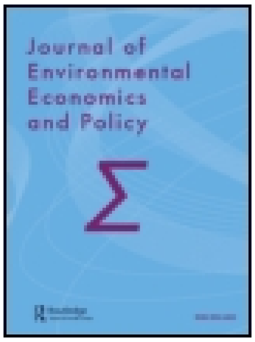

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The value of wetlands in Quebec: a comparison between contingent valuation and choice experiment

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ABSTRACT
This study aims to evaluate the non-market values of ecosystem services generated by wetlands in southern Quebec. To accomplish this, we evaluated the value of wetland services related to (1) habitat for biodiversity, (2) flood control, (3) water quality and (4) climate regulation. Two non-market valuation methods are proposed, contingent valuation and choice experiment. Our study aims to measure both the population's willingness to pay (WTP) for wetland preservation and restoration and to understand which environmental attributes and socioeconomic characteristics motivate people's responses. We also compared the results of the two methods. Our conclusion suggests that the two methods provide statistically convergent WTP values, both in total value and in relative importance for different attributes involved. Our result also confirms the coefficient equivalence between the estimation models using the data from the two methods.

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Contingent valuation; choice experiment; comparison; willingness to pay; wetland-related ecological services; Quebec; Canada

1. Introduction

Wetlands are among the most important and productive natural systems on the planet. Canada hosts 25% of the planet's wetlands (127 million hectares; Environnement Canada 2004). In urban areas, however, their extent has been reduced by 80%–98% over the last two centuries because of drainage, filling or direct destruction (Environnement Canada 1991). The Canadian situation is representative of the trends throughout Quebec, where conversion of wetlands to other uses has been widely observed. The province currently has 17 million hectares of wetlands. In areas where development pressure is intense (approximately 10% of the territory of the province), their loss over the past 40 years has been very high and often close to 50% (Joly et al. 2008).

In southern Quebec, particularly in the lowlands of the St. Lawrence River, which is the most populated area of Quebec, the conflicting priorities between the protection of natural environments and their conversion to other uses is even more intense. Urbanisation, development of naval and road networks and agriculture lead to fragmentation and changes in land use (Paquette and Domon 2003; Jean and Létourneau 2011). Southern Quebec, however, also happens to be the area with the greatest biodiversity in Quebec and the best agricultural land: realities that exacerbate tensions between users. Over the past 40 years, the St. Lawrence River Lowlands have lost more than 45% of their wetlands, and 65% of the remaining areas have been disrupted by human activities (Joly et al. 2008). In addition, wetlands host 38% of species at risk and 25% of the rare vascular plants in

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Quebec (Canards Illimités Canada 2011). If the loss of wetlands reduces biodiversity in the short term and impairs multiple ecological functions and services in the mid to long term, this habitat destruction will also weaken the resilience of communities to various pressures such as climate change (Brinson and Malwares 2002; Wang et al. 2008).

The economic explanation for the significant loss of wetlands is that the private net benefits of converting the wetlands to other uses are in most cases higher than the net private benefits of conservation (Pattison, Boxall, and Adamowicz 2011). This individual benefit calculation does not include the value of the ecosystem services (ES) that wetlands provide to communities, often in the form of positive externalities beyond the scope of private benefits. Among the ES most frequently associated with wetlands are water purification and supply, flood control, erosion control, carbon storage and sequestration, and habitat for biodiversity (Joly et al. 2008; Birol et al. 2009).

This paper aims to assess the non-market values of some of these ES generated by wetland ecosystems in southern Quebec. To our knowledge, there has been no previous such study for the province of Quebec, though three studies were conducted in other Canadian provinces. Pattison, Boxall, and Adamowicz (2011) estimated the value of wetlands in Manitoba, Lantz et al. (2013) evaluated the social benefit of wetlands conservation in southern Ontario and Dias (2011) reported the value of the ecological goods and services provided by the wetlands in Saskatchewan. The first two studies were based on the contingent valuation (CV) method and the third one on a choice experiment (CE) study. In addition to providing the first case study of the wetland-related valuation for Quebec, this study will also allow us to compare our results with those previous studies and to verify whether the results are transferable between provinces of different geographical, climatic, demographic and economic characteristics. These last variables are elements of particular interest in many meta-analyses of wetland economic value, such as those by Brander, Florax, and Vermaat (2006), Germandi et al. (2010) and He et al. (2015).

This study evaluates the value of four services provided by wetlands: (1) habitat for biodiversity, (2) flood control, (3) water quality and (4) the regulation of climate via two non-market valuation methods, CV and CE. These four attributes were also evaluated in Pattison, Boxall, and Adamowicz (2011) and Lantz et al. (2013) and partially in Dias (2011). Using both methods in our paper allows us to measure both the willingness to pay (WTP) for an explicit wetlands preservation and restoration programme and to understand the marginal WTP for various environmental attributes. We also compare the results of these two methods.

This paper is presented in the following manner. Section 2 presents a brief literature review on previous valuation studies that have been applied to the ES provided by wetlands in the world and in Canada and the comparative studies between CV and CE methods. Section 3 provides the empirical design used in our study. Section 4 discusses the details of the survey. Section 5 provides details on the data and we present and discuss the empirical results in Section 6. Finally, we offer conclusions in Section 7.

2. Literature review

Since the publication of the first study on the value of wetlands by Hammack and Brown in 1974, numerous studies have focused on this issue. As identified in Ghermandi et al. (2010), between 1974 and 2009, more than 170 studies on 186 different sites were conducted to assess the non-market benefits of wetlands. Though several studies on the value of wetlands have been carried out for North American areas, only Pattison, Boxall, and Adamowicz (2011), Dias (2011) and Lantz et al. (2013) focus on wetlands in Canada. Based on the CV method, Pattison, Boxall, and Adamowicz (2011) evaluated the preferences of Manitobans for restoring wetlands to the level of 1968, by focusing on the hypothetical improvements in flood control, habitat for biodiversity, soil erosion control, climate regulation and water quality. Lantz et al. (2013) estimated the social benefits of wetland conservation in Credit River watershed, located in southern Ontario. Also based on the CV method, this study evaluates the WTP of the respondents for the improvements in flood control, water quality, wildlife habitat and carbon storage. Dias (2011) conducted a CE study which estimates the economic value for enlarged riparian area, larger wildlife population and better water quality provided by the wetlands of the province of Saskatchewan.

In our study, we use both CV and CE methods. The CV method has been used for decades to measure the value of services provided by nature (Davis 1963). Most widely used since the 1980s, this technique is suitable for assessing the value of ES from a global perspective. On the other hand, the CE method was developed to estimate the value for separate components of a wider whole improvement scenario (Louviere, Hensher, and Swait 2000).

Both methods offer specific advantages in the context of the management of public projects. CV proves to be an appropriate technique to evaluate whole scenarios, for example for cost−benefit analyses. By reporting marginal WTP of the population for different attributes that can be improved in the proposed project, the results of CE can provide useful information for the decision-maker to prioritise certain aspects, particularly in a context of budget constraint.

Both methods also have limitations. In CV, due to the biases associated with the creation of a simulated market (e.g. hypothetical bias, strategic responses, scoping, warm glow), two important concerns about this method are 'validity [concerns] which refers to the "accuracy" and reliability [concerns that] refers to "consistency" or "reproducibility" of the CV results' (Venkatachalam 2004, 90). In addition, CV often assesses the value of a bundle of ES, sometimes difficult to dissociate. This 'inclusion effect' can act as a complicating element in respondents' assessment: several attributes and levels combined into a single object may render a detailed understanding of the relationship between utility and modulation of the environment difficult. One resulting bias is the so-called 'part-whole' bias (Kahneman and Knetsch 1992), which indicates the possibility that a respondent may bid for a more inclusive category of the goods being valued, rather than the goods themselves. An example was raised by Boxall et al. (1996). Their CV study reported a WTP 20 times higher than the CE exercise. One explanation that they provided is the possibility for the respondents in a CV study to ignore the existence of substitute goods, given the complexity of the combined hypothetical scenario.

These limitations may be partly addressed, at least theoretically, by the CE method (Hanley, Wright, and Adamowicz 1998; Goldberg and Roosen 2007). Indeed, the decomposition of the environmental object into attributes and levels allows respondents to identify the marginal value for each of the attributes and therefore facilitates the comparison of their relative importance (e.g. Adamowicz et al. 1998; Hanley, Wright, and Adamowicz 1998). This avenue is of particular interest in view of the design of public policy where the decision-maker can juggle various combinations of attributes and levels and therefore measure effects more accurately (Hanley, Wright, and Adamowicz 1998; Christie and Azevedo 2002; Mogas, Riera, and Bennett 2005).

However, even if the marginal estimate of attributes' value can be extrapolated and used to generate other evolutionary scenarios, it may be more difficult to aggregate a total value. Hanley, Wright, and Adamowicz (1998) underlined their concerns over whether the essential nature of an environment asset, especially a wetland, can be simply described in terms of its individual components. The value of the wetland in total may be greater than the simple sum of the value of its attributes. On the other hand, some authors have found that when the two evaluation methods are based on the same scenario, the sum of the values of CE attributes can generate a higher value than that proposed by the CV overall value. Hanemann (1984) suggested that the substitution effect and decreasing marginal rates cannot be captured by the marginal utility value obtained by the CE for each attribute.

Moreover, despite the similar theoretical foundations of the approaches, a number of authors prefer to differentiate the two methods according to what is emphasised by the respondents and the related psychological impact that they feel when they answer the valuation question. According to these authors, the WTP question in CE surveys provides the respondents with a more natural context to maximise their utility improvement by providing the trade-off between the proposed attribute improvement and the related cost in a more balanced way (McKenzie 1993). In contrast, in a

CV, the focus is potentially placed more on the monetary attributes than on the environmental improvement scenario, which leads the respondents to give more consideration to their budget constraints (McKenzie 1993; Birol et al. 2009). This might be another explanation for the inclusion effect or the 'part-whole' bias as mentioned above.

