A Mire of Discount Rates: Delaying Conservation Payment Schedules in a Choice Experiment

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Abstract
Studies on the public's implicit discount rate in the willingness to pay for environmental amenities have mostly employed contingent valuation surveys. We investigate respondents' time preferences using choice experiments with four payment schedules in a split-sample design in the context of mire conservation. We first examine preference and taste heterogeneity among respondents, finding them to a large extent independent of payment schedules. Next we use an endogenous approach to jointly estimate the implicit discount rates and preferences using choice experiments data. We explore exponential and hyperbolic discounting model specifications. We find insensitivity to the length of the payment period and support for hyperbolic discounting. Furthermore, we provide policy relevant valuation results concerning mire conservation.

1 Introduction

Stated preferences studies require respondents to trade between flows of benefits and costs. The role of these flows in valuation and decision making is exacerbated when assessing benefits related to conservation measures. Perceived and actual conservation benefits accrue relatively slowly after measure implementation compared to costs, which are typically borne immediately. Such tradeoffs require valuation survey respondents intertemporal choice making thus including time preferences in the valuations. Time preferences are manifested in cost–benefit analysis by the choice of a discount rate. The economic feasibility of a lengthy environmental restoration or conservation project with immediate (opportunity) costs and a slow flow of benefits over time is sensitive to the choice of discount rate (Vasquez-Lavin et al. 2019) and its form. While the appropriate social discount rate

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in cost–benefit analysis of intergenerational policy effects is a topic of discussion in itself (Freeman and Groom 2014; Groom et al. 2005), the discount rate and its form implicitly or explicitly expressed by the current generation remains an area with relatively few empirical examples.

In valuation context the public's discount rate has been studied by altering the time schedule for providing the good or the payments. The typical approach in analysing the effect of a payment schedule on willingness to pay, or the embedding effect in timing, has been to compare a lump-sum payment with some series of payments (Table 8, "Appendix"). The typical series include annual payments for ten years and an intermediate time period, while a group of studies (Brouwer et al. 2008; Kim and Haab 2009; Egan et al. 2015) have also tested perpetual payments. Previous stated preference valuation studies—contingent valuation and choice experiment studies have found implicit discount rates ranging between 20 and 270% (Table 8, "Appendix"). A direct comparison between the prior studies is challenging due to the difference in the valued environmental good and time schedules of the proposed change. However, it appears that willingness to pay (WTP) per payment occasion is rather insensitive to the number of payment occasions, i.e. the *total* WTP increases as a function of the presented number of payment occasions.

Egan et al. (2015) recently called for investigation into how consumers consider payments in different settings and time horizons. Our study takes the challenge considering the effect of a varying payment schedule on a population level in connection with long-term environmental change in a mire conservation setting using choice experiments (CE).

We focus on ecosystem services provided by mires in southern Finland up until the year 2050. Mire conservation produces a slowly increasing flow of benefits under natural processes, where conservation costs are borne up front via compensated voluntary and involuntary land acquisitions. This feature provides a possibility to analyse whether small delays in the payment schedule affect WTP while credibly maintaining the expected realization time of environmental outcomes. Delays in payment schedule may affect the stated preferences for mire protection attributes. Further, the setting allows analysing if taste heterogeneity changes by the payment schedule.

Prior studies have commonly employed a constant discount rate over time, or exponential discounting. In the context of nature conservation this assumption suppresses values in the distant future (Vasquez-Lavin et al. 2019). Previous studies have demonstrated that consumers show signs of hyperbolic discounting, i.e. a 'present bias' where the discount rate decreases over time (Lew 2018). This behavior implies a lower discount rate for the far future than the near future. In other words, hyperbolic discounting behavior is more impatient (i.e. discount values heavily) for immediate benefit–cost tradeoffs but has more patience for benefit–cost tradeoffs that occur far in the future (Meyer, 2013a). In project evaluation, compared to exponential discounting, hyperbolic discounting behavior increases the importance of values accruing over a long run in decision making (Karp 2005; Karp and Tsur 2011). In this paper we explore both exponential and hyperbolic specifications of discounting.

For measuring discount rates in stated preferences studies two approaches have been employed; an exogenous, or external approach (as in Viscusi et al. 2008 and Egan et al. 2015; Wange and He 2018), and an endogenous, or internal one (as in Bond et al. 2009; Andersson et al. 2013; Lew 2018). In the exogenous approach the discount rate is calculated outside the valuation model, while in the endogenous approach the discount rate is directly estimated within the valuation model by using sample-level variation in the benefits or the payment horizon.

We use the endogenous approach to jointly estimate the implicit discount rates and preferences using choice experiment data. We explore the discount rate varying the payment schedule across the sample where payments are specified as either lump-sum payments of annual ten-year payments. To show the effect of delay of payments we propose respondents annual ten-year payments with three different time delays, i.e. 0, 3 and 6 years of delay. These treatments allow us to analyse the relative strength of the time-embedding effect in relation to understanding the role of payment timing in a more or less distant future period.

Our findings will enhance the rather limited literature regarding the effect of payments using choice experiment data. Most of the relevant past studies refer to contingent valuation applications. By exploring whether a discount rate can be jointly estimated in choice modelling we aim to contribute to the discussion mainly raised in Egan et al. (2015) and Lew (2018) regarding the use of lump-sum vs annuals streams of payments. Also, by incorporating variation in the delay of payments we will explore whether the payment schedule follows a certain form of discounting. To the best of our knowledge this is the first study in CE literature that investigates this. Unlike prior studies, we study the discount rates by time schedule treatments with a split sample design rather than looking at individual consumers' time preferences. This makes our approach free of individual level survey anchoring effects in the time preference elicitation. Finally, we provide an addition to the literature on discount rates and welfare estimates for the conservation of northern European mire ecosystem services, filling an essential knowledge gap.

We next describe the case study, data collection and choice experiment and the design of time-frame treatment in the data and methods section. The econometric models and discount rate calculation are explained in a respectively named section followed by the results and final discussion.

2 Case Study Description

Benefits from mire protection emerge over a long period of time. The implementation costs of a conservation program constitute mainly from land purchases and can be scheduled either in the very beginning of implementation or they can take place during a longer time period of land acquisition. This feature of the conservation program provides a natural setting to test the effect of payment scheme on willingness to pay.

Originally over a quarter of the nation's land area, the majority of mires in Finland have been drained for forestry (Metsähallitus, State Forest Enterprise 2016). Mires have also been cleared and drained for peat extraction and, to a smaller degree, agricultural use. Concerns over self-sufficiency and the political impetus for bioeconomy-based economic growth (Prime Minister's Office 2015) have increased pressure to expand the use of peat as an energy source. Due to exhausting production areas, just maintaining the current peat use in energy production will require tripling of the production area, currently about 400 km^2, to 1200 km^2 by 2050.

