Contingent valuation: How opportunity costs influence the stated willingness to pay

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Online Appendix

Appendix 1: Reasons why respondents state a negative WTP

Bohara et al. (2001) provide four explanations of why a stated WTP might be negative.

First, negative responses are sometimes interpreted as misunderstandings and are considered not reasonable. This is particularly plausible if the public good is freely available and an increased provision "can simply be ignored" without decreasing utility (Bohara et al. 2001). For example, Bowker and Stoll (1988) argue that a negative WTP for the provision of refuge land for the whooping crane is not reasonable. Others have interpreted zero (and negative) responses as political, social, or moral sentiments rather than economic preferences (Lo and Jim 2015). Second, the public good might actually be a "public bad" for some respondents. This is plausible if the provision of a public good generates winners and losers. For example, a policy to restrict mining in favor of more intensive wilderness management in Australia obviously creates winners and losers (Cameron and Quiggin 1994). A third explanation is that respondents dislike the method of payment (e.g., taxes) or government involvement (e.g., local participation vs. central government involvement). Fourth, a negative WTP can occur if the change in one public good is accompanied by a reduction in other public goods. For example, the prescribed burning of underbrush in forests reduces the risk of catastrophic wildfires but produces smoke emissions (Loureiro et al. 2004).

The fourth explanation is related to our explanation of a negative stated WTP. However, as the example of wildfires shows, the argument is about the side effects of one public good on other public goods. Typically, such side effects are of a biophysical nature. According to our explanation, no biophysical relationship must exist, and only the forgone value of the second-best alternative influences the stated WTP. This is the case whenever the respondent thinks the offered public good is financed by an existing government budget and not by a new tax. Whenever a new tax seems unrealistic, rational respondents will think that the public good will be financed at the cost of other government expenditure. Formally explaining this influence of alternative government expenditure is the main contribution of our article to the literature. We also provide evidence based on existing literature.

Appendix 2: Six propositions for incentive compatibility

The six propositions by Carson et al. (2014) are:

- Their first proposition is that
  - a binding (binary) referendum vote with a plurality voting rule is incentive-compatible in the sense that truthful preference revelation is the dominant strategy when the following additional conditions hold:
    (a) the vote is coercive in that all members of the population will be forced to follow the conditions of the referendum if the requisite plurality favors its passage; and
    (b) the vote on the referendum does not influence any other offer that might be made available to the relevant population.
- Propositions 2 to 5 show that some of the assumptions can be formulated weaker without changing the incentive structure:
  - the binding referendum can be reduced to an advisory referendum;
  - the "requisite plurality vote" can be reduced "to more supporters, more public good";
  - the decision-maker needs to consider only the outcome with a probability greater than zero;
  - the vote can be replaced with a random sample survey.
- In a sixth proposition, they show that
  - if the probability of influencing the decision becomes zero, truthful preference revelation is no longer a dominant strategy as any response has the same influence on the respondent's utility.

Appendix 3: Numerical example of bias

Our numerical examples in this Appendix illustrate what is described above for the case α=1 (i.e., the respondent believes, if the offered public good is not provided, the alternative public good is offered). Tab. A1 shows that for all six cases, we have chosen to hold the cardinal utility of the two public goods constant at t'=20 and t''=50. The contributions t_0' and t_0'' are chosen such that the utility rankings are according to the six cases. Whenever the surplus of the offered public good is greater than the surplus of the alternative public good, the respondent votes "yes". In the cases B1, B2, and B3, t', t_0' and consequently (t'–t_0') are identical. Whether the respondent votes "yes"

Tab. A1: Example for the single binary choice question where the response depends on the alternative second-best option *(see illustration in Fig. A1)*