Many studies proposed to compare the two approaches; however, there is still a discrepancy in the literature on the comparability of their WTP estimates. Some studies show a higher WTP in the CE than in the CV (Hanley, Wright, and Adamowicz 1998; Stevens et al. 2000; Christie and Azevedo 2002; Foster and Mourato 2003; Christie et al. 2004; Mathews, Kask and Stewart 2004; Hasler et al. 2005; Travisi and Nijkamp 2004; Kimenju, Morawetz, and De Groote 2005). In contrast, some studies have documented the opposite trend (e.g. Boxall et al. 1996), and yet others have concluded the difference to be insignificant (Lockwood and Carberry 1998; Adamowicz et al. 1998; Colombo, Cavalatra-Requena, and Hanley 2006; Jin et al. 2006; Mogas, Riera, and Bennett 2006). The resolution of this issue is of great importance because it is directly related to the convergent validity of the results (Mitchell and Carson 1989). Passing the convergent validity test would mean a failure to reject the null hypothesis of no significant difference between the two estimates and is seen by many as a useful measure of the validity of the stated preference estimates (Lockwood and Carberry 1998; Colombo, Cavalatra-Requena, and Hanley 2006; Mogas, Riera, and Bennett 2005).[1]

To allow efficient comparisons, most recent studies comparing these two valuation methods have chosen to use exactly the same scenario and the same visual presentation format (e.g. Lockwood and Carberry 1998; Jin 2006; Christie and Azevedo 2009). This involves specifying the attributes and their levels in the hypothetical environmental improvement scenario in CV as in CE survey, instead of providing a text-heavy global description of the improved conditions. Some studies (Mogas, Riera, and Bennett 2006, Colombo, Cavalatra-Requena, and Hanley 2006) have also stressed the importance of working with a fully specified model with the data obtained from the CE to ensure an efficient comparability with those of the CV (Colombo, Cavalatra-Requena, and Hanley 2006). Following this idea, Christie and Azevedo (2009) further proposed to use repeated CV scenarios to provide comparable attributes in addition to the cost. In turn, Mogas, Riera, and Brey (2009) used in split sample two different CV scenarios to test the feasibility of combining the two approaches by using the CV estimates to value a base scenario and then using the CE results to adjust the base values according to any new additional changes in the scenario.

Repeating CV questions, however, may suffer of a bias similar to the so-called 'anchoring effect' (Herriges and Shrogen, 1996). The 'anchoring effect' was used to measure the bias that a first bid can create on people's answer to a follow-up question in double bound dichotomous choice WTP elicitation format. We suspect a similar bias to be applicable to the repeated CV questions proposed by Christie and Azevedo (2009) although they used three improvement scenarios that were constructed by different levels of forest quality. Following such logic, this paper proposes another comparison study for the equality of WTP estimate and WTP parameter equality between CV and CE methods. Different from Christie and Azevedo (2009), in this study, we put together the single-bid dichotomous CV method and the multiple three-alternative choice sets based CE methods, both were frequently used in the past literature to evaluate non-market value for environment and natural resources.

3. Empirical design

3.1. Wetland preservation and restoration scenario

The wetland preservation and restoration scenario design were developed in collaboration with a geographer, a geometrician, a biologist and an ecologist with research experience in different aspects of wetlands in Quebec, after three rounds focus group discussion around a scenario draft.

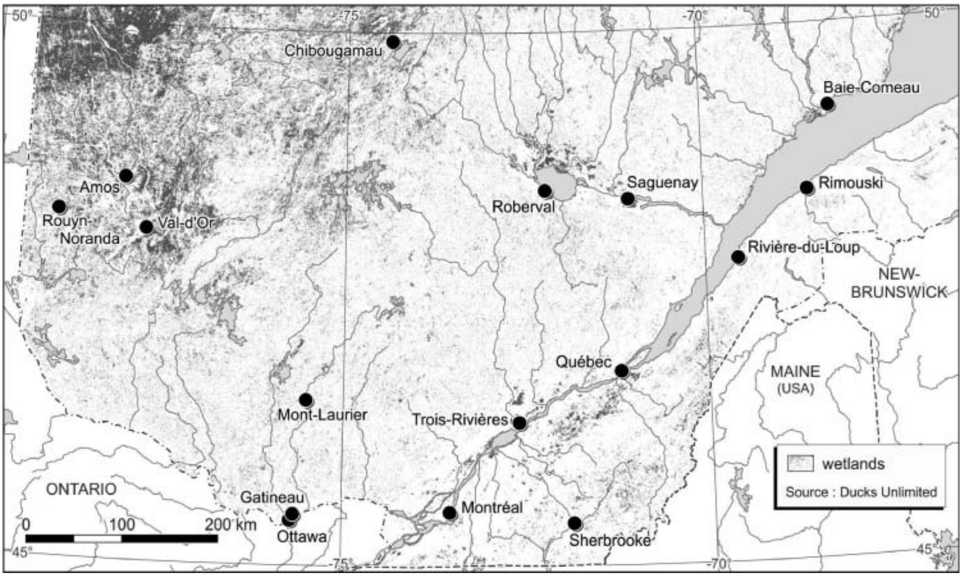

Figure 1. Mapping of southern Quebec's wetlands.

To generate wetland preservation and restoration scenarios, we first needed to know the size of the current stock of wetlands in the south of Quebec and their historical rate of loss. Despite some studies on this issue, it is difficult to identify a precise historical trend in terms of wetlands located in populated areas of Quebec. While wetlands represent a little more than 10% of Quebec's territory (17 million hectares), most are located in the sparsely inhabited northern region (MDDEFP 2013a). Figure 1 presents the study area, where the wetlands and their density are illustrated by the intensity of grey colour. We observe that most of these wetlands are located in regions with relatively low population density along the St. Lawrence River and concentrated in the boreal forest belt (northern part of the study area).

We retain a total area of 400,000 hectares to represent the wetland area in southern Quebec (Olar and Sauvé 2010). As reported in Joly et al. (2008), during the past 40 years, the lowlands of the St. Lawrence River (LSLR) have lost more than 45% of their wetland area, and 65% of the remaining areas are disturbed by human activities. In our study, the most optimal scenario of protection and restoration of wetlands proposed to the respondents is therefore based on a reversal of this situation and thus a roughly doubling of current wetland areas (i.e. an increase of the area of 400,000 hectares).[2]

3.2. Selection of attributes and levels

To help respondents better understand the consequences related to the changes in wetland area, as Pattison, Boxall, and Adamowicz (2011) and Lantz et al. (2013), we describe the present and hypothetically improved condition of the wetlands by the four selected ES: (1) habitat for biodiversity, (2) flood control, (3) water quality and (4) climate regulation through carbon storage and sequestration. These services were selected according to their relative importance in the overall services provided by wetlands, the possibility of a relatively good understanding by the general public, their ubiquity in wetlands covered by our study and the accessibility of data. In addition, as reported by Verhoeven et al. (2006), the majority of wetland restoration cases have focused on these four services. Table 1 shows the attributes and levels selected for this study.

We used the number of endangered species to represent biodiversity. The high pressures on wetlands in inhabited areas have resulted in a growing number of endangered species. Among the 736

Table 1. Attributes and levels used in the construction of scenarios.

Attributes	Definition	Levels
Biodiversity habitat	The ability to provide habitat and preserve a large number of plants, insects and animals. The more the medium fulfils its function, the less species found are endangered.	Low: 90 endangered species; Medium: 60 endangered species; High: 30 endangered species.
Flood protection	The ability to retain water and to reduce the potential for flooding during heavy rains.	Low: 14 catastrophic flooding in 10 years; Medium: 10 catastrophic flooding in 10 years; High: 6 catastrophic flooding in 10 years.
Water quality	The ability to filter sediment and pollutants to ensure water quality in rivers and lakes.	Low: 100 cfu of faecal coliforms per 100 ml (unsuitable for any use) Medium: between 1 and 100 cfu of faecal coliforms per 100 ml (some activities are possible) High: less than 1 cfu of faecal coliforms per 100 ml (drinkable water)
Climate regulation	Wetlands act as carbon sinks to capture CO_2 emitted into the atmosphere.	Low: equivalent to 30,000 cars removed from circulation in Quebec; Medium: equivalent to 45,000 cars removed from circulation in Quebec; High: equivalent to 60,000 cars removed from circulation in Quebec.
Annual cost	An annual supplement of municipal taxes on water and sanitation (paid directly to the municipality by the owners and an increase in the tenants' rent).	$5, 10, 15, 25, 40, 60, 80, 150, 250, 400 or 600

plant or animal species that are endangered in Quebec (MDDEFP 2013b; MNR 2013), a large portion is associated with the loss of biodiversity in wetlands. Ducks Unlimited Canada (Canards Illimités Canada 2011) estimated that 25%−38% of endangered species are found in wetlands. The Quebec Government considers that half of the endangered plant species depend on wetland and riparian areas (information from MDDEP: http://grandquebec.com/eaux-du-quebec/les-milieux-humides/). In the absence of accurate data on the number of endangered species found in the wetlands located in residential areas of southern Quebec and the effects of restoration on the reduction of endangered species, we determined the biodiversity in our scenario by using the case of the Yamaska River watershed. This watershed is typical of the dynamics observed in LSLR and, more generally, of the situation in southern Quebec. A total of 62 plant and 26 animal endangered species are found in this watershed (information from OBV Yamaska: http://www.obv-yamaska.qc.ca/files/Portrait_2.pdf). We transposed these values to the Quebec scale, and distinguished three levels of biodiversity. At the low level, 90 of the wetland species are endangered. At the medium level, this number is reduced to 60 species, and at the high level, only 30 species are considered endangered.[3]

Flood control by wetlands represents their capacity to act as a buffer that stores water and reduces the flow. Floods are the most recurrent natural disasters in Quebec and represent the main risk to communities and the developed environment in Canada (INSPQ 2013). In fact, 80% of municipalities in the vicinity of rivers are affected by these events. In Quebec, 27 catastrophic floods have occurred between 1990 and 2010, with an average annual cost of 10−15 million dollars (INSPQ 2013). Recognising that wetlands can reduce the changes caused by floods by approximately 50% (Canards Illimités Canada, n.d.), we determined the risk levels of flooding in Quebec over a period of 10 years in three levels: 14 events of catastrophic proportion due to low level flood control, 10 due to medium level control and 6 due to high level control, where the high-level situation corresponds to about a 50% reduction of flood risk.

Wetlands are natural filters. They serve as retention basins for sedimentation of suspended particles that may contain several types of chemical contaminants, metals and other pollutants. They also metabolise certain organic or inorganic pollutants such as phosphorus and nitrogen (Ardon et al. 2010). To establish levels of water quality and associated uses, we used a conservative adaptation of the water quality reference index by the Government of Quebec (MDDEFP 2013c), in which water is considered excellent (drinkable) if it contains less than 1 unit of faecal coliforms (cfu) per 100 ml, and it is considered good or medium if it contains less than 100 cfu/100 ml, allowing for recreational activities such as swimming but not for drinking. Water quality is bad if it contains more than 100 cfu/100 ml and is unsuitable for any purpose.

