Temporal Insensitivity of *PVWTP* and Implied Discount Rates in CVM

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I. Introduction

The recent literature has noted two interrelated anomalies associated with elicited willingness to pay for public goods over time: insensitivity of willingness to pay to payment schedules and variation in discount rates over time. Kahneman and Knetsch (1992) found a temporal embedding effect wherein the respondents do not distinguish between temporal payment schemes. A series of papers (Rowe, Shaw, and Schulze, 1992; Stevens, DeCoteau, and Willis, 1997; Ibáñez and McConnell, 2001; Bond et. al., 2002) find that a weak temporal embedding effect is common in contingent valuation studies and derived implicit discount rates are quite high; ranging from two digits to several thousand percent.[1]

In the context of responses to contingent valuation questions across temporal payment schemes, Stevens, DeCoteau and Willis (1997) defined two types of embedding effects: strong and weak insensitivity to payment schedule. Strong insensitivity to payment schedule is a temporal embedding where respondents are unable to differentiate between an annual payment and a lump sum WTP across subjects (e.g. see Kahneman and Knetsch). Define W as the lump sum WTP for a project, and W_j as the jth payment in a temporal payment scheme. Strong insensitivity is defined as $W = W_1 = W_2 = \cdots = W_J$ where J is the terminal period of the temporal payment scheme.

Weak insensitivity is defined to be inequality between two temporally differentiated payment schemes but with unreasonably high implicit discount rates.

[1] High implicit discount rates have been reported in experimental research as well. Harrison and Johnson (2002) and Harrison et al. (2002) estimated individual discount rates in Denmark by a field experiment. Besides the main test for the constant discount rate across time horizon and variant discount rate across individual, they report a 28.1 percent average discount rate over all subjects, which is relatively low compared to the non-experimental literature but still high. Coller, Harrison and Rutström (2002) showed a consistent experimental result.

Weak insensitivity is also defined as $W = W_1 + \frac{W_2}{(1+r)^1} + \cdots + \frac{W_J}{(1+r)^{J-1}}$ where r is less than infinity.

Ibáñez and McConnell (2001) and Bond et al. (2002) have found that elicited WTP in a CV framework exhibits weak insensitivity to the offered payment schedule, and derived discount rates tend to exceed reasonable expectations. Ibáñez and McConnell (2001) investigated WTP for reduction in pathogen discharge in Columbia using an intertemporal random utility model with a constant discount rate. Either a lump sum payment or three monthly installments were randomly assigned to respondents. The estimation results showed a wide range of the mean WTP a calculated discount rate as high as 5,102%.

Bond et al. (2002) estimated the discount rate using an intertemporal WTP function. The payment schemes included three temporal treatments of one, five, and fifteen years. They found that the implicit discount rates were high relative to the market discount rate and the explicit discount rates were generally insignificant.

Test of insensitivity to temporal payment schedule and estimates of implicit or explicit discount rates depend on the temporal dimension of proposed cost and benefit streams. Generally, strong insensitivity has been rejected in empirical tests and weak insensitivity has been observed. Strong insensitivity may represent inconsistency in respondents' behavior or misunderstanding the survey questions. While moral satisfaction (Kahneman and Knetsch 1992; Diamond and Hausman 1994), symbolic bias (Mitchell and Carson 1989), or design and analysis product (Smith 1992; Hanemann 1994) are responsible for scope and scale embedding effect, temporal embedding effect, i.e. individual time preference, is argued to depend on situation and commodity specifics

(Crocker and Shogren 1993), money specifics (Thaler 1981), or respondents specifics (Stevens et al. 1997).

These previous contingent valuation studies typically include a comparison of a one time payment to a payment equally divided over a fixed number of periods. Insensitivity tests are conducted under the implicit assumption that the present value of willingness to pay is same across the payment scheme. In this paper, we argue that the assumption of constant present value of willingness to pay should be tested rather than imposed.[2] If the estimated present value of WTP is not constant, then estimated models that impose constant PVWTP provide biased estimates of discount rates.

In this paper, an alternative concept of temporal insensitivity is defined with respect to the present value of willingness to pay (*PVWTP*) and the present value of cost (*PVC*).[3] The theoretical model using *PVWTP* and *PVC* are explained in the next section. In the following two sections, the insensitivity of *PVWTP* is tested and the implied discount rate is derived using a mail survey data on the restoration program of oyster reef in the Chesapeake Bay. We find that *PVWTP* does not depend on the payment scheme or on the length of the stream of benefits and that implicit discount rates vary significantly across project lengths, but not across payment schemes.

II. Present Value Model of CVM and Insensitivity of WTP

Hypothetically proposed environmental projects include temporal dimension of benefit and cost. Consider a project that consists of a stream of annual benefits B_t, $t = 1$,

[2] Haab, Huang and Whitehead (1999) test the consistency in the respect of real and hypothetical format. Huhtala (2000) investigates the heterogeneous preference in CVM in which the author distinguishes preferences according to the respondent's attitude on environmental policy. Inconsistent willingness to pay can be explained by heterogeneity of preference.

[3] *PVWTP* concept can be an explanation of the temporal reliability of natural resource damage estimates derived from CV which was recommended to assess by NOAA panel (1993). Carson et al. (1997) showed that CV estimates exhibited no significant sensitivity to the timing of interviews.

2,…, T_B and an associated stream of annual costs, C_t, t = 1, 2,…, T_C, where T_B represents the life of the benefits of the project and T_C is the life of the costs. The life of benefits and costs can be made different explicitly by the researcher and also can be implicitly accepted different by respondents. In any case, a rational respondent will vote for the proposed project in the survey when the present value of willingness to pay for the benefit stream of the project exceeds the present value of cost stream required.

