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Three reasons to use annual payments in contingent valuation surveys: Convergent validity, discount rates, and mental accounting ☆

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ABSTRACT

We present three arguments for using ongoing annual payments in contingent valuation (CV) surveys that estimate the benefit of a long-lasting environmental improvement. First, by matching the duration of the payments with the duration of the environmental benefits, survey respondents are spared from performing complicated present value calculations. Second, willingness to pay (WTP) estimates from CV surveys that include ongoing annual payments best match WTP estimates obtained using travel cost surveys. Third, respondents are less likely to face binding mental budget constraints with ongoing annual payments than with a larger one-time payment. In addition, respondents' discount rates may be estimated by collecting non-hypothetical, individual time preference data as part of the valuation survey.

Introduction

Contingent valuation (CV) surveys typically describe a proposed environmental improvement and then present survey respondents with a hypothetical referendum asking at what cost they would support adopting the proposed improvement. Examples of dichotomous choice CV surveys include Andersson et al., 2014, Cunha-e-Sa et al. (2012), Evans et al. (2011), Herriges et al. (2010) and McConnell (1990). Proposed environmental benefits are typically long lasting, but researchers sometimes present survey respondents with a one-time payment or a series of annual installments spread over a few years. For example, in Loomis and White's (1996) meta-analysis of willingness to pay (WTP) for the preservation of rare and endangered species, nine of twenty studies included a one-time payment and eleven included perpetual annual payments.

In this paper, we present three reasons to estimate the value of an ongoing stream of annual *benefits* with a matching ongoing stream of annual *payments*. First, survey respondents are spared from performing complicated present value calculations. When respondents compare their known *annual* WTP (Kovacs and Larson, 2008) to a proposed annual payment, discount rates cancel out in their benefit-cost analysis. When asked to make a one-time payment for a long-lasting environmental improvement, respondents must know their personal discount rate and perform the relevant present value

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calculation, while having complete fungibility of their income across time and no binding budget or liquidity constraints (Bond et al., 2009). Second, we conduct a convergent validity test by comparing CV estimates from surveys with one-time and ongoing annual payments to annual consumer surplus estimates from a travel cost analysis. We demonstrate that CV estimates from surveys with ongoing *annual* payments better match *annual* travel cost consumer surplus estimates. Third, a behavioral argument based on mental accounting (Thaler, 1999) suggests that survey respondents who mentally set aside a fixed annual dollar amount for charitable giving will feel more constrained by a large one-time payment compared to a relatively small annual payment. Researchers and policy makers are presumably more interested in what respondents are willing to pay *annually* for an environmental improvement rather than a one-time WTP that is the lesser of either a present discounted value of future annual WTPs or current charity budget.

The study reported here is the first convergent validity test concerning a time horizon in CV surveys and travel cost analysis, and also the first to collect non-hypothetical individual time preference data to directly estimate respondents' discount rates. Consistent with the experimental economics literature (e.g., Collier and Williams, 1999; Harrison et al., 2002), we observed median discount rates in the range of 12.5 – 15%. These discount rates are greater than the 3 – 10% range normally used in environmental valuation literature, but less than the 20 – 270% range implied by previous environmental valuation surveys that compare CV estimates using different time horizons (Kovacs and Larson, 2008; Bond et al., 2009). This suggests that our respondents do not have inordinately high discount rates and that published, high implied discount rates could be due to faulty assumptions that respondents are rational, present value discounters with no binding liquidity or mental accounting constraints.

Literature review

The two most common methods for estimating the value of environmental public goods are the travel cost method and CV. It is not unusual to find that value estimates from the travel cost method exceed those from the CV method. For example, Carson et al. (1996) survey 83 studies including 616 comparisons of CV to revealed preference (RP) estimates. The authors report a sample mean CV/RP ratio of 0.89. While the authors controlled for many factors, they do not mention the time horizon for payments utilized in the CV analysis. Since they are only considering ratios, the time horizon is of no concern if the CV and RP estimates have the same time horizon, which is likely given the same researchers are implementing both methods for each good.

A more recent meta-analysis by Moeltner and Woodward (2009) concerning benefit transfer for wetland valuation did consider the time horizon in the CV surveys. Two of the nine CV studies they considered originally elicited a one-time payment, while the other seven elicited perpetual annual payments. Therefore, using a 6% discount rate, the authors annualized the two one-time payment CV studies. Obviously, the authors' choice of this discount rate has a major impact on the annualized value.

Several papers have investigated different payment time horizons in CV studies and the resulting implied discount rates. Stevens et al. (1997) survey 88 undergraduate students concerning WTP for restoration of Atlantic salmon. In their split sample design, the authors ask half of respondents for a one-time payment and ask the remaining half to pay each year for the next five years. Implicit discount rate estimates range from 50% to 270% depending on the scope of the restoration. Bateman and Langford (1997) estimate WTP for wetlands restoration in the U.K. They ask every respondent for both a one-time payment and a perpetual annual stream of payments. The authors find "inordinately high" discount rates of 50%, with a mean lump sum WTP of £50.86 and an annual WTP of £23.29. Stumborg et al. (2001) report a 40% implied discount rate to equate mean present value WTP from a split-sample design with either 3- or 10-year time horizons. More recently, Kovacs and Larson (2008) ask for a temporary monthly surcharge to local residents' water bills to fund an 18% expansion of a local public park. The authors conduct a split sample design with four time periods—one, four, seven, and 10 years. When using all the information from the payment schedules, the authors find average implied discount rates of 30%. Kim and Haab's (2009) split-sample design include one-time payments, 5- and 10-year annual payments, and perpetual annual payments. The authors report implied discount rates ranging from 20% to 100%. Similarly, Bond et al. (2009) conduct a split-sample design with three time periods—one, five, and 15 years. Implied discount rates range from 23% to 80%. Related, when the authors assume a market discount rate of 5.5%, the present value WTP from the 15-year time horizon is four to nine times that of the WTP estimate from a one-time payment. Brouwer et al. (2008) allow respondents to choose between one-time, monthly, or annual donations. The authors report a higher mean WTP estimate for the annual contribution versus the one-time payment, implying negative discount rates. However, the authors argue self-selection of the time horizon is likely responsible for the unexpected result.