The carbon storage and sequestration by wetlands contribute to climate regulation and mitigate the effects of climate change. The annual rate of capture by wetlands in southern Quebec is estimated at 0.3 t/ha (Ju and Chen 2005). To facilitate the respondents' understanding of this attribute, we symbolised the service in terms of the equivalent number of cars taken off the road. Considering that a car emits 4 t/CO_2/year for a 20,000 km use (Ressources naturelles Canada 2013), the 400,000 ha of existing wetlands sequester the equivalent of approximately 30,000 cars. We have set the levels of this attribute to 30,000 cars off the road for the low level, 45,000 for the medium level and 60,000 for the high level. The similar presentation format for the climate regulation related ecological services via carbon sequestration was used by Pattison, Boxall, and Adamowicz (2011) and Lantz et al. (2013). Sticking to the same format should allow a better comparability between studies.

Finally, to estimate the WTP associated with these improvements, respondents were asked to pay an increase in their annual water and sanitation tax. We have developed a spectrum of values ranging between \$5 and \$600 (\$5, 10, 15, 25, 40, 60, 80, 150, 250, 400 and 600). It is noteworthy that in our study, the proposed prices covered that used in Pattison, Boxall, and Adamowicz (2011) (\$25−\$600) and Lantz et al. (2013) (\$50−\$600).

3.3. Design of the CV method

In the CV study, our questionnaire provided an optimistic wetland restoration programme compared to the status quo scenario. The highest improvement levels for the four ecological service related attributes were chosen here to form the wetland restoration scenario. Respondents were then asked whether they were willing to pay the amount of X dollars (any value among \$5, 10, 15, 25, 40, 60, 80, 150, 250, 400 and 600) per year for these changes or to stay at status quo with a zero annual payment. The question format used is of a dichotomous choice, following the advice of NOAA's expert panel (Arrow et al. 1993). Before answering, each respondent was reminded to carefully take into account that each potential payment would reduce their annual household budget for the purchase of other goods and services. Respondents who answered positively to the WTP question were further asked to determine in what percentage they are willing to assign their WTP to each of the four ES. (Table 2 illustrates the scenario presentation format used in CV question. See Appendix 1 for the exact WTP question used in questionnaire, in French.)

3.4. Design of the CE method

In the CE questionnaire, respondents were asked to choose among three alternatives in each choice set: a status quo scenario where all attribute levels were lower but combined with zero cost (the same as in CV questionnaire) and two wetland-improvement scenarios with various levels of the five attributes. Experimental design techniques (Louviere, Hensher, and Swait 2000) and SAS experimental and choice design software were used to obtain an orthogonal design, which consisted of

Table 2. Scenario proposed to the respondents in the contingent valuation.

Attributes	Status quo	Scenario of environmental change
Biodiversity habitat	90 endangered species	30 endangered species
Flood protection	14 catastrophic flooding in 10 years	6 catastrophic flooding in 10 years
Water quality	Bad (100 cfu/100 ml and unsuitable for any use)	Good (less than 1 cfu/100 ml, drinkable water)
Climate regulation	Equivalent to 30,000 cars removed from circulation	Equivalent to 60,000 cars removed from circulation
Annual cost	\$0	\$X

Table 3. Example of choice set proposed to respondents in the choice experiment.

If you choose project A or B, you will pay an increment of your municipal tax for water and sanitation. No payment will be required for the choice of the status quo, but wetlands will continue to be degraded as well as ecosystem services such as biodiversity, water quality, flood management and climate regulation.

	Project A	Project B	Status quo
Biodiversity habitat The ability to provide habitat and preserve a large number of plants, insects and animals.	Medium 60 endangered species	High 30 endangered species	Low 90 endangered species
Flood protection The ability to retain water and to reduce the potential for flooding during heavy rains.	Low 14 catastrophic flooding in 10 years	Medium 10 catastrophic flooding in 10 years	Low 14 catastrophic flooding in 10 years
Water quality The ability to filter sediment and pollutant and to ensure water quality in rivers and lakes.	Medium Undrinkable but some activities are possible: $1 < FCC < 100$	Bad Unsuitable for any use: $FCC > 100$	Bad Unsuitable for any use: $FCC > 100$
Climate regulation Wetlands act as carbon sinks to capture CO_2 emitted into the atmosphere.	Low Equivalent to 30,000 cars removed from circulation	High Equivalent to 60,000 cars removed from circulation	Low Equivalent to 30,000 cars removed from circulation
Annual cost An annual supplement of municipal taxes on water and sanitation (paid directly to the municipality by the owners and an increase in the tenants' rent).	$400	$150	$0
I prefer	A_______	B_______	None_______

Note: FCC, = faecal coliforms concentration in cfu/100 ml.

only the main effects, and resulted in 25 choice sets after excluding the dominating/dominated ones. Subsequently, these choice sets were randomly divided into five blocks, and each respondent was presented with one of the five blocks. Table 3 shows an example of the choice sets used in the questionnaires.

A difference in WTP question design used in our CV survey from that used in Pattison, Boxall, and Adamowicz (2011) and Lantz et al. (2013) is that the proposed hypothetical scenario does not explicitly mention the variation in wetland area but only describes the improvements in the related wetland services. Such arrangement is necessary for our study since we use exactly the same presentation format in CV and CE survey. Considering the combinations of improvements of the wetland-related services (i.e. attributes) to be random in CE survey and the potential confusion that might be caused by the co-presence of randomly chosen wetland area changes and random chosen improvement levels of wetland services,[4] we therefore decided to exclude the wetland area variation from both CV and CE surveys. In addition, as the social benefits from the wetland restoration stem more directly from the related ES, we believe omitting the information regarding wetland area enlargement to be a trivial difference from the previous Canadian studies.

4. Survey

4.1. Questionnaire

Our final questionnaire was divided into three parts. The first included a series of questions to test the knowledge and sensitivity of respondents concerning the problem of wetlands and the environment in general. Certain questions helped determine their knowledge about wetlands, and others were used to appraise their sensitivity about the environment and what actions they had undertaken in the past to support environmental protection. The second part is the core of the study and offers wetland improvement scenarios that are valued by respondents. The third section includes a series of socioeconomic questions to be used in our analyses and to assess the statistical representativeness of our sample.

4.2. Survey mode

A pilot study was conducted with more than 15 colleagues/students who answered and commented the paper-version questionnaire prior to the large-scale on-line survey which was conducted during March−April 2013. Access to potential respondents was purchased from Survey Sampling International (SSI) and MBA Recherche. Both companies possess and regularly update their own web-based panel of Quebec's adult residents, who agree to complete occasional online questionnaires in return for either participation in a lottery prize or other small gifts. Email invitations were sent by the web-based survey company to their panel, based on a random selection process. The persons receiving the email could decide whether to visit the survey web page and then decide whether to answer the questionnaire. In average, respondents took between 10 and 15 minutes to answer the whole questionnaire.

In order to stratify our sampling geographically and have a good representation of the population, we first asked MBA to select a sample of 400 persons over 18 years old who lived in the Montérégie Region, one of the regions in Quebec that has significant wetland loss due to the pressure of residential, industrial and agricultural development. We subsequently mandated SSI to sample another 1400 individuals over 18 years old from all populated areas of Quebec. No individuals already investigated by MBA were reselected by SSI, based on the identification strategy according to respondents' CIP addresses.

5. Data

A total of 1891 questionnaires were returned, about one quarter by MBA (437 questionnaires) and the others by SSI (1454 questionnaires). Based on a random split-sample strategy, we obtained 908 CV questionnaires and 983 CE questionnaires from the survey companies. Figure 2(a) shows the geolocalisation of CE respondents, and Figure 2(b) shows those for the CV study. We note that in both studies, the majority of respondents were in the LSLR region, especially in the Greater Montreal Area.

After removing the incomplete socio-demographical responses, we have 859 usable questionnaires for the CV study and 930 for the CE. We further deleted 44 questionnaires due to incomplete WTP questions in the CE while zero questionnaire has been deleted due to the same reason in the CV. This reveals that respondents had greater difficulty answering the CE WTP questions, which require making subtle trade-offs between various attributes instead of a simple 'take it or leave it' decision like the CV method. We also identified 21 protest WTP answers in CV data and 28 in CE data, principally due to respondents' incomprehension or suspicion about the proposed improvement scenarios.

The comparisons of the principal socio-demographical variables such as age, gender, income and education level, etc. between our database and the general population of Quebec are reported in Table 4. The two subsamples (CE vs. CV) show relatively similar mean (c.f. Student test) and variance (c.f. *F* test). In total, our data reveal a relatively good representativeness, although a more detailed structure check show that our sample generally contains fewer persons aged over 65, fewer individuals whose annual household income exceeds $80,000 and fewer individuals with low education (see Appendices 2−5).

Our data also reveal a rather positive attitude of the respondents towards wetlands. Over 80% of respondents believe that wetlands provide valuable ES, and only 18% of respondents believe that wetlands must be converted to enable economic development. However, only 38% of the respondents are aware of the actual situation of deterioration of wetlands in Quebec, and almost two-thirds

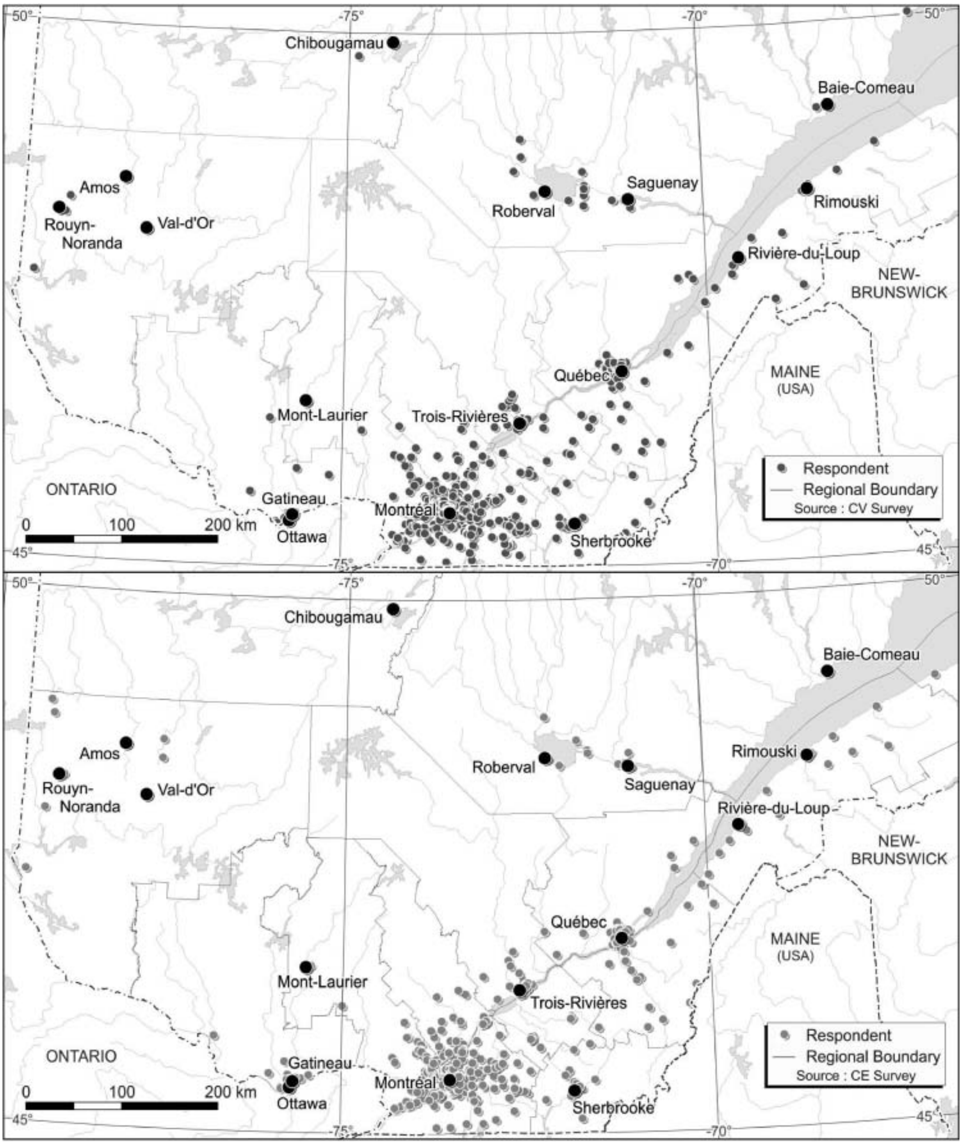

Figure 2. Geolocalisation of CV (dark grey) and CE (light grey) respondents.

