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Estimating discount rates for environmental goods: Are People's responses inadequate to frequency of payments?

Felipe Vásquez-Lavín [a,b,c,d,*], Moisés Carrasco [e], Manuel Barrientos [f], Stefan Gelcich [b,c,g], Roberto D. Ponce Oliva [a,b,c]

[a] School of Business and Economics, Universidad del Desarrollo, Chile. Ainavillo 456, Concepcion, Chile
[b] Center of Applied Ecology and Sustainability (CAPES), Chile
[c] Instituto Milenio en Socio-Ecologia Costera (SECOS), Chile
[d] Center for Climate and Resilience Research (CR2), Santiago, Chile
[e] Departamento de Gestión Empresarial, Universidad de Concepción, Los Angeles, Chile
[f] Department of Economics, Universidad de Concepción, Concepcion, Chile
[g] Departamento de Ecología, Facultad de Ciencias Biológicas, Pontificia Universidad Católica de Chile, Santiago, Chile

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ABSTRACT

Most stated preference studies estimate discount rates using a split-sample approach. Each sample faces a different payment frequency (for instance, 1, 5, 10) together with a randomly assigned bid vector; both the frequency of payments and the bid are fixed for a specific individual. This paper evaluates whether allowing respondents to choose their preferred payment frequency affects the estimated discount rate. We use data from a contingent valuation survey of a network of marine reserves and estimate discount rates using both an exogenous and endogenous approach. The former calculates the mean of the willingness to pay (WTP) for each sample and then finds the discount rate that makes the present value of each payment frequency equivalent. The latter estimates the WTP and the discount rate jointly. Results show that allowing people to choose the payment schedule significantly reduces the implicit discount rate. We observed the highest reductions in discount rates when we used all the information available from the valuation questions to bound the WTP distribution. Our analysis suggests that the exogenous approach would not be recommended for testing the adequacy of people's responses to the frequency of payments.

1. Introduction

Many economists now believe that the implied discount rate—or subjective rate of time preferences—estimated from stated preferences (SP) using different payment frequencies is "*implausibly high*" (Egan et al., 2015; Lew, 2018; Myers et al., 2017). This phenomenon has been known as *temporal embedding* in the nonmarket valuation literature (Bateman and Langford, 1997a,b; Carson et al., 1997; Faccioli et al., 2016; Johnson et al., 2006; Kahneman and Knetsch, 1992; Stevens et al., 1997). However, studies in experimental economics and transportation also find high discount rates, sometimes

* Corresponding author. School of Business and Economics, Universidad del Desarrollo, Chile. Ainavillo 456, Concepcion, Chile.
E-mail address: fvasquez@udd.cl (F. Vásquez-Lavín).

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Table 1
Discount rates, Payment Frequencies, and Approaches in the Literature.

	Author and Year	Implicit Discount Rate	Payment Frequencies	Approach	Method
1	Howard et al. (2020)	14.5%–200%	1,5,10	Endogenous and Exogenous	CV
2	Vasquez-Lavín et al. (2019)	60%–340%	1,5,10	Endogenous	CV
3	Wang and He (2018)	141%, 315%	1,60	Exogenous	CV
4	Lew (2018)	122%, 227%	5, 10	Endogenous	CE
5	Myers et al. (2017)	837%, 351%	1, perpetual	Exogenous	CV
6	Egan et al. (2015)	15%, 104%, 62%	1,10, perpetual	Exogenous	CV
7	Chen et al. (2014)	100.3%	1,5	Exogenous	CV
	Bond et al. (2009)	23–80%	1,5,15	Endogenous	CV
8		1,315%,61%, 5.85% *	1,5,15	Exogenous	CV
9	Kim and Haab (2009)	20%–131%	1,5,10, perpetual	Exogenous	CV
10	Kovacs and Larson (2008)	30%	1,4,7,10	Endogenous	CV
		85%*	1,4,7,10	Exogenous	CV
11	Brouwer et al. (2008)	negative	1,12, perpetual	Exogenous	CV (Tobit)
12	Stumborg et al. (2001)	40%	3, 10	Exogenous	CV (Tobit)
13	Stevens et al. (1997)	50%–270%	1,5	Exogenous	CV
14	Bateman and Langford (1997)	50%	1, perpetual	Exogenous	CV-OE
15	Echeverría et al. (1995)	559%	1, perpetual	Exogenous	CV
16	Kahneman and Knetsch (1992)	130%*	1, 5	Exogenous	CV

* values imputed by Myers et al. (2017). CV = contingent valuation, CE= Choice Experiment, OE= Open-ended.

even higher than those found in SP studies (Andreoni and Sprenger, 2012; Andreoni et al., 2015; Cheung, 2019; Wang and Daziano, 2015).

The literature addressing implicit discount rates is vast, including studies on transportation, adoption of technologies, the value of statistical life, and environmental valuation (Anderson and Newell, 2004; Andersson et al., 2013; Grammatikopoulou et al., 2020; Lew, 2018; Wang and Daziano, 2015; Wang and He, 2018). From this literature, we found 16 articles satisfying two criteria: 1) they use SP to estimate both the implicit discount rate (discount rate, hereafter) and the willingness to pay (WTP); and 2) they use variation in the frequency of payments.

Our review shows that contingent valuation (CV) dominates this literature stream, characterizing 15 out of 16 articles (see Table 1). Lew (2018) is the only application using choice experiments (CEs). Recently, Grammatikopoulou et al. (2020) used CE, but we did not include this paper in our selection because they do not vary the payment frequency. Instead, they have the same frequency (10 years) with three different time delays (0, 3, and 6 years).[1]

Moreover, all the selected articles use a split-sample approach in which each sample faces a different payment schedule together with a randomly assigned bid vector (BID). For instance, one sample faces a one-time payment, while another faces a 5- or a 10-payment schedule (1, 5, 10, and 15 periods are widespread in the literature).

Most of the selected studies use an exogenous approach to estimate the discount rate. In this approach, the discount rate is estimated “outside” the valuation exercise (Howard et al., 2020; Lew, 2018; Wang and Daziano, 2015). The exogenous method calculates the mean WTP for each sample and then finds the discount rate that makes the present value (PV) of each payment frequency equivalent (Kovacs and Larson, 2008). The endogenous approach though takes advantage of the variation in the payment frequency across samples to jointly estimate the WTP and the discount rate (Bond et al., 2009; Howard et al., 2020; Kovacs and Larson, 2008; Meyer, 2013a, 2013b; Vasquez-Lavín et al., 2019).

Some of these articles found a “surprisingly” high discount rate (Crocker and Shogren, 1993; Kim and Haab, 2009; Lew, 2018; Myers et al., 2017; Stevens et al., 1997). For instance, values for the discount rate are above 500% in some cases (Bond et al., 2009; Echeverría et al., 1995; Myers et al., 2017) and 200–350% (Myers et al., 2017; Stevens et al., 1997; Wang and He, 2018), 100–151% (Chen et al., 2014; Egan et al., 2015; Kahneman and Knetsch, 1992; Kim and Haab, 2009; Stevens et al., 1997; Wang and He, 2018), 50–100% (Egan et al., 2015) or below 50% (Stumborg et al., 2001) in other cases.