Similarly, many studies have used actual behavior to estimate discount rates, and these studies typically find discount rates well above normal market rates. Looking at the tradeoff between the purchase price and energy consumption of window air conditioners, Hausman (1979) finds that American consumers discount the future at a rate of 15 – 25% per year. Hassett and Metcalf (1993) develop a theoretical model and provide simulation results showing that people who are uncertain about future energy prices may put off investing in improved energy efficiency even when the investment easily passes the benefit-cost test at current energy prices. Looking at the tradeoff between the purchase price, fuel efficiency, and safety of automobiles, Dreyfus and Viscusi (1995) find that car buyers discount the future at a rate of 15 – 21% per year. Warner and Pleeter (2001) focus on U.S. military base closings during the 1990s. They find that furloughed military personnel routinely choose lump-sum payments over annuities with implicit rates of return of between 17.5% and 19.8%.

In summary, the wide range and high values of the implied discount rates from the existing empirical literature underscore the importance of understanding how time horizon affects present value WTP estimates.

With annual payments, respondents don't need to perform present value analysis

While using a one-time payment in the CV scenario may be appealing because it does not require the researcher to choose a discount rate to recover present value WTP (Carson et al., 2003), the researcher may be forcing the respondent to conduct their own present value analysis instead. Kovacs and Larson (2008) reasonably assume that individuals have a constant *annual* WTP, W_i, for the annual stream of benefits provided from a long-lasting public good like improved environmental quality. In general, respondents answer "yes" to the CV referendum if

$$\frac{W_i}{r} \geq B_i(r, T_i), \tag{1}$$

where $B_i(r, T_i)$ is the present value of the future stream of bids and is equal to

$$B_i(r, T_i) = b_i\left(\frac{1}{(1+r)} + \frac{1}{(1+r)^2} + \ldots + \frac{1}{(1+r)^{T_i}}\right), \tag{2}$$

where r is the individual's discount rate, b_i is the per-period bid amount, and T_i is the number of annual bid payments. The respondent compares the present value of their WTP to the present value of the bids and answers accordingly. Note that with a perpetual annual bid payment, the respondent answers yes if

$$\frac{W_i}{r} \geq \frac{b_i}{r}, \tag{3}$$

which simplifies to

$$W_i \geq b_i. \tag{4}$$

In this case, the respondent does *not* need to perform a present value calculation. The respondent simply answers "yes" so long as their per period WTP, W_i, is greater than the per period bid amount, b_i.[1]

When asked for a one-time payment, respondents answer "yes" if

$$\frac{W_i}{r} \geq \frac{B_i}{(1+r)}, \tag{5}$$

where the respondent is offered the one-time bid, B_i. The respondent must compare the present value of their annual stream of WTP to the one-time payment. Do we really trust that respondents can make an accurate ad-hoc guess at this calculation? Fischhoff and Furby (1988) worry that respondents may not be able to perform "the mental arithmetic needed to compute discount rates" (page 170). Their concern is well founded. In a survey of 1269 Americans over the age of 50, Lusardi and Mitchell (2011) found that only two thirds of respondents could correctly answer the following question:

Suppose you had \$100 in a savings account and the interest rate was 2% per year. After 5 years, how much do you think you would have in the account if you left the money to grow: more than \$102, exactly \$102, less than \$102?

And just one third of respondents could correctly answer the above question *and* two additional basic financial literacy questions.

With a series of T ongoing annual payments, the respondent answers "yes" if

$$\frac{W_i}{r} \geq b_i\left[\frac{1}{(1+r)} + \frac{1}{(1+r)^2} + \ldots + \frac{1}{(1+r)^T}\right] = b_i\left[\frac{1}{r}\left(1 - \frac{1}{(1+r)^T}\right)\right]. \tag{6}$$

This is an even more complicated calculation, though the terms in brackets approach $1/r$ when either T or r are large.

Convergent validity analysis

In this section we present the design and results of an environmental valuation study specifically designed to compare travel cost WTP estimates with CV WTP estimates from referenda with varying payment terms. In our split-sample design, we present respondents with a CV referendum asking for a one-time payment, ten annual payments, or perpetual annual payments. We find that both perpetual annual payments and a series of ten annual payments outperform a one-time payment when estimating the value survey respondents place on a long-lasting water quality improvement.

Survey design

We use a random population mail survey sent to 3000 households in northwest Ohio concerning proposed wetlands restoration near the Maumee Bay State Park Beach located on Lake Erie in northwest Ohio about 20 miles east of Toledo. In

[1] For respondents planning to live in the area for less than T_i years, Eq. (2) simplifies to Eq. (4).

Table 1
Summary statistics: $N=967$.

Variable	Description	Mean	Std. Dev.	Min.	Max.
$Trips_1$	No. of trips to MBSP next year	1.58	5.2	0	100
$Trips_2$	No. of trips to MBSP next year with restored wetlands	2.08	5.8	0	100
Price	Travel cost of a trip	52.92	33.42	2.4	249.46
Bid values	Bid value for the water quality improvement	48.63	47.6	5	200
CV vote	Response to DC-CV question (yes=1, no=0)	0.47	0.50	0	1
Income	Households before tax income for 2007	68,059	41,929	7,500	200,000
Gender	=1 if male; =0 otherwise	0.72	0.44	0	1
Age	Respondent's age	55.8	14.9	18	82
School	=1 if any college education; =0 otherwise	0.69	0.45	0	1
License	=1 if own a license; =0 otherwise	0.42	0.49	0	1
Env. org.	=1 if belong to env.org.; =0 otherwise	0.07	0.25	0	1

Table 2
Original bid values and Turnbull monotonically smoothed bid values (in bold).

Perpetual annual payments				Ten annual payments				One-time payment			
N=	Bid value	%Yes	Turnbull %Yes	N=	Bid value	%Yes	Turnbull %Yes	N=	Bid value	%Yes	Turnbull %Yes
47	**$5**	0.70	**0.70**	38	**$5**	0.63	**0.63**	43	**$20**	0.47	**0.47**
43	**$10**	0.58	**0.58**	38	$10	0.63	Pooled	38	$40	0.39	Pooled
37	**$15**	0.49	**0.50**	30	**$15**	0.47	**0.53**	52	$60	0.54	Pooled
36	$20	0.50	Pooled	43	$20	0.51	Pooled	44	**$80**	0.43	**0.43**
37	$25	0.49	Pooled	47	$25	0.55	Pooled	40	**$100**	0.33	**0.32**
43	$30	0.53	Pooled	26	$30	0.61	Pooled	43	**$120**	0.16	**0.28**
40	**$40**	0.30	**0.36**	41	**$40**	0.46	**0.46**	42	$160	0.29	Pooled
38	$50	0.42	Pooled	48	**$50**	0.40	**0.40**	33	$200	0.42	Pooled
Avg.		0.51				0.53				0.38	

the last section of the survey, we ask all respondents how many trips they expected to take next year *given current water quality*, and how many trips they would take next year *given the proposed wetland restoration's ability to improve the water quality at the swimming beach* by eliminating the beach advisories due to high bacteria counts.