of the respondents underestimated the rate of wetland loss in the last 40 years. In addition, more than half of the respondents (57%) are aware of one or more wetlands in their region. Among these, about one half (49%) reported having wetlands less than 5 km from their homes.

6. Analyses and results

Table 5 reports the estimates from the CV data. Here, we used logit models to explain the probability for a respondent to accept the proposed wetland preservation and restoration scenario. The simple CV model only uses bid price and constant as independent variables. We also report in Table 5 three other models which include respondents' socioeconomic characters as explanative variables for people's WTP. Model (1) includes both respondents' income in level and several environment-related attitude variables (i.e. *wetland_know*, *recycle*, *transport*). Considering the potential measurement

Table 4. Descriptive statistics of variables used in the estimates.

		CV (838)				CE (865)				Student *t* test	*F* test (standard deviation test)
Var.	Description	Mean	Stand. dev.	Min	Max	Mean	Stand. dev.	Min	Max	(CV vs. CE)	Prob(sd(CV)/sd(CE)! = 1
MBA	Respondent recruited by MBA	0.28	0.45	0	1	0.19	0.39	0	1	4.44***	0.000***
Wetland-know	Respondent knowing the wetlands near their house.	0.60	0.49	0	1	0.55	0.50	0	1	2.23**	0.64
Recycle	Respondents practise recycling. (4 = always, 3 = often, 2 = rare, 1 = never)	3.75	0.57	1	4	3.74	0.58	1	4	0.50	0.38
Transport	Frequency in using public transport modes (4 = always, 3 = often, 2 = rare, 1 = never)	2.46	0.97	0	4	2.54	0.99	0	4	1.61*	0.50
Age	Age (year)	46.55	15.10	21	80	47.01	15.68	21	80	0,62	0.27
Income	Household annual income ($)	55313	35248	5000	125000	53768	34336	5000	125000	0.91	0.45
Sex	Male = 1, female = 0	0.48	0.50	0	1	0.48	0.50	0	1	0.07	0.99
Edu	Years of education	12.25	3.02	5	16	12.29	2.97	5	16	0.22	0.58
Kids	Respondent living with kids	0.36	0.48	0	1	0.35	0.48	0	1	0.67	0.78
House-owner	Respondent owning the house where he/she lives	0.60	0.49	0	1	0.58	0.49	0	1	0.63	0.87

Note: * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 5. Contingent valuation (logit model, observations 838).

	Simple model	Model (1)	Model (2)	Model (3)
Cost	−0.00277***	−0.00293***	−0.00294***	−0.00293***
	(0.000373)	(0.000424)	(0.000426)	(0.000419)
Age		−0.0120**	−0.0120**	−0.00996*
		(0.00573)	(0.00574)	(0.00556)
Income (per $1000)		0.006**		
		(0.002)		
Income_mid (dummy)			0.336*	0.214
			(0.204)	(0.196)
Income_high (dummy)			0.724***	0.617**
			(0.269)	(0.262)
Sex		0.368**	0.354**	0.284*
		(0.168)	(0.168)	(0.163)
Education (Year)		0.0341	0.0317	0.0431
		(0.0282)	(0.0281)	(0.0274)
Kids		0.138	0.128	0.156
		(0.179)	(0.179)	(0.175)
House-owner		-0.181	-0.207	-0.281
		(0.187)	(0.187)	(0.181)
MBA		0.120	0.0932	0.0709
		(0.205)	(0.206)	(0.204)
Wetland_know		0.214	0.217	
		(0.164)	(0.164)	
Recycle		0.309**	0.304**	
		(0.143)	(0.143)	
Transport		0.316***	0.327***	
		(0.0885)	(0.0896)	
Constant	1.270***	−1.066	−1.016	0.958**
	(0.103)	(0.676)	(0.683)	(0.431)
Log likelihood	−491.57	−470.45	−469.11	−479.99
Pseudo R^2	0.054	0.095	0.098	0.077
LR	56.41	98.65	101.33	79.57
WTP	465.12	458.42	458.05	456.45
95% CI	[384.63, 580.49]	[380.13, 580.73]	[380.05, 579.43]	[371.86, 571.56]

Note: Absolute values of standard deviations in parentheses; *significant at 10%; **significant at 5%; ***significant at 1%.

bias in the information about income collected in our survey and the related endogeneity bias (Haab and McConnel, 2002), we redefine the continuous income variable by three 1/0 dummies that identify people's income into three categories, high, middle and low income, in Model (2).[5] We also suspect that environmental action/knowledge variables (i.e. *wetland_know*, *recycle* and *transport*), whose information were collected after the WTP questions, to be endogenous to the choices in the discrete choice model.[6] We therefore further remove these three variables from estimation in Model (3).

The four models based on CV data show relatively good stability. The negative coefficient associated with the variable cost reveals that, as expected, a higher cost will reduce the chance for the improvement scenario to be chosen. We also find that age negatively affects the probability for a person to accept the project. Male respondents reported significantly higher WTP than the female ones. A person with higher level of income are more willing to accept the proposal, which is logical because a higher level of income means a lower budget constraint related to the project. Although not significant, a person with higher education and living with children seem more willing to accept the proposal, all else being equal. The dummy variable MBA identifies the subsample of respondents recruited by the Quebec survey company from the region Montérégie, where the wetlands are under greater pressure of urbanisation and agriculture. Although the positive coefficients found for this variable confirm with our expectation, our estimation does not reveal statistically significant difference in their WTP answers with respect to those obtained from more general Quebec population. Finally, the three environment-related attitudinal variables provided intuitive results: A person, who is aware of a wetland close to his place of residence (*wetland_know*, although not significant), regularly practises recycling and uses public transport, will be more likely to accept the improvement project. Their exclusion from the estimation, while reducing model's explanative power, does not affect the final calculation of the mean WTP, whose values are very close between the four models, around $460 per household per year.

Table 6 reports the results obtained with the data from the CE. Both conditional logit (CL) model and random parameter logit (RPL) models are used. The dependent variable in the estimation model is the probability for a project presented in a choice group to be chosen by the respondent. Each respondent was asked to choose the best project in each of the five choice sets in the questionnaire. Thus, each individual has $5 \times 3 = 15$ information lines. Consequently, we had $15 \times 858 = 12{,}870$ observations in total, grouped into $858 \times 5 = 4290$ groups/choice sets. Each choice set contains three choices: project A, project B and status quo (O).

Compared to the estimation model for the CV data, the advantage of CE data is the variability in the scenarios, which makes it possible to estimate how individual choices are affected by the levels of attributes. Therefore, we can simultaneously include variables that capture different levels of attributes (biodiversity, flood control, water quality and climate regulation) next to the cost to explain how the decision to choose a scenario depends on the proposed conditions.

Moreover, respondents may have different perceptions of the importance of each attribute and be differently sensitive towards a proposed attribute. We believe that this difference may be partly determined by the socio-demographic characteristics of the respondents. We therefore also use multiplicative terms between environmental attributes and socio-demographic variables in our estimation to capture this part of influence (see Table 7 for detailed results).

Table 6 reports first two conditional logit-based models: a simple conditional logit (CL) model (the first result column), and a resume of the multiplicative CL model (the second result column, see Table 7 for detailed results).[7] One underlying assumption of CL model evolving from the independence of error terms across the options is the independence of irrelevant alternatives (IIAs). This independence requires that the ratio of the choice probabilities of any two alternatives does not depend on the inclusion or omission of other alternatives in the choice set. We applied the Hausman and McFadden (1984) test to check the validity of the IIA assumption of the simple CL model. A χ^2 value of 13.8 (prob $> \chi^2 = 0.0317$) was found when the 'project B' alternative is excluded from the choice set, which means that the assumption of IIA is not met in the CL model.

As a consequence, we chose to employ a RPL model, which does not assume IIA (Train 1998; Colombo, Cavalatra-Requena, and Hanley 2006). Another advantage of RPL model is its flexibility to attribute respondent-specific coefficients. We report in Table 6 two RPL models. The first one allows all the four ecological service related attributes to have random coefficients. As the mean random coefficient for the climate regulation attribute is found to be very weak in statistical significance, in the second RPL model, we decide to exclude this attribute from the random coefficient variable list.[8] Clearly, the comparison among values of log likelihood confirms the need to differentiate the coefficients of attributes between individuals (RPL > Multiplicative CL > simple CL). In the RPL model, the highly significant standard deviation of random coefficients also reveals the superiority of individualising the coefficients of the environmental attributes among respondents.

The coefficients reported in Table 6 show good coherence between different models. The variable *ASC* is the alternative specific constant, with a value set to 1 when either project A or B is selected and to 0 when the status quo is preferred. This variable actually measures the respondents' general preference regarding the changes. The positive and significant coefficients for this variable reveal the willingness of the respondents to adopt changes, which signifies a positive WTP. We also obtain, as expected, the negative coefficients for cost. For the three attributes biodiversity, flood and water quality, as their improvement is presented by the reduction of related risk indicators (number of endangered species, number of flood in 10 years and concentration of cfu in water), the negative coefficients actually signify positive WTP for improvement. In the bottom of Table 6 we reported the marginal WTP for each of the four attributes.[9] Although the exact values vary between models, it is easy to observe relatively good stability for a same attribute across different models (especially for *water_quality* and for *biodiversity*) and for the relative values across different attributes.