There are fewer estimations of the discount rate using the endogenous approach. The reported values are in the order of 23–80% (Bond et al., 2009), 30% (Howard et al., 2020; Kovacs and Larson, 2008), 121–285% (Lew, 2018), and 60–340% (Vasquez-Lavín et al., 2019). The only three comparisons between exogenous and endogenous approaches using the same data were reported by Kovacs and Larson (2008), Bond et al. (2009), and Howard et al. (2020). The evidence regarding which approach provides higher discount rates is mixed. In the study of Kovacs and Larson (2008), the endogenous method provides lower discount rates than the exogenous approach. The discount rates from Bond et al. (2009) using the exogenous method (provided by Myers et al. (2017)) are, in one case, extremely high (1,315%), while the other two values are either similar or lower than some estimates using the endogenous approach (61% and 5.85%, respectively). Finally, Howard et al. (2020) found similar discount rates between the exogenous and endogenous approach, with only one outlier (200%) using the endogenous one and a random parameter model. The other two studies using the endogenous approach (Lew, 2018; Vasquez-Lavín et al., 2019) provide discount rates that are, in some cases, higher than several others using the exogenous one. Given that the

[1] We compare our results with those presented in this paper in the discussion section.

results seem to be considerably context-dependent, many authors note the need for more research on this issue (Boyle, 2017; Cook et al., 2018; Johnston et al., 2017).

Another characteristic common to all these studies is that an individual faces only one of various possible payment schedules (1, 5, 10 years, or perpetuity) (Echeverría et al., 1995). However, in many real markets, people have some flexibility to choose the frequency of payments for the goods they want to buy. Even in the few CEs found in the literature, researchers keep the frequency of payments fixed among the alternatives presented to individuals (Grammatikopoulou et al., 2020; Lew, 2018). Only one paper (Brouwer et al., 2008) offers respondents the option to choose the number of payment periods, but it does so sequentially such that they cannot take advantage of this information to estimate the discount rate.[2]

This paper evaluates whether estimated discount rates can be reduced by allowing respondents to choose the payment frequency provided in a CV survey. We show that the discount rates are indeed reduced significantly by following this approach.

In our application, we compare two different surveys to estimate the WTP and the discount rate for five marine protected areas (MPAs) in Chile. The first survey follows the traditional split-sample approach, with three different payment schedules: payments for 1, 5, and 10 years and a BID randomly assigned to each individual. In this version of the survey, respondents cannot choose the payment schedule. In the second survey, we provide respondents with the same options—1, 5, or 10 years (and the option of not paying)—and ask them to choose one and discard the others. We compare the discount rate from each approach using both the exogenous and endogenous ones. Our application resembles the payment card and the double-bounded method used in the CV literature (Champ et al., 2012). It would also work with the rank-ordered logit approach used by Lew (2018), but unlike this author, we vary both the BID and the frequency of payments among the alternatives presented to the respondents.

This paper presents two novel contributions to the literature. First, to the best of our knowledge, all previous studies estimating discount rates using SP did not allow respondents to choose their payment frequency. In our opinion, a CV study should create a scenario with situations as similar as possible to those encountered in real markets. When people want to buy durable goods, they hardly ever face a fixed payment schedule. Conversely, people generally decide jointly the amount of money they will pay and the number of payments they will make.[3] In our application, we replicate this scenario, presenting respondents with four alternatives: not purchasing the good or paying in 1, 5, or 10 annual payments whose value varies among the options.

Second, we argue, using a simple example, that the estimation of the implicit discount rate using the exogenous approach would not constitute a good practice for testing the adequacy of people's responses to the frequency of payments. The exogenous approach is based on the premise that a CV scenario asks people about the PV of a flow of benefits provided by an environmental good. Instead, CV asks people whether the PV of the payment alternatives is lower than the PV of the benefits. Although this might seem like a subtle difference, it implies that if we do not consider the (unknown) total value of the good, we cannot say anything about the consistency of people's responses under the exogenous approach. Comparing two PVs of payments does not reveal a subjective rate of time preferences but a *rate of return* that makes two payment schedules equally desirable (same PV). This *rate of return*, although high, could be entirely consistent with a low discount rate.

2. Materials and methods

CV uses questionnaires to elicit people's WTP for a good or service, creating a hypothetical market in which they can declare their preferences. There exist thousands of CV applications in diverse areas of economics whose main results are summarized in numerous publications covering both theoretical and empirical issues (Bateman and Willis, 2001; Bateman et al., 2002; Hoyos, 2010; Hoyos and Mariel, 2010; Mitchell and Carson, 1989). Although we are aware of many SP's criticisms, in this paper, we will focus on the specific issue of discounting in SP. Readers interested in those issues may refer articles regarding sound practices for economic valuation (Arrow et al., 1993; Bateman and Willis, 2001; Bateman et al., 2002;

[2] We do not include some groups of articles in our selection in Table 1. First, Andersson et al. (2013) compare different payment frequencies to estimate the value of a statistical life, but they do not provide any discount rate. Second, other articles using SP include time as part of the latency of the benefits and not in the payment frequency (Alberini et al., 2006; Alberini and Ščasný, 2011; Meyer, 2013a, 2013b·bib_Meyer_2013a·bib_Meyer_2013b; Rheinberger, 2011; Viscusi et al., 2008). Therefore, they do not satisfy the second criterion (variation in the frequency of payments). The discount rates in such articles are much lower than those in Table 1, ranging from 0% to 13% (see, for example, Meyer, 2013a; 2013b). Third, approximately 20 studies in the transportation literature use SP and, more commonly, CE (Wang and Daziano, 2015). The discount rates in these studies are more conservative than those reported in Table 1. Most of them are between 2% and 102% (Ewing and Sarigöllü, 2000; Hess et al., 2012; Musti and Kockelman, 2011), and there are even some negative values (Lloro and Brownstone, 2018). These articles assume perpetuity of future costs of transportation alternatives, and they do not vary the frequency of payments among alternatives; therefore, they do not satisfy the second criterion. Finally, another approach to estimating the discount rate is the experimental approach (Andreoni and Sprenger, 2012; Andreoni et al., 2015; Attema and Versteegh, 2013; Cheung, 2019; Dolan and Gudex, 1995; Harrison et al., 2002; Kirby, 1997; Kirby and Maraković, 1996; Kirby and Petry, 2004; McDonald et al., 2017; Redelmeier and Heller, 1993; Tanaka et al., 2010; Viscusi and Moore, 1989). The experimental elicitation results are broader than those in Table 1, showing discount rates ranging from 0% (Redelmeier and Heller, 1993) to 5,747% (Kirby, 1997). These experiments have a different design from our approach; they present respondents with two payment options at different time horizons (a smaller payment now or a larger one later) (Wang and Daziano, 2015). We focus on those articles using SP to value environmental goods and satisfy the two criteria described above.

[3] For instance, if you want to buy a car, you could likely pay for it in cash, or with flexible payment schedules of 2, 3, or 4 years with a different monthly payment and different interest rate for each alternative.

Champ et al., 2012; Johnston et al., 2017; Whittington, 1998, 2002, 2004, 2010). In a CV scenario with time horizons, people face the following question:

"Are you willing to pay B_t for T periods for the provision of the good?"

As in any market, people consider the budget constraint they face in each period and answer according to whether they can afford and desire to pay the requested amount. They make this decision regularly in formal markets, especially for durable goods. For instance, if they want to buy a house, they evaluate how much they can pay monthly and adjust the number of installments (and the implicit interest rate) to avoid commitments that may jeopardize their financial stability. Some may accept more payments at a lower value, although the PV they pay could be higher than one of the alternative options with fewer periods but higher payments, merely because they cannot afford the latter (Solino et al., 2009). Notably, to provide an adequate response to payment frequencies and interest rates, people do not need to engage in complicated PV calculations (Egan et al., 2015). We only need respondents to react appropriately to the "symptoms" of changes in the interest rate that affect what is relevant for them: the monthly payment and the number of periods.

2.1. The exogenous approach

The exogenous approach, which compares two present values from different time schedules, is based on the premise that a CV scenario directly asks about the PV of a flow of benefits provided by an environmental good. Therefore, accepting two alternatives with different bids and payment frequencies is the same as saying that both alternatives generate the same PV.