The utilization of non-market ecosystem services from mires is in direct conflict with most economic activities. Draining typically deteriorates, and peat extraction essentially shuts down the functioning of mires as a habitat for animal and plant species, and also hinders recreational activities (e.g. berry picking and hiking). Peat extraction areas release large amounts of carbon to the atmosphere. After extractive processes have ended, mires may restore naturally over a long time period.

The most recent estimate in 2008 lists roughly 50% of the undrained mire areas in southern Finland as endangered and 40% as near threatened biotopes (Kaakinen et al. 2008). Despite considering the current conservation areas inadequate, in late 2014, the Finnish Ministry of the Environment postponed a prepared update to the mire protection programme, the Complementing Mire Protection Programme (CMPP). The CMPP aimed at conserving biodiversity by protecting spatially connected areas with high natural values. The focus of the legislator shifted from government-enforced actions to favouring voluntary mire conservation by private land owners. As there is inherent uncertainty in the success of a voluntary programme, we study mire protection scenarios that are better and worse than the goals of the original CMPP.

3 Choice Experiment Design and Data Collection

3.1 Defining the Attributes and Their Levels

We used the CICES classification (CICES 2016) of ecosystem services to identify the set of ecosystem services enhanced by mire conservation. After an initial expert screening of relevant ecosystem services, we arranged a layman focus group discussion to highlight the most important services to be used as attributes in a choice experiment. This process led to identification of five attributes that describe the effects of mire protection: climate effects and carbon storage, mire species diversity, water quality, the area of mires suitable for berry picking, and a change in the level of peat production and the share of domestic fuels in national energy production (Table 1). The last attribute takes into account the effect of peat production on local employment and energy self-sufficiency.

To determine realistic attribute descriptions and levels, we used expert advice and GIS analyses to construct a baseline scenario for the year 2050. This was a peat-based bioeconomy scenario, where annual peat extraction would be increased by 30% from its current level, mostly targeting unprotected peatland areas, but also some areas with a high natural value if profitable. The other end of the range of attribute levels was obtained from a conservation programme in which peat extraction would decrease by 30% and economic activities would only focus on previously drained mires. These scenarios provided the attribute level ranges (see Sect. 3.3 Implementation of the CE).

3.2 Design of the Choice Tasks

Attribute levels for the choice tasks were allocated using an efficient experimental design in the choice experiment survey (Rose and Bliemer 2009). Generating an efficient design requires specifying priors for the parameter estimates. The pilot survey design was constructed with uninformed priors, where parameter estimates from the pilot study provided priors for the final experimental design. This was a Bayesian D-efficient design using Ngene (v. 1.0.2) software, taking 500 Halton draws for the prior parameter distributions.[1] We generated 36 choice tasks, blocked into 6 subsets, resulting in six choice situations for each respondent.

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[1] D-error 0.097854.

Table 1 Descriptions of attributes in the choice experiment

Attributes	Variable name	Level	Description of effect
Carbon storage	Climate_H Climate_M Climate_L	Decrease by 6% Decrease by 9% Decrease by 12% (status quo)	*Carbon storage and climate effects* The peat and trees in peatlands bind carbon from the air. Peat production areas heavily release the stored carbon to the atmosphere, accelerating climate change
Peatland species diversity	Peatland_H Peatland_M Peatland_L	Remains at current level Deteriorates slightly from current level Deteriorates significantly from current level (status quo)	*Peatland species diversity effects* Peatlands offer a habitat for species acclimatized to peatlands. Peat production destroys peatland species habitats
Number of lakes with poor water quality	Water_H Water_M Water_L	Increase by 10 Increase by 70 Increase by 100 (status quo)	*Water quality effects* Peatlands with drainage release humus and nutrients to downstream surface waters. These effects can cause local harm to water recreation and aquatic species
Area in a natural state suitable for berry picking	Berry_L Berry_M Berry_H	120 km^2 (status quo) 370 km^2 850 km^2	*Berry picking effects* Berry picking is allowed in peatlands, regardless of their protection status, by everyman's rights. Significant edible berries growing in peatlands are the cloudberry, cranberry and bilberry
Use of peat and share of domestic energy production	Energy_H Energy_M Energy_L	Decreases by 7% Remains at the current level, 10% Increase by 13% (status quo)	*Peat use for energy production effects* In peat production, the peatland requires drainage and the peat is extracted for fuel and use as a seedbed. Peat is a domestic fuel and in the short term replaces coal burning from foreign sources
Tax payments	Tax	0, 10, 20, 50, 100, 200, 300, 500	*Welfare effects* Economic contribution to peatland conservation through taxation

3.3 Implementation of the CE

The choice situation was introduced to survey respondents explaining the alternatives for mire use in southern Finland. Survey respondents were motivated with a note stating that the information acquired would help decision-makers to guide the future use of peatlands in Finland. Each choice task was also preceded by a reminder on the personal budget constraint, alternate uses of money including other forms of nature protection, and on the time scale of the effects, beginning to form in 2017 and reaching their full extent in 2050.

Table 2 provides an example of a choice set, where option Y includes the best environmental state for each attribute and the lowest peat production level, and option Z an intermediate level for each attribute. The current development has the worst environmental state for each attribute and the highest peat production level.

3.4 Payment Schedule Treatment

We tested four payment schedules with independent split samples to avoid having individual respondents anchoring or adjusting their stated preferences to multiple payment schedules. An equal number of respondents were allocated to each split sample. The split sample design implies that the time preferences are observed at a population level instead of individual level. The payment schedule subsamples were as follows:

1. Lump-sum payment: a single payment in 2017
2. 10-years annual payment (total sum informed) starting in 2017 and lasting until 2026
3. 10-years annual payment (total sum informed) starting in 2020 and lasting until 2029
4. 10-years annual payment (total sum informed) starting in 2023 and lasting until 2032

The lump-sum payment varied between 0, 10, 20, 50, 150, 200 and 500 euros. The same scale was used for annual payments in subsamples 2, 3 and 4, implying accumulating payments of up to €5 000 over ten years. The total sums were shown to respondents as suggested by Egan et al. (2015). For the lump-sum payment, respondents were reminded that the single payment would cover the whole policy period.