II. 1. The Present Value of the Stream of Willingness to Pay

A simple way to incorporate the *PVWTP* is to assume the maximum WTP of individual i in period t to be a function of benefit of the period and individual specific covariates as traditionally specified. WTP for each period can be derived by the difference of expenditure functions or from the indirect utility functions. When the environmental change in the proposed project is an infinite stream, in the expenditure difference case, *PVWTP* is a discounted sum of difference of expenditure of each period:

$$
\begin{aligned}
&PVWTP \\
&= e_1(p, q_1^0, u) - e_1(p, q_1^1, u) + \frac{e_2(p, q_2^0, u) - e_2(p, q_2^1, u)}{1+r} + \frac{e_3(p, q_3^0, u) - e_3(p, q_3^1, u)}{(1+r)^2} + \cdots \\
&= WTP_1 + \frac{WTP_2}{1+r} + \frac{WTP_3}{(1+r)^2} + \cdots \\
&= X_1\beta + \varepsilon_1 + \frac{X_2\beta + \varepsilon_2}{1+r} + \frac{X_3\beta + \varepsilon_3}{(1+r)^2} + \cdots
\end{aligned}
$$

where $e_t(\cdot)$ and $WTP_t(\cdot)$ are expenditure and WTP at time t. X_t includes a path of the environmental change at each period as well as individual demographic variables. WTP in each period can be different based on the proposed environmental stream and individual specific covariates which may or may not vary across time. Even though the respondents are assumed to have constant covariates, the estimation requires a strong assumption about temporal correlation of error term.

An alternative way is to define *PVWTP* representing the maximum willingness to pay based on the whole benefit stream conditional on individual specific covariates. For simplicity, suppose that the benefit-life of the project to be infinite ($T_B = \infty$). Then, the *PVWTP* is a function of the discounted stream of benefits and other variables as

$$\begin{aligned} PVWTP &= \alpha_B \sum_{t=1}^{\infty} \frac{B_t}{(1+r_b)^t} + X\beta_B + \varepsilon \\ &= \alpha_B D(B, r_b) + X\beta_B + \varepsilon \\ &= \tilde{X}\beta_B + \varepsilon \end{aligned} \tag{1}$$

where r_b is a discount rate representing time preference for the benefit stream and ε is a mean zero random error component representing unobserved influences on the *PVWTP* , which has constant variance across individuals. In this formulation, *PVWTP* is not a sum of discounted WTP's but a value that individual assigns on the environmental change at decision time.

An advantage of this formulation is that the model does not require to summing the discounted errors across time. To a researcher, it makes the problem much easier because the error term is mean zero with constant variance across individuals. Another advantage is the simplicity for the individual covariates which may not be related to the discount rate. For respondents, it is easier way to think that the amount of total WTP at the decision time than to consider WTP at each period and then discount the stream. Finally, the estimation result gives the *PVWTP* of the project that is valued at decision (present) time. The present value of willingness to pay is not affected by the discount rate but implies the individual discount rate.

Suppose that a multi-period environmental project is proposed and also that the benefit stream after the project is constant at a level of environmental quality. Let the life of project be L, then the benefit stream of this study is

$$B_t = \begin{cases} bt & \text{if } t \leq L \\ bL & \text{if } t > L \end{cases}$$

where b is a constant rate at which the annual benefit is accumulated. Notice that L is not the life of benefit but the terminal period of project after which the benefit stream is constant[4]. If the final level proposed in the project is $\tilde{B} = \sum_{t=1}^{L} b_t = b \cdot L$, then the infinite benefit stream is

$$\begin{aligned} D(B, r_b) &= b\sum_{t=0}^{L-1} \frac{t}{(1+r)^t} + \tilde{B}\sum_{t=L}^{\infty} \frac{1}{(1+r)^t} \\ &= b\gamma_0 + \tilde{B}\gamma_L \\ &= d_{L,b} \end{aligned} \tag{2}$$

where $\gamma_0 = \sum_{t=0}^{1} \frac{t}{(1+r)^t} = \left(\frac{(1+r)^L - 1}{r^2 (1+r)^{L-2}} - \frac{L}{(1+r)^{L-1}} \right)$ and $\gamma_L = \sum_{t=L}^{\infty} \frac{1}{(1+r)^t} = \frac{1}{r(1+r)^{L-1}}$.

II. 2. The Present Value of the Stream of Costs

The PVC is calculated as the discounted stream of payments. By design, the annual payment is constant for all payment mechanisms ($C_t = C$). The present value of costs becomes

$$\begin{aligned} PVC &= C\sum_{t=0}^{T_C - 1} \frac{1}{(1+r_c)^t} \\ &= Cd_{T_C} \end{aligned} \tag{3}$$

[4] We have assumed that there is no degradation of the project after the full provision of the benefits.

where d_{T_C} is the discount factor for a constant stream of annual payments over T_C time-periods with a constant discount rate r.

In a one time payment, C, in period 1, the present value of cost is

$$PVC_1 = C. \tag{4}$$

If the cost consists of T_C annual payments, the present value of the payment stream is:

$$PVC_2 = C\left(\frac{1+r_c}{r_c}\right)\left(1-\frac{1}{(1+r_c)^{T_C}}\right). \tag{5}$$

Finally, with a perpetuity payment scheme, the present value of this perpetuity is

$$PVC_3 = C\sum_{t=0}^{\infty}\frac{1}{(1+r_c)^t} = C\left(\frac{1+r_c}{r_c}\right). \tag{6}$$

In each case, the present value of the stream of payments is represented as:

$$PVC_j = C\beta_C^j \quad (7)$$

where j indexes the three payment schemes and $\beta_C^1 = 1$, $\beta_C^2 = (1+r_c)\left(1-(1+r_c)^{-T_C}\right)/r_c$, and $\beta_C^3 = (1+r_c)/r_c$. Recall that the discount factor is assumed to be nonnegative.

II. 3. Responses to the Referendum Question

An individual will vote for the project if $PVWTP \geq PVC$. While comparing the present values of willingness to pay to cost is not new, most previous work has discriminated between the present value of willingness to pay and willingness to pay per time period.