In a CV approach and assuming a constant discount rate (r) and a finite stream of constant benefits, the expression for the present value (PV) is as follows:

$$PV = \sum_{t=0}^{n} \frac{WTP_t}{(1+r)^t} \tag{1}$$

The exogenous approach estimates a different regression for each payment schedule (let us say 1 and 5 years) and then the WTP for each case: WTP^1 and WTP^5, respectively. To infer the discount rate, researchers estimate the value of v that makes these two payment schedules equal in terms of PVWTP:

$$PVWTP^1 = WTP^1 = \sum_{t=1}^{5} \frac{WTP_t^5}{(1+v)^t} = PVWTP^5$$

Nevertheless, comparing two independently accepted payment schedules provides no information about the discount rate or the consistency of people's choices for two reasons. First, finding a high value for v using this procedure does not mean that the discount rate is also high. As the researcher does not know the total value of the good under valuation, many response patterns can be appropriate for a high-value environmental good. The exogenous approach simply assumes that $v = r$.

Let us consider a simple example to illustrate this claim. Assume that we offer an individual the option to buy a luxury car with a market value of US$100,000. The individual would be willing to pay up to US$80,000 in PV, but they cannot afford to pay this amount in 1, 5, or 10 installments (they could do it in more payments). Subsequently, assume that we ask this individual (independently) if they would be willing to pay US$5,000 in one lump sum value, US$2,500 for five periods, or US$ 2,000 for ten periods, and suppose they can afford these values. Let us assume that their discount rate is 20%. Fig. 1 shows the PV of the three hypothetical payment schedules for different discount rates. The PVs of these options using a 20% discount rate are 5,000, 8,970, and 10,061, respectively. Therefore, the PV of the benefits is larger than the present value of the car's costs.

Consequently, they will answer "yes" to all three options. Nevertheless, the implicit discount rates estimated using the exogenous approach are 92.8%, 66%, and 32% for choices of between 1 and 5, 1 and 10, and 5 and 10 periods, respectively. All these rates are significantly higher than the individual's implicit discount rate. The exogenous approach would require an individual's WTP of 80,000, 26,752, and 19,082 for one, five, and ten periods, respectively, to be consistent with the discount rate, although this individual cannot afford those payments. It is easy to find similar examples with values that provide even higher discount rates and for which it is still reasonable for the individual to pay for the good. For environmental good valuation problems, the difference from the luxury car example is that we do not know the value of the good. From the responses to the different WTP questions, we only know that the PV of the cost is greater or lower than the unknown total value of the good. Importantly, observing high discount rates in the exogenous approach does not mean that people's responses to the frequency of payments are inadequate. We cannot infer anything about the time preferences of an individual by comparing two accepted payment profiles.

Furthermore, even if the experimental design defines payment schedules that provide similar PVs (higher values for short periods and lower values for extended periods), an individual would be indifferent to these payment schedules only if their discount rate is the same as the one used by the researcher in the design.

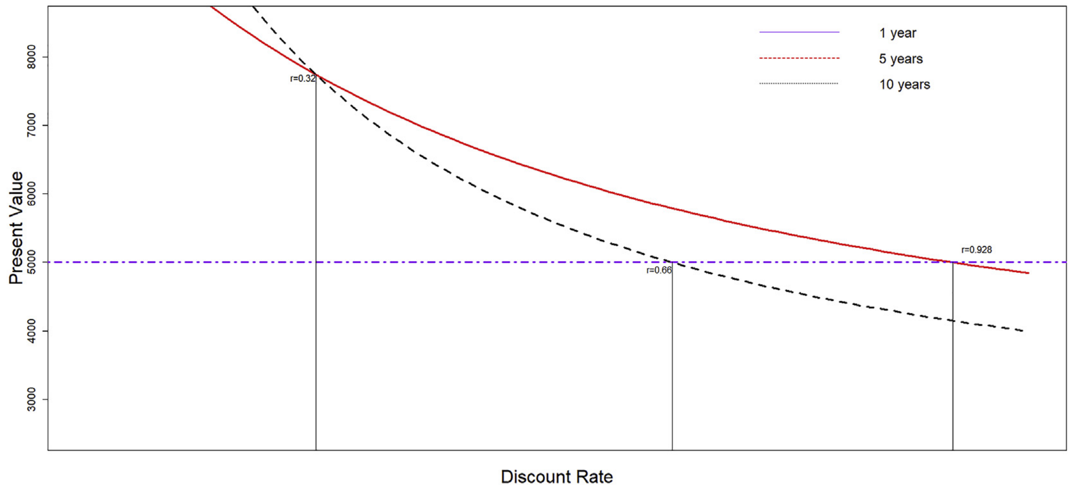

Fig. 1. Present Values for different Payment Schedules and Discount Rates.

2.2. *The endogenous approach*

Alternatively, it is possible to take advantage of the variability in the payment schedules and jointly estimate the WTP and the discount rate, as was suggested by Bond et al. (2009). Assuming an infinite horizon for the flow of benefits implies that the PV of the benefits is given by $V_0^{\infty}(WTP_i) = WTP_i\left(\frac{1+r}{r}\right)$, while the cost is the PV of the finite stream of payments $PV_t(B_i) = B_i\left(\frac{1+r}{r}\right)\left(1-\frac{1}{(1+r)^t}\right)$. A respondent agrees to pay a given amount of money according to the payment schedule of t annual payments if their PV of the benefits is greater than or equal to that of the cost. We denote a positive response (yes) using the indicator $y_i = 1$ and$y_i = 0$ otherwise. Therefore, the decision can be represented as follows:

$$y_i = \begin{cases} 1 & if \quad V_0^{\infty}(WTP_i) \geq V_t(B_i) \\ 0 & in\ any\ other\ case \end{cases} \tag{2}$$

Following Bond et al. (2009), the generation of the individual's benefits is WTP = $X_i\beta + \sigma\varepsilon_i$, where $\varepsilon_i \sim N(0, \sigma^2)$. The probability of observing a negative response to an offered amount B_i^t can be written as follows:

$$\begin{aligned} Pr\{y_i = 0\} &= Pr\{\, PV_0^{\infty}(WTP_i) < PV_t(B_i^t)\} \\ &= Pr\left\{(X_i\beta + \sigma\varepsilon_i)\cdot\left(\frac{1+r}{r}\right) < B_i\left(\frac{1+r}{r}\right)\left(1-\frac{1}{(1+r)^t}\right)\right\} \\ &= Pr\left\{\varepsilon_i < -\frac{X_i\beta}{\sigma} + \frac{B_i^t}{\sigma}\cdot\delta(r,\ t_i)\right\} \end{aligned} \tag{3}$$

In this case, t_i is known and corresponds to how each payment schedule is offered to the interviewees, but r is unknown. The following likelihood function can be derived from [3]:

$$lnL = \sum_{i=1}^{N_i}\left\{y_i ln\left[1-\Phi\left(-\frac{X_i\beta}{\sigma}+\frac{B_i^t}{\sigma}\cdot\delta(r,\ t_i)\right)\right] + (1-y_i)ln\left[\Phi\left(-\frac{X_i\beta}{\sigma}+\frac{B_i^t}{\sigma}\bullet\delta(r,\ t_i)\right)\right]\right\} \tag{4}$$

where X_i is a vector of the individual's characteristics, B_i is the cost to interviewees if they accept the schedule, and β, σ, and r are the parameters to be estimated. Therefore, with equation [4], we can jointly estimate the *WTP* and *r*.