3.5 Data Collection

The choice experiment attributes were tested in a focus group meeting and the collected experience helped to clarify and sharpen the questionnaire. The survey questionnaire was tested on a pilot sample of 204 respondents. The final survey was gathered between August and October 2016 as an internet survey from a respondent panel to ensure a nationally representative sample for the survey. The internet panel by Taloustutkimus Oy comprised over thirty thousand respondents recruited to the panel using random sampling to represent the population (Taloustutkimus 2017). The invitation e-mail that was sent to respondents did not reveal the topic of the survey but informed them about the possibility of obtaining a prize. From the contacted panel members 71% did not start responding the survey and 11% interrupted either immediately or during the survey. It was challenging to obtain respondents especially from younger panellists who are reluctant to respond to longer and more demanding surveys and who tended to interrupt responding. After five reminders, 1997

Table 2 An example of a choice set

	Situation in 2050		
Effects on peatlands of southern Finland in 2050	Current development	Option Y	Option Z
Carbon storage decreases from the current level (strengthening climate change)	12%	6%	9%
Peatland species diversity	Deteriorates significantly from the current level	Remains at the current level	Deteriorates slightly from the current level
Number of poor water quality lakes increases by	100 lakes	10 lakes	70 lakes
Area of peatland in a natural state suitable for berry picking	120 km²	850 km²	370 km²
Change in the use of peat and share of domestic energy production	Increases from the current level, 13% share	Decreases from the current level, 7% share	Remains at the current level, 10% share
Effect on your taxes (*payment schedule treatment*)	€0/year	€Y/year (in ten years altogether €Y*10)	€Z/year (in ten years altogether €Z*10)
I support this alternative	–	–	–

Which of the following options would suit you best in the absence of other options? Please remember that the money amount collected through taxes would be away from other consumption and that policy effects on mires begin immediately in 2017, reaching their full extent in 2050

Table 3 Descriptive statistics for the full sample

Socio-demographic variables	Sample	Population
Age (mean)	52.2	42.0[a]
Gender (% males)	54.7	49.3[a]
Educational level (college or higher, %)	56.8	32.5[a]
Household size (equal to or lower than 2 members, %)	70.4	75.8[a]
Median annual household income (gross, €)	40 000–50 000	43 780[b]

[a]Statistics Finland 2016 (www.stat.fi/index_en.html)

[b]Statistics Finland 2015

respondents completed the whole survey, giving a response rate of 18%. The response rate, although low, was higher than the average (13%) for the panel. Table 3 presents descriptive statistics for the final data showing overrepresentation by males, an older population with above-average education and income, and underrepresented by the population with larger households. There were essentially no statistically significant differences across the payment schedule treatment groups by age, region, gender, income or education level.[2]

4 Econometric Models and Welfare Estimates

4.1 Mixed Logit with Interactions Model

Preference heterogeneity can be modelled by employing a mixed logit model (Mc Fadden and Train 2000; Train 1998, 2003; Hensher and Greene 2003). The model reveals preference variation both in terms of unconditional taste heterogeneity (random heterogeneity) as well as conditional heterogeneity (systematic heterogeneity) where individual characteristics or other factors of interest interact with choice-specific attributes and/or with the alternative specific constant (ASC) (Train 2003; Hensher et al. 2015). A mixed logit model with interactions (McFadden and Train 2000; Train 1998) is employed in case of a priori assumptions regarding the sources of heterogeneity. In this paper we investigate whether preferences are affected by the version of payment schedule. Hence, we first explore a mixed logit with interactions model where all attributes (including the ASC) interact with the four payment versions of the choice experiment.

The random utility theory (Mc Fadden 1974) is the baseline framework for modeling individual preferences within the choice experiment context. The framework suggests that each respondent faces a set of mutually exclusive alternatives, $j = 1, 2,…,J$. The level of respondents' utility U_j that is obtained from each alternative is decomposed into the deterministic part V_j and the unobserved part ε_j $\forall j$ which is considered random. V_j is linear in the k observable attributes x_j and payment A_j [Eq. (1)].

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[2] Chi-square tests reveal significant difference (*p*-value 0.05) across versions in education—version 2 subsample has 8.8% respondents with comprehensive school level compared to version 3 sub-sample's 7.4%.

$$U_{nj} = V_{nj} + \varepsilon_{nj} = \sum_k \beta * x_{nkj} + \gamma * A_{nj} + \varepsilon_{nj} \tag{1}$$

Accounting for heterogeneity, the utility model includes two additional terms; the term $\delta_n * x_j$ that aims to capture random taste among individuals and $\mu_m * p_m$ that captures the systematic heterogeneity around each attribute (and/or ASC) which here is associated with payment version p, thus interacting with each attribute x. The utility for any individual n is specified as:

$$U_{nj} = \sum_k \beta * x_{nkj} + \delta_n * x_{nkj} + \sum_k \sum_m \mu_m * p_m * x_{nkj} + \gamma * A_{nj} + \varepsilon_{nj} \tag{2}$$

Equation (2) can be rewritten in a comparable form to the standard conditional logit by substituting $b_n = \beta + \delta_n$, implying that the coefficients may now vary randomly across individuals n. Since the coefficient vector b_n is not observed, we may assume that it follows a distribution with density $f(b_n)$. The mixed logit probability of choosing alternative j is a weighted average of the logit formula evaluated at different values of b with the weights given by the density $f(b)$. The model assumes that the mixing distribution is continuous and b follows a normal, log-normal, uniform, triangular, gamma or any other distribution (Hensher et al. 2015). Choice probabilities are the integral of standard logit probabilities over a density of parameters

$$P_{nj} = \int \frac{exp(x_{nj}b_n')}{\sum_{j=0}^J exp(x_{nj}b_n')} f(\beta) d\beta \tag{3}$$

The integral has no analytical solution but can be approximated by simulation. One must make assumptions about how b coefficients are distributed over the population, take a set of R draws and then calculate the logit probability for each draw.

4.2 Discount Rate Estimation Models and Econometric Specifications

The present value (*PV*) of payment A is estimated using a non-linear specification of the discount formula. Here we investigate two forms of discounting, i.e. an exponential form and a hyperbolic one.[3] *PV* is the sum of T discounted payments of size A which begin at time t$=$0 and finish at time T $-$ 1 for all model specifications. *PV* is estimated according to the anticipated discount formula:

a. In case of exponential discounting the *PV* is:

$$PV = \left[\sum_{t=0}^{T-1} A * \frac{1}{(1+\rho)^{t+D}} \right] = A * \left(1 + \frac{1}{\rho}\right) * \left(1 - \frac{1}{(1+\rho)^T}\right) * \left(\frac{1}{(1+\rho)^D}\right) \tag{4}$$

b. in case of a Mazur hyperbolic discounting (Mazur 1987) the *PV* is:

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[3] We also tried to explore a quasi-hyperbolic model so as to estimate the present bias parameter. Our model outcome showed a small bias parameter implying a strong present bias. Though, the discount rate parameter was negative and when restricted to be positive (by using an exponential expression) was found close to zero and outside 95% confidence intervals (questioning hence model convergence). This is a counterintuitive result that we cannot interpret.

$$PV = \left[\sum_{t=0}^{T-1} A * \frac{1}{1 + \omega * (t + D)}\right] \tag{5}$$

c. and under Harvey hyperbolic discounting (Harvey 1986) the *PV* is:

$$PV = \left[\sum_{t=0}^{T-1} A * \left(\frac{1}{1 + (t + D)}\right)^{\mu}\right] \tag{6}$$

where ρ, ω *and* μ and D denote the discount rate parameters and the delay of payments, respectively.