Following the above expressions, the probability that a respondent will vote for a program k given the payment version j is

$$P(\text{vote for k} \mid j) = P\left(PVWTP_k \geq PVC_j\right) \tag{8}$$

Assuming a normally distributed error term:

$$
\begin{aligned}
P(\text{vote for k} \mid j) &= P\left(\tilde{X}_k \beta_B + \varepsilon_{kj} \geq C\beta_C^j\right) \\
&= P\left(\varepsilon_{kj} \geq C\beta_C^j - \tilde{X}_k \beta_B\right) \\
&= P\left(\frac{\varepsilon_{kj}}{\sigma_{kj}} \geq C\frac{\beta_C^j}{\sigma_{kj}} - \tilde{X}_k \frac{\beta_B}{\sigma_{kj}}\right) \\
&= \Phi\left(\tilde{X}_k \tilde{\beta}_B - C\tilde{\beta}_C^j\right)
\end{aligned} \tag{9}
$$

where $\tilde{\beta}\ (=\frac{\beta}{\sigma})$ is the normalized parameter vector, and $\Phi(\cdot)$ is the standard normal cumulative distribution function. The variance of error term may or may not vary by payment version. The probability is conditioned on the assignment of the project and the payment version *j*. This probability is to be recognized as the standard probability of a yes response to a Probit referendum model.[5] Unfortunately, the constant and the coefficient of benefit stream can not be identified in split data. A dummy variable in data pooled across project versions would capture the difference of benefit stream of different projects.

If variances are the same across payment schedule *j* and project version *k*, and if *PVWTP* has the same parameter set, then the unconditioned probability of a vote for the project is

$$
\begin{aligned}
P(\text{vote for}) &= P(PVWTP \geq PVC) \\
&= P\left(\sum_{k=1}^{K-1} d_k + X\beta_B + \varepsilon \geq \sum_{j=1}^{J} Cd_j \beta_C^j\right). \\
&= \Phi\left(\sum_{k=1}^{K-1} d_k + X\tilde{\beta}_B - \sum_{j=1}^{J} Cd_j \tilde{\beta}_C^j\right)
\end{aligned} \tag{10}
$$

Where d_j and d_k are dummy indicators for payment version *j* and program *k*. The covariate vector does not include any project specific variables. The probability of vote against the project is defined as the complement to the probability of vote for.

[5] See Haab and McConnell (2002) for details.

II. 4. A Sequential Test for Insensitivity and Heterogeneity

Previous studies have defined the temporal embedding effect in terms of time separable WTP. The insensitivity has been tested based on pooled data which assumes implicitly that respondents behave by the same decision rule no matter what payment schedules are assigned to them. Therefore, the weak or strong insensitivity means, at least, poor representation of data for population response. In this study, with the assumption of rational behavior of respondent, insensitivity to temporal payment schedules is tested in terms of *PVWTP*. Insensitivity of *PVWTP* means that respondents do not change their valuation of environmental good due to the payment schedule.

Heterogeneity across payments schemes is another source of concern in deriving the implied discount rate. Implicit in the derivation of equation 10 is the assumption that the variance of the error term be the same across all payment schemes. Pooling data across payment schemes and dummying for payment scheme imposes the restriction of a common variance. But, relaxing this assumption and allowing the variance of the error term differs across payment schemes, introduces an identification problem in equation (8), (9) and (10). In particular, only two of the three variances can be separately identified (or the constants must be restricted to be equal. If the PVWTP is to be insensitive to payment scheme, it must be the case that both the mean parameter vector and error parameters are insensitive and homeoskedastic:

$$H_0 = \begin{Bmatrix} \beta_B^j = \beta_B^k \\ \sigma_j = \sigma_k \end{Bmatrix}. \tag{11}$$

Following the sequential test for consistency proposed by Swait and Louviere (1993) and adapted by Haab, Huang and Whitehead (1999) in a contingent valuation framework, two alternative models are introduced; one that assumes equal covariate effect and heteroskedasticity, and the other that assumes equal covariate effect and homoskedasticity. The test shows whether the *PVWTP* in different payment schedules are based on the same set of parameters ($\beta_B^j = \beta_B^k$) and/or whether the variances of the *PVWTP* are the same across the payment schedules ($\sigma^j = \sigma^k$). Insensitivity and invariance can be tested on the temporal difference in the benefit.

A simple description for the sequential test is as follows.[6] First, given the possibility of heteroskedasticity, the equality of covariate effect is tested by simple LR test. The log likelihood of unrestricted model is estimated from split data across payment schedules. Split sample is free from the restriction of equal covariate effect and homoskedasticity. The restricted model is the rescaled data model in which the rescale parameter is estimated to maximize the log likelihood function by grid searching. Present computer program packages like Limdep 7.0 provide the Probit estimation result for heteroskedasticity. The variance is defined as $\sigma_i^2 = [\exp(\gamma' w_i)]^2$ to ensure the positive variance. By using dummy variables for payment types in the error variance function, heteroskedasticity estimates are equivalent to the rescaled model estimates.

Based on the failure to reject the first hypothesis, the second step is to test heteroskedasticity across payment schedules. The conditional unrestricted model is the rescaled data model in the first step. The conditional restricted model is a pooled data model in which data is stacked in the usual way. To reject the second hypothesis means that there is heteroskedasticity across payment version even though *PVWTP* is derived by the same parameter set.

[6] For details, see Haab, Huang and Whitehead (1999)

Recall that the normalized parameters of *PVC* as defined above, $\tilde{\beta}_C^1 = \frac{1}{\sigma}$,

$\tilde{\beta}_C^2 = \frac{1+r_c}{\sigma r_c}\left[1 - \frac{1}{(1+r_c)^{T_C}}\right]$, and $\tilde{\beta}_C^3 = \frac{1+r_c}{\sigma r_c}$. The sequential test for insensitivity of *PVWTP* guarantees a unique discount rate because *PVWTP* is invariant on the payment schedule and the error terms are iid. Based on the definition of parameters, the unknown discount rate is uniquely derived from estimates of $\tilde{\beta}_C^1$ and $\tilde{\beta}_C^3$ as $r_c = \frac{\tilde{\beta}_C^1}{\tilde{\beta}_C^3 - \tilde{\beta}_C^1}$. For a unique discount rate, a necessary restriction on the remaining parameters is

$$\tilde{\beta}_C^2 = \tilde{\beta}_C^3\left(1 - \left(\frac{\tilde{\beta}_C^3 - \tilde{\beta}_C^1}{\tilde{\beta}_C^3}\right)^{T_C}\right).$$

However, if we allow different discount rate over different time interval, $\tilde{\beta}_C^2$ and $\tilde{\beta}_C^3$ provide another implicit estimates which can be tested for the time structure of discount rate.