This approach appropriately captures the decision process and the information provided by the individuals. It still relies on a split-sample in which the variability in responses is obtained from different individuals with different discount rates and not with an individual choosing among the three payment profiles with the same discount rate. Each individual has their own discount rate and a different total value for the good. Therefore, individuals will differ in the order of preferences for the three options. Providing a respondent with all payment schedules implies that the individual compares the three options against the same total value of the good using the same discount rate. This allows us to estimate the discount rate with less noise.

2.3. Endogenous approach with multiple alternatives

In our application, we allow the individuals to choose the payment and the payment frequency. People face four alternatives with a randomly assigned BID (B^n) and different payment frequencies (n_j): no purchase ($B^0 = 0$, $n_0 = 0$), paying B^1 in one year ($n_1 = 1$), paying B^5 in five equal annual payments ($n_5 = 5$), or paying B^{10} in ten equal annual payments ($n_{10} = 10$). A basic model would ask people to choose one alternative as in a CE. Another option is to ask them about their willingness to accept each of the alternatives given a combination of yes/no answers that will bound the WTP in the same way as the double (or multiple) bounded CV approach (Champ et al., 2012). By asking respondents to choose only one option and (explicitly) reject the others, we try to bound the WTP.

The order of magnitude of the PV for the three payment alternatives changes depending on the value of r used by the individual. As this discount rate is a parameter to be estimated, it will change in each iteration of the maximum likelihood process. Consider the four alternatives described above, and let us assume that the individual chooses the alternative with $n = 10$ payments. Therefore, $PV_{10}(B_i^{10}, r)$is the alternative with the lowest cost.

A crucial issue to define the econometric approach to deal with this data is whether people understood the valuation question's task. Our attempt to bound the WTP implies that the individual accepts to pay the lowest PV but not the next more expensive one (we have a yes/no answer). Future research should develop “good practices” guidelines to verify this element of the survey. This issue is important because a person who does not choose the other payment options could still have a PV of WTP greater than those, although they are not the preferred ones. In this case, we will need a different likelihood function. To consider this possibility, we develop and estimate two models as follows:

1) Simple model: Here, a person who does not choose the other payment options could still have a PV of WTP greater than those, although they are not the preferred ones. As in Bond et al. (2009), we only know that their PVWTP is higher than the present value of the cost of 10 payments, that is, $0 \le PV_{10}(B_i^{10}, r) \le PV(\mathrm{WTP}, \mathrm{r})$.
2) Multiple bounded case: The person rejects the other two options ($n = 1$ and $n = 5$ in our example). Thus, as before, we know that $0 \le PV_{10}(B_i^{10}, r) \le PV(\mathrm{WTP}, \mathrm{r})$, and we assume that 2) $0 \le PV(\mathrm{WTP}, \mathrm{r}) \le PV_t(B_i^t, r)$ for either $t = 1$ or $t = 5$. That is, the respondent rejects to pay the next more expensive alternative. The exact upper bound depends on the value of r. In each iteration of the maximum likelihood process, as r is a parameter to be estimated, we will need to identify for each individual the order of the PVs for all alternatives. For instance, a possible result is as follows:

$$0 \le PV_{10}\left(B_i^{10}, r\right) \le PV_1\left(B_i^1, r\right) \le PV_5\left(B_i^5, r\right) \qquad [5]$$

However, this will be true only for some values of r. As the payment value varies across payment schedules, changes in the discount rate will eventually change the order in equation (5). In Fig. 1, we plot the PVs of three hypothetical payment schedules: one-time payment of US$5,000, five payments of US$2,500, and ten payments of US$2,000. We can notice two relevant issues. First, each line is above, in the middle, and below the other two lines depending on the discount rate. Therefore, if we begin with the starting value $r^0 = 10\%$, we see that the highest PV is given by the 10-year option, followed by the 5-year and the 1-year options. The switching points between profiles are r = 92%, 66%, and 31%.

The general econometric approach is appropriate whenever researchers have a valid method to bound the WTP. The likelihood function for the case in which we can bound the WTP between a lower and an upper bound is given in equation [7]. People choose among the PVs of each payment schedule, denoted by $PV_{n_j}(B_i^{n_j})$ with j = 0,1,5, and 10. Therefore, if the individual chooses option $PV_{n_j}(B_i^{n_j})$ and rejects the other two, it implies that their true present value of WTP is between this value and the next more expensive PV in the order $PV_{n_l}(B_i^{n_l})$:

$$\begin{aligned} Pr\left\{y_{n_j}=1\right\} &= Pr\left\{PV_{n_j}\left(B_i^{n_j}\right) < PV_0^{\infty}(WTP_i) < PV_{n_l}\left(B_i^{n_l}\right)\right\} \\ &= Pr\left\{\begin{array}{l} B_i^{n_j}\left(\frac{1+r}{r}\right)\left(1-\frac{1}{(1+r)^{n_j}}\right) < (X_i\beta+\sigma\varepsilon_i)\cdot\left(\frac{1+r}{r}\right) < \\ B_i^{n_l}\left(\frac{1+r}{r}\right)\left(1-\frac{1}{(1+r)^{n_l}}\right) \end{array}\right\} \\ &= Pr\left\{-\frac{X_i\beta}{\sigma}+\frac{B_i^{n_j}}{\sigma}\delta(r,n_j) < \varepsilon_i < -\frac{X_i\beta}{\sigma}+\frac{B_i^{n_l}}{\sigma}\delta(r,n_l)\right\} \end{aligned}$$

$$Pr\left\{y_{n_j}=1\right\} = \int_{\frac{B_i^{n_j}}{\sigma}\delta(r,n_j)-\frac{X_i\beta}{\sigma}}^{\frac{B_i^{n_l}}{\sigma}\delta(r,\,n_l)-\frac{X_i\beta}{\sigma}} \phi(Z)dZ$$

$$Pr\left\{y_{n_j}=1\right\} = \Phi\left(\frac{B_i^{n_j}}{\sigma}\delta(r,n_l)-\frac{X_i\beta}{\sigma}\right)-\Phi\left(\frac{B_i^{n_l}}{\sigma}\delta(r,n_j)-\frac{X_i\beta}{\sigma}\right) \quad [6]$$

The likelihood function is as follows:

$$\text{logL} = \sum_1^N \ln\left[\Phi\left(\frac{B_i^{n_j}}{\sigma}\delta(r,n_l)-\frac{X_i\beta}{\sigma}\right)-\Phi\left(\frac{B_i^{n_l}}{\sigma}\delta(r,n_j)-\frac{X_i\beta}{\sigma}\right)\right] \quad [7]$$

in which $\Phi(.)$ is the CDF of a normal distribution and $\delta(r, n_l)$.

If we are not confident about the upper bound of the WTP, we could adjust the likelihood function, considering that the upper bound would be infinite for a positive response. In the case of a negative response, the lower bound would be zero, and the upper bound would be the lowest PV of all the alternatives:

$$Pr\left\{y_{n_j}=1\right\} = \int_{\frac{B_i^{n_j}}{\sigma}\delta(r,n_j)-\frac{X_i\beta}{\sigma}}^{\infty} \phi(Z)dZ$$

$$Pr\left\{y_{n_j}=0\right\} = \int_0^{\frac{B_i^{n_j}}{\sigma}\delta(r,\,n_j)-\frac{X_i\beta}{\sigma}} \phi(Z)dZ = 1-\int_{\frac{B_i^{n_j}}{\sigma}\delta(r,n_j)-\frac{X_i\beta}{\sigma}}^{\infty} \phi(Z)dZ \quad [8]$$

2.4. Case study

Each interviewee was required to value a network of five marine reserves, which covers an area equivalent to 8,579 ha and includes the following areas: La Rinconada (331.6 ha) in the Antofagasta region; Chañaral Island (2,894 ha) in the Atacama Region; Choros–Damas Islands (3,863 ha) in the Coquimbo Region; and Pullinque (740 ha) and Putemún (751 ha) on Chiloé Island. While there are other MPAs in Chile, this study concentrates on those under the national fisheries service's exclusive administration. Fig. 2 shows the MPAs under analysis.