The exponential formula implies constant discount rates whereas the hyperbolic specifications imply discount rates that decline as the discounted event is moved further away in time (Loewenstein and Prelec 1992). Outcomes in the near future are discounted at a higher implicit rate than events in the distant future. To estimate the instantaneous discount rates at time t we used the following formula:

$$\frac{-f'(t)}{f(t)} \tag{7}$$

where $f(t)$ is the discount formula in each model specification. For exponential discount formula, the discount rate is constant and is represented by a constant rate equal to ln $(1 + \rho)$. For Mazur and Harvey hyperbolic formulas the instant rate declines with time and corresponds to $\frac{\omega}{1 + \omega * t}$ and $\frac{\mu}{1 + t}$ respectively.

The data are analysed using a non-linear mixed logit model that extends the utility function beyond the linear specification. The corresponding utility is then:

$$U_{nj} = V_{nj} + \varepsilon_{nj} = \sum_{k} b * x_{nkj} + \gamma * PV + \varepsilon_{nj} \tag{8}$$

Each model specification incorporates all environmental attributes (Table 1), the implicit discount rate r as well as an alternative specific constant (ASC) that takes the value of one when the status quo choice is selected and zero otherwise. All environmental attributes are coded by applying effects-coding so as to avoid misinterpretation of estimates and correlation problems with ASC (Bech and Gyrd-Hansen 2005; Hensher et al. 2015). With the exception of the payment variable and the discount rate, all parameters are specified random under a normal distribution. The latter specification facilitates the calculation of WTP estimates. As WTP from a mixed logit model is given by the ratio of two random distributions, the resulting WTP distribution has infinite moments and, hence, poorly defined mean and standard deviation (Czajkowski et al. 2016). Parameter estimates of the mixed models are based on simulation. To reduce computation time, the estimations were performed using intelligent draws. All models were estimated using NLOGIT 6. Nonlinear mixed logit models were performed using 250 Halton draws while mixed logit with interactions models were performed using 500 Halton draws.

4.3 Welfare Estimates

The welfare change related to a hypothetical choice scenario can be estimated by using the compensating surplus (CS) measure, which corresponds to the amount of money that individuals must pay or accept, so that after the hypothetical change they can be as well off as

Table 4 Probability of accepting the tax payment per version of the payment

	Lump-sum payment (V1)	Payment over 10 years/Starts in 2017 (V2)	Payment over 10 years/Starts in 2020 (V3)	Payment over 10 years/Starts in 2023 (V4)	Sig
Payment	Probability of accepting the payment (%)				
0	0.676	0.657	0.625	0.624	0.070
10	0.590	0.613	0.580	0.579	0.437
20	0.559	0.557	0.543	0.536	0.755
50	0.342	0.336	0.318	0.361	0.320
100	0.248	0.286	0.307	0.323	0.014
200	0.223	0.245	0.251	0.262	0.448
300	0.248	0.212	0.300	0.304	0.000
500	0.248	0.292	0.256	0.273	0.293

before the change. Given an increase in the quality of a public good, the CS is represented by the expected WTP, which can be derived by substituting the estimated parameters in the formula below (e.g. Colombo et al. 2009; Casey et al. 2008; Kosenius 2010; Birol et al. 2006):

$$E(WTP) = -\frac{1}{\gamma} \sum b_i \left(x_i^1 - x_i^0 \right) \tag{9}$$

where $b_i x_i^1$ and $b_i x_i^0$ represent the states before and after the change. The CS estimation was adjusted so as to account for the fact that all environmental attributes are coded using effects coding. In this case the reference point is defined as the negative sum of the estimated coefficients. For a change where all attributes are improved from a baseline state, i.e. low preservation level to a high preservation state the CS will be:

$$E(WTP) = -\frac{\sum \left[b_{H,i} - \left(-b_{H,i} - b_{M,i} \right) \right]}{\gamma} \tag{10}$$

where $b_{H,i}$ correspondents to the estimated parameter of attribute i at high preservation state and $b_{M,i}$ at medium preservation state. The baseline state will be equal to the negative sum of both.

5 Results

5.1 Descriptive Results

Table 4 reports the probability of accepting an alternative choice according to the bid and payment schedule. Despite some noise around the tendency, the probability of accepting an offered bid or payment declined with higher offers. The probability of accepting a zero bid decreased with annual payments that extent in future. For the lump-sum payment version (V1), the proportion of acceptance reached a high of approximately 60% for €10/year and a low of 22% for €200/year. For the majority of payments, the probability of acceptance did not differ statistically significantly across versions, and the same high and low percentages

were noticed at corresponding payment levels. With the exception of €100 and €300 bids, the probability of acceptance didn't increase when prolonging the period of non-payment (V3 and V4). This baseline figure indicates signs of payment schedule insensitivity across subsamples.

The high % proportion of 'Yes' responses for the highest bids (over 200) resulted in fat tails of payment distribution. Possibly this is due to the 'yea saying' phenomenon often observed in stated preferences surveys (Parsons and Myers 2016) but further investigation is out of the scope of this paper. To deal with this we replaced all values over 200€ with random numbers assuming a half normal distribution. The distribution is reported in Fig. 3 in "Appendix".

5.2 Mixed Logit: Interactions with Payment Versions

We first explored whether benefits differed by payment schedule.[4] Table 5 reports the results of the mixed logit with interactions model where all attributes (except tax) interact with the different payment versions. The table is limited to show only the statistically significant estimates (for an extensive version see Table 9 in "Appendix"). Pseudo R^2 value indicated an adequate performance of the model.

Almost all parameter coefficients were found statistically significant with values increasing alongside improved attribute levels. The ASC estimate was negative, suggesting higher utility from shifting away from the status quo, but possibly also indicating external factors playing a role in choices. The coefficient of tax payment was negative, as expected. Peatland diversity and quality of water were the attributes with the highest marginal utility when the conservation is attained at high level. We found for almost all attributes significant presence of heterogeneity. Hence all individuals within the sample could not be represented by the same sign for these attributes. The ASC, in particular, showed large dispersion calling for further exploration of heterogeneity.

The systematic heterogeneity around the mean values of model parameters could be explained by the time frame of payment but only for ASC and two CE attributes, i.e. peatland diversity and water quality. For the rest of CE attributes the interaction terms weren't found statistically significant. Therefore the benefit side of the valuation exercise could only be partially dependent on the payment side. For peatland diversity and water quality at high preservation state the expected welfare benefits would decrease in the case of annual payments and delay of payments. Also, heterogeneity in the mean parameter estimate of the interaction term of ASC with payment versions was found smaller for all annual versions compared to the lump sum one, suggesting that respondent would be more willing to shift from the status quo and choose a preservation option in case of annual payments than lump sum one. Though for delayed payments respondents' marginal utility for options away from current state would decrease since interaction terms estimates were found to be lower for V3 and V4 compare to V2. Hence, the welfare estimate for ASC would depend on the payment side.

5.3 Discounting Models

Table 6 reports the results of the mixed logit models given different specifications of the discount formula, i.e. exponential and hyperbolic (Mazur and Harvey). All models were

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[4] The survey respondents were informed that the stream of benefits start immediately in year 2017 where full benefits would occur by 2050 irrespective of the payment schedule split sample.