III. Survey Design

In this paper, we utilize a unique mail survey about a proposed oyster restoration program over several states around Chesapeake Bay to test for insensitivity of willingness to pay and to derive implicit discount rates to payment schedules in a dichotomous choice contingent valuation setting. Due to overharvest and environmental degradation, oyster populations in the Chesapeake Bay have fallen to less than 1% of their historic maximum levels. The National Marine Fisheries Service conducted a random digit dial (RDD) telephone survey to assess attitudes toward oysters and oyster reef restoration in the Chesapeake Bay. A follow-up mail survey was sent to 1,785 respondents of the 8,077 contacted in the RDD survey, who agreed to participate in the mail survey. The mail survey included a brief explanation of the role and benefits of oysters in the Bay and questions about attitudes and preferences towards the Chesapeake Bay, the water quality in the bay, and knowledge of oyster reefs. A hypothetical referendum question followed by questions about respondents' demographic information was asked.

The hypothetical restoration project consisted of two temporal versions (A for five year and B for ten year) of an oyster reef restoration plan and three temporal payment schedules. Both restoration plans varied by the time to reach the proposed level of 10,000 acres of oyster habitat and 1,000 acres in artificial reef. Five year (ten year) restoration program accumulates at a rate of 200 (100) acres of reef restoration and 2,000 (1,000) acres of habitat preservation per year. The temporal payment schedules consisted of three payment mechanism; one-time (lump sum) payment on the next year state tax return, annual state tax return over the life of the project, and a permanent annual payment on the state tax return, which are denoted 1, 2, and 3 respectively. The final survey consisted of a 2x3 design (2 project lengths and 3 payment schemes). For each design, one of three possible bid levels was assigned, resulting in 18 possible survey versions, which were randomly assigned to respondents. Figure 1 shows the survey design structure. The referendum question offered to each respondent varied by six scenarios and three payment amounts for each scenario as follows

The restoration program is estimated to cost your household a total of **$__ (per year)**. Your household would pay this as (a special one time tax, an annual tax over the next __ years, or an annual amount) added to next year's state income tax. **If an election were to be held today and the cost to your household was $__ (total, per year for next __ years, or indefinitely), would you vote for or against the __ year restoration program** (Check one)?

- ❑ I would vote for the program
- ❑ I would vote against the program
- ❑ I do not know whether I would vote for or against the program

Table 1 summarizes the responses to the referendum questions and Table 2 explains the summary of some demographic variables. 577 respondents completed the follow-up mail survey for a response rate of 33.7 percent. For a conservative estimate of WTP, the 'I don't know' response is assumed as 'vote against' response (Carson et al. 1998; Groothuis and Whitehead 1998).

Except for two cases from A1a to A1b and from B3b to B3c, the response rate of voting for decreases as the bid amount increases. The reversal of response rate to vote for in those two cases shows that the data is not consistent to monotonic probability of voting against as bid amount increases. In nonparametric distribution estimation such as Turnbull estimator of WTP, the pooled adjacent violators algorithm (PAVA) implemented by Kriström (1990) provides a self-consistent bound estimator for the data. However, in parametric estimation, the reversal, especially in ten year project, may affect the estimation result severely because it happens in the highest bid amount; the tail of the distribution.

IV. Estimation Results and Sequential Test for Insensitivity

The *PVWTP* is assumed to be a linear function and for simplicity, the difference between two project plans is supposed to be captured by dummy variable for project version. For example, the conditional probability of a vote for the project given payment type *j* is

$$\begin{aligned} &P(\text{i votes for k} \mid j) \\ &= \Phi\left(const + \tilde{\beta}_{j1}FIVE + \tilde{\beta}_{j2}RE + \tilde{\beta}_{j3}HS + \tilde{\beta}_{j4}SEX + \tilde{\beta}_{j5}AGE + \tilde{\beta}_{j6}EDUC - C_j\tilde{\beta}_j\right) \end{aligned} \quad (12)$$

where *FIVE* is a dummy indicator that equals one if individual *i* receives five year restoration plan and zero otherwise. *RE* is a variable for ranking the role of restoration program as an environmental among food, economic, and fish habitat. *HS*, *AGE* and *EDUC* are the size of household, age and education variables as in Table 2, while *SEX* is a dummy variable which is one for female.

Table 3 shows the estimation results of split and pooled data. The first six columns show the estimates of each project and payment type, which are based on the assumption that the variance and coefficients of model can be different across temporal payment schedules. With the assumption that the difference of project version is assumed to make only shift in the mean *PVWTP*, the last three columns are estimation results with pooled data over different project version. As expected from the data statistics, 10-year project with perpetuity type payment yields unreliable estimation result. The negative sign of the *FEE3* is due to the inconsistency of response rate. All estimates of annual and perpetuity type payments are insignificant when they are pooled over project version. Notice also that the estimated coefficient of *FIVE* which is a dummy for five-year project is insignificant across all payment types. Respondents are seemingly unable to distinguish project versions that differ by the stream of benefits but are the same in the final target quality.

The sequential tests for homoskedasticity are conducted on the four scenarios for each project version and another four scenarios for pooled over project versions; one time vs. annual payment vs. perpetuity; one time vs. annual; one time vs. perpetuity; annual vs. perpetuity. The pair-wise comparisons of payment schedules are tested for the case in which two of payment schedules dominate the behavior of the other payment schedule. For the first stage of the sequential test, the rescale factor of the variance is defined as $\sigma_i^2 = [\exp(\gamma' w_i)]^2 = [\exp(\gamma_2 d_2 + \gamma_3 d_3)]^2$ by normalizing the variance of one time payment equal to one.[7] Table 4, 5, and 6 provide estimates of scaled data and pooled data for each combination of payment types.

Table 7 shows the log likelihood ratio test result for the sequential test. The test statistics are derived by $LR = -2(\ln(L_r) - \ln(L_u))$, which is distributed as χ^2 with degrees of freedom equal to the number of restrictions. LR1 is for the insensitivity of *PVWTP* and LR2 is for the heteroskedasticity under the first test. As can be seen in Table 7, all combinations of payment schedules except one time vs. perpetuity with pooled data fail to be rejected under the hypothesis of $\beta_B^j = \beta_B^k$, which means that *PVWTP* is same across payment types. Respondents value the restoration program no matter what payment schemes they have to pay. In this case, respondents do not distinguish the payment schedule but the policy maker has the freedom to choose the method to fund the environmental program. With keeping this assumption correct, the second test shows that the variance of *PVWTP* is not statistically different across the payment type. The test result supports the possibility to pool across all payment schedules and to estimate *PVWTP* and implicit discount rate.