La Rinconada, Pullinque, and Putemún were created to ensure the flow of ecosystem services associated with strategic commercial shellfish species. These can be exploited through authorized extractive activities or as seed banks. Their objectives include recovering natural populations, strengthening the availability of seeds, and promoting artisanal fishers and groups of growers in managing species such as the northern scallop, the Chilean scallop, and the Chilean mussel (*Choro Zapato)*. The MPAs of Chañaral Island and Choros–Damas Islands are devoted to biodiversity conservation activities, focusing on marine mammals' emblematic species such as the bottlenose dolphin, Humboldt penguin, and sea lion, as well as birds, all of which are not subject to exploitation. In this case, the flow of benefits is associated with tourism activities based on marine biodiversity. Although both MPAs—Chañaral Island and Choros–Damas Islands—provide nearly the same tourism activities based around flagship species, those developed in Choros–Damas Islands are well known and consolidated.

Main Ecosystem service	Conservation objective	Area (Ha.)
Seed supply	Scallop (*Argopecten Purpuratus*)	331.61
Tourism activities	Marine Biodiversity	2894
Tourism activities	Marine Biodiversity	3863
Seed supply	Oyster (*Tiostrea Chilensis*)	740
Seed supply	Mussel (*Choromytilus chorus)*	751

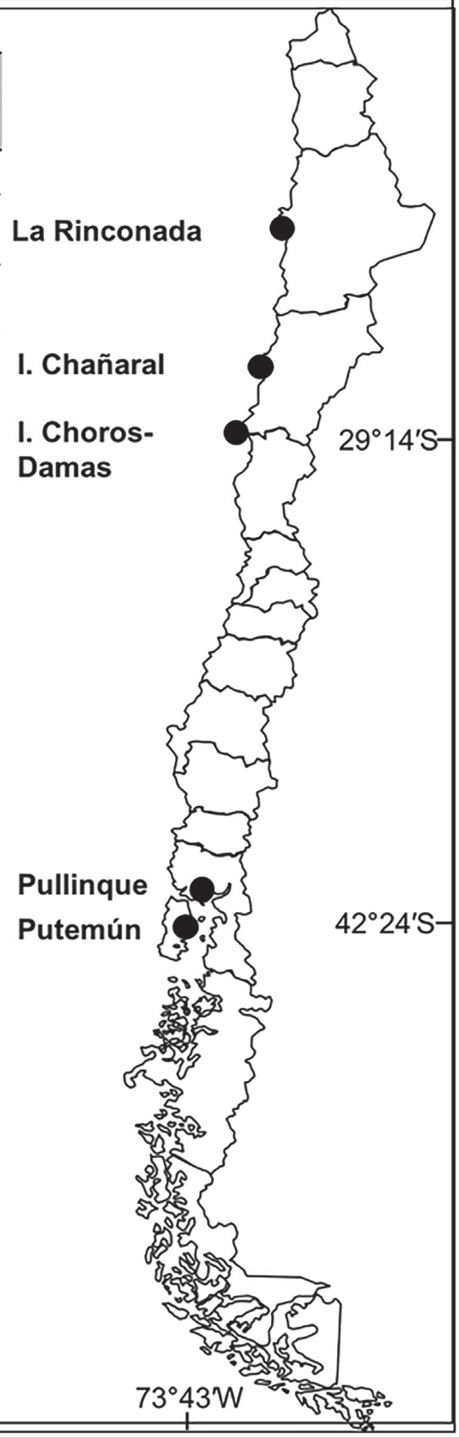

Fig. 2. Network of the studied Marine Protected Areas Source: Vasquez et al. (2010)

2.4.1. Survey design and implementation

We developed a face-to-face survey that was conducted from September to November 2009 in six cities, four of which are located near the MPAs (Antofagasta, La Serena, Ancud, and Castro); the other two, Concepción and Santiago, were selected due to their relatively large populations. The design of the final survey followed three steps. First, we conducted five

Table 2
WTP and discount rates using an exogenous approach.

	Chañaral			*Choros-Damas*			*La Rinconada*			*Pullinque*			*Putemún*		
Periods	1	5	10	1	5	10	1	5	10	1	5	10	1	5	10
Intercept	0.46***	0.43***	0.64***	0.05	0.40***	0.88***	0.21	0.50***	0.34***	0.12	0.22*	0.24**	0.29*	0.72***	0.70***
	(2.96)	(2.93)	(4.89)	(0.35)	(3.07)	(6.01)	(1.27)	(3.98)	(2.96)	(0.82)	(1.81)	(2.19)	(1.88)	(5.3)	(4.82)
Bid (E−05)	−6***	−9***	−0.1***	−4***	−0.1***	−0.2***	−4***	−0.1***	−0.1***	−5***	−7***	−8***	−8***	−0.1***	−0.2***
	(-7.4)	(-5.65)	(-7.18)	(-5.59)	(-5.88)	(-7.58)	(-4.54)	(-5.93)	(-4.91)	(-5.53)	(-5.22)	(-4.98)	(-7.28)	(-7.49)	(-6.87)
N	563	433	568	556	504	504	376	639	549	492	510	562	524	555	485
Log-lik	632.83	156.17	90.27	108.66	2297.31	288.67	84.89	126.84	43.62	587.74	161.63	114.94	22.59	310.79	27.22
WTP(US$)	***14.93***	***8.54***	***9.02***	***2.32***	***7.44***	***8.35***	***8.59***	***5.92***	***5.14***	***4.75***	***5.66***	***5.35***	***6.83***	***7.3***	***5.74***
WTP_{pvalue}	***0.00***	***0.00***	***0.00***	***0.71***	***0.00***	***0.00***	***0.12***	***0.00***	***0.00***	***0.36***	***0.03***	***0.01***	***0.02***	***0.00***	***0.00***
r_{1-5}	1.29			Und.			Und.			Und.			Und.		
r_{5-10}		Und.			Und.			0.46			0.77			0.30	
r_{1-10}			1.53			Und.			Und.			Und.			5.27

***p < 0.01, **p < 0.05, *p < 0.1. Und. = undetermined.

workshops with local communities in each area, including fishers, authorities, and NGOs, to identify the MPA's environmental services. Second, we conducted four focus groups (two each in Concepción and Santiago) to explore how people reacted to specific aspects of the hypothetical scenario and identify wording problems or misleading sections in the survey. Third, we applied 100 pilot surveys to field-test the instrument's design (50 each in Concepción and Santiago).

We relied on a random sampling process based on the Chile National Socioeconomic Characterization Survey (CASEN). We followed a probabilistic multistage sampling, randomly selecting the neighborhood and blocks. Next, we systematically selected households to be interviewed—one in each block starting in the north—and if we did not get an answer from there, we skipped the next four and knocked on the following one. More than 90% of households agreed to participate in the study, with the lowest response rate in the highest-income families. We also had two aspects for the survey. The first one had no option to choose the payment schedules; respondents only faced a "*take or leave it*" option (1, 5, or 10 payments). The second included all options, and people were asked to choose one of the alternatives and explicitly reject the others. We randomly assigned this, but given the budget constraints, we aimed to have lower observations in the second case, as more statistical efficiency can be obtained from multiple question surveys (Hanemann et al., 1991; Hanemann and Kanninen, 1999).