In addition, we presented respondents with an incentive-compatible advisory referendum question (Carson and Groves, 2007; Carson and List, 2014) about the same water quality improvement. Respondents also read a "cheap talk" script (Cummings and Taylor, 1999) before answering the referendum question. Our referendum question read "Would you vote 'yes' on a referendum to restore wetlands on nearby public land at Maumee Bay State Park that would lead to the improvements summarized in the previous section? The proposed project would cost you **$X.**" There were three versions of the survey with the respondent only receiving one version. The split-sample design varied the time horizon of the payment vehicle from a one-time payment (the quoted question), a payment for a finite time of ten years ("The proposed project would cost you **$X for ten years.**"), or a perpetual annual payment ("The proposed project would cost you **$X per year.**"), where the bold font was used in the mailed surveys.

Data and summary statistics

Table 1 provides the summary statistics for our sample. Approximately 50% of the 3000 surveys were returned (1426). Of these, 967 respondents provided all of the necessary information. Like Misra et al. (1991); Andrews (2001); Thompson et al. (2002); and Corrigan et al. (2008), our sample is more male, has higher income, is more educated, and is older than the general population.

The respondents expected to take 1.58 trips on average to Maumee Bay State Park (MBSP) the following year. The average number of trips is low given that 52% of the sample expected to take no trips. With the proposed water quality improvement at the swimming beach, the average expected number of trips increased 30% to 2.08 trips. Most of this increase is due to current visitors taking more trips, as only 3% of the respondents expecting to take zero trips under current conditions switched to taking a positive number of trips with the quality improvement.

Turning to the contingent valuation data, Table 2 shows that bids range from $5 to $50 for surveys with ten annual payments or perpetual payments. We used a 25% discount rate to convert perpetual payment bids into one-time payment bids ranging from $20 to $200. Across all three surveys, 47% of the respondents voted "yes" on the advisory referendum. Among respondents who would visit MBSP next year given the quality improvement, 66% voted "yes". Among respondents who would not visit MBSP next year given the quality improvement, only 27% voted "yes". Considering the split sample, 51% of the respondents asked to make perpetual annual payments voted "yes", and 53% asked to make ten annual payments voted "yes". Only 38% of the respondents asked for a one-time payment voted "yes". Assuming our respondents are perfectly rational present value discounters with no mental accounting or liquidity constraints, these results indicate that respondents discounted the future at a rate higher than the 25% rate we used to convert perpetual annual payments into a one-time payment.

To analyze the contingent valuation data we use the Turnbull distribution-free estimator (Turnbull, 1976). Table 2 shows there is not a monotonically decreasing percentage of respondents answering "yes" to each of the eight successively higher bid values. The Turnbull estimator requires monotonicity. If a higher bid value does not produce a lower percentage of "yes" responses, then the bid value is "pooled back" with the previous bid (Haab and McConnell, 2002).[2] Table 2 shows the minimum amount of smoothing necessary to create a monotonically decreasing percentage of respondents voting "yes" to higher bid values.

Travel cost results

We use the bivariate Poisson-lognormal random effects count data model (Egan and Herriges, 2006) to analyze the travel cost data. We estimate the price of a recreational trip as $0.25 per mile multiplied by round-trip miles plus the opportunity cost of time, which is estimated as round-trip hours multiplied by one third of the respondent's average wage rate. As discussed by Awondo et al. (2011), the American Automobile Association reports vehicle operating cost estimates of $0.17 per mile (gasoline, maintenance, and tires) and depreciation estimates per year per mile of $0.22 for a total of $0.39 per mile. By using $0.25 per mile we are including 100% of the vehicle operating cost and 36% of the average vehicle depreciation cost. We include only part of the depreciation cost because a vehicle depreciates every year regardless of how much it is driven, and recreators likely consider vehicle ownership a sunk cost needed for other purposes. While using one third of the average wage rate for the opportunity cost of time is arbitrary, it is the most widely used estimate of the opportunity cost of respondents' time (e.g., Baerenklau, 2010; Egan and Herriges, 2006; Hagerty and Moeltner, 2005; Phaneuf, 1999; Whitehead et al., 2008). We used PC-Miler to calculate the round-trip miles and the round-trip hours from the respondent's zip code to MBSP. We calculated a respondent's average wage rate as the household's annual income divided by 2000, representing forty hours of work per week for 50 weeks.

Table 3 presents the results from the travel cost model. Respondents that have lower travel cost, higher income, more education, are male, are younger, or have a fishing or hunting license all take statistically significantly more trips to MBSP. All of these results are as expected. Respondents with lower travel cost can visit MBSP at lower opportunity and will, on average, visit more frequently. Assuming outdoor recreation is a normal good, we expect higher income and more educated individuals to take more trips, holding travel cost constant. Given that 80% of Ohio anglers are male (Armon, 2013), we expect men to take more trips. Closely related, we would expect respondents with fishing or hunting licenses to take more trips to MBSP. Young respondents might be expected to engage in more outdoor recreation of all types, including taking trips to MBSP. Only belonging to an environmental organization has no statistically significant effect.

WTP for the wetlands restoration at MBSP can be estimated as the additional consumer surplus from the additional trips to MBSP due to the quality improvement. We calculate WTP from this semi-log travel cost model as

$$WTP_{tc} = \frac{Trips_2}{-\beta_{tc,2}} - \frac{Trips_1}{-\beta_{tc,1}}, \tag{7}$$

where $Trips_2$ and $Trips_1$ are the reported trip levels, and $\beta_{tc,2}$ and $\beta_{tc,1}$ are the estimated coefficients on the travel cost variable. Table 4 presents estimated WTP for the quality improvement along with a 95% confidence interval. Mean annual WTP is $19.