Implicit discount rates are reported in the rows following *LR* statistics in Table 7. Estimated variances are also reported below the implicit discount rates. Implicit discount rates are calculated using equation (4), (5) and (6). Each estimate is normalized by the same variance, the difference among the coefficient estimates of PVC is supposed to come from the discount rate. Except the case in which estimates are insignificant or not applicable due to negative value, the numerical solution for implicit discount rate ranges from 20% to more than 100%. In five year project, long term discount rate, r_3 is much

[7] In comparison of annual and perpetuity payment, the variance of perpetuity is normalized to one. Therefore, the rescale factor is multiplied to the annual payment data.

lower than short term discount rate, r_{2A}. However, due to the inconsistent data, 10-year project yields problematic long term discount rate. This also may be responsible for the reversal of r_3 in magnitude in pooled data; 1.2859, 0.9594 and 1.2045 for r_{2A}, r_{2B} and r_3, respectively in test 1; 1.1058, 1.0464 and 1.2549 in test 2 and 3. When we focus on only 5-year project because it is seemingly less problematic than 10-year project or pooled data, the implicit discount rate shows the hyperbolic discounting.[8]

Table 8 shows the mean of *PVWTP* and its 95% interval estimated using Krinsky-Robb (K-R) procedure. The mean of *PVWTP* is estimated at the mean of covariates. K-R simulates the uncertainty from randomness of parameter estimates. Even though the separate estimate of *PVWTP* with ten year project is much less than that of 5 year project, consistency test suggests that the difference is not statistically significant. Estimated coefficient of *FIVE* is positive usually but insignificant in all combinations.

Finally, Table 9 reports estimation results for the comparison of five year and ten year projects. The hypothesis is that the coefficient estimates of *PVWTP* are the same across project versions. The sequential test of consistency and heteroskedasticity also fails to be rejected in all payment types. The result supports the insensitivity of *PVWTP* to project version which is tested previously with *FIVE* dummy variable.

V. Conclusion and Further Study

In previous studies, insensitivity to temporal payment schedules has been defined and tested in terms of a payment per period while imposing the assumption of equal present value of willingness to pay across payment schemes. In this study, the insensitivity is tested in terms of the *PVWTP*. Test shows that respondents assign the

[8] The hyperbolic discount rate implies that larger discount rate is applied to near-term returns than to distant-term returns (Cropper and Laibson, 1999).

same *PVWTP* to the project regardless of the payment schemes. Holding the length of the project constant, *PVWTP* does not vary significantly with the payment types. Homoskedasticity across payment types confirm using pooled data to elicit implicit discount rate.

However, holding the payment scheme constant, *PVWTP* is same across project versions. Even though the five year plan reaches the final status more quickly, which means that the plan provide more environmental services during the project period, respondents seem not to distinguish the difference. Indifference may be due to the fact that they consider only the final status but do not pay attention to how to get to the proposed status.

Implicit discount rates vary significantly across payment schemes and project version but show consistent behavior to some degree; higher in short term and lower in long term. In this paper, however, individual specific discount rates are not analyzed. Comparing different project version may provide WTP for the delay of benefit, which is not possible with this data. Inconsistency of response in some survey scenarios is responsible for ill estimation of ten and pooled projects. More accurate estimation with well behaved data is recommended. Relaxing assumption of functional form or distribution also will give another estimation result worth considering.

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Figure 1: Experimental Design of Benefit and Cost