The process provided a useable sample of 1,389 observations for the first subsample (without the selection of payment frequencies) and 380 for the second one (with the selection of payment frequencies). We tested whether the samples were statistically different about their sociodemographic information, mainly income and age, and gender, and we could not reject the hypothesis of equal distribution of sociodemographic variables. Table A1 in appendix A shows a summary of the sample statistics.

In the pilot study, we used an open-ended elicitation format to define the first BID candidates to be offered in each MPA final questionnaire. Subsequently, following Cooper (1993) optimal design methodology, we determined the initial payoff vector to be provided for each area. Using these values, we conducted an iterative process of BID construction (Nyquist, 1992). After implementing a defined number of surveys (generally 100), we redefined the optimal payoff vector using Cooper's optimal design methodology. We followed this procedure until the design of the BID vector stabilized. For the 5- and 10-year cases, we used the market interest rates observed in banks and other institutions, including the retail industry, to estimate the corresponding bids. The presentation of these bids was randomly assigned among interviewees until we achieved the sample's optimal portion for the BID vector design. Table A2 in appendix A shows the distribution of the BIDS for each marine reserve. The probability of a "yes" answer monotonically decreased for all cases and payment schedules (1, 5, 10 years), with a few minor exceptions—La Rinconada with only one jump in the probability in the single payment case and Choros−Damas with one leap in the 10-year payment. However, this did not affect the overall estimation of the probability function. Table A3 shows that the probability of positive responses increased with the payment periods. This result, in which people prefer 5- or 10-year payment instead of the 1-year payment, has also been found in other CV applications (Gómez et al., 2017).

The survey included three sections. Section A was a warm-up, in which we asked respondents about their general interest, including views on the country's main environmental problems, the relevance of environmental issues to their daily lives, and their knowledge of the MPA network. Section B presented the study area and explained the MPAs' legal status and the differences within the network regarding the ecosystem services they provide. We used visual aids, including maps and pictures. This section included both the hypothetical market description and the WTP question. Finally, section C aimed to collect the socioeconomic characteristics of those interviewed and those of their household.[4]

To avoid both order and anchoring effects in the valuation responses, we used advance disclosure (Bateman et al., 2004; Day et al., 2012) and random assignment of treatments. People knew from the beginning that they would have to respond to five valuation questions, and we provided all the information and the description of each MPA in advance (before any

[4] The exact wording of the survey for each case is in appendix B.

Table 3
WTP and discount rate using endogenous approach.

	Chañaral	Choros-Damas	La Rinconada	Pullinque	Putemún
Constant	0.254**	−0.015	−0.017	−0.372·	0.168***
	(0.084)	(0.107)	(0.076)	(0.190)	(0.048)
Income	0.442***	0.642***	0.510***	0.990***	0.272***
	(0.109)	(0.133)	(0.104)	(0.243)	(0.062)
Sigma	1.485***	1.912***	1.352***	3.080***	0.874***
	(0.101)	(0.121)	(0.164)	(0.344)	(0.058)
R	1.314***	1.006***	0.596***	3.472·	1.171***
	(0.258)	(0.202)	(0.144)	(1.892)	(0.235)
N	1389	1389	1389	1389	1389
Log-likelihood	828.8	858.3	888.5	878.1	832.5
WTP (US dollars)	9.227	6.031	4.697	2.617	5.901
WTP Std. Err	0.060	0.069	0.054	0.120	0.036
WTP P-Value	0.000	0.000	0.000	0.256	0.000

***p < 0.001, **p < 0.01, *p < 0.05, p < 0.1.

valuation questions were administered). Additionally, the order of the valuation questions for the MPAs presented in the survey was randomized. Each interviewee received one of the following payment schedules, which was also randomly assigned among marine reserves: 1) a single payment, 2) payments for the next five years, and 3) payments for the next ten years. In the second survey, people chose the schedule length for each marine reserve.

3. Results

We start by showing the results using the exogenous approach to estimate the implicit discount rate. Further, we show the estimation of the case in which people cannot choose the payment scheme but in which the discount rate is estimated endogenously. Finally, we present the estimation using the subsample in which individuals could choose the payment alternative. We report the simplest logit model, which includes only the BID vector using the Hanemann (1984) indirect utility approach. We also perform the estimation with sociodemographic explanatory variables, and the results are qualitatively the same.

3.1. Exogenous approach

We estimate the implicit rate of return for all five reserves and all payment periods. The WTP for all reserves and payment periods is statistically significant except for that of Choros–Damas, La Rinconada, and Pullinque in the case of the 1-period payment (Table 2).

The most conspicuous issue is that the discount rate is undetermined for 9 out of the 15 calculations—the prospects never cross each other. It is sufficient to have a higher annual payment in the larger payment schedules to obtain this allegedly inconsistent result. However, this finding provides no useful information to evaluate the individual time preference, as we argued above. All three results (one for each payment schedule) could be economically correct if the good's total PV exceeds that of annual payments.

This seems to be the case for almost all the environmental goods under valuation because the values we asked people to pay are not considerably significant in terms of their available income and cover only a finite and short number of periods. For those in which the implicit discount rate is finite, we found rates ranging from 30% for Putemún, 46% for La Rinconada, and 0.77% for Pullinque, to 129% and 153% for Chañaral and 527% for Putemún. These rates are not significantly different from values found in the literature; the first three are not different from interest rates seen in the country's formal markets. In terms of the WTP, considering the typical income in Chile, the estimates are reasonable, with the values ranging from US$2.32 for Choros–Damas (one payment) to US$14 for Chañaral (one payment).

3.2. Endogenous approach

Using the same subsample as in the exogenous case, we estimate the WTP and discount rate using the endogenous approach. Under this scenario, the estimated discount rates range from 59.6% for La Rinconada and 100% for Choros–Damas to 117% for Putemún and 131.4% for Chañaral. The discount rate for Pullinque is enormous but not statistically significant (Table 3). These extremely high values are in the same magnitude as those found in many previous articles using both the exogenous and endogenous approaches.

Notably, these discount rates are all finite, showing that the endogenous approach contributes to identifying the discount rate. For instance, for Chañaral, the discount rate is lower in the endogenous case than in the exogenous one. Conversely, for La Rinconada and Putemún, the rate is lower in the exogenous case (46% versus 59.6% and 30–527% versus 117%, respectively).

Table 4
WTP and Discount Rate Using an Endogenous Approach with Payment Schedule Selection (double bounded).

	Chañaral	Choros-Damas	La Rinconada	Pullinque	Putemún
Constant	0.008	0.004	0.006***	0.003	0.003
	(0.008)	(0.002)	(0.001)	(0.006)	(0.002)
Income	0.013*	0.005**	0.001	0.014**	0.004*
	(0.008)	(0.002)	(0.002)	(0.006)	(0.002)
Sigma	0.069***	0.019***	0.013***	0.049***	0.018***
	(0.005)	(0.002)	(0.001)	(0.004)	(0.002)
R	0.524***	0.137***	0.159***	0.507***	0.158***
	(0.016)	(0.011)	(0.013)	(0.019)	(0.014)
N	303	305	325	307	309
Log-likelihood	417.9	344.3	376.2	377.8	328.3
WTP (US$)	3.036	1.191	1.241	2.127	1.108
WTP Std. Err	0.004	0.001	0.001	0.003	0.001
WTP P-Value	0.094	0.048	0.000	0.020	0.069
Present value (US$)	8.829	9.857	9.033	6.319	8.137

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

The highest mean WTP is for Chañaral, reaching US$9.22, and the lowest is for Pullinque, at US$2.60, both of a similar order of magnitude to their values under the exogenous estimation and following a similar one among the marine reserves. These values are, on average, lower than those reported under the exogenous case. Of course, the comparison of the annual WTP values is not appropriate because a correct one should consider the good's PV.