Table 5 Mixed logit with interactions model

Attributes	Coef.f	Std. error	Std. dev	Std. error
ASC_{SQ}	−1.324***	0.362	4.326***	0.187
Climate_M	0.192***	0.053	0.032	0.088
Climate_H	0.202***	0.055	0.233***	0.066
Peatland_M	0.203***	0.050	0.191**	0.083
Peatland_H	0.589***	0.069	0.539***	0.043
Water_M	0.009	0.052	0.213**	0.067
Water_H	0.602***	0.061	0.409***	0.047
Berry_M	0.140**	0.057	0.313***	0.054
Berry_H	0.110	0.069	0.440***	0.047
Energy_M	0.099*	0.056	0.004	0.059
Energy_H	0.226***	0.058	0.395***	0.047
Tax	−0.006***	0.000	–	–
Interactions (V1 as reference)	Heterogeneity around the mean			
ASC_{SQ} x V2	−1.709***	0.463	–	–
ASC_{SQ} x V3	−0.875*	0.466	–	–
ASC_{SQ} x V4	−1.357**	0.460	–	–
Peatland_H x V2	−0.166*	0.089	–	–
Peatland_H x V3	−0.195**	0.089	–	–
Peatland_H x V4	−0.314***	0.089	–	–
Water_H x V2	−0.251**	0.081	–	–
Water_H x V4	−0.162*	0.081	–	–
LL	−8703.081	–	–	–
AIC	17,518.2	–	–	–
R^2	0.339	–	–	–
Sample size	11,982	–	–	–

The notation V1, V2, V3, V4 stands for payment version 1: lump sum, 2: 10 year annual no delay, 3:10 year annual 3 years delay and 4 10 year annual 6 years delay, respectively

***1% significance level, **5% significance level, *10% significance level

statistically significant with a pseudo-R^2 fit measure to be around 0.32 units across models. The exponential model specification showed the lowest model fit based on performance statistics (Akaike's Information Criterion (AIC), Bayes Information Criterion (BIC) and Log Likelihood (LL) estimates). Mazur specification fit data better than Harvey specification, but only marginally. For the latter, we estimated the relative likelihood value to compare the relative plausibility of Mazur and Harvey specifications. The relative likelihood value implied that Harvey model is 0,35 times as likely as the Mazur model to minimize the information loss.

Overall, the estimated parameters varied across different models but mainly only in magnitude. In all models a better state of CE attributes was associated with a higher marginal utility level with few exceptions, e.g. the area of berry picking. The ASC estimate found to be smaller when discount rate is assumed constant than at declining rate. The coefficient of tax parameters ranged from 0.001 to 0.003 where the exponential model specification showed smaller estimates than the hyperbolic specifications. This implies that under the assumption of a constant discount rate respondents seem less payment sensitive

Table 6 Results of mixed logit models assuming different specifications of discount rate

Attributes	Exponential		Mazur		Harvey	
	Coeff	Std. error	Coeff	Std.error	Coeff	Std.error
ASC$_{SQ}$	−1.085***	0.205	−1.356***	0.214	−1.339***	0.213
Climate_M	0.150***	0.024	0.141***	0.024	0.141***	0.024
Climate_H	0.246***	0.023	0.222***	0.023	0.222***	0.023
Peatland_M	0.174***	0.023	0.166***	0.023	0.167***	0.023
Peatland_H	0.543***	0.034	0.502***	0.034	0.501***	0.035
Water_M	0.020	0.023	0.001	0.023	0.001	0.024
Water_H	0.494***	0.030	0.469***	0.030	0.471***	0.030
Berry_M	0.127***	0.026	0.104***	0.027	0.103***	0.027
Berry_H	0.007	0.031	0.040	0.031	0.042	0.032
Energy_M	0.123***	0.025	0.107***	0.026	0.106***	0.026
Energy_H	0.178***	0.027	0.155***	0.028	0.153***	0.028
Tax in present value terms	−0.001***	0.000	−0.003***	0.000	−0.003***	0.000
δ	0.141***	0.021	–	–	–	–
ω	–	–	1.309***	0.162	–	–
μ	–	–	–	–	0.938***	0.054
Marginal discount rate						
Year 1	0.132	–	0.567	–	0.469	–
Year 2	0.132	–	0.313	–	0.362	–
Heterogeneity	Std. dev	Std. error	Std. dev	Std. error	Std. dev	Std. error
ASC$_{SQ}$	3.204***	0.146	3.296***	0.151	3.280***	0.150
Climate_M	0.045	0.040	0.054	0.040	0.054	0.040
Climate_H	0.069	0.046	0.074	0.046	0.074	0.046
Peatland_M	0.124**	0.044	0.139**	0.043	0.139**	0.043
Peatland_H	0.469***	0.037	0.454***	0.037	0.456***	0.037
Water_M	0.114**	0.041	0.128**	0.041	0.125**	0.041
Water_H	0.399***	0.044	0.409***	0.043	0.411***	0.043
Berry_M	0.254***	0.041	0.265***	0.040	0.263***	0.040
Berry_H	0.184***	0.052	0.185***	0.052	0.188***	0.052
Energy_M	0.021	0.054	0.032	0.056	0.029	0.055
Energy_H	0.352***	0.039	0.335***	0.040	0.337***	0.040
LL	−8936.929	–	−8902.349	–	−8903.384	–
AIC	17,921.9	–	17,852.7	–	17,854.8	–
BIC	18,099.3	–	18,030.1	–	18,032.2	–
R^2	0.321	–	0.324	–	0.324	–
Sample size	11,982	–	11,982	–	11,982	–

***1% significance level, **5% significance level, *10% significance level

that under the assumption of a decreasing rate. The estimated discount rate parameter was found statistically significant in all model specifications but of different magnitude, leading to different speculations on discounting. In the exponential model the discount rate

parameter was 14% whereas in the hyperbolic models the estimate was 131% for Mazur specification and 94% for Harvey one.

In hyperbolic discounting future values decline heavily after $t = 0$ but they don't reach zero in the long-run. The exponential discount specification prolonged the period of zero future values but that was because the discount rate found small in magnitude (if the model would result in high discount estimate then the importance of future values would be reduced to zero more rapidly, Groum et al. 2005).

Figures 1 and 2 illustrate how discount factors and discount rates are developed through time. At time $t = 0$ the discount factors in all cases is 1 since individuals don't discount the present. Respondents would value only the present ignoring the payment specifics that is whether it is a lump sum or annual payments or whether annual payments are delayed. Later times are discounted heavily and the discount factor is almost zero. Assuming a constant discount rate the discount factor decreases smoothly and people would discount the utility received in 10 years at about 27% relative to the present. In case of a declining discount rate, the discount factor drops quickly after $t = 0$, while after $t = 4$ and $t = 6$ the curves start to flatten out in Mazur and Harvey specification, respectively. The discount factors in year 10 were 10% and 7%, respectively. Though, in a longer time perspective, constant discounting results to an almost zero discount factor while hyperbolic discount implies small but over zero discount factors. Hence, while individuals are impatient with near term tradeoffs, hyperbolic discount suggests that people become more patient and consider each increment in the distant future more than they would in case of constant discounting.