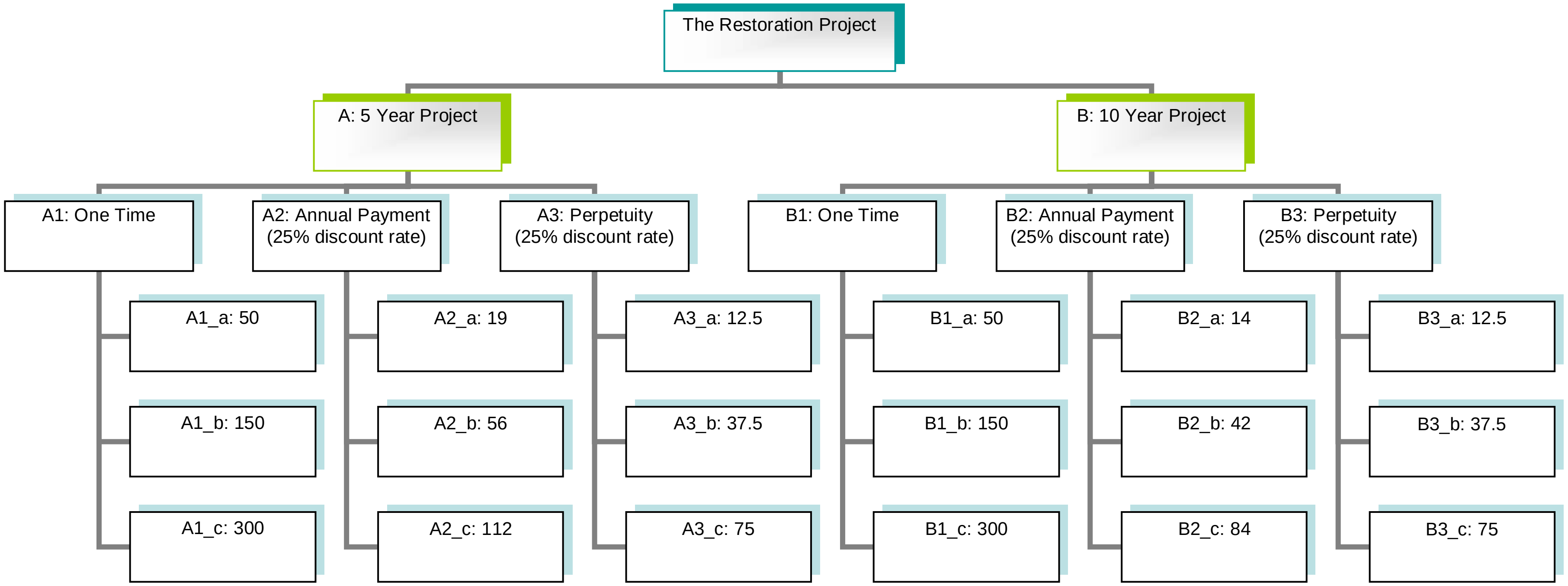

Table 1: Responses (Rates) to the Referendum Question in Each Category

		A									B								
		1			2			3			1			2			3		
		a	b	c	a	b	c	a	b	c	a	b	c	a	B	c	a	b	c
Vote for	333 (64.2)	17 (60.7)	33 (73.3)	12 (42.9)	21 (77.8)	22 (64.7)	13 (59.1)	16 (84.2)	25 (69.4)	9 (50)	21 (77.8)	26 (53.1)	7 (28)	19 (86.4)	25 (64.1)	12 (57.1)	15 (71.4)	25 (67.6)	15 (71.4)
Response	519	28	45	28	27	34	22	19	36	18	27	49	25	22	39	21	21	37	21
Total	1710	103	137	103	78	101	77	77	102	77	102	138	104	77	102	77	77	102	76

Parenthesis reports the percentage

Table 2: Demographic Variables

	Average	**Std. Dev.**	**Minimum**	**Maximum**
Size of Household	2.7553	1.3768	1	12
Age	49.7919	14.4101	15	90
Education	14.9075	2.6797	8	20
	1	**2**	**3**	**4**
Ranking of Environment	399 (76.9)	65 (12.5)	36 (6.9)	19 (3.7)
	Female	**Male**		
Sex	273 (52.6)	246 (47.4)		

Table 3: Estimation Results for Split and Pooled over Project Version

	5-year Project			10-year Project			Project		
	One Time	**Annual**	**Perpetuity**	**One Time**	**Annual**	**Perpetuity**	**One Time**	**Annual**	**Perpetuity**
Const	-0.8726 (1.0970)	2.1975 (1.2577)	0.9891 (1.4054)	-1.3436 (1.2341)	0.3837 (1.3487)	1.0987 (1.2841)	-1.0353 (0.7997)	1.3334 (0.9163)	1.1250 (0.8959)
FIVE	—	—	—	—	—	—	0.2757 (0.1936)	-0.0821 (0.4350)	-0.0198 (0.2183)
RE	-0.5018* (0.2050)	-0.1448 (0.1674)	-0.3698 (0.2059)	-0.0978 (0.1819)	-0.0784 (0.3007)	-0.0160 (0.1951)	-0.2667* (0.1327)	-0.1177 (0.1454)	-0.1781 (0.1320)
HS	0.2077 (0.1367)	-0.0918 (0.1477)	0.0296 (0.0864)	-0.0664 (0.1057)	-0.1031 (0.1330)	-0.1551 (0.1076)	0.0421 (0.0812)	-0.1169 (0.0977)	-0.0620 (0.0678)
SEX	0.1370 (0.2842)	0.5178 (0.3229)	-0.0473 (0.3483)	-0.0341 (0.2914)	0.0503 (0.3258)	-0.7667* (0.3308)	0.0567 (0.1992)	0.1954 (0.2202)	-0.3929 (0.2289)
AGE	0.0429* (0.0121)	0.0074 (0.0130)	-0.0053 (0.0105)	0.0274* (0.0109)	0.0008 (0.0125)	-0.0076 (0.0119)	0.0316* (0.0077)	0.0004 (0.0086)	-0.0057 (0.0077)
EDUC	-0.0226 (0.0504)	-0.1074 (0.0624)	0.0554 (0.0673)	0.0973 (0.0610)	0.0566 (0.0549)	0.0485 (0.0576)	0.0351 (0.0374)	-0.0068 (0.0393)	0.0426 (0.0419)
FEE1	0.0033* (0.0015)	—	—	0.0068* (0.0017)	—	—	0.0048* (0.0011)	—	—
FEE2A	—	0.0059 (0.0042)	—	—	—	—	—	0.0059 (0.0041)	—
FEE2B	—	—	—	—	0.0098 (0.0060)	—	—	0.0096 (0.0059)	—
FEE3	—	—	0.0152* (0.0072)	—	—	-0.0009 (0.0071)	—	—	0.0068 (0.0048)
Observations	101	83	73	101	82	79	202	165	152
Mean ln(*L*)	-0.563545	-0.585194	-0.556581	-0.572385	-0.587763	-0.556881	-0.590213	-0.600678	-0.586453

* significant at 95% confidence level.

Table 4: Estimation Results for Pooled and Scaled Data of 5-year Project

	One Time : Annual : Perpetuity		One Time : Perpetuity		One Time : Annual		Perpetuity : Annual	
	Scaled	**Pooled**	**Scaled**	**Pooled**	**Scaled**	**Pooled**	**Scaled**	**Pooled**
Const	0.2993 (0.8034)	0.4940 (0.6379)	-0.3034 (0.9232)	-0.0230 (0.6874)	-0.0082 (0.6664)	0.3011 (0.7991)	1.4791 (1.0287)	1.3088 (0.8444)
RE	-0.3956* (0.1390)	-0.2759* (0.1053)	-0.4685* (0.1732)	-0.3510* (0.1384)	-0.4227* (0.1564)	-0.3031* (0.1267)	-0.2886 (0.1555)	-0.2244 (0.1264)
HS	0.0734 (0.0848)	0.0355 (0.0628)	0.1196 (0.0977)	0.0605 (0.0687)	0.1247 (0.1069)	0.0775 (0.0983)	-0.0018 (0.0790)	-0.0068 (0.0728)
SEX	0.2607 (0.2124)	0.2028 (0.1684)	0.2163 (0.2481)	0.1795 (0.2059)	0.2597 (0.2419)	0.2585 (0.2038)	0.1028 (0.2642)	0.1447 (0.2206)
AGE	0.0229* (0.0080)	0.0140* (0.0062)	0.0282* (0.0093)	0.0164* (0.0070)	0.0342* (0.0095)	0.0254* (0.0086)	0.0001 (0.0087)	0.0016 (0.0076)
EDUC	-0.0114 (0.0393)	-0.0100 (0.0317)	0.0097 (0.0449)	0.0224 (0.0358)	-0.0421 (0.0390)	-0.0458 (0.0375)	0.0002 (0.0512)	-0.0139 (0.0429)
FEE1	0.0041* (0.0012)	0.0032* (0.0010)	0.0041* (0.0014)	0.0034* (0.0012)	0.0037* (0.0013)	0.0029* (0.0012)	—	—
FEE2A	0.0063 (0.0042)	0.0064* (0.0029)	—	—	0.0049 (0.0045)	0.0058 (0.0032)	0.0074 (0.0045)	0.0071* (0.0034)
FEE3	0.0108 (0.0065)	0.0103* (0.0046)	0.0092 (0.0076)	0.0112* (0.0052)	—	—	0.0156* (0.0060)	0.0117* (0.0053)
Scale Factors	0.4645	—	—	—	0.4850	—	0.3957	—
	0.4266	—	0.5620	—	—	—	—	—
Observations	257		174		184		156	
Mean ln(*L*)	-0.599198	-0.601452	-0.590015	-0.592957	-0.591264	-0.595141	-0.592860	-0.594799