3.3. *Endogenous approach with payment schedule selection*

Our final set of results estimates the discount rate endogenously but allows people to choose the number of payment periods. We use the two econometric approaches. First, we assume that the PV WTP is bounded as in equation (6). Second, we assume that we do not have additional information regarding the unchosen payment schedules and use only the chosen alternative's information as in Bond et al. (2009).

Tables 4 and 5 present the results. The estimation in which respondents could choose the payment period shows a remarkable reduction in the implicit discount rate. These reductions are between 60% and 87% for the discount rate and between 20% and 80% for the WTP. Of course, it is important to evaluate whether the PV is the same. The new discount rates range from 14% for Choros–Damas and 16% for La Rinconada and Putemún to 51% and 52% for Pullinque and Chañaral, respectively. As this approach also reduces the upper bound of the WTP distribution, it is also reduced.

Finally, the estimation of not using the upper bound of the WTP provides a discount rate of approximately 24% for three areas and 56% for La Rinconada. As in other cases, the discount rate is statistically nonsignificant for Pullinque. As expected, the estimation precision is lower when we use only one bound for the WTP. Importantly, this section's main conclusion holds even if we do not rely on the bounded WTP. We attempted to force people to bound their WTP among two present values. However, when we ignored this information, the discount rates are still lower than those without choice.

Table 6 shows the present value of the benefit flows within the network for perpetuity, using the associated discount rate for each MPA. The PVs were calculated only for statistically significant WTPs and finite discount rates. Several conclusions can be derived here. First, the endogenous approach without payment schedule selection provides more similar PVWTP values than the endogenous approach with selection using the single bounded interpretation. Nevertheless, these approaches provide completely different discount rates (Tables 3 and 5). As expected, the double-bounded endogenous approach provides a more conservative estimation of the PVWTP as it bounds the upper tail of the WTP distribution in the estimation process except for Pullinque. Finally, the exogenous approach, on average, tends to overstate the PVWTP when the associated discount rate is finite. The only exception is Chañaral, in which the value is similar to the endogenous approach with choice and the endogenous approach with choice and single bound.[5]

4. Discussion and conclusion

Our results for the discount rates computed using the exogenous approach (29–152%, ignoring the undetermined cases) are distributed within the values reported in the literature. Our lower tail results are 29–52%, and the ones associated with the middle of the distribution are 52–77%, whereas our upper tail results are 128–152%. The main anomaly reported while using the exogenous approach is that the discount rate is undetermined for several cases. The estimates using the endogenous

[5] We estimated these models using a random parameter approach for the discount rate following Meyer (2013a, 2013b) and hyperbolic discount rates as the latter articles and that of Lew (2018). We found significant heterogeneity from the random parameter model. Furthermore, the hyperbolic discount rate for the endogenous approach without election is again higher than the discount rate with a choice. As our main results are not altered by these estimations, these results are available upon request.

Table 5
WTP and Discount Rate Using an Endogenous Approach with Payment Schedule Selection (single bounded).

	Chañaral	Choros-Damas	La Rinconada	Pullinque	Putemún
Constant	0.007	0.002	−0.003	−0.015	0.002
	(0.009)	(0.008)	(0.011)	(0.018)	(0.006)
Income	0.018*	0.021*	0.031**	0.039**	0.015**
	(0.010)	(0.011)	(0.012)	(0.020)	(0.007)
Sigma	0.062***	0.056**	0.079***	0.111***	0.042***
	(0.017)	(0.024)	(0.017)	(0.040)	(0.012)
R	0.240**	0.240*	0.560***	0.581	0.238**
	(0.098)	(0.150)	(0.212)	(1.163)	(0.117)
N	303	305	325	307	309
Log-likelihood	171.2	172.9	203.9	182.8	164.9
WTP (US$)	3.161	2.777	2.933	1.398	2.010
WTP Std. Err	0.005	0.006	0.007	0.011	0.004
WTP P-Value	0.068	0.054	0.012	0.048	0.028
Present value (US$)	16.314	14.332	8.166	3.804	10.466

***p < 0.01, **p < 0.05, *p < 0.1.

Table 6
Present values for all approaches.

	Estimation using Endogenous approach Bond et al. Model				
	Chañaral	Choros-Damas	La Rinconada	Pullinque	Putemún
PV-WTP no Choice	16.249	12.026	12.578	3.371	10.940
	Endogenous approach with selection of payment schedule (a)				
	Chañaral	Choros-Damas	La Rinconada	Pullinque	Putemún
PV-WTP Choice multiple bounds	8.830	9.884	9.046	6.322	8.121
	Endogenous approach with selection of payment schedule (b)				
	Chañaral	Choros-Damas	La Rinconada	Pullinque	Putemún
PV-WTP Choice single bound	16.332	14.348	8.171	3.808	10.455
	Estimation approach from Myers et al. (2017)				
	Chañaral	Choros-Damas	La Rinconada	Pullinque	Putemún
PV_WTP_one payment	14.930	–	–	–	6.830
PV-WTP_ 5 payments rate 1-5	15.160	–	–	–	–
PV-WTP_5 payments rate 1-10	14.122	–	–	–	8.685
PV-WTP_5 payments rate 5-10	–	–	18.790	13.011	31.633
PV-WTP_10 payments rate 1-5	16.012	–	–	–	–
PV-WTP_10 payments rate 1-10	14.915	–	–	–	6.829
PV-WTP_10 payments rate 5-10	–	–	16.314	12.298	24.873
Average	15.028	–	17.552	12.654	15.770

approach without selecting payment frequency periods [69–131%] are in the middle-upper tail of previous studies' distribution. Altogether, these figures are of the same order of magnitude as those in previous studies using CV. For instance, Stevens et al. (1997) report a discount rate within the range [50–270%] for the restoration of Atlantic salmon; Kim and Haab (2009) report a rate within the range [20–100%] for oyster reef restoration programs; Bond et al. (2009) report a rate within the range [23–80%]; and Egan et al. (2015) also report a rate within the range [62–104%]. Notably, the endogenous approach with payment schedule selection provides estimates in the lower tail of the distribution [13–50%]. The double-bounded approach is the more conservative in terms of the discount rate and WTP. Two of the values associated with the discount rate (51% and 52%) are in the lower tail of the distribution in previous studies, while three of them (13.7%–15.9%) are significantly lower than the values found in previous literature; only Meyer (2013a) and Grammatikopoulou et al. (2020) find similar values, both using CE.

Overall, our results are conservative in comparison with other studies that do not use CV, such as the experimental approach in which the discounting rates range from negative values to infinity and commonly have values above 3 and 4 digits (Chapman et al., 1999; Chapman and Winquist, 1998; Kirby, 1997). For instance, Loewenstein (1987) uses experiments to analyze delays in consumption and reports a discount rate of −6%, while Kirby and Maraković (1996) report a discount rate within the range [500–1500%] for the same topic.

Most remarkably, our estimates using an endogenous approach with a choice of payment schedules provide the most conservative discount rate and WTP. Whether this finding would extend to other applications is an empirical question; we believe it is worth including the option to choose the payment schedule to simulate a more realistic market transaction scenario in CV. We hypothesize that showing the respondent all payment frequencies and letting them choose one forces them to think carefully about the different frequencies and not merely the dollar amount shown. More evidence needs to be gathered to set a pattern in this regard. This result is similar to that of Wang and Daziano (2015), in which a binary option produces a discount rate of 94%, while a multiple price list generates one of 14%. Our results are also close to the estimates provided by several studies using different latencies of the benefits (Alberini et al., 2006; Alberini and Ščasný, 2011; Meyer, 2013a, 2013b; Rheinberger, 2011; Viscusi et al., 2008) and the values obtained in the transportation literature (Ewing and Sarigöllü, 2000; Hess et al., 2012; McFadden and Train, 2000; Musti and Kockelman, 2011).