Contingent valuation results

We use the Turnbull distribution-free estimator to estimate WTP for the proposed wetlands restoration at MBSP because this estimator requires no distributional assumptions for WTP and it is a conservative lower bound estimate of mean WTP (Haab and McConnell, 2002). All of the information needed to estimate the lower bound on the population mean WTP is given in Table 2. We use Eq. (3.28) from Haab and McConnell (2002),

$$E_{LB}(WTP) = \sum_{j=0}^{M^*} t_j (F^*_{j+1} - F^*_j) \tag{8}$$

where t_j denotes the j bid values, M^* is the total number of Turnbull monotonically smoothed bid values (i.e., the four bold bid values in Table 2), and F^*_j is the percent of respondents voting "no" who received the jth bid value, and F^*_{j+1} is the percent of respondents voting "no" who received the jth+1 bid value. This estimator "is appealing because it offers a conservative lower bound on willingness to pay for all non-negative distributions of WTP, independent of the true underlying distribution" (Haab and McConnell, 2002, page 74). This method assumes that no respondent has WTP greater than the highest bid value, therefore the resulting mean WTP estimate is a lower bound on the actual mean WTP. The

[2] Haab and McConnell (2002) use the percentage of "no" responses, which obviously could be derived from Table 2.

Table 3
Travel cost model results from a bivariate Poisson-lognormal model ($N=967$)[a].

Variable	Coefficient	p-value
Constant 1	0.39	0.085
Constant 2	0.56	0.012
Travel cost 1	−3.58	0.000
Travel cost 2	−3.30	0.000
Income	0.93	0.000
Male	4.67	0.000
Age	−0.12	0.000
Attended college	2.33	0.024
Hunting or fishing license	3.35	0.000
Environmental org.	2.05	0.201
Sigma 1	1.46	0.000
Sigma 2	1.48	0.000
Rho	0.99	0.000

[a] All variables scaled by 10 except travel cost (scaled by 100) and income (scaled by 100,000). LL = −2654.49.

Table 4
WTP estimates.

	Travel cost model (TC)		Contingent valuation model (CV)			
	Poisson-lognormal random effects count data model		Turnbull dist.-free estimator		Bound probit model	
	Mean WTP	95% C.I.[a]	$E_{LB}(WTP)$	95% C.I.	Median WTP	95% C.I.[a]
TC—perpetual annual additional consumer surplus	$19	($14, $24)				
CV—perpetual annual payments			$18	($15, $21)	$26	($3, $49)
CV—ten annual payments			$24	($20, $28)	$28	($3, $50)
CV—one-time payment			$47	($38, $57)	$41	($2, $140)

[a] Estimated using the Krinsky and Robb (1986) technique.

estimated lower bound WTP is asymptotically normally distributed with variance

$$V(E_{LB}(WTP)) = \sum_{j=1}^{M^*} \frac{F_j^*\left(1-F_j^*\right)}{T_j^*}(t_j - t_{j-1})^2, \tag{9}$$

where T_j^* is the total number of respondents for the jth bid value. Using Eq. (8) to estimate the lower bound for mean WTP with perpetual annual payments, we find

$$E_{LB}(WTP_\infty) = \$0*0.30+\$5*0.12+\$10*0.08+\$15*0.14+\$40*0.36 = \$17.91, \tag{10}$$

With ten annual payments, we estimate the lower bound for mean WTP as

$$E_{LB}(WTP_{10}) = \$0*0.37+\$5*0.1+\$15*0.07+\$40*0.06+\$50*0.40 = \$24.04, \tag{11}$$

With the one-time payment, we estimate the lower bound for mean WTP as

$$E_{LB}(WTP_1) = \$0*0.53+\$20*0.04+\$80*0.11+\$100*0.04+\$120*0.28 = \$47.48. \tag{12}$$

The WTP estimates are also reported in Table 4 with 95% confidence intervals.

The Turnbull estimator is a convenient, conservative estimator for WTP, but only a limited number of covariates can be included. Therefore, in order to investigate the impact of explanatory variables on the probability respondents vote "yes" in the referendum we also estimated a bound probit model following Haab and McConnell (2002). We bounded respondents' WTP between $0 and $50 for ongoing payments and between $0 and $200 for the one-time payment in order to parallel the Turnbull estimator as closely as possible. The bound probit model does not require monotonicity in the bids so we used the original bid values and responses shown in Table 2. We pooled all three versions of the survey together and ran one bound probit model, but included a constant and variance coefficient for all three versions of the survey.

Table 5 reports the results from the bound probit model. Respondents who have lower travel cost to MBSP, who are younger, who are more educated, or who belong to an environmental organization are more likely to vote "yes" on the advisory referendum. Statistically insignificant explanatory variables include gender and having a fishing or hunting license.[3] Having a fishing or hunting license was a statistically significant regressor for the travel cost model, while

Table 5
CV referendum results (N=967). Bound Probit Model ($0 < WTP < $Highest Bid + $1)[a].

Variable	Coeff.	p-value
Constant	−1.50	0.560
Travel cost	−0.082	0.001
Male	0.22	0.830
Age	−0.061	0.061
Attended college	4.84	0.001
Hunting or fishing license	1.29	0.17
Environmental org.	9.42	0.001
Ver. 1 (annual payment)	4.13	0.023
Ver. 2 (10 year payment)	5.89	0.003
Sigma ver. 1 (annual payment)	9.38	0.000
Sigma ver. 2 (10 year payment)	8.44	0.000
Sigma ver. 3 (one-time payment)	15.20	0.001

[a] $1 is added to the highest bid so for those respondents receiving the highest bid, when maximizing the likelihood function, a ln(0) error is avoided in the income/bid term: ln[(bound-bid)/bid]. LL = −602.40.

belonging to an environmental organization was not. This seems reasonable since a license is directly related to use value, while belonging to an environmental organization may correlate more highly with a respondent's nonuse value.