* significant at 95% confidence level

Table 5: Estimation Results for Pooled and Scaled Data of 10-year Project

	One Time : Annual : Perpetuity		One Time : Perpetuity		One Time : Annual		Perpetuity : Annual	
	Scaled	**Pooled**	**Scaled**	**Pooled**	**Scaled**	**Pooled**	**Scaled**	**Pooled**
Const	-0.3385 (0.9077)	0.0748 (0.7161)	-0.4325 (1.0360)	0.0486 (0.8465)	-0.9441 (1.0400)	-0.6070 (0.8829)	0.8622 (0.9387)	0.8098 (0.9067)
RE	-0.0521 (0.1436)	-0.0322 (0.1148)	-0.0414 (0.1533)	-0.0248 (0.1276)	-0.0876 (0.1647)	-0.0520 (0.1481)	-0.0568 (0.1604)	-0.0538 (0.1567)
HS	-0.1209 (0.0810)	-0.1087 (0.0636)	-0.1211 (0.0900)	-0.1200 (0.0740)	-0.0889 (0.0927)	-0.0702 (0.0808)	-0.1434 (0.0825)	-0.1355 (0.0802)
SEX	-0.2152 (0.2174)	-0.2630 (0.1733)	-0.3293 (0.2493)	-0.3990 (0.2098)	-0.0149 (0.2439)	-0.0486 (0.2099)	-0.3598 (0.2336)	-0.3308 (0.2252)
AGE	0.0146 (0.0080)	0.0091 (0.0063)	0.0169 (0.0090)	0.0114 (0.0074)	0.0215* (0.0092)	0.0159* (0.0079)	-0.0020 (0.0087)	-0.0019 (0.0084)
EDUC	0.0834* (0.0422)	0.0556 (0.0324)	0.0797 (0.0500)	0.0541 (0.0401)	0.0967* (0.0491)	0.0738 (0.0404)	0.0474 (0.0404)	0.0461 (0.0389)
FEE1	0.0067* (0.0013)	0.0054* (0.0011)	0.0064* (0.0015)	0.0055* (0.0013)	0.0070* (0.0014)	0.0059* (0.0013)	—	—
FEE2B	0.0110* (0.0052)	0.0088* (0.0040)	—	—	0.0117* (0.0059)	0.0111* (0.0044)	0.0072 (0.0048)	0.0072 (0.0046)
FEE3	0.0024 (0.0071)	0.0055 (0.0046)	0.0021 (0.0071)	0.0047 (0.0051)	—	—	0.0040 (0.0054)	0.0036 (0.0053)
Scale Factors	0.3180	—	—	—	0.4341	—	0.0755	—
	0.5864	—	0.4982	—	—	—	—	—
Observations	262		180		183		161	
Mean ln(*L*)	-0.591832	-0.593972	-0.589986	-0.591607	-0.583979	-0.587389	-0.587562	-0.587629

* significant at 95% confidence level.

Table 6: Estimation Results for Pooled and Scaled Data of 5 and 10-year Project

	One Time : Annual : Perpetuity		**One Time : Perpetuity**		**One Time : Annual**		**Perpetuity : Annual**	
	Scaled	**Pooled**	**Scaled**	**Pooled**	**Scaled**	**Pooled**	**Scaled**	**Pooled**
Const	-0.0422 (0.6104)	0.2748 (0.4772)	-0.5469 (0.7104)	-0.0615 (0.5691)	-0.3877 (0.6948)	-0.0870 (0.5859)	1.1265 (0.6408)	1.0837 (0.6168)
FIVE	0.1686 (0.1640)	0.1038 (0.1336)	0.2127 (0.1749)	0.1361 (0.1419)	0.2264 (0.1841)	0.1904 (0.1714)	-0.0434 (0.1958)	-0.0452 (0.1927)
RE	-0.2293* (0.0999)	-0.1595* (0.0760)	-0.2361* (0.1160)	-0.1632 (0.0903)	-0.2522* (0.1132)	-0.1901* (0.0950)	-0.1609 (0.1000)	-0.1537 (0.0966)
HS	-0.0353 (0.0601)	-0.0426 (0.0447)	-0.0037 (0.0684)	-0.0300 (0.0508)	-0.0074 (0.0717)	-0.0179 (0.0615)	-0.0768 (0.0559)	-0.0739 (0.0545)
SEX	0.0324 (0.1541)	-0.0192 (0.1184)	-0.0195 (0.1802)	-0.0911 (0.1446)	0.1220 (0.1700)	0.0960 (0.1431)	-0.1159 (0.1606)	-0.1003 (0.1544)
AGE	0.0182* (0.0057)	0.0102* (0.0043)	0.0231* (0.0066)	0.0134* (0.0051)	0.0248* (0.0066)	0.0178* (0.0056)	-0.0014 (0.0058)	-0.0013 (0.0056)
EDUC	0.0369 (0.0287)	0.0251 (0.0222)	0.0468 (0.0338)	0.0376 (0.0272)	0.0270 (0.0319)	0.0166 (0.0265)	0.0232 (0.0295)	0.0217 (0.0284)
FEE1	0.0053* (0.0009)	0.0041* (0.0008)	0.0051* (0.0010)	0.0043* (0.0009)	0.0051* (0.0010)	0.0042* (0.0008)	—	—
FEE2A	0.0082* (0.0040)	0.0072* (0.0027)	—	—	0.0081* (0.0041)	0.0081* (0.0029)	0.0061 (0.0032)	0.0059 (0.0030)
FEE2B	0.0090 (0.0052)	0.0084* (0.0035)	—	—	0.0079 (0.0054)	0.0082* (0.0039)	0.0095* (0.0043)	0.0093* (0.0040)
FEE3	0.0063 (0.0049)	0.0076* (0.0032)	0.0035 (0.0057)	0.0077* (0.0036)	—	—	0.0081* (0.0037)	0.0074* (0.0037)
Scale Factors	0.4744	—	—	—	0.4750	—	0.0780	—
	0.5495	—	0.6813	—	—	—	—	—
Observations	519		354		367		317	
Mean ln(*L*)	-0.609624	-0.611483	-0.608022	-0.611704	-0.603025	-0.606419	-0.601857	-0.601939