Marginal discount rates were estimated according to function 7. The constant model suggested a flat rate of 13% annually. Hyperbolic models start with a high rate of 46–56% which indicates a high degree of impatience from year 0 to year 1, then in year 2 the rate drops in 32–36% and by the end of the period of payments ($t = 10$) the implied rate is
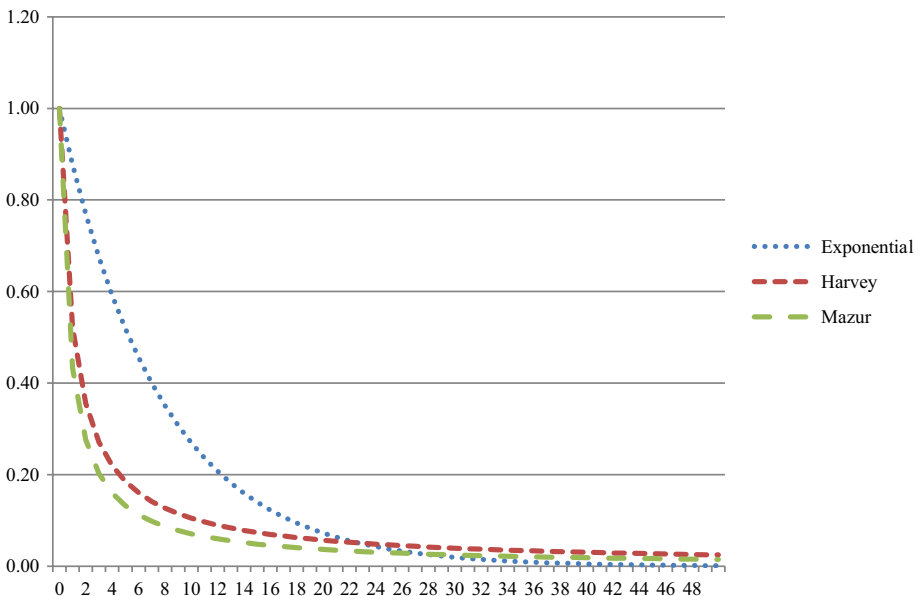

Fig. 1 Discount factors by year under different discount formulas and discount estimates
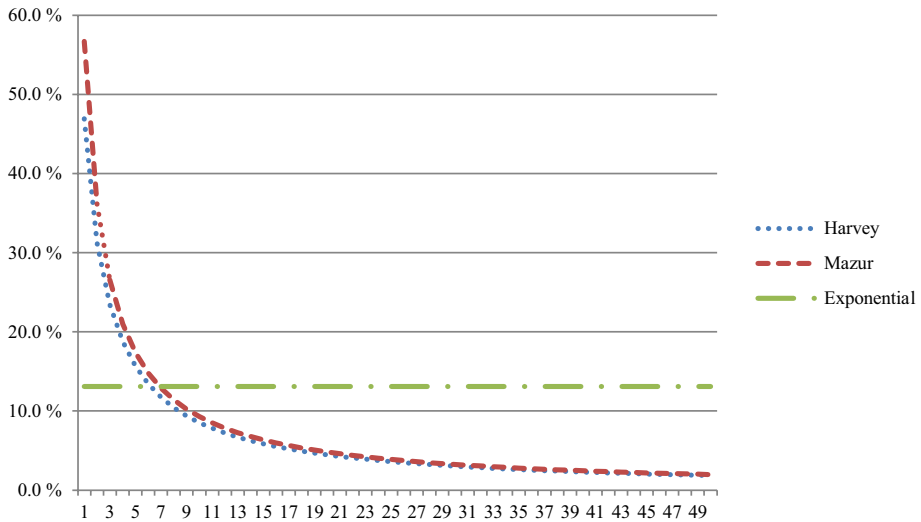
Fig. 2 Marginal discount rates by year under different discount formulas

below 9%. For a longer-term horizon the rates decrease to almost 2%. This is substantially lower than the constant rate.

5.4 Estimates of Compensating Surplus

Welfare analysis (Table 7) was specified for the baseline case that represents a policy orientation towards peat production and for two scenarios; scenario A and B where all environmental attributes are preserved at average and at the highest level, respectively. The baseline scenario was associated with negative CS in all model specifications and the welfare was improving when moving from baseline to either average or high preservation level. All model specifications suggested that a change from scenario A to B would reflect an increase in CS by almost 23%.

The present value of welfare estimates variated across the anticipated discount models. The lowest CS was observed under hyperbolic Mazur specification model and the higher under constant discounting. For the best preservation case scenario (i.e. scenario B) exponential model provided an estimate close to 4117€ per respondent, whereas hyperbolic gave as much as 57% lower estimates. This outcome is partly explained by the different payment coefficient and thus the different payment sensitivity that each model revealed. The exponential model showed the lowest payment sensitivity. Both hyperbolic models provide comparable estimates while their 95% confidence intervals were overlapping to some degree. The findings highlight that the choice of discounting is an important decision to be made in welfare analysis and results differentiate given the speculations around discounting specifics.

Table 7 Welfare change from baseline state to scenarios A and B (in €/respondent)

	Baseline	Scenario A: Peatland conservation at average level	Scenario B: Peatland conservation at the highest level
Status quo constant	1	0	0
Carbon storage	Decreases by 12%	Decreases by 9%	Decreases by 6%
Peatland species diversity deteriorates	Deteriorates significantly from the current level	Deteriorates slightly from the current level	Remains at current level
Number of lakes with poor water quality	Increases by 100	Increases by 70	Increases by 10
Area of peatland in a natural state suitable for berry picking	120 km^2	370 km^2	850 km^2
Share of peat use in domestic energy production	13%	10%	7%
Compensating surplus (with 95% confidence intervals in parenthesis)			
Exponential	−2807.95*** (−3386.16 to −2229.75)	3338.73*** (2628.31 to 4049.16)	4117.16*** (3269.37 to 4964.96)
Hyperbolic_Harvey	−1235.08*** (−1433.87 to −1036.28)	1432.22*** (1191.76 to 1672.67)	1763.61*** (1482.57 to 2044.64)
Hyperbolic_Mazur	−993.746*** (−1150.960 to −836.532)	1151.65*** (962.15 to 1341.15)	1416.49*** (1195.69 to 1637.28)

*** 1% significance level

6 Discussion and Conclusions

We investigated the effect of different payment schedules for a long-term mire conservation project employing a choice experiment. The study sample was divided into four subsamples, where the payment schedule varied (a lump sum payment, a 10-years annual payment starting from 2017, a 10-years annual payment starting from 2020 and a 10-years annual payment starting from 2022) for each subsample. This split sample approach aimed to explore the time preferences at population rather than at individual level, avoiding hence individual survey induced anchoring effects on time preferences.