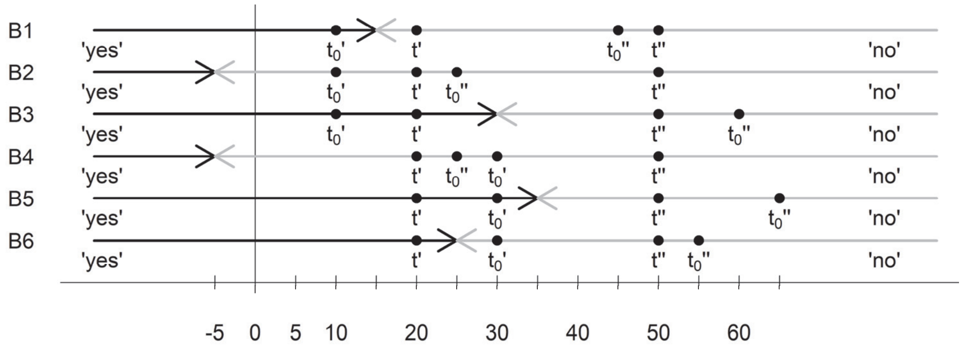
	Offered public good			Altern. public good			Vote	Bias	Change vote if	
	t'	t_0'	Surplus	t''	t_0''	Surplus			t_0' bigger	t_0' smaller
B1	20	10	10	50	45	5	"Yes"	No bias	15	
B2	20	10	10	50	25	25	"No"	Downward by 10		−5
B3	20	10	10	50	60	−10	"Yes"	No bias	30	
B4	20	30	−10	50	25	25	"No"	No bias		−5
B5	20	30	−10	50	65	−15	"Yes"	Upward by 10	35	
B6	20	30	−10	50	55	−5	"No"	No bias		25

or "no" depends on the surplus of the alternative public good ($t''-t_0''$). In case B1, the respondent votes "yes" and the surplus of the offered public good is positive. No bias occurs, because the respondent would have voted identically if there had been no alternative public good. If the contribution t_0' grows above 15, the vote would switch to "no", i.e., to case B2, as the utility of the alternative public good is higher than the utility of the offered public good.

In case B2, the respondent votes "no" although the surplus of the offered public good is positive. Hence, in the single binary choice survey, there will be a downward bias of 10 for this respondent (i.e., the respondent would be recorded to vote "no" on a value by 10 lower than he would if there were no alternative public good). The required contribution t_0' could even become negative (i.e., a compensation payment), and the respondent would still vote "no". For example, if $t_0'=-3$, the respondent would vote "no" because the surplus of the offered public good is 23 and the surplus of the alternative public good is 25. A bias by 23 would be recorded. The maximum bias would be 25 if the respondent was asked whether he accepted a compensation of 5 (assuming voting "no" if indifferent). Only if the compensation payment was higher than 5, the respondent would switch to "yes". Thus, the stated WTP can be negative due to opportunity costs.

Fig. A1 illustrates all six cases of the example. The black "yes" arrows show the value of t_0' for which the respondent would vote "yes" for each of the six cases, holding t', t'' and t_0'' constant. The gray "no" arrows show the values of t_0' where the respondent would vote "no". The case switches if t_0' crosses from one color to the other because the utility ranking changes ("switch point").

Whenever t_0' is on the black arrow to the left of t', no bias occurs (the vote is the same as if no alternative public good would have been present): cases B1 and B3. We are also biasfree for t_0' on the gray arrow to the right of the t': B4 and B6. A downward bias occurs if t_0' is on the gray arrow to the left of t': B2. An upward bias occurs if t_0' is on the black arrow to the right of t': B5.



The black "yes" (gray "no") arrows show the value of t_0' in which the respondent would vote "yes" ("no") holding t', t'' and t_0'' constant. Cases change as t_0' passes the arrowhead at $t'-(t''-t_0'')$.