For the bound probit model median WTP can be estimated as

$$MD(WTP_{bp,i}) = \frac{\max \text{bid}_i}{1+\exp(-z_i\gamma)}, \tag{13}$$

where z_i denotes the covariates and γ denotes the coefficients. The median WTP estimates from the bound probit model (Table 4) are similar to the estimates using the Turnbull distribution-free estimator. The 95% confidence intervals for the bound-probit WTP estimates are larger than those from the Turnbull estimator. We think this is due to insufficient data to determine the right tail of the WTP distribution. Like Carson et al. (2003), we chose the bids to capture data points around the median population WTP, as that is our statistic of interest. We arrived at ex ante estimates of median WTP in pre-test surveys where we iteratively raised the bids until approximately 50% of the respondents voted "yes" overall. Carson and Groves (2007, page 185) emphasize the importance of not asking "implausibly high or low cost for providing the good" since the respondents may substitute what they consider to be a more realistic cost. Our concern was with implausibly high cost estimates in the advisory referendum. Awondo et al. (2011) estimated it would cost $1.8 million to restore the wetlands discussed in the survey. Given our population of 621,000 households in the 23 counties of northwest Ohio, the average cost to each household for the provision of the environmental good is less than $3.[4] In order to avoid including implausibly high cost estimates, we did not include higher bids that would have allowed us to capture the right tail of the distribution. Using the Turnbull estimator avoids any distributional issues.

As in previous studies, we find relatively small differences in the mean WTP estimates across the three time horizon versions, which lead to large differences in present value WTP at market discount rates or large implied discount rates to equate present value WTP.

Convergent validity test

Table 6 shows present value WTP estimates for various discount rates using the results from the travel cost model and the Turnbull distribution-free estimator presented in Table 4. With perpetual payments, present value CV WTP estimates are always similar to present value travel cost WTP estimates regardless of the discount rate. With ten annual payments, the present value of the CV WTP estimate roughly equals the present value of the travel cost WTP estimate at a discount rate of 17.5%. While it is not obvious from Table 6, a discount rate equal to 68% equates the present value WTP from the travel cost model with the present value WTP from the one-time payment version.[5]

Our convergent validity test supports ongoing payments over one-time payments for the long-lived environmental good considered in this study. Present value WTP estimates from *perpetual* annual payments closely match the present value WTP estimates from the travel cost model given that both methods give similar mean perpetual annual WTP estimates—$19 for the travel cost model and $18 for CV. For ten annual payments, the discount rate that equates the present value WTP

[3] We also ran the bound probit model on each version separately. Largely the same explanatory variables were statistically significant for the perpetual annual payment and ten-annual-payment versions but no explanatory variables were statistically significant for the one-time payment version.

[4] We are happy to report that, in part due to our study showing its efficiency, the wetlands have now been restored. Preliminary results show they are improving water quality at MBSP as predicted (Dwyer et al., 2014).

[5] For the travel cost model, the present value of the additional consumer surplus equals $19/$r$. For the one-time payment version of the CV survey, the present value of WTP equals $47/(1 + r) assuming as in eq. (5) that the payment occurs one year in the future. Both present value calculations yield an answer of $28 with a discount rate of 68%.

Table 6
Present value WTP estimates from the travel cost (TC) model and the contingent valuation (CV) method using various discount rates.

	Discount rate						
	5%	**7.5%**	**10%**	**12.5%**	**15%**	**17.5%**	**20%**
PV(WTP) from: TC—perpetual annual additional consumer surplus	$380	$253	$190	$152	$127	$109	$95
PV(WTP) from: CV—perpetual annual payments	$360	$240	$180	$144	$120	$103	$90
PV(WTP) from: CV—ten annual payments	$185	$165	$148	$133	$121	$110	$101
PV(WTP) from: CV—one-time payment	$45[a]	$44	$43	$42	$41	$40	$39

[a] In order to be consistent with the rest of the table, we assume one-time payments occur one year in the future.

estimates falls comfortably within the range of values found in studies using actual behavior to estimate discount rates (e.g., Hausman, 1979; Warner and Pleeter, 2001) and in economic experiments estimating discount rates (e.g., Collier and Williams, 1999; Harrison et al., 2002). For the one-time payment, the discount rate that equates the present value WTP estimates falls outside of this range of values found in studies using actual behavior to estimate discount rates.

Mental accounting

Many of the papers we discussed in the literature review find that CV respondents are surprisingly insensitive to the time horizon of payments (e.g., Bateman and Langford, 1997). One explanation could be that individuals really do have “inordinately high” discount rates, however in this section we will show that our respondents' discount rates are in line with the existing literature (e.g., Collier and Williams, 1999).

Referring to the results of a study estimating WTP for wetland restoration in the English Broadland, Bateman and Langford argue that

Respondents have a deep concern for the Broadland, so they are WTP a large proportion of their annual countryside/recreation budget towards its preservation such that budget constraints quickly bind upon their attempt to convert this to a once-and-for-all payment. Here then the similarity between the two WTP means is indicative of respondents taking the question seriously, weighing together all pertinent factors (such as relevant budget constraints) and answering as honestly as possible. (p. 579)

Because of these binding budget constraints, the authors conclude that “we should not immediately interpret once-and-for-all sums as discounted perpetuity benefit values” (p. 581). Bateman and Langford's reasoning is not consistent with neoclassical theory, which assumes that because wealth is fungible there is no reason for participants to partition their outdoor recreation budget from their grocery budget or from their rainy day fund. But the authors' reasoning is entirely consistent with the behavioral concept of “mental accounting”. Thaler (1999) points out that individuals routinely partition their wealth either formally or informally into separate budgets—groceries, travel, entertainment, Christmas, charity, retirement, etc. And because some of these budget constraints bind in any given period while others do not, this partitioning has a meaningful impact on behavior. If CV survey respondents engage in this kind of mental accounting, then this is another reason for researchers to choose ongoing annual payments over a one-time payment. While budget constraints may bind in either case, they are less likely to bind when respondents are presented with a smaller ongoing payment rather than a larger one-time payment.

To date no study has been able to test this mental accounting hypothesis in a contingent valuation model because no one has directly estimated respondents' discount rates. Our survey includes a series of nonhypothetical time-preference questions, allowing us to estimate respondents' discount rates and to compare these with the implicit discount rates necessary to equate WTP estimates from the one-time and ongoing-payment versions of our CV survey. We find that our respondents have reasonable discount rates in the context of a reward lottery.

Discount rate survey

We follow the experimental economics procedures from Harrison and Williams (2002) to derive non-hypothetical estimates of respondents' discount rates using a reward lottery of $1000 or more. The reward lottery form is provided in full in Fig. 1. At the end of the mail survey, we informed respondents that we would draw one of their names at random on June 27, 2008, and that individual would receive their preferred payment option for one randomly chosen prize alternative. The date of the random reward drawing was one month after the third and final mailing of the survey to non-respondents, thus they would either receive the prize in a few months or a few months plus one year. The reward was made large enough, $1000 or more, so that respondents would carefully consider the exercise.