* significant at 95% confidence level.

Table 7: Test of Insensitivity to Temporal Payment Schedules

	Test 1	Test 2	Test 3	Test 4
	One Time : Annual : Perpetuity	**One Time : Perpetuity**	**One Time : Annual**	**Perpetuity : Annual**
5-Year				
LR1	15.7489	10.2284	6.6068	6.5694
LR2	1.1582	1.0236	1.4267	0.6049
‡$\mathbf{r_A}$	0.9430	—	0.9816**	0.2044§
†$\mathbf{r_3}$	0.4581	0.4461	—	—
σ^2	310.2877	290.1352	339.1012	503.7268
10-Year				
LR1	10.1176	8.7861	1.7215	4.8148
LR2	1.1214	0.5833	1.2482	0.0213
‡$\mathbf{r_B}$	1.6222	—	1.1393	N/A
†$\mathbf{r_3}$	56.4694**	N/A	—	—
σ^2	183.5840	182.6592	168.7441	308.5847
5, 10-Year				
LR1	17.8385	13.7515*	5.9510	5.0718
LR2	1.9299	2.6074	2.4911	0.0524
‡$\mathbf{r_A}$	1.2859	—	1.0158	0.3785§**
‡$\mathbf{r_B}$	0.9594	—	1.0464	N/A
†$\mathbf{r_3}$	1.2045	1.2549	—	—
σ^2	241.4849	234.0705	238.2515	489.1814

* Rejected in 90% confidence interval in Chi-squared distribution with D.F of seven.
** Coefficient of FEE is not significantly different from zero.
† Calculated using coefficients of One time and Perpetuity in pooled data.
‡ Calculated using coefficients of One time and Annual in pooled data.
§ Calculated using coefficients of Annual and Perpetuity in pooled data.

Table 8: Mean of *PVWTP* and 95% Interval by Krinsky-Robb Procedure

	One Time Project		**Test 1**		**Test 2**		**Test 3**	
			One Time : Annual : Perpetuity		**One Time : Perpetuity**		**One Time : Annual**	
5-Year								
E(PVWTP)	263.98		268.50		263.28		276.70	
95% KR	(170.48	629.97)	(186.81	517.92)	(184.53	510.33)	(182.52	645.28)
10-Year								
E(PVWTP)	176.47		163.91		159.92		176.03	
95% KR	(135.35	223.47)	(122.99	221.41)	(115.46	215.18)	(134.99	231.88)
5, 10-Year								
E(PVWTP)	207.65		208.35		202.76		214.45	
95% KR	(168.91	266.46)	(167.66	272.99)	(162.78	264.34)	(172.34	282.27)
E(PVWTP)	233.49		218.68		216.99		233.82	
95% KR	(177.78	318.74)	(167.45	296.22)	(165.13	294.56)	(175.86	324.17)
E(PVWTP)	181.82		198.22		189.01		194.98	
95% KR	(126.74	249.03)	(148.86	270.05)	(139.13	257.57)	(139.71	271.92)

Table 9: Estimation Results for Pooled and Scaled Data over Project Period

	One Time		**Annual**		**Perpetuity**	
	Scaled	**Pooled**	**Scaled**	**Pooled**	**Scaled**	**Pooled**
Const	-0.7762 (0.7793)	-0.7729 (0.7733)	1.3024 (0.8948)	1.2940 (0.8915)	1.1238 (0.8969)	1.1197 (0.8938)
RE	-0.2868* (0.1338)	-0.2825* (0.1325)	-0.1222 (0.1443)	-0.1216 (0.1440)	-0.1788 (0.1324)	-0.1777 (0.1319)
HS	0.0378 (0.0820)	0.0360 (0.0811)	-0.1195 (0.0976)	-0.1189 (0.0972)	-0.0623 (0.0678)	-0.0624 (0.0677)
SEX	0.1063 (0.1974)	0.1057 (0.1957)	0.1995 (0.2205)	0.1978 (0.2197)	-0.3949 (0.2290)	-0.3944 (0.2282)
AGE	0.0307* (0.0077)	0.0304* (0.0077)	0.0005 (0.0087)	0.0005 (0.0086)	-0.0057 (0.0077)	-0.0057 (0.0077)
EDUC	0.0310 (0.0374)	0.0314 (0.0371)	-0.0069 (0.0394)	-0.0066 (0.0392)	0.0425 (0.0420)	0.0424 (0.0419)
FEE1	0.0047* (0.0011)	0.0047* (0.0011)	—	—	—	—
FEE2A	—	—	0.0064 (0.0033)	0.0064 (0.0033)	—	—
FEE2B	—	—	0.0089* (0.0044)	0.0089* (0.0044)	—	—
FEE3	—	—	—	—	0.0069 (0.0048)	0.0068 (0.0048)
Scale Factors	0.0180	—	—	—	0.0065	—
Observations	202		165		152	
Mean ln(*L*)	-0.595252	-0.595256	-0.600785	-0.600786	-0.586477	-0.586480