***Fig. A1:* Example for the single binary choice question where the response depends on the alternative second-best option** *(see figures in Tab. A1).*

Changing the perspective from the decision problem of one respondent to the estimated WTP, we need assumptions about the distribution of t' and the surplus of the alternative public good $(t''-t_0'')$ in the sample. For the sake of argument, assume all respondents value the offered public good equally at t'=20 and α=1 for all respondents. However, the respondents face different surpluses of the alternative public good. First, consider the surplus of the alternative public good to be normally distributed with a mean zero and standard deviation of 25. We denote this as *N(0, 25)*. The distribution of the stated maximum WTP is then also normally distributed with a mean of $t'-(t''-t_0'') = t'-0$ = 20 and a standard deviation of 25 or *N(20, 25)*. There is no bias in the mean WTP, but the standard deviation is higher. Next, assume the distribution of the surplus of the alternative public good to be *N(50, 25)*. The distribution of the stated maximum WTP for the offered public good is *N(–30, 25)*. The mean WTP is now biased downwards and negative, and the standard deviation has increased. Finally, assume the distribution of the surplus of the alternative public good is *N(–10, 25)*. The distribution of the stated maximum WTP is *N(40, 25)* and biased upwards with a higher standard deviation.

The example shows that the distribution of the stated WTP depends on the distribution of the alternative public good. The simulations confirm our results (see Appendix 4). If the measures of central tendency are zero, the distribution of the WTP of the offered public good does not change. Allowing α=0 for a share of the respondents will reduce the bias of the distribution. If all respondents assume α=0, there is no influence of the alternative public good. If respondents are uncertain about α and have expected values distributed uniformly in the interval [0, 1], the optimal choice depends on their attitude towards risk. The simulations in the Appendix 4 show the case for risk-neutral behavior of expected utility maximizing respondents. Under these conditions the influence of the opportunity cost is reduced.

Appendix 4: Simulations based with consideration of risk

Obviously, the respondent might also face uncertainty whether the alternative public good or the status quo would materialize in case of a rejection of the referendum by the majority rule (i.e., α being between 0 and 1). This would require introducing probabilities about the likelihood for the status quo and the alternative public good. Optimal behavior under risk requires strong behavioral assumptions, and for the purpose of this article, the extreme cases are sufficient to show the impact of alternative public goods. For illustration, we simulate the decision under risk for risk-neutral respondents who maximized expected utility.

WTP estimation with simulated data

For the simulation, we assume the following:

- The true WTP for the offered public good t' of all respondents is 20 with variation zero;
- The contribution t_0' for the offered public good is either 10 or 30. It is determined randomly with equal probabilities of which contribution is asked for;
- The surplus of the alternative public good $(t''-t_0'')$ is normally distributed. We generate three sets of data with different distributions of the surplus:
  - Set 1 $N(0,25)$;
  - Set 2 $N(50,25)$;
  - Set 3 $N(-10,25)$.
- The vote by the respondent is "yes" if $t_0'<t'-(t''-t_0'')$, and "no" otherwise. This implies that respondents think the alternative project is provided if the offered project is not provided (i.e., $\alpha=1$);
- All random generations are made with the same seed to allow replication.

We use the software R (R Core Team 2015) to generate 100,000 observations for each of the three datasets. We estimate a probit model with only an intercept and t_0' as explanatory variables. To estimate the mean, we divide the coefficient of the intercept by the coefficient of t_0'. Tab. A2 summarizes the results. The estimated mean deviates slightly from $t'-(t''-t_0'')$. The difference is a random error, which changes with different seeds for random number generation (not shown here). Fig. A2 shows the distribution of the switch points between "yes" and "no", $t'-(t''-t_0'')$, for the three datasets. The true WTP is indicated by the gray horizontal line at the value of 20.

If we add *(t''−t₀'')* as explanatory variable, the bias disappears and the estimated mean WTP equals the mean value of the offered public good *t'* (not shown here but demonstrated in the code[1]).