Table 6. Conditional logit vs. random parameter logit.

	Conditional logit		Random parameter logit		Random parameter logit (climate not included as random variable)	
	Simple	Multiplicative terms included	Coefficient	Standard deviation of the random coefficients	Coefficient	Standard deviation of the random coefficients
ASC	0.0637	0.0824	0.381***		0.318***	
	(0.0672)	(0.068)	(0.0875)		(0.0827)	
Cost	−0.0027***	−0.0029***	−0.0043***		−0.00434***	
	(0.001)	(0.001)	(0.0007)		(0.000632)	
Biodiversity	−0.0055***	−0.0056***	−0.0063***	0.0284***	−0.00697***	0.0267***
	(0.001)	(0.001)	(0.0015)	(0.0019)	(0.00142)	(0.00176)
Flood	−0.0294***	−0.0296***	−0.037***	0.140***	−0.0203**	0.156***
	(0.006)	(0.006)	(0.0098)	(0.0142)	(0.00949)	(0.0125)
Water quality	−0.0065***	−0.0065***	−0.0089***	−0.0169***	−0.00819***	−0.0162***
	(0.001)	(0.001)	(0.0009)	(0.0011)	(0.000845)	(0.00102)
Climate regulation	0.0065***	0.0068***	0.0029	-0.0516***	0.00604***	
	(0.0016)	(0.001)	(0.0029)	(0.0039)	(0.00212)	
Loglikelihood	−4395.90	4321.24	−4027.07		−4078.47	
LR	634.29	783.61	737.66		634.86	
	(0.000)	(0.000)	(0.000)		(0.000)	
R2	0.0673	0.0831				
MWTP_biodiversity	$2.02/endangered species in less	$1.94/endangered species in less	$1.46/endangered species in less		$1.60/endangered species in less	
MWTP_flood	$10.78/flood in less in 10 years	$10.21/flood in less in 10 years	$8.61/flood in less in 10 years		$4.68/flood in less in 10 years	
MWTP_water quality	$2.40/unit of cfu reduced	$2.20/unit of cfu reduced	$2.06/unit of cfu reduced		$1.88/unit of cfu reduced	
MWTP_climate	$2.39/1000 cars removed	$2.34/1000 cars removed	$0.67/1000 cars removed		$1.39/1000 cars removed	
Observations			12,870 = 858 * 5 * 3			
Number of choices			5, each among 3 options			
Respondents			858			

Table 7. Choice experiment: conditional logit (total observations = 12,870 = 858 × 5 × 3).

Variables	Model (1)				Model (2)			
ASC		0.0951				0.0824		
		(0.068)				(0.068)		
Cost		−0.0029***				−0.0029***		
		(0.001)				(0.001)		
Multiplicative terms	Biodiversity	Flood	Water quality	Climate	Biodiversity	Flood	Water quality	Climate
Variable	0.0007	0.1266**	−0.0024	−0.0399***	−0.0101**	0.0262	−0.0047*	−0.0182**
	(0.007)	(0.050)	(0.004)	(0.014)	(0.004)	(0.031)	(0.002)	(0.009)
Variable*age	0.0002***	−0.0003	0.0000	0.0000	0.0002***	−0.0004	0.0000	0.0001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Variable*sex	−0.0038**	−0.0067	0.0009	−0.0033	−0.0034**	−0.0035	0.0011	−0.0038
	(0.002)	(0.012)	(0.001)	(0.003)	(0.002)	(0.012)	(0.001)	(0.003)
Variable*edu	−0.0001	−0.0003	−0.0001	0.0012**	−0.0002	−0.0010	−0.0002	0.0015***
	(0.000)	(0.002)	(0.000)	(0.001)	(0.000)	(0.002)	(0.000)	(0.001)
Variable*kids	−0.0029*	0.0043	−0.0013	0.0035	−0.0029*	0.0031	−0.0013	0.0036
	(0.002)	(0.013)	(0.001)	(0.003)	(0.002)	(0.012)	(0.001)	(0.003)
Variable*income	−0.0001**	−0.0005**	0.0000	0.0001				
(per 1000$)	(0.000)	(0.000)	(0.000)	(0.000)				
Variable*income_mid					−0.0016	−0.0226	−0.0024**	0.0085**
					(0.002)	(0.015)	(0.001)	(0.004)
Variable*income_high					−0.0041	−0.0379**	0.0011	0.0039
					(0.003)	(0.019)	(0.001)	(0.005)
Variable*houseowner	0.0032*	0.0073	0.0025**	−0.0027	0.0023	0.0019	0.0025**	−0.0013
	(0.002)	(0.014)	(0.001)	(0.004)	(0.002)	(0.013)	(0.001)	(0.004)
Variable*MBA	−0.0017	−0.0184	−0.0050***	−0.0034	−0.0020	−0.0186	−0.0054***	−0.0019
	(0.002)	(0.015)	(0.001)	(0.004)	(0.002)	(0.015)	(0.001)	(0.004)
Variable*wetland_know	−0.0003	−0.0071	−0.0011	0.0074**				
	(0.002)	(0.012)	(0.001)	(0.003)				
Variable*transport	−0.0003	−0.0007	−0.0003	0.0008				
	(0.001)	(0.006)	(0.000)	(0.002)				
Variable*recycle	−0.0029**	−0.0279***	−0.0007	0.0058*				
	(0.001)	(0.011)	(0.001)	(0.003)				
Log-likelihood		−4299.98				−4321.24		
LR		826.14				783.61		
R^2		0.0876				0.0831		
Total coefficient	−0.0056***	−0.0285***	−0.0065***	0.0067***	−0.0056***	−0.0296***	−0.0065***	0.0068***
Standard deviation	(6.86)	(4.60)	(13.40)	(4.01)	(6.79)	(4.88)	(13.09)	(4.06)
CI	[−0.007, −0.004]	[−0.041, −0.017]	[−0.0075, −0.0056]	[0.0036, 0.010]	[−0.007, −0.004]	[−0.042, −0.018]	[−0.0075, −0.0055]	[0.0036, 0.010]
Standard error	(0.0008)	(0.0062)	(0.0005)	(0.0017)	(0.0008)	(0.0061)	(0.0005)	(0.0017)
Marginal WTP ($)	$1.94/endangered species less	$9.54/flood less in 10 years	$2.25/unit of cfu reduced	$2.32/1000 cars removed	$1.94/endangered species less	$10.21/flood less in 10 years	$2.20/unit of cfu reduced	$2.34/1000 cars removed

Note: Absolute values of z statistics in parentheses: *significant at 10%; **significant at 5%; ***significant at 1%. As the attributes biodiversity, flood and water quality are measured, respectively, by the number of endangered species, the number of flood in 10 years and concentration indicator of faecal coliforms, a lower level signifies an improvement in the situation; therefore a negative coefficient means a positive attitude of the respondents. ASC, = alternative specific constant, ASC = 1 when either A or B project is chosen, ASC = 0 when status quo is chosen. We also experimented with alternative specific constants representing projects A and B; however, including such constants made little change to the models, and so only the 'deviation-from-the status-quo constants included' versions are reported here. The calculation of marginal WTP is based on the equation: $WTP_{marginal} = -(\beta_{attribute}/\beta_{cost})$, where the $\beta_{attribute}$ includes the coefficients of the cross-terms and the sample average value of the involved socio-economics variables. Climate sequestration is measured by per 1000 cars removed from traffic.

Table 8. Comparison of WTP between the contingent valuation and the choice experiment ($ per household per year).

	CV (simple logit)		CE: CL (simple Clogit)		CE: RPL		CE: RPL (Climate not as rand var.)	
	WTP[a]	%	WTP[a]	%[b]	WTP[a]	%[b]	WTP[a]	%[b]
Biodiversity	n.d	28.24	121.23	23.36	89.95	22.87	98.27	26.32
CI 95%			[78.45, 196.19]		[45.72, 149.40]		[55.95, 153.00]	
Flood control	n.d	21.24	86.39	16.65	70.85	18.02	38.25	10.24
CI 95%			[46.56, 148.76]		[32.75, 120.20]		[2.24, 77.93]	
Water quality	n.d	29.81	239.63	46.18	211.30	53.73	193.65	51.86
CI 95%			[173.85, 375.68]		[147.24, 304.31]		[134.87, 273.43]	
Climate CI 95%	n.d	20.70	71.70 [35.14, 129.32]	13.82	21.17 [-19.01, 64.61]	5.38	43.23 [13.06, 79.38]	11.58
Total	465.12 [384.63, 580.49]		542.40 [413.98, 805.34]		482.29 [358.34, 671.85]		447.12 [339.88, 601.75]	
Poe, Welsh, and Champ (1997) (vs. CV)[c]			0.0008		0.60		0.97	

Note: The percentage points reported in the CV study come from a follow-up question which is asked if a respondent accept to pay for the improvement project. The question is: in which percentage will you distribute the accepted amount of payment between the four aspects of the improvement? biodiversity ______%, flood control _____%, water quality______% and climate regulation_____%. The sum of the four percentage points is equal to 100%.

[a]The unit of WTP is $/year/household.

[b]The estimation models applied to CE data include an Alternative Specific Constant (ASC); therefore, the calculation of the % for each attribute in WTP for the CE model is based on the sum of the WTP for the four attributes instead of the total WTP. This arrangement ensures the comparability of CE data with those of CV, where we simply asked the respondents to allocate the total WTP amongst four attributes.

[c]The value of the Poe, Welsh, and Champ (1997) test indicates the percentage level of the statistical significance of the difference between two distributions.

[d]The scenario used in calculation is the one presented in the CV questionnaire. More precisely, this scenario assumes that there is a reduction of 60 threatened species (from 90 species to 30 species), a reduction of 8 catastrophic flooding in 10 years (from 14 to 6 floods), a reduction in the concentration of faecal coliforms (cfu) of 100 units or more per 100 ml (from >100 to <1), and a reduction in carbon emissions equivalent to a withdrawal from circulation of 30,000 cars (from 60,000 to 30,000 cars).

Table 8 reports the calculated WTPs based on the estimates made from sub-samples of CV and CE. To ensure comparability, the values reported in this table are calculated using the maximal improvement scenario proposed in the CV questionnaire. The bracketed figures in Table 8 show the confidence interval of WTP calculated according to the method of Krinsky and Robb (1986).

The total values for a typical scenario vary from $465.12/year/household with the CV method to $482.29/year/household and $447.12/year/household according to the two RPL models with CE data.[10] If the value reported by simple CL model with CE data ($542/year/household) seems to be statistically larger,[11] we can conclude that the two methods are fairly consistent at determining the total value of the wetland protection while concentrating on simple Logit (CV) and RPL (CE) results. This is also confirmed by the test of Poe, Welsh, and Champ (1997), in which the simulated benefit compensation surpluses measured by two alternative valuation models are differentiated and a one-sided approximate significance level is estimated by calculating the proportion of the difference with a negative sign (Christie and Azevedo 2009).