If a respondent circled payment option A for all fifteen payoff alternatives, we estimate her discount rate to be greater than 100% per year. If a respondent circled payment option B for all fifteen payoff alternatives, we estimate her discount rate to be less than 2% per year. And if, for example, a respondent circled payment option A for the first nine payoff alternatives but then circled payment option B for the remaining six, we would estimate her discount rate to be between 17.5% and 20% per year. Of the full sample of 967 respondents, 726 (75%) completed the non-hypothetical discount rate

Reward Lottery

Please complete this form to enter the lottery drawing, where one winner will receive between $1,000 and $2,000. This information will be used only to enter you into the drawing and pay your requested amount. Your answers to the survey are strictly confidential; the survey will be separated from this form as soon as it arrives. Thank you for your help with this research!

One survey respondent will receive one of the 15 cash prizes below in exchange for completing this survey, where the prize will be chosen at random. For each of the 15 prizes, please circle the amount you would rather receive: the dollar amount in PAYMENT OPTION A on June 27, 2008, or the dollar amount in PAYMENT OPTION B on June 27, 2009. For example, if you are randomly selected as the winner, and Prize 6 is randomly chosen as the prize, we will send you a check for $1000 on June 27, 2008 if you circled the letter A in the last column, or you will be sent a check for $1100 on June 27, 2009 if you circled the letter B.

Payoff Alternative	Payment Option A (Pays amount below on June 27, *2008*)	Payment Option B (Pays amount below on June 27, *2009*)	Annual Interest Rate	Preferred Payment Option **(CIRCLE A OR B)**
Prize 1	$1000	$1020	2.0%	A B
Prize 2	$1000	$1030	3.0%	A B
Prize 3	$1000	$1040	4.0%	A B
Prize 4	$1000	$1050	5.0%	A B
Prize 5	$1000	$1075	7.5%	A B
Prize 6	$1000	$1100	10.0%	A B
Prize 7	$1000	$1125	12.5%	A B
Prize 8	$1000	$1150	15.0%	A B
Prize 9	$1000	$1175	17.5%	A B
Prize 10	$1000	$1200	20.0%	A B
Prize 11	$1000	$1250	25.0%	A B
Prize 12	$1000	$1350	35.0%	A B
Prize 13	$1000	$1500	50.0%	A B
Prize 14	$1000	$1750	75.0%	A B
Prize 15	$1000	$2000	100.0%	A B

To contact you if you win, please write your name and then either your address, phone number or e-mail address.

Name ____
Address ______________________________________
Cite, State Zip _________________________________
Or
Phone Number _________________________________
Or
E-mail address _________________________________

Fig. 1. Reward lottery form.

survey at the end of the mail survey. A 25% drop-out rate seems reasonable for a possibly mentally challenging exercise at the end of a mail survey.

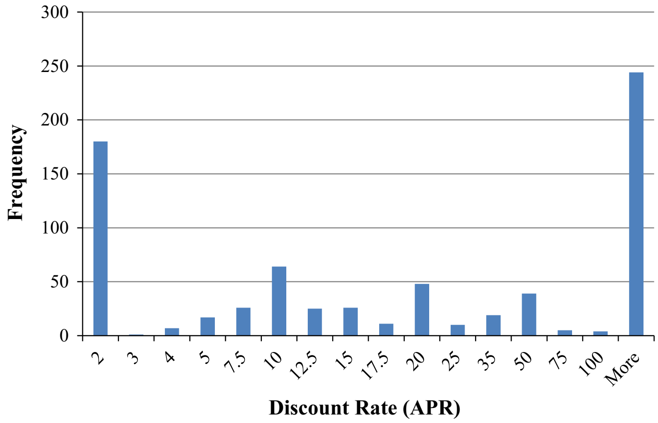

Fig. 2. Non-hypothetical discount rate results (N=726)[a,b].
[a]If a respondent always chose payment option B this implies a personal discount rate of 2% or less since even for prize 1 the respondent chose $1020 in one year and a few months (payment option B) versus $1000 in a few months (payment option A).
[b]If a respondent always chose payment option A this implies a personal discount rate of "more" than 100% since even for prize 15 the respondent chose $1000 in a few months (payment option A) versus $2,000 in one year and a few months (payment option B).

Table 7
Implied discount rates equating present value WTP estimates from the three different CV time horizon payment options.[a]

	Ten annual payments	Perpetual annual payments
One-time payment	104%	62%
Ten annual payments	–	15%

[a] Implied discount rates based on the Turnbull distribution-free WTP estimates.

Results

Fig. 2 presents the results from the non-hypothetical discount rate survey.[6] From the sample of respondents completing the discount rate survey (N=726), 25% always chose payment option A and 34% always chose payment option B. The remaining 41% at some point switched from payment option A to payment option B indicating the bounds for their personal discount rate for this exercise. Our median discount rate is in the 17.5–20% range, which is lower than Harrison et al.'s 28% estimate, but is exactly equal to the median from a similar study by Collier and Williams (1999). An alternative, more conservative estimate uses only the subset of respondents who at some point switched from payment option A to payment option B; the median discount rate for this subset is in the 12.5–15% range. We say this is more conservative because respondents choosing one prize option exclusively may not have carefully considered the exercise.

As discussed in the literature review, several papers have investigated different payment time horizons in CV studies and the resulting implied discount rates. In Table 7 we present this information for our survey data, (i.e., calculating the implied discount rates that equate the present value of the CV WTP estimates from Table 4). The implied discount rate that equates the present value of the WTP estimate for ten annual payments with that for perpetual annual payments is 15%, which can also be seen in Table 6 where at a 15% discount rate the present value WTP is approximately $120 for both these time horizon versions. This discount rate falls within the 12.5–20% range we find in our time preference survey.

The implied discount rate that equates the present value of the perpetual annual payments with the one-time payment is 62%. The implied discount rate that equates the present value of the ten annual payments with the one-time payment is 104%. These estimates fall within the 20–270% range we identify in our review of the implied discount rate literature, but they fall well outside of the 12.5–20% range we find using our nonhypothetical time preference survey. In their extensive review of the time preference literature Frederick et al. (2002) explain that individuals' discount rates are highly context dependent, varying depending on the size of the stakes, time frame, and whether individuals face a loss or a gain. Still, we find it hard to believe that differences in the context of our CV and time preference survey are so great as to explain differences in discount rates as large as an order of magnitude.