We first explored whether payment versions are associated with preference heterogeneity and as such whether benefits would differ under different payment schedules. Next we estimated the implicit rate of time preferences under alternative discount rate specifications jointly with CE data to measure preferences. We assumed the following specifications: an exponential and a hyperbolic one. The CE data were estimated with a mixed logit model that accounts for preference heterogeneity.

We found strong indications of taste heterogeneity while the time frame of the payment could partly explain this observed taste heterogeneity. For most of the environmental attributes preferences were detached from the payment schedule. This temporal insensitivity of welfare benefits is in line with respondents' choices that are anticipated independent of payment schemes (Kim and Haab 2009). Though for changing peatland diversity and water quality to a high preservation state welfare benefits would lessen in the case of payment delays affecting thus the welfare analysis estimates for the best case scenario (i.e. environmental attributes at the highest preservation state). Also we found strong heterogeneity in the mean of ASC parameter implying that respondents would better prefer to forgo status quo and choose a preservation option when payments are annual than lump sum ones.

Our model findings revealed important information for the conservation of northern European mire ecosystem services. The case showed that Finnish citizens are in favour of mire conservation with a focus on preserving habitat ecosystem services and avoiding the deterioration of lake water quality. Nonetheless, the presence of heterogeneity implies that policy measures directed towards mire conservation would hardly be accepted in a consensus calling for the exploration of tailored local measures.

Across the discounting models we concluded that the hyperbolic specification performed better (under Mazur specification in particular), given the model fit statistics. Findings of previous studies are mixed with some studies providing evidence in favor of exponential discounting (e.g. Meyer 2013a, b) or evidence in favor of hyperbolic discounting (Grijalva et al. 2014; Vasquez-Lavín et al. 2019) or evidence in favor of both with no strong indications (Lew 2018).

A declining discount rate implies dynamic inconsistency in preferences and respondents that appear to be present-biased and thus more impatient for immediate benefit–cost trade offs. This may explain why according to summary statistics respondents were indifferent between lump sum and annual streams of payments even though annual payments would match with the duration of the benefits. Some possible explanation for the near-sighted behaviour of respondents is the difficulty of discounting and/or the inability of respondents to seriously consider the future streams of payments implied by the payment scheme (Myers 2017) that is regarded a temporal embedding problem similar to that of scope or scale embedding problems (Stevens et al. 1997).

When using a constant (exponential) discount rate function, we found an implied marginal discount rate of 13%, while when assuming declining rates we found a rate in the

range of 47–57% which decreases to almost 9% by the end of the payment period (i.e. in ten years). The substantial decline of discount rates in the long run is a desirable outcome particularly for our case specific study where the benefits are anticipated to be realized in the distant future and hence cost–benefit analysis should be extended further than the 10 years of time horizon.

Compared to former studies, our exponential and hyperbolic discount rate estimates are at the low end of some studies (e.g. Lew 2018; Wang and He 2018) as well as at the high end of other studies such as Bond et al. 2009 or Kim and Haab 2009 (Table 8, "Appendix"). High (low) discount rates can be justified by the short (long) time horizon of payments and hence a comparison of outcomes is only indicative. A full comparison is also difficult due to our population level approach. Integrating the timing of payment as a variable in future meta-analyses of empirical research could provide a comprehensive outline of the discounting behaviour findings, which, attached to certain approaches, could improve future CE design and interpretation of results.

Our results studying the discounting behaviour at a population level, rather than at individual level, raise a concern that survey respondents struggle with unassisted discounting. Offering multiple payment schedules with different time frames could maybe induce time consistent response behavior. Lacking comparative data to affirm this theory, we leave it for further studies.

Evidence of hyperbolic may involve confounding factors that reflect individuals' preference to care less about the future and which should not be mixed with pure time preferences. These factors include uncertainty about a future outcome, perceived future transaction costs and the phenomenon of subadditive discounting (Meyer 2013a). Payment structure insensitivity could also be related to attribute non-attendance and particularly to payment non-attendance. We found signs of payment non-attendance for the present CE study in Grammatikopoulou et al. (2019).

We conducted welfare analysis for different scenarios of peatland preservation and under different discounting model specifications. The lowest welfare estimate was anticipated when assuming hyperbolic discounting and the highest when assuming a constant discount rate. As noted in Lew 2018, a welfare analysis where future benefits and costs are involved and discount rate is either not estimated or is implied at a level commonly used for policy analysis (e.g., 3 or 7%) may result to misleading conclusions. Considering our empirical findings we support this view and suggest that future CE studies should include discount rate estimations under different specifications or approaches, if possible. Devoid the chance to do this, the choice of payment vehicle remains a challenging one; the use of a lump sum would be free of determining a discount rate (Lew 2018) while the use of a stream of annual payments would most likely correspond to the benefit horizon (Egan et al. 2015).

Similar to Egan et al. (2015), we would like to stress the importance of clear exposition of the total payment over the payment horizon and reminders for the entire payment period. We suggest that both lump-sum and yearly payments should be considered and implemented in future CE so that WTP estimates from both versions can be further tested.

Several studies in the past have demonstrated the presence of heterogeneity in discount rate estimates suggesting that discount rate can be a function of socio-demographic factors such as age, gender, income and education (i.e. Bond et al. 2009; Grijalva et al. 2014; Richards and Greene 2015; Meyer 2013a, b) or can be randomly varied across individuals (Meyer 2013a, b). To this end, we also recommend using a variety of model specifications, including joint mixed logit models that account for both taste and scale heterogeneity as well as choice heuristics such as attribute non-attendance (as in Lew 2018). One approach

to further delineate the heterogeneity of respondents concerning reactions to the timing of payment is latent class modelling which could provide more possibilities to illustrate the differences in WTP and discount rate estimates for respondent groups.
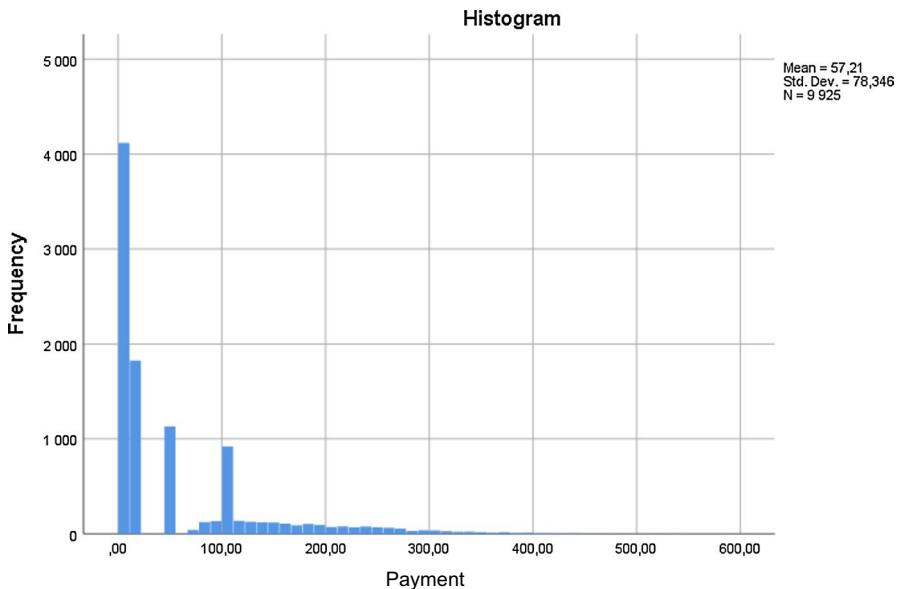
Appendix

See Fig. 3 and Tables 8 and 9.

