dummy variable value of one, the negative sign is to be expected. The hypothesis of equal income effects and equal variances can be rejected (i.e. $\beta_{11} = \beta_{21}$, $\sigma_1 = \sigma_2$).

In the third and fourth parts of the table, the results with the “net mistakes” variable are presented. We started by including the variable in both boundaries but it turns out that, based on statistical significance, the net mistakes variable drives only the lower bound of WTP. The sole factor driving the upper bound is income and the income elasticities of the bounds differ statistically from each other (i.e. $\beta_{11} \neq \beta_{12}$). The variances turn out to be equal in the statistical sense. This points to the possibility that the bounds do not come as drawings from two different distributions (see Equation (8)).

Now that we have shown that there clearly is vagueness in the answering process we can turn to testing the hypothesis that the boundaries of WTP actually come from differ-

TABLE 6. THE BIVARIATE PROBIT OF BASIC DEFINITION SAMPLE (BDS).

	$\underline{WTP}$		$\overline{WTP}$	
Log of income	0.518 (171.7)			*Log of income*
Log of birth year			0.171 (6.82)	*Log of birth year*
			0.890 (5.31)	*Female*
σ	1.48 (14.0)			
ρ		.999		
Standard error of ρ		.002		
logL		–375.3		

Table 7. The Bivariate Probit of Statement Based Definition Sample (SDS).

	$\underline{WTP}$		$\overline{WTP}$	
Log of income	0.523 (74.9)		0.644 (35.8)	*Log of income*
Net mistakes	1.57 (5.61)			
σ_1	1.82 (8.28)		2.16 (7.30)	σ_2
ρ		.998		
Standard error of ρ		.006		
logL		–321.3		

ent distributions, i.e. we shall turn to the bivariate model. In Tables 6 and 7 estimation results for the bivariate probit model (13) are presented. The hypothesis $\rho = 1$ (i.e. that the error terms are perfectly correlated) cannot be rejected in either case. Even though there is strong unawareness in answering the situation is still comforting in the sense that there is a linear tie between the bounds of willingness to pay. The vagueness zone arises inside one WTP distribution.

Conclusions

In analyzing uncertainties related to the outcome of a project, we have shown how a general test for the hypothesis that different forces drive "yes" and "no" answers can be formulated and estimated using a trichotomous choice discrete valuation framework. We have also shown how it can be tested, using system estimations, whether the boundaries of willingness to pay actually are drawings from two different distributions. We have found clear evidence of the vagueness zone and of the fact that different covariates move respondents' lower and upper bounds of willingness to pay. Fortunately there seems, at least in our data, to exist a linear dependency between the boundaries so that the vagueness zone itself is not completely random.

We have also found clear evidence of the fact that target misspecification widens the wedge between the lower and upper bounds of WTP.

This approach enables the researchers to detect possible problems in target specificity from any data. Since there is no need for controlling with different sub-samples also the cost-efficiency in hypothetical market studies can be increased.

Many questions remain open, however. There is no need to restrict our approach to public or specifically environmental commodities. To gain more understanding about vagueness in WTP answering in general, studies valuing private goods, or in any case goods with very exact contents, should be conducted with this method. A central question is if the method is so sensitive that it always detects vagueness. If this turns out to be the case— which we do not expect — the statistical properties of the test procedure should be worked out more thoroughly, and in particular we should work out confidence bounds for the vagueness interval. We see many interesting questions opening up in this line of research in the future.

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