Taken together, the results presented in this section support the hypothesis that mental accounting at least partly explains the surprisingly modest difference between one-time WTP and annual WTP when presented with ongoing payments. Of course, for some households liquidity constraints could also play a role. Large one-time payments may bump

[6] It is also possible to include these exogenously determined individual discount rates as explanatory variables in the bound probit model. We attempted this, and the results weakly supported our conclusions, but none of the exogenous rates were statistically significant explanatory variables so we do not present the results.

up against respondents' binding mental budget constraints (or liquidity constraints). This leads to WTP estimates that suggest "inordinately high" implied discount rates when compared with WTP estimates from surveys asking for ongoing payments. In this section we show that these high implied discount rates are not consistent with the results of a nonhypothetical time preference survey or with the implied discount rates equating the present value WTP from surveys asking for ten annual or perpetual annual payments.

Convergent validity sensitivity analysis

Here we investigate the sensitivity of our convergent validity results from the previous section. We begin with the travel cost model. Recent papers indicate it may be appropriate to use a higher fraction of the wage rate for the opportunity cost of travel time. Using drivers' speeding behavior as a function of the gasoline price, Wolff (2014) concludes 50% of the wage rate is a better approximation of the average value of time. Fezzi et al. (2013) use actual driving choices to coastal beaches on the Italian Riviera, where drivers choose between slower open access roads or faster toll roads. The authors conclude that 75% of the wage rate is the best approximation of the average value of time. These results in mind, we re-run our travel cost model assuming the opportunity cost of time in the travel cost variable is now estimated using 50% of the respondent's average wage rate and then 75%, versus our base case of 33%. Table 8 presents these results. As expected, using a larger fraction of the wage rate shifts the recreation demand curve up leading to larger consumer surplus estimates and larger WTP estimates for the proposed water quality improvement. The mean WTP increases from $19 in the base case using 33% of the average wage rate to $24 using 50% of the average wage rate to $42 using 50% of the average wage rate. There is little *a priori* basis to choose among these alternatives. However, directly comparing log-likelihood values as in Egan et al. (2009), we find that the preferred model is that using 33% of the wage rate. Assuming a 50% fraction leads to a slightly worse fit (−2658 vs. −2654). Assuming a 75% fraction leads to a worse fit still (−2696 vs. −2654).

In terms of the convergent validity test, assuming a larger fraction of the wage rate increases the annual WTP estimate from the travel cost model, and thus increases the divergence between the travel cost and CV WTP estimates. Table 9 shows the present value WTP estimates for various discount rates using the results from the travel cost model and the Turnbull distribution-free estimator. For all discount rates up to 20% the alternative travel cost specifications increase divergence between travel cost WTP estimates and the one-time CV WTP estimate. This reinforces the results from our convergent validity test from the previous section. At any reasonable discount rate, CV WTP estimates from surveys with ongoing payments are more consistent with the annual stream of WTP estimates from the travel cost model.

To test the sensitivity of our CV results, we reestimate our WTP values using a basic probit. With ongoing payments our new mean WTP estimates differ from those presented in Table 4 by only a few dollars. With the one-time payment the new mean WTP estimate is $18, versus $47 for the Turnbull. However, the 95% confidence interval for this new WTP estimate is large and includes negative WTP values, a common outcome when using the unbounded probit model.

Additionally, we could investigate the impact of respondent uncertainty in the advisory CV referendum adjusting responses based on answers to a follow-up question providing a 5-point certainty scale. However, incorporating uncertainty would reduce WTP estimates for any of the three time horizons (Li and Mattsson, 1995; Champ, 1997). This would not change our conclusion given that all of the CV WTP estimates are already lower than the travel cost WTP estimate.

In conclusion our sensitivity analysis strengthens the results from the convergent validity test, giving us more confidence that annual payments in a CV survey best match the annual stream of WTP from a travel cost model. More sensitivity analysis could be done, especially regarding the travel cost model, where we could also consider variations in the assumed cost per mile. However, our assumed cost of $0.25 per mile is already quite conservative compared with the IRS's official reimbursement rate of $0.505 per mile in 2008. Using a higher cost per mile would increase the divergence between travel cost and one-time CV WTP estimates in the same way that increasing the fraction of the wage rate did.

Conclusions

In this paper we have presented three arguments for using ongoing annual payments in CV surveys. First, the respondent's personal discount rate is irrelevant when comparing a stream of annual *benefits* with a stream of annual *payments*. Second, we find that the WTP estimates from a CV survey with ongoing annual payments better match WTP

Table 8
Travel cost model perpetual annual WTP estimates using alternative assumptions for the opportunity cost of time.

	Travel cost model			
	Mean price	Mean annual WTP	95% C.I.[a]	Log-likelihood
Base case: 33% of wage rate	$52.92	$19	($14, $24)	−2654.5
50% of wage rate	$65.83	$24	($17, $30)	−2658.3
75% of wage rate	$85.19	$42	($28, $54)	−2696.3

[a] Estimated using the Krinsky and Robb (1986) technique.

Table 9
Present value WTP with the travel cost model (TC) and the Turnbull distribution-free estimator (CV); Similar to Table 6, with alternative travel cost specifications added.

	Discount rate	5%	10%	15%	20%
PV(WTP) from: TC—perpetual annual additional consumer surplus	75% of wage rate	$840	$420	$280	$210
PV(WTP) from: TC—perpetual annual additional consumer surplus	50% of wage rate	$480	$240	$160	$120
PV(WTP) from: TC—perpetual annual additional consumer surplus	33% of wage rate	$380	$190	$127	$95
PV(WTP) from: CV—perpetual annual payments		$360	$180	$120	$90
PV(WTP) from: CV—ten annual payments		$185	$148	$121	$101
PV(WTP) from: CV—one-time payment		$45[a]	$43	$41	$39

[a] In order to be consistent with the rest of the table, we assume one-time payments begin (and end) one year into the future.

estimates from a travel cost survey. Third, we make the behavioral argument that respondents are less likely to face a binding mental accounting budget constraint when facing ongoing annual payments. Considered together, these three arguments make a strong case for matching the duration of a CV survey's payments with the duration of the proposed benefits, which will most often mean presenting survey respondents with ongoing annual payments.