Table 8 also reports the relative importance of each attribute allocated by the CV respondents based on their answers given to the follow-up question in which we ask the respondents to distribute the accepted amount of payment among the four attributes. Although we are aware that these percentage points are reported only by respondents who answered positively to the WTP questions therefore from a non-random sample, which is different from the percentage points reported for each attribute in the CE study by the whole randomly selected sample. A general impression is that the ranking of the four attributes stay relatively stable between the two methods. The relative importance measured by both the value of the WTP in CE and the percentage points in CV predicted a first place for water quality, a second place for biodiversity, followed by more similar importance for flood management and climate regulation (see CV and CE:RPL model in which climate is not as random variable).

Although the CL model estimated with CE data is found to violate the IIAs assumptions, it is still interesting to compare Table 7 (detailed results of multiplicative CL models) with Table 5 for potential evidence about the similarity in the role of socioeconomic characteristic on WTP's determination between CV and CE data. Table 7 reveals that older people attach significantly less importance to biodiversity (positive coefficient for *biodiversity×age*), male respondents give more importance to biodiversity than female ones (negative coefficient for *biodiversity×sex*), respondents living with children are more sensitive to biodiversity (negative coefficient for *biodiversity×kids*), people residing in the region of Montérégie are more sensitive to water quality (negative coefficient for *water_quality×MBA*), more educated people seem to be more concerned by climate change (negative coefficients for *climate×education*), richer respondents are significantly more sensitive to the improvement almost all the four aspects of ecological services (significant coefficients for most of the multiplicative terms with continuous income or income dummies) and finally house-owner seems to be less willing to pay for water quality improvement (positive coefficient for *water_quality×houseowner*).[12] Most of these findings provide relatively good correspondence to what we find in logit model with CV data, except that the estimation based on multiplicative CL model further indicates with precision about which type of socioeconomic characters to be more sensitive about which type of ecological services, while the CV results only provide a more global idea about how the different types of socioeconomic characteristics affect the total WTP.

We further test the hypothesis that the estimated attributes' parameters are equal across the models. The central question for the test of the coefficient equivalence is therefore whether $\mu_{CV}\beta_{CV} = \mu_{CE}\beta_{CE}$. By rearranging, we obtain:

$$\beta_{CV} = \frac{\mu_{CE}}{\mu_{CV}}\beta_{CE}$$

This signifies that the difference between the parameters in the two data-sets can be due to true difference in the parameters $\beta_{CE}\beta_{CV}$ or to a difference in the scales of the data $\frac{\mu_{CE}}{\mu_{CV}}1$. Therefore, the test will be carried out in two steps.

1. Test whether β_{CV} and β_{CE} are equal via the hypothesis H_{1A}: $\beta_{CV} = \beta_{CE} = \beta$ but $\mu \neq 1$.
2. If H_{1A} cannot be rejected, we test the hypothesis H_{1B}: $\mu_{CV} = \mu_{CE,}$ so $\mu = 1$.

If both H_{1A} and H_{1B} cannot be rejected, we can say that $\mu_{CV}\beta_{CV} = \mu_{CE}\beta_{CE}$, so the CV and CE data-sets generate the same parameters. If H_{1A} is rejected, naturally H_{1B} is also rejected, we therefore can reject the hypothesis of parameter equality between CV and CE. More details about the test can be found in Appendix 7.

The results reported in Table 9 illustrated very small LR values for the both steps of the test; we therefore cannot reject either hypothesis, which means the parameters are equivalent in both data-sets. Different from the previous studies such as Adamowicz et al. (1998), Mogas, Riera, and Brey (2009) and Christie and Azevedo (2009) that also used the approach proposed by Swait and Louviere (1993) to compute the relative scale parameters, our study reports a the scale factor $\mu_{CE/CV}$ smaller than one. The LR test for hypothesis H_{1B} reported in our study is a very small value 1.02, which signifies the $\mu_{CE/CV}$ is statistically not different from zero. This can be considered as a strong signal about the equality of the parameters between the estimation models using CV and CE data.

7. Discussion and conclusion

In this study, we used two non-market valuation methods (CV and CE) to estimate the social benefit generated from improving wetlands in Quebec through preservation and restoration. Our results show that the WTP per year per household varies from \$447 (CE) to \$465 (CV), depending on methods. This mean WTP value can also be affected by respondents' socioeconomic characteristics

Table 9. The parameter equivalency test values.

	CV	CE1	Pooled and scaled	Pooled
Log likelihood	−491.57	−4078.47	−4566.27	−4566.78
Number of observations	1676	12,870	14,564	14,564
$\mu = \mu_{CE}/\mu_{CV}$	–	–	0.7344	1
LR test (H_{1A})2	7.54			
$\beta_{CV} = \beta_{CE} = \beta$ but $\mu = \mu_{CV}/\mu_{CE} \neq 1$	(1.000)			
LR test (H_{1B})3			1.02	
$\mu_{CV} = \mu_{CE}$			(1.000)	

[1]CE data used random parameter logit model with carbon not included as random coefficient variables (i.e. the last model presented in Table 8). This is the only combination which allows us to combine CV data with those of CE to estimate in a random parameter logit model with or without scale parameter adjustment.
[2]$LR = -2[(\log L^{CV} + \log L^{CE}) - \log L^{\mu}]$. $\log L^{CV}$ is the log likelihood of the logit model estimation with CV subsample. $\log L^{CE}$ signifies log likelihood of the RPL model estimation with CE subsample. $\log L^{\mu}$ is the log likelihood of the RPL model estimation with combined CV and CE data, in which the parameter scale $\mu = \mu_{CE}/\mu_{CV}$ is determined by the approach proposed by Swait and Louviere (1993).
[3]$LR = -2[\log L^{POOL} - \log L^{\mu}]$ $\log L^{\mu}$ is the log likelihood of the RPL model estimation with combined CV and CE data, in which the parameter scale $\mu = \mu_{CE}/\mu_{CV}$ is determined by the approach proposed by Swait and Louviere (1993) and $\log L^{POOL}$ is the log likelihood of the RPL model estimation with combined CV and CE data, in which the parameter scale $\mu = \mu_{CE}/\mu_{CV}$ is assumed to be equal to 1.
[4]The value reported here is obtained by the approach proposed by Swait and Louviere (1993).

such as age (−), income (+), education (+), gender (male > female), etc. Our conclusion suggests that the two methods provide statistically convergent WTP values, both in total value and in relative importance of different attributes involved. Using the method proposed by Swait and Louviere (1993), our result also confirms the coefficient equivalence between the estimation models using the data from the two methods. These conclusions suggest a fairly robust and consistent equivalence between CV and CE and provide an interesting contrast with the study of Christie and Azevedo (2009), which suggested that the WTP reported by repeated CV data to be lower than that reported by full-set CE data, but at the same time, it provided the evidence of coefficient equivalence between the two methods.

We can also compare our WTP value to that reported by previous Canadian studies that evaluated the similar wetland-related ecological services. Pattison, Boxall, and Adamowicz (2011) based on a scenario aiming at restoring the wetlands in Manitoba to 100% of 1968 level, reported a range of \$319−\$375 for annual per household WTP which englobes five attributes: water quality, flood control, soil erosion, wildlife habitat, carbon capture and storage.[13] Lantz et al. (2013), based on a scenario of over 40% increase in wetland area in southern Ontario, reported a WTP per year per household varying from \$264 to \$273 for the improvement of four attributes: water quality, flood control, wildlife habitat and carbon storage.[14] Finally, Dias (2011) reported a range of WTP varying between \$240 and \$375 per annual per household[15], but their study only considered three attributes, including riparian buffer width, wildlife habitat and water quality. Clearly, the composition of ecological service attributes proposed in our paper is very similar to that of Pattison, Boxall, and Adamowicz (2011), it is therefore logic to see our reported WTP per year per household to be closest to this study, with the WTP values reported by Pattison, Boxall, and Adamowicz (2011) falling well into the 95% confidence interval of our WTP estimate.

Multiplying the per household per year payment with the number of the household in Quebec (i.e. 3,325,584), we can obtain the total yearly value of the ES generated by the restored wetlands in Quebec as being equal to 1.49−1.55 billion dollars for 400,000 hectares or approximately \$3725−\$3866 per hectare per year. This result is comparable with values obtained through benefit transfer approaches for the wetlands in Quebec, such as Dupras, Alam, and Revéret (2015), \$5284−\$5463/ha/year for five ES,[16] and Dupras and Alam (2015), \$4593/ha/year for seven ES,[17] both for the region of Montreal, or He et al. (2015), \$4702 and \$9080/ha/year for the average value of the wetland located in the drainage basins of Yamaska and Becancour rivers based on a meta-analysis and detailed geographical information.

The comparison of the per hectare WTP value between several current Canadian studies, however, reveals a more different situation. Pattison, Boxall, and Adamowicz (2011) reported a value of \$296−\$326 per ha for Manitoba in 2008, which equals to \$319−\$352 in 2013 Canadian dollar. It is about 10 times lower than the value reported in our study. Based on the information available in Lantz et al. (2013), we calculated the wetland in urban area of southern Ontario to be as high as \$92,000 per ha, about 30 times higher than ours. Such divergence can be explained by both the specificity of the wetland sites and by the specificity of socioeconomic situation of the people considered as the beneficiaries of the studied ecological services. A similar situation can also be seen in He et al. (2015, Table 2, 713), where the authors calculated the average value of wetland by hectare for over 51 different wetland sites covering the five continents. Besides the big differences in the mean value of per hectare wetland between continents, the sites belonging to a same continent also show very big difference in their per hectare values, revealed by the larger-than-mean standard deviation.

As the hypothetical choice sets proposed in our CE study is a three-alternative format, in which a status quo is presented with two different projects (A and B) each time, another potential risk, as mentioned by Carson and Grove (2007) and Vossler, Doyon, and Rondeau (2012), is that given the public good characteristics of the wetland improvement project, a respondent may not be incentive compatible to reveal their best choice since they may first consider strategically which options are more likely to be provided under collective votes, instead of focusing on the choice that corresponds to his/her highest utility. Such consideration may bias the choice to a second best. We are not sure about the importance of this risk in our paper; however, given the relatively good equivalence between the CE and results of CV, which was based on a referendum design, we consider such risk to be small. A useful strategy for future comparative study between CV and CE may consider using referendum CV versus two-alternative (project A vs. status quo) CE to isolate this bias. Another advantage of this arrangement will be its possibility to understand whether CV respondents are more cost-focalised (a higher reaction to the increase in the cost) and CE respondents are more attribute-focalised and whether such difference in focus of respondents can lead to divergence in two valuation methods.