Tab. A2: Estimation results for the three sets of simulated data analyzed with a probit model

	Set 1	Set 2	Set 3
Mean value offered public good *(t')*	20.00	20.00	20.00
Mean contribution to offered public good (t_0'')	20.02	20.02	20.02
Mean surplus alternative public good ($t''-t_0''$)	0.00	50.00	−10.00
Simulation without risk ($\alpha=1$)			
Mean level of vote switch ($t'-(t''-t_0'')$)	20.00	−30.00	30.00
Share of "yes" votes	0.50	0.03	0.64
Estimated mean WTP	19.92	−33.17	29.86
Simulation with risk (α between 1 and 0)			
Mean level of vote switch ($t'-\alpha\,(t''-t_0'')$)	19.98	−5.05	24.98
Share of "yes" votes	0.61	0.25	0.70
Estimated mean WTP	24.42	9.68	28.32

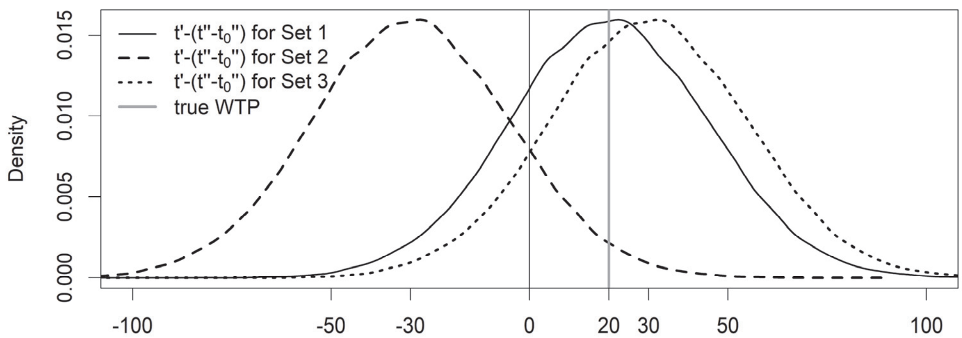


Fig. A2: Density curves of the elicited WTP for the single binary choice question, $t'-(t''-t_0'')$, for the three sets of simulated data

Influence of risk on results

The respondent has to decide to vote "yes" ($D=1$) or "no" ($D=0$). Voting $D=0$ is now a lottery with probabilities α for the alternative project and $(1-\alpha)$ for the status quo. Starting from (9), adding the utility U to the "lottery" option and the indirect utility changes as discussed for the three possible outcomes $V_1 = (t'-t_0')$, $V_2 = (t''-t_0'')$ and $V_3=0$, we get:

$$max\{D\cdot(t'-t_0')+(1-D)\,U[\alpha\cdot(t''-t_0'')+(1-\alpha)\cdot 0]\,\} \qquad (10)$$

$$max\{D\cdot(t'-t_0')+(1-D)\,U[\alpha\cdot(t''-t_0'')]\,\} \qquad (11)$$

[1] Available as Supplementary Material

Assuming expected utility maximization, we add the expectation operator to the uncertain outcome

$$max\{D \cdot (t' - t_0') + (1 - D)\, \mathrm{E}[\, \mathrm{U}[\alpha \cdot (t'' - t_0'')]\,]\} \tag{12}$$

Assuming risk neutrality $E(U()) = U(E())$, the certain term $(t''-t_0'')$ can be extracted from the expectation operator

$$max\{D \cdot (t' - t_0') + (1 - D)\, \mathrm{E}[\alpha] \cdot (t'' - t_0'')\, \} \tag{13}$$

$$max\{D \cdot [(t' - t_0') - \mathrm{E}[\alpha] \cdot (t'' - t_0'')\,] + \mathrm{E}[\alpha] \cdot (t'' - t_0'')\} \tag{14}$$

If $D=0$, the expected utility is $E[\alpha]\, (t''-t_0'')$. If $D=1$, the expected utility is $(t'-t_0')$. The risk neutral expected utility maximizing respondent will select $D=1$ if $(t'-t_0') > \alpha\, (t''-t_0'')$. Being offered a contribution t_0', the respondent will vote "yes" if $t_0' < t' - \alpha\, (t''-t_0'')$. Thus, the estimated WTP will be lower than in the case without risk.