Carson et al. (2003, page 263) state that there is "no obvious *a priori* basis on which to choose between the lump sum and the annual payment schemes." This paper continues the very limited prior research addressing this issue, with our findings supporting annual payments. Carson et al. chose a one-time payment in part to be more conservative as in present value terms a one-time payment leads to lower WTP than annual payments. We have provided evidence with our convergent validity test, and our mental accounting argument, that one-time payments lead to present value WTP that is too small. Moreover, Carson et al. argue for one-time payments since they, "have the advantage of eliminating the need to determine what rate ought to be applied to discount future payments." (page 263) Carson et al. are pointing out that by asking a one-time payment, the resulting WTP is already present value, thus short cutting the usual need by the researcher to assume a discount rate for future benefits, for example, is as needed if one wanted to present the present value of annual WTP from the travel cost model. However, as we have discussed, if we assume respondents have known annual WTP for a long-lived environmental good, and the researcher presents the respondent a one-time payment, present value analysis still needs to be conducted. The researcher has now pushed the task onto the respondent, whom is likely to be ill-suited to the task.

As discussed in the literature review section, previous studies have found implied discount rates ranging from 20% to 270% to equate present value WTP from CV surveys with different time horizons. However, these estimates may be tainted by the difficulty of the discounting exercise and the existence of mental accounting budgeting constraints. When we use a nonhypothetical time preference survey to estimate discount rates for our sample, we find median discount rates in the range of 12.5 – 20%. But when comparing one-time CV WTP estimates with present value WTP from annual payments, we calculate implicit discount rates as high as 162%. We agree with Bond et al. (2009) that, "respondents do not behave in strict accordance to the context of net present value analysis at market rates, and as such, … true willingness to pay may be greater than that implied by the standard lump-sum payment vehicle" (p. 2757). In other words, the high implied discount rates are the result of CV surveys including one-time aka lump-sum payment vehicles that result in respondents having difficulty with the present value analysis forced upon them or due to the existence of mental accounting budgeting constraints.

However, Bond et al. (2009) also state that using ongoing annual payments is "more complex for respondents" (p. 2757). We disagree with this conclusion, as we have shown that if respondents have known annual WTP, they need not do any discounting if presented with a perpetual annual payment, but can instead simply compare their annual WTP to the annual bid. We do agree with Bond et al. (2009) that ongoing annual payments may be more realistic, as usually payments for quasi-public goods, such as local zoos, science centers, or community recreation centers, all ask for an annual membership payment commensurate with the flow of annual services provided. In many instances the environmental public goods researchers are valuing are best thought of as assets providing a flow of annual services into the future, such as, in this paper, the restored wetlands providing the service of improved water quality, or the preservation of rare and endangered species (Loomis and White, 1996). Some might argue that perpetual payments lack realism for respondents who only plan to live in an area for a few years. In our study, for example, University of Toledo students may plan to leave northwest Ohio within the next four years, at which point they would presumably no longer make the annual payments named in ongoing-payment versions of our CV survey. But when they leave northwest Ohio, they will also lose access to the proposed improvements at Maumee Bay State Park. When dealing with long-lasting local public goods like water quality at a state park, ongoing annual payments match the duration of the payment with the duration of the benefits even for those who do not expect to stay in the area in the long term. Indeed this matches the assumption made in the travel cost framework, where visitors are assumed to continue their future stream of higher trips and extra travel cost expenses to match the future stream of higher quality at the visited site.

We recognize that difficulty discounting and mental accounting budget issues are not the only explanations for the apparently near-sighted behavior of our respondents. The first could be that our respondents simply do not think about the future. This is not consistent with our data. Namely, our discount rate survey shows that our respondents do think about the future. Our median discount rate estimate is not inordinately high, and is in fact in line with what has been found in other similar experimental studies (e.g., Collier and Williams, 1999).

A second alternative explanation for our results is that respondents did not take the valuation task seriously. There are at least two reasons to reject this explanation. First, factors that we would expect to influence voting behavior—age, educational attainment, distance to the site, having a hunting or fishing license, and environmental membership—do influence voting behavior. As Table 5 shows, all of these variables are significant determinants of CV-referendum voting behavior, and all have the expected sign. Second, 24% of the respondents wrote a comment on the back of the survey in the "comments" section. Many indicated strong feelings regarding the restoration of wetlands in Northwest Ohio.

Finally, it is also possible that respondents took every aspect of the valuation survey seriously except the payment term. A cynical conclusion is that some respondents simply ignore time horizons, focusing only on the dollar value presented in the survey, and ask themselves if their WTP is greater than this dollar value? If this is true, then the crucial question is what WTP do they have in mind–an annual WTP or a one-time WTP? Our conjecture is that annual WTP is more likely because it matches the annual stream of benefits the proposed environmental improvements would provide. In this case, an annual payment vehicle is more justified.

Future research could investigate how respondents are considering the time horizon when they choose their advisory vote. Researchers could replicate the vast "cheap talk" literature used to focus the respondent on their budget constraint, expanding it to "cheap time horizon talk" that motivates respondents to focus attention on the time horizon of the payments.[7] For example, it may be important that respondents see the bid both as an annual amount and total cost over a certain number of years so they see this as a reoccurring payment[8]. Fischhoff and Furby (1988) state researchers need to consider "special sensitivity to respondents' capacity for mental arithmetic. For example, respondents asked about monthly installments may not realize the annual payment involved" (p. 168). As Smith (1992) discusses, time horizon issues are not unique to CV studies, with studies relying on actual revealed choices also showing what economists would describe as irrational behavior. We believe it is important for future research to investigate more fully how respondents are considering various time horizon payments when they are answering CV studies, and our conclusions from this paper are to simply match the time horizon of the payment to the time horizon of the environmental good—environmental goods providing ecosystem services over many years should be valued with a CV study using annual payments.

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[7] For example, we now include this statement in our CV surveys asking for perpetual annual payments, "Consider this to be an annual payment for the foreseeable future which would exist unless voters passed a future changed referendum." This may help to address Carson et al.'s (2003) concern that the future is uncertain so one-time payments are preferred. While certainly true, in any actual referendum there is always some uncertainty that a vote today could be overturned by a new referendum and vote in the future. We leave it to future research to consider alternative language. Moreover, the annual WTP estimates from the travel cost model have the same concerns about the future, where we are assuming the current recreators will continue to provide the stream of higher trips in future years just like in the CV context we are assuming the current recreators will continue to pay the annual payment.

[8] For example, we now include in our CV surveys asking for perpetual annual payments, "The proposed project would cost you $100 annually. Keep in mind that over 10 years this costs you $1000".

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