Our study may still suffer the so-called ‘anchoring effect’ (Herriges and Shrogen, 1996). Although the anchoring effect was initially used to measure the bias that a first bid can create on people’s answer to a follow-up question in double bound dichotomous choice WTP elicitation format. We suspect a similar bias may also be applicable to the repeated choice-set based questions that are generally used in CE studies, such as ours. Following such logic, a potentially new research line for comparison study between CV and CE methods will be to compare the estimation based on single-bound referendum CV data with that using only the first-round CE question. Our paper has made several trials in this direction, without clear results, principally due to the insignificant coefficients for certain key attributes, such as the cost. We suspect the presence of five attributes in the CE choice set may make the trade-off difficult for the respondent (Miller 1956), especially in the first-round choice due to the lack of the learning effect. We therefore believe it to be an interesting future research topics for CV and CE comparison by proposing simpler CE choice set with fewer attributes.

Another point that needs to be discussed is the pertinence to represent the climate regulation services provided by wetlands by the number of cars removed from traffic. The concern is that the respondent may also lump in other benefits of removing cars from the roads, such as reduced highway congestion, shorter commutes, better air quality, etc. If it is the case, we may expect the part-worth value estimated to be biased upward.

Finally, we wish to emphasise that our study only includes four attributes of wetlands, namely biodiversity habitat, water quality, flood management and climate regulation. The overall WTP thus obtained does not include the potential value that wetlands derive from other aspects of ecological goods and services they provide, such as tourist services and the supply of food. It is thus quite possible that the real value of wetlands in southern Quebec is higher than the value given here.

Notes

1. However, we cannot reject the possibility that both estimates are equally wrong, just as indicated in Hanley and Spash (1994).
2. The scale of wetland restoration proposed in our study, seemingly large, is comparable to the 100% restoration scenario used in Pattison, Boxall, and Adamowicz (2011) for the Manitoban wetlands case, which proposes an increase of wetland area of 407,000 acres, equal to 164,707 hectares.
3. A linear extrapolation with respect to the size of wetlands is used here to construct the various levels for the attributes in different scenarios. This simplified assumption about the linear relationship between the quality of ecological services and wetland size is for certain not ideal for extrapolation. However, since we do not have precise information about the geographical distribution of different ecological services considered in our paper, we could not propose better alternative assumption.
4. We assume here that people in general believe a linear correlation between the size of wetlands and the quality of ecological services that they can provide.
5. Due to colinearity, we cannot include the third income dummy that identifies people with low income.
6. We thank one of the two anonymous referees for this comment.
7. The coefficients reported in the multiplicative conditional logit model for different attributes are calculated with the CE sub-sample mean value of the related socioeconomic variables included into the multiplicative terms.
8. Excluding climate regulation attribute from random coefficient variable list is also necessary for our investigation about the parameter equality between CV and CE methods since pooling CV and CE data for RPL estimation will face the problem of under-identification problem if all the four ecological services are included into the list for random coefficient variables.
9. The marginal WTP for an attribute (say X, X∈biodiversity, flood, water quality, climate regulation)$= -\hat{\beta}_X/\hat{\beta}_{cost}$.
10. We decide to use simple logit, simple conditional logit and RPL models to make comparison in calculated WTP value to avoid the potential bias created by the presence/omission of socioeconomic variables.
11. Whose result suffers from the bias related to its violation of IIAs.
12. The payment vehicle used in this paper is a municipal water and sanitation tax, to avoid the potential bias related to the universality nature of the payment vehicle, we explicitly indicated in our questionnaire (c.f. Table 1) that this tax would be directly applied on house-owners and indirectly applied on tenants via an increase in house rent. We admit that this mention is not 100% efficient to avoid a potential WTP reducing influence for house-owners due to this specific payment vehicle. This influence is however, only found in CE data but not in CV data (c.f. the insignificant positive coefficient before variable *houseowner*).
13. The initial WTP per household per year reported in the paper is $295−$348 in 2008 price. We used the conversion factor calculated from consumer price index: 1 dollar in 2008 = 1.073 dollar in 2013 to calculate the equivalent value in 2013 Canadian dollars.
14. The initial WTP per household per year reported in the paper is $246–$254 in 2008 price. We used the conversion factor calculated from consumer price index: 1 dollar in 2008 = 1.073 dollar in 2013 to calculate the equivalent value in 2013 Canadian dollars.
15. The WTP for the conversion factor is calculated from consumer price index: 1 dollar in 2010 = 1.054 dollar in 2013.
16. Water provisioning, waste treatment, biodiversity habitat, disturbance protection and recreation.
17. Climate regulation, water provisioning, waste treatment, biodiversity habitat, disturbance protection, aesthetics and recreation.

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Appendix 1. Contingent valuation question used in our study (in French).

Le meilleur projet pour l'environnement est celui qui permettra de réduire le nombre d'espèces menacées à 30, de réduire la fréquence des crues à moins de 6 sur 10 ans, d'augmenter la qualité de l'eau des rivières à potable (coliformes fécaux à moins de 1ufc/100ml), d'augmenter la capacité de stockage de carbone (soit l'équivalent de 60.000 véhicules retirés de la circulation), le tout pour un coût annuel de X$ par ménage.

Voici un tableau récapitulatif de ces différents éléments:

	Statut quo	Projet le plus favorable à l'environnement
Biodiversité La capacité à servir d'habitat et à préserver un grand nombre de plantes, d'insectes et d'animaux.	90 espèces végétales et animales menacées de disparition	30 espèces végétales et animales menacées de disparition
Régulation des crues la capacité à retenir l'eau pour réduire le potentiel d'inondation lors de pluies abondantes.	14 inondations catastrophiques en 10 ans	6 inondations catastrophiques en 10 ans
Qualité de l'eau la capacité à filtrer les sédiments et les polluants afin d'assurer une eau de qualité dans les rivières et les lacs.	Mauvaise qualité (ne permet pas des activités récréatives, coliformes fécaux supérieurs à 200ufc/100ml)	Bonne qualité (eau potable, coliformes fécaux inférieurs à 1ufc/100ml)
Stockage du carbone Les milieux humides servent de puits de carbone et captent les émissions issues de l'activité économique	Équivalent de 30.000 véhicules retirés de la circulation	Équivalent de 60.000 véhicules retirés de la circulation
Coût annuel un supplément de taxe municipale sur l'eau et l'assainissement (payé directement ou à travers une augmentation des loyers)	0$	X$

Les questions suivantes sont hypothétiques et il n'existe pas de réponses correctes ou fausses. Avant de donner votre réponse, veuillez prendre en considération que chaque action de payer conduira à une réduction du montant d'argent dont vous disposez pour payer d'autres biens et services (ex.: loisirs, vêtements, voyages, etc.).

Compte tenu des différents avantages fournis par le projet le plus favorable à l'environnement par rapport au statut quo (situation actuelle) seriez-vous prêt à payer X dollars pour la mise en place de ce projet et ainsi restaurer et préserver les milieux humides dans les zones habitées du Québec ? Le mode de financement serait ici une augmentation de la taxe municipale sur l'eau et l'assainissement (payée directement ou à travers une augmentation des loyers).

☐ Oui, je voterai pour.

☐ Non, je voterai contre

Appendix 2. Age structure of respondents.

Age range	CV		CE		Total		Quebec population (2013)
	Number of respondents	%	Number of respondents	%	Number of respondents	%	%
18–24 years	75	8.95	72	8.39	147	8.67	11.06
25–34 years	159	18.97	171	19.93	330	19.46	16.26
35–44 years	137	16.35	150	17.48	287	16.92	15.86
45–54 years	184	21.96	163	19	347	20.46	18.31
55–64 years	191	22.79	166	19.35	357	21.05	16.77
65 years +	92	10.97	136	15.85	228	13.44	21.75
Total	838	100.00	858	100.00	1696	100.00	100.00
Average	46.55		47.01		46.79		48.21

Source of Quebec data: Institut de la Statistique du Québec.

Appendix 3. Distribution of respondents according to their sex.

Sex	CV		CE		Total		Quebec population (2013)
	Number of respondents	%	Number of respondents	%	Number of respondents	%	%
Female	437	52.15	449	52.33	886	52.24	50.8
Male	401	47.85	409	47.67	810	47.76	49.2
Total	838	100.00	858	100.00	1696	100.00	100.00

Source of Quebec data: Institut de la Statistique du Québec.

Appendix 4. Distribution of respondents according to the household income.

Household income ($)	CV		CE		Total		ISQ classification	Quebec population (2013)
	Number of respondents	%	Number of respondents	%	Number of respondents	%		%
9999 or less	47	5.61	52	6.06	99	5.84	9999 or less	2.9
10,000–29,999	182	21.72	194	22.61	376	22.17	10,000–19,999	9.5
30,000–49,999	216	25.78	222	25.87	438	25.83	20,000–39,999	24.7
50,000–74,999	187	22.32	183	21.33	370	21.82	40,000–59,999	22.8
75,000–99,999	96	11.46	112	13.05	208	12.26	60,000–79,999	16.8
100,000+	110	13.13	95	11.07	205	12.09	80,000+	23.4
Total	838	100.00	858	100.00	1,696	100.00	Total	100.00
Average	55313		53767		54531			54515

Source of Quebec data: Institut de la Statistique du Québec.

Appendix 5. Distribution of respondents according to their education.

Education	CV		CE		Total		Quebec population (2013)
	Number of respondents	%	Number of respondents	%	Number of respondents	%	%
Primary	13	1.55	12	1.40	25	1.47	13.5
Secondary	243	29.00	251	29.25	494	29.13	19.5
DEP	114	13.60	97	11.31	211	12.44	17.4
High school	203	24.22	238	27.74	441	26.00	23.7
University	265	31.62	260	30.30	525	30.96	25.9
Total	838	100.00	858	100.00	1,696	100.00	100.00

Source of Quebec data: Institut de la Statistique du Québec.

Appendix 6. Estimation models.