Fig. 3 Payment distribution after payment reconfiguration

Table 8 Examples of prior studies using payment schedule variation to assess discount rates

Reference	Source of time variation	Discount rates	Valuation method
Stevens et al. 1997	Payment schedule, split sample: lump-sum versus five annual payments	50–270% between lump sum and annual payments over 5 years	Contingent valuation, dichotomous choice followed by open-ended questions
Stumborg et al. 2001	Payment schedule, split sample: 3-year versus 10-year annual payments	40% between yearly payments over 3 and 10 years	Contingent valuation, payment card
Brouwer et al. 2008	Payment schedule, respondent-chosen: lump-sum, perpetual monthly or annual payments	No assessment. 'Annual WTP values appear to be significantly higher than one-time-off WTP values, suggesting a negative implicit discount rate'	Contingent valuation, payment card
Kovacs and Larson 2008	Payment schedule, split sample: monthly payments over 1, 4, 7 or 10 years	35% between one-year monthly payments and other periods pooled, 20–71% between one-year monthly payments and other periods separately	Contingent valuation, double-bounded
Kim and Haab 2009	Programme completion, split sample: 5 and 10 years	98% between lump-sum payment and annual payments over 5 years	Contingent valuation, referendum dichotomous choice
	Payment schedule, split sample: lump-sum, annual payments for 5 or 10 years, perpetual annual payments discounted at 25% rate	102–131% between lump-sum payment and annual payments over 5 and 10 years 20% between annual payments over a 5-year period and perpetual annual payments 12–38% between annual payments over 5- and 10-year periods and perpetual annual payments	
Bond et al. 2009	Payment schedule, split sample: lump-sum, annual payments for 5 or 15 years	No difference in annual payments between lump-sum and 5-year annual payments 23% between lump-sum and annual payments over 5- and 15-year periods 80% between lump-sum and 15-year annual payments	Contingent valuation, referendum dichotomous choice

Table 8 (continued)

Reference	Source of time variation	Discount rates	Valuation method
Egan et al. 2015	Payment schedule, split sample: lump-sum, 10-year annual payments, perpetual annual payments	104% between lump-sum payment and annual payments over 10 years 62% between lump-sum payment and perpetual annual payments 15% between 10-year annual payments and perpetual annual payments	Contingent valuation, referendum dichotomous choice
Wang and He 2018	Payment schedule, split sample: lump-sum, 5-year monthly payments	Monthly discount rate of 7.6–12.6% or annual discount rate of 141–315%	Contingent valuation, multiple bound discrete choice
Lew 2018	Payment schedule, split sample: lump-sum, 5-year annual, and 10-year annual	Exponential and hyperbolic discounting assumptions lead to very similar results. Rates estimated within a range of 121–285%	Choice experiment
Vasquez-Lavin et al. 2019	Payment schedule, split sample: lump-sum, 5-year annual, and 10-year annual	Exponential and hyperbolic discount rates estimated within a range of 69–372%	Contingent valuation, open-ended format

Table 9 Extensive version of mixed logit with interactions model

Attributes	Coeff	Std.error	Std. dev	Std. error
ASC$_{SQ}$	− 1.324***	0.362	4.326***	0.187
Climate_M	0.192***	0.053	0.032	0.088
Climate_H	0.202***	0.055	0.233***	0.066
Peatland_M	0.203***	0.050	0.191**	0.083
Peatland_H	0.589***	0.069	0.539***	0.043
Water_M	0.009	0.052	0.213**	0.067
Water_H	0.602***	0.061	0.409***	0.047
Berry_M	0.140**	0.057	0.313***	0.054
Berry_H	0.110	0.069	0.440***	0.047
Energy_M	0.099*	0.056	0.004	0.059
Energy_H	0.226***	0.058	0.395***	0.047
Tax	− 0.006***	0.000	–	–
Interactions (V1 as reference)	Heterogeneity around the mean			
ASC$_{SQ}$ x V2	− 1.709***	0.463	–	–
ASC$_{SQ}$ x V3	− 0.875*	0.466	–	–
ASC$_{SQ}$ x V4	− 1.357**	0.460	–	–
Climate_M x V2	0.001	0.073	–	–
Climate_M x V3	− 0.028	0.074	–	–
Climate_M x V4	− 0.141*	0.073	–	–
Climate_H x V2	− 0.077	0.077	–	–
Climate_H x V3	− 0.073	0.077	–	–
Climate_H x V4	0.032	0.075	–	–
Peatland_M x v2	0.009	0.069	–	–
Peatland_M x v3	0.002	0.070	–	–
Peatland_M x v4	0.024	0.069	–	–
Peatland_H x V2	− 0.166*	0.089	–	–
Peatland_H x V3	− 0.195**	0.089	–	–
Peatland_H x V4	− 0.314***	0.089	–	–
Water_M x V2	− 0.107	0.070	–	–
Water_M x V3	− 0.112	0.072	–	–
Water_M x V4	− 0.052	0.070	–	–
Water_H x V2	− 0.251**	0.081	–	–
Water_H x V3	− 0.125	0.083	–	–
Water_H x V4	− 0.162*	0.081	–	–
Berry_M x V2	− 0.016	0.078	–	–
Berry_M x V3	− 0.043	0.080	–	–
Berry_M x V4	− 0.121	0.078	–	–
Berry_H x V2	− 0.045	0.095	–	–
Berry_H x V3	0.029	0.094	–	–
Berry_H x V4	0.110	0.092	–	–
Energy_M x V2	− 0.068	0.076	–	–
Energy_M x V3	− 0.031	0.079	–	–
Energy_M x V4	− 0.068	0.075	–	–
Energy_H x V2	− 0.108	0.078	–	–

Table 9 (continued)

Attributes	Coeff	Std.error	Std. dev	Std. error
Energy_H x V3	−0.106	0.079	–	–
Energy_H x V4	−0.115	0.078	–	–
LL	−8703.081	–	–	–
AIC	17,518.2	–	–	–
R^2	0.339	–	–	–
Sample size	11,982	–	–	–

The notation V1, V2, V3, V4 stands for payment version 1: lump sum, 2: 10 year annual no delay, 3:10 year annual 3 years delay and 4 10 year annual 6 years delay, respectively

*** 1% significance level, ** 5% significance level, * 10% significance level

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