Assuming risk aversion instead of risk neutrality would reduce the utility of the setting $D=0$. With specific assumptions about risk aversion, it would be possible to calculate the reduction in the stated WTP. In many applications, where the value of a public good is estimated, the influence of risk aversion will be low as $(t''-t_0'')$ will typically be small relative to income.

For the following simulation with risk, we assume risk neutrality and draw α from a uniform distribution [0, 1]. The last three lines of Tab. A2 summarize the results. The mean value of the switch point is now closer to the true WTP. This is because the opportunity costs, $(t''-t_0'')$, are now multiplied by α.

In our simulation the distribution of the switch-point, $t' - \alpha\, (t''-t_0'')$, is determined by the product of the uniform and normal distribution. The density curves are shown in Fig. A3, which are non-symmetric.

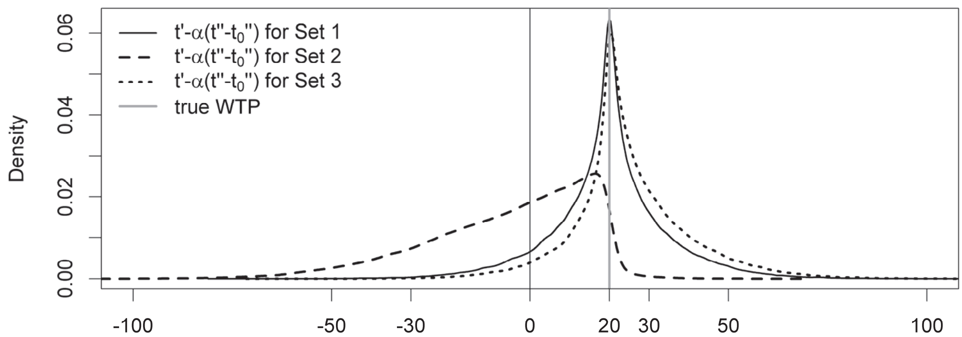


Fig. A3: Density curves of the elicited WTP under risk for the single binary choice question

By adding $\alpha\ (t''-t_0'')$ as explanatory variable, the bias disappears and the estimated mean WTP equals the mean value of the offered public good t'. This is not shown here, but demonstrated in the code[2].

Literature

Bohara, A. K., Kerkvliet, J., & Berrens, R. P. (2001). Addressing negative willingness to pay in dichotomous choice contingent valuation. *Environmental and Resource Economics*, *20*, 173–195. https://doi.org/10.1023/A:1012642902910.

Bowker, J. M., & Stoll, J. R. (1988). Use of dichotomous choice nonmarket methods to value the whooping crane resource. *American Journal of Agricultural Economics*, *70*, 372–381. https://doi.org/10.2307/1242078.

Cameron, T. A., & Quiggin, J. (1994). Estimation using contingent valuation data from a "dichotomous choice with follow-up" questionnaire. *Journal of Environmental Economics and Management*, *27*, 218–234. https://doi.org/10.1006/jeem.1994.1035.

Carson, R. T., Groves, T., & List, J. A. (2014). Consequentiality: A theoretical and experimental exploration of a single binary choice. *Journal of the Association of Environmental and Resource Economists*, *1*(1/2), 171–207. https://doi.org/10.1086/676450.

Lo, A. Y., & Jim, C. Y. (2015). Protest response and willingness to pay for culturally significant urban trees: Implications for contingent valuation method. *Ecological Economics*, *114*, 58–66. https://doi.org/10.1016/j.ecolecon.2015.03.012.

Loureiro, M. L., Loomis, J. B., & Nahuelhual, L. (2004). A comparison of a parametric and a non-parametric method to value a non-rejectable public good. *Journal of Forest Economics*, *10*, 61–74. https://doi.org/10.1016/j.jfe.2004.05.002.

R Core Team (2015). R: A language and environment for statistical computing. R Foundation for Statistical Computing. Vienna, Austria. Retrieved November 8, 2021, from https://www.R-project.org/.

[2] Available as Supplementary Material