To facilitate our comparison, we use logit model for CV data and conditional logit and random parameter logit models for CE data; all three models derive their theoretical foundation from the random utility theory (McFadden 1974) which allows taking into account the uncertain knowledge of individual utility as a latent variable. We can therefore represent the utility of respondent i for the jth choice as U_{ij}. Treating U_{ij} as an independent random variable with a systematic component V_{ij} and a random non-observable component ε_{ij}, we have:

$$U_{ij} = V_{ij} + \varepsilon_{ij}$$

To maximise his/her utility, a respondent i will choose the alternative j if U_{ij} is the highest among U_{i1}, U_{i2}, U_{i3}, …and U_{iJ}. Therefore we can write the probability for a respondent i to use the project j as:

$$\Pr\{Y_i = j\} = Pr\{\max(U_{i1},\ U_{i2},\ U_{i3}, \ldots U_{iJ}) = U_{ij}\}$$

By making the assumption that the random component ε_{ij} is independently and identically distributed (iid) with a Type I extreme value distribution, the probability for one of the J scenarios j to be selected by a respondent i can be written as a conditional logit model as following:

$$P_{ij} = \frac{\exp(V_{ij})}{\sum_k \exp(V_{jk})}$$

In the special case where $J = 2$ (1 = project, 0 = status quo), which corresponds to our CV data. The individual i will choose 1 = project if $U_{i1} - U_{i0} > 0$. If the random utilities U_{ij} have independent extreme value distributions, their difference can be shown to have a logistic distribution, and we therefore obtain the standard logistic regression model.

$$P_{i,Y=1} = \frac{\exp(V_{i1})}{1 + \exp(V_{i1})}$$

We can further write the indirect utility determination function for the systematic component of utility. V_{ij} to be binding on the attribute levels for alternative j (A_j), the suggested donation amount (C_j), and the respondent i's socio-economic and attitudinal characteristics (S_i) as follows:

$$V_{ij}^{\text{CE\_CL}} = ASC + \beta A_i + \gamma C_j + \delta A_j \times S_i$$

Where ASC = 1 if the choice of respondent i is one of the two improvement scenarios (project A or project B), ASC = 0 if respondent i chooses status quo. We can also allow the inclusion of multiplicative terms between attributes (A_j) and respondents' socioeconomic characteristics (S_i). By doing so, we assume the utility that a scenario can bring to a respondent depends not only on the absolute level of the attributes but also his/her reaction to these attributes, depending on his/her specific socioeconomic characteristics.

Instead of including the multiplicative terms $A_j \times S_i$ as does CL model to allow variable reactions of respondents towards the same level of improvement in attributes, the random parameter logit (RPL) model based on CE data assumes β to be respondent-specific. The indirect utility determination function for RPL therefore becomes:

$$V_{ij}^{\mathrm{CE\_RPL}} = ASC + \beta_i A_i + \gamma C_j$$

For CV data, as the attribute level for the option 1, the improvement project, is the same among all respondents, we therefore have,

$$V_i^{\mathrm{CV}} = ASC + \gamma C_j + \delta S_i$$

Clearly, as there are only two scenarios in CV survey, we therefore have $ASC = 1$ if respondent i chooses the improvement scenario, and ASC = 0 if the choice is status quo.

One objective of our estimations based on the CE data is to obtain the value of marginal WTP (MWTP) for each attributes, which indicates the amount of money that consumers are willing to pay to maintain their current level of utility if there is a unit change in the level of an attribute. As we use a linear function for the indirect utility V_{ij}, the MWTP for an attribute A can be written as:

$$\overline{MWTP_A{}^{\mathrm{CL}}} = -\frac{\overline{\partial V_{ij}/\partial A_j}}{\partial V_{ij}/\partial C_j} = -\frac{\hat{\beta} + \hat{\delta}\,\overline{S_i}}{\hat{\gamma}};$$

$$\overline{MWTP_A{}^{\mathrm{RPL}}} = -\frac{\overline{\partial V_{ij}/\partial A_j}}{\partial V_{ij}/\partial C_j} = -\frac{\hat{\overline{\beta_i}}}{\hat{\gamma}}.$$

Based on the linear indirect utility determination function, we can also derive the total WTP for a specific scenario (for example the maximal improvement scenario proposed in CV survey):

$$\overline{WTP^{\mathrm{CL}}} = -\frac{\hat{\beta} + \sum A\,\hat{\delta}\,\overline{S_i}\Delta A + \hat{ASC}}{\hat{\gamma}};$$

$$\overline{WTP^{\mathrm{CE}}} = -\frac{\sum A\hat{\overline{\beta_i}}\,\Delta A + \hat{ASC}}{\hat{\gamma}};$$

$$\overline{WTP^{\mathrm{CL}}} = -\frac{\sum S\,\widehat{\delta\,\overline{S_i}}}{\hat{\gamma}}.$$

Appendix 7. Details about the parameter equality test.

To conduct this test, we combined the data from CE and the data from CV together (stacked on the top of each other). Let V^{CE} represent the utility in the CE task and V^{CV} be the utility in the CV task. For the portion of data containing CV data, the joint estimation occurs by specifying:

$\mathrm{prob}\{j\} = \frac{e^{\mu_{CV} V_j^{CV}}}{\sum_{j \in Y} e^{\mu_{CV} V_j^{CV}}}$, where prob$\{j\}$ is the probability for project j (j = status quo or the proposed maximal scenario) to be chosen. Y includes alternatives yes (maximal scenario with required payment) and no (status quo with zero payment); for the portion of the data that contains CE data, the specification will be: $\mathrm{prob}\{j\} = \frac{e^{\mu_{CE} V_j^{CE}}}{\sum_{j \in Y} e^{\mu_{CE} V_j^{CE}}}$, where prob$\{j\}$ is the probability for project j to be selected and Y includes alternatives projects A and B and status quo. Here the projects A and B change with the specific choice sets.

Here, $U_j^{\mathrm{CV}} = V_j^{\mathrm{CV}} + \varepsilon_j$, and $U_j^{\mathrm{CE}} = V_j^{\mathrm{CE}} + \varepsilon_j$ indicate the overall utility associated with an alternative j. More precisely, the alternative j, more specifically yes/no in CV or project A, B or O in CE, can be considered as a discrete choice from a set of alternatives. Each alternative is represented with a utility function that contains (1) a deterministic component ($U_j^{\mathrm{CV}} = e^{X_j{}' \beta_{\mathrm{CV}} + \varepsilon_j}$, $U_j^{\mathrm{CE}} = e^{X_j{}' \beta_{\mathrm{CE}} + \varepsilon_j}$)

specified as a function of $X_j^{'}$, more specifically the vector of characteristics of the project (attributes and their levels) and the socioeconomic characteristics of the respondent, with β representing the vector of the estimated parameters; and (2) a stochastic component ($\boldsymbol{\varepsilon}_j$), representing unobserved factors that affect the choice.

The central question for the test of the coefficient equivalence is therefore whether $\mu_{\mathrm{CV}}\beta_{\mathrm{CV}} = \mu_{\mathrm{CE}}\beta_{\mathrm{CE}}$. By rearranging, we obtain:

$$\beta_{\mathrm{CV}} = \frac{\mu_{\mathrm{CE}}}{\mu_{\mathrm{CV}}}\beta_{\mathrm{CE}}$$

This signifies that the difference between the parameters in the two data-sets can be due to true difference in the parameters $\beta_{\mathrm{CE}}\beta_{\mathrm{CV}}$ or to a difference in the scales of the data $\frac{\mu_{\mathrm{CE}}}{\mu_{\mathrm{CV}}}1$. Since we have separated the data-sets, we can calibrate the relative scale parameter $\mu = \mu_{\mathrm{CE}}/\mu_{\mathrm{CV}}$ by multiplying μ with one of the two data-sets. Therefore, the test will be carried out in two steps.

First, we test whether β_{CV} and β_{CE} are equal via the hypothesis $\mathrm{H_{1A}}$: $\beta_{\mathrm{CV}} = \beta_{\mathrm{CE}} = \beta$ but $\mu \neq 1$, which permits the scale factors to be different between data-sets. If $\mathrm{H_{1A}}$ is rejected, $\mathrm{H_1}$ is also rejected. If $\mathrm{H_{1A}}$ cannot be rejected, then we can further test the hypothesis $\mathrm{H_{1B}}$: $\mu_{\mathrm{CV}} = \mu_{\mathrm{CE},}$ so $\mu =$ 1. If $\mathrm{H_{1B}}$ also cannot be rejected, then we can say that $\mu_{\mathrm{CV}}\beta_{\mathrm{CV}} = \mu_{\mathrm{CE}}\beta_{\mathrm{CE}}$, so the CV and CE data-sets generate the same parameters.

This two-step test requires us to estimate the separate parameter vectors by sample, β_{CV} and ($\mu\beta_{\mathrm{CE}}$) in the first step. We therefore obtain the values of the log likelihood function from the separated estimates of the two data-sets, $\log L^{\mathrm{CV}}$ and $\log L^{\mathrm{CE}}$. After imposing $\mathrm{H_{1A}}$: $\beta_{\mathrm{CV}} = \beta_{\mathrm{CE}} = \beta$, we pool the two data-sets together and calibrate the best value of μ and obtain consistent estimates of β and the $\mathrm{Log}L^{\boldsymbol{\mu}}$, indicating the value of the log likelihood function from the pooled and scaled models. To calibrate the value of the scale parameter μ, we follow the approach outlined by Swait and Louviere (1993) to obtain the value of μ that gives the highest log likelihood value for the estimates based on the pooled and partially scaled data-sets. After these two steps, we can test $\mathrm{H_{1A}}$ by using a likelihood ratio test where the test statistic is defined as:

$$\mathrm{LR} = -2\left[\left(\log L^{\mathrm{CV}} + \log L^{\mathrm{CE}}\right) - \log L^{\mu}\right]$$

This statistic is distributed asymptotically chi-squared with the number of degrees of freedom equal to the number of parameter restrictions imposed on the model. Failure to reject the null hypothesis $\mathrm{H_{1A}}$ is evidence in favour of consistency. More precisely, we cannot reject the hypothesis that the CV and CE generate the same parameters and that the difference might be only caused by the relative scale parameter μ.

Next, we need to compare a simply pooled conditional logit model, which suggests the hypothesis $\mathrm{H_{1B}}$: $\mu_{\mathrm{CV}} = \mu_{\mathrm{CE}}$ so $\mu = 1$, to the pooled and partially scaled models, which suggests that $\mu_{\mathrm{CV}} \neq \mu_{\mathrm{CE}}$ and $\mu = \mu_{\mathrm{CE}}/\mu_{\mathrm{CV}} \neq 1$. The $\mathrm{H_{1B}}$ can be tested also by an LR test as follows:

$$\mathrm{LR} = -2\left[\log L^{\mathrm{POOL}} - \log L^{\mu}\right]$$

Similarly, this statistic is distributed asymptotically chi-squared with the degrees of freedom equal to the number of restrictions the parameters impose on the model. Failure to reject the null hypothesis $\mathrm{H_{1B}}$ is evidence in favour of the hypothesis that $\mu = 1$.

Therefore, if neither $\mathrm{H_{1A}}$ nor $\mathrm{H_{1B}}$ can be rejected, we can say that the CV and CE data-sets have approximately equal estimated parameters.