The analysis of the present value of future benefits, using the associated discounting rate for each MPA, allows us to derive several conclusions. First, the endogenous approach without payment schedule selection provides PVWTP values similar to those obtained using the endogenous single bounded approach. As expected, the double-bounded endogenous approach provides a more conservative estimation of the PVWTP as it bounds the WTP distribution's upper tail in the estimation process. Finally, the exogenous approach tends to, on average, overstate the PVWTP when the associated discount rate is finite.

In conclusion, our results suggest that allowing people to choose the payment schedule in SP scenarios significantly reduces both the implicit discount rate and the PVWTP. The highest reduction is achieved when we ask several questions to bound the distribution of the WTP. Furthermore, we show that the exogenous approach is not recommended for evaluating the consistency of people's responses to different payment schedules.

Declaration of competing interest

The authors declare no known interests related to their submitted manuscript.

In this figure, we see the present value for different payment schedules at different discount rates. Additionally, we see that these payment schedules have the same present value (cross each other) at several values for the discount rate (32%, 66%, and 92.8%).

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Appendix A

Table A.1: Descriptive Statistics for the sample with and without a selection of payment frequency

Statistic	Sample with Choice N	Mean	St. Dev.	Min	Max
Income	381	586,877	594,043	75,000	3,000,000
Age	381	42	15	17	84
Sex (1 = male)	380	0.503	0.501	0	1
	Sample without Choice				
Statistic	N	Mean	St. Dev.	Min	Max
Income	1,389	513,985	509,907	75,000	3,000,000
Age	1,389	42	15	18	88
Sex (1 = male)	1,389	0.503	0.500	0	1

Table A.2: Bids for conservation programs in each MPA (CLP)

Chañaral Single payment	No	Yes	% Yes	5-year payments	No	Yes	% Yes	10-years payment	No	Yes	% Yes
1,000	7	38	84.44	220	10	26	72.22	120	6	43	87.76
3,500	23	26	53.06	506	13	26	66.67	186	15	35	70.00
5,700	55	54	49.54	1,220	34	41	54.67	621	32	63	66.32
15,382	73	23	23.96	3,932	39	39	50.00	2,933	59	45	43.27
19,400	55	15	21.43	7,228	48	24	33.33	6,868	69	21	23.33
29,100	120	19	13.67	11,496	62	18	22.50	9,879	83	30	26.55
Choros-Damas Single payment	No	Yes	% Yes	5-years payments	No	Yes	% Yes	10-years payments	No	Yes	% Yes
800	15	35	70.00	176	8	35	81.40	104	9	34	79.07
3,396.5	18	19	51.35	515	18	28	60.87	420	16	31	65.96
5,700	67	43	39.09	1,197	40	49	55.06	768	26	61	70.11
9,480	36	23	38.98	3,120	29	35	54.69	2,488	41	52	55.91

15,700	54	22	28.95	5,057	79	36	31.30	5,579.8	58	31	34.83
24,600	131	29	18.13	10,788	75	15	16.67	9,134	79	12	13.19
La Rinconada											
Single payment				5-years payments				10-years payments			
	No	Yes	% Yes		No	Yes	% Yes		No	Yes	% Yes
1,000	3	18	85.71	395	5	27	84.38	124.6	9	30	76.92
1,300	21	25	54.35	419	25	51	67.11	323	23	35	60.34
5,020	42	23	35.38	903	57	55	49.11	483	34	50	59.52
9,200	37	30	44.78	2,673	55	53	49.07	1,816	61	53	46.49
17,100	50	19	27.54	3,840	63	47	42.73	2,710	64	43	40.19
24,200	55	12	17.91	7,441	89	24	21.24	5,384.8	72	29	28.71
Pullinque											
Single payment				5-years payments				10-years payments			
	No	Yes	% Yes		No	Yes	% Yes		No	Yes	% Yes
900	15	30	66.67	198	11	35	76.09	108	13	36	73.47
1,570	20	18	47.37	581	21	21	50.00	196.2	15	29	65.91
5,000	46	44	48.89	1,220	36	53	59.55	610	32	42	56.76
9,900	56	35	38.46	3,189	54	36	40.00	1,244	64	59	47.97
15,700	63	15	19.23	6,171	60	34	36.17	3,416	60	36	37.50
27,200	96	10	9.43	9,854	77	18	18.95	6,121	71	28	28.28
Putemún											
Single payment				5-years payments				10-years payments			
	No	Yes	% Yes		No	Yes	% Yes		No	Yes	% Yes
500	33	51	60.71	192	22	77	77.78	130	16	65	80.25
3,500	46	39	45.88	647	45	54	54.55	460	38	57	60.00
8,300	69	29	29.59	2,200	50	48	48.98	1,897.8	49	38	43.68
16,900	57	15	20.83	4,579	61	43	41.35	4,124.2	63	25	28.41
23,100	98	13	11.71	8,124.6	85	15	15.00	5,867.6	67	21	23.86

Table A.3: Positive response rate

	Chañaral		Choros-Damas		Rinconada		Pullinque		Putemún	
	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
1 year	65.55%	34.45%	65.24%	34.76%	62.09%	37.91%	66.07%	33.93%	67.33%	32.67%
5 years	54.21%	45.79%	55.71%	44.29%	53.36%	46.64%	56.80%	43.20%	52.60%	47.40%
10 years	52.70%	47.30%	50.89%	49.11%	52.29%	47.71%	52.58%	47.42%	53.08%	46.93%

Appendix B. Wording in the survey

Interviewees were given the following valuation context:

"The national fisheries service is responsible for preserving and improving the flow of ecosystem services provided by the MPA network through conservation programs. Due to its legal status, the use of the MPAs cannot be changed. The service faces a budget constraint in which it can afford only 10% of the total financial resources needed to reach its objective. Thus, to obtain the necessary funds to develop these programs, the Chilean government is planning to call for a referendum in which they will ask every household in the country whether they are willing to pay a certain amount of money to support each of the conservation programs. The evaluation will be done for each MPA individually. If the majority votes in favor, then each Chilean household must pay, and the program for that MPA will be developed. If the majority consensus is not reached, the program cannot be developed, and the area will likely decrease its flow of ecosystem services."

Once the valuation context was explained, we provided the interviewees with specific information about each area. For instance, for the Choros—Damas Islands, the information provided was their location, extension, conservation program objective (in this case biodiversity-based tourism), and the description of the ecosystem services provided as follows:

> "The Choros—Damas Islands' biodiversity is characterized by a resident population of bottlenose dolphins (40 individuals), sea otters (28 individuals), sea lions (1,123 individuals), and Humboldt penguins (1,479 individuals). The conservation actions will take place in the next8[6] years, helping to maintain the current biodiversity levels for future generations."

[6] Each MPA requires different actions to assure the provision of the ESs.

Subsequently, the valuation question was worded as follows:

> *"Are you willing to pay \$$B_t$ annually for the next_T_year(s) to develop conservation actions that ensure the flow of the ecosystem services of this area in the future?"*

In the second sample, people face the following questions:

We will show you four options to support the conservation actions that ensure the flow of the ecosystem services of this area in the future. We ask you to consider each of these options carefully and choose only one of them and discard the other three:

The options are the following:

1. Paying \$ B^1 once.
2. Paying \$ B^5 annually for the next_5_years
3. "Paying \$ B^{10} annually for the next_10_year(s)?"}
4. Not paying for this program.

Appendix C. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jeem.2021.102446.

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