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Research article

Accounting for substitution and spatial heterogeneity in a labelled choice experiment

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ABSTRACT

Many environmental valuation studies using stated preferences techniques are single-site studies that ignore essential spatial aspects, including possible substitution effects. In this paper substitution effects are captured explicitly in the design of a labelled choice experiment and the inclusion of different distance variables in the choice model specification. We test the effect of spatial heterogeneity on welfare estimates and transfer errors for minor and major river restoration works, and the transferability of river specific utility functions, accounting for key variables such as site visitation, spatial clustering and income. River specific utility functions appear to be transferable, resulting in low transfer errors. However, ignoring spatial heterogeneity increases transfer errors.

1. Introduction

One of the first stated preferences studies by Hanley et al. (2006) in the United Kingdom, estimating the non-market benefits of river ecology improvements as a result of implementation of the European Water Framework Directive (WFD) kick-started a series of related valuation studies across European member states. Examples include Brouwer (2008), Schaafsma et al. (2012, 2013) for the Netherlands, Brouwer (2011) for France, Belgium and the Netherlands, Del Saz-Salazar et al. (2009), Brouwer et al. (2010) and Martin-Ortega et al. (2012) for Spain, Bateman et al. (2011) for the UK, Norway, Lithuania and Belgium, Kataria et al. (2012) for Denmark, Metcalfe et al. (2012) and Ferrini et al. (2014) for the United Kingdom, Meyerhoff et al. (2014) for Germany, and Brouwer et al. (2015) for Spain, Greece and Italy. In all of these studies, the non-market benefits are estimated of reaching a good chemical and ecological status of water bodies as prescribed by the WFD, most importantly to assess the extent to which the costs of WFD implementation are proportionate to their benefits (Brouwer, 2008). The studies differ from each other in terms of the extent to which local case study characteristics have been accounted for in the valuation of the non-market benefits. This includes differences in geo-climatic conditions and pollution sources across different parts of Europe (e.g. north and south) and their impact on river basin ecology (e.g. flow rates, concentration levels of different types of chemicals).

A number of studies specifically focused on the general applicability and transferability of these non-market benefits given the lack of studies across Europe examining the benefits of WFD implementation. For an overview of the use and development of benefit transfer in Europe, see Brouwer and Navrud (2015). European demand for transfer values is strongly linked to regulation and legislation. In the specific context of water and the WFD, practical guidelines were developed for the assessment of the nonmarket values of water resources management in the project AquaMoney, accounting for some of the main water management issues across European member states, i.e. ecological restoration of rivers, improvement of water quality levels to a good chemical and ecological state, and water conservation. By developing harmonized water quality ladders and employing state-of-the-art nonmarket valuation procedures, the transferability of the estimated values was tested across member states. Bateman et al. (2011) did this for example for water quality improvements in north-western Europe, Brouwer et al. (2015) for water conservation in south Europe, and Brouwer et al. (2016) for ecological restoration

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of the international Danube river. Experiences in these case studies were converted into guidelines for future applications of value transfer.

Compared to contingent valuation, discrete choice experiments (DCE's) have been argued to be particularly well suited to account for differences in local spatial context and facilitate the transferability of estimated non-market values (e.g. Jiang et al. (2005) and Johnston (2007)) and are therefore increasingly used also in the water valuation domain. A spatially sensitive value function approach may not only produce better verifiable and validated results, but also produces more conservative and hence acceptable values for decision makers (Brouwer and Navrud, 2015). Still, unit value transfer remains the most widely applied valuation method in Europe for use in cost-benefit analysis, although it has been shown that the transfer of a constant unit value can lead in some cases to large errors (e.g. Liekens et al., 2013). Research in this particular field is ongoing to determine (i) more valid and reliable benefits transfer procedures based on spatially sensitive value functions as in this particular study, (ii) ways to update benefit transfer functions to account for temporal instability of preferences (e.g. Schaafsma et al. (2014)) and (iii) cases in which unit value transfer is acceptable (e.g. Bateman et al. (2011)).

The number of studies focusing on the non-market valuation of the benefits of ecological river restoration is very limited (e.g. Loomis et al. (2000), Bliem et al. (2012) and Brouwer et al. (2016)). In this study, not only water quality levels are often improved, but especially also the local characteristics of the water bodies' hydromorphology and hence their visual attractiveness to residents and visitors. In this latter case, a water body's specific location and the spatial distribution of the population of beneficiaries often plays a more important role than in the case of non-spatially defined water quality management measures aimed at pollution and abstraction sources in a watershed or river basin more generally. As a result, distance-decay and substitution effects are also expected to play a more important role in these cases where the specific location of a water quality improvement or restoration project takes place. The inclusion of these spatial considerations is expected to improve the transferability of the estimated values (Colombo and Hanley, 2008). Similarly, policymakers will be interested to know which water bodies they should restore first in order to obtain most value for their money given their limited budgets.

In the study reported in this paper, we add to the limited empirical evidence base and investigate the impact of substitution and distance-decay on the non-market valuation of water body restoration using a labelled DCE in the context of WFD implementation in two river basins in Flanders in Belgium. The main objective of the study is to test to what extent the labelled DCE generates water body specific or generic value functions, accounting for the spatial characteristics of the restoration projects and the spatial characteristics of the population of beneficiaries, including the distance they live from the two different water bodies and current and past visitation behavior. Finding a generic value function implies that the estimated utility functions are transferable, which would mean that they can be used more generally also to other restoration sites. If, however, the utility functions are water body specific, this means that they are not transferable and a new valuation study would be needed in principle every time a new restoration project requires valuation of its non-market benefits. Schaafsma et al. (2012) investigated the effects of the spatial characteristics of water quality improvements and the spatial distribution of the population of beneficiaries in the north-western lake district in the Netherlands by means of labelled DCEs and concluded that a generic distance-decay function might not be sufficient to capture all spatial heterogeneity. We put this finding to the test in this study focusing specifically on river restoration.

The paper is organized as follows. Section 2 first describes the theoretical model and research methodology, including the data collection procedure. This is followed in Section 3 by a description of the case study area and the two water bodies to be restored. Section 4 presents the results and Section 5 concludes.

2. Modeling framework and research methodology

2.1. Modeling framework and hypothesis testing

The choices of the survey participants in the DCE are modelled in a random utility framework (e.g. Ben-Akiva and Lerman (1985)). In this framework, a respondent's utility is decomposed into an observable deterministic part and an unobservable random part. The multinomial logit (MNL) model is the most used model in choice analysis because of its convenient closed form (Hensher et al., 2005). However, the MNL model is subject to a number of restrictive assumptions, such as independence of irrelevant alternatives (IIA) and associated proportional substitution. Moreover, it does not account for possible unobserved preference heterogeneity. Mixed logit models are more flexible and allow relaxing the above mentioned restrictions.

In this paper an error component random parameters logit (ECRPL) model is estimated. The indirect utility specification U of alternative j for individual i at choice moment t for such a model is presented in Equation (1). In this function α_j refers to the alternative specific constant (ASC) for alternative j and X_{ijt} and β^x_{ij} represent the vectors with choice attributes X of alternative j for individual i in choice task t and their parameters, respectively.

$$U_{ijt} = \alpha_j + \beta^x_{ij}X_{ijt} + \beta^y Y_i + \beta^d_j D_{ij} + \beta^s_j D_{ik} + \beta^{du}_j D_{ij}*User_{ij} + \lambda_{ij}H_j + \varepsilon_{ijt} \quad (1)$$

The first hypothesis that will be tested in this study is equality of the labelled alternatives for the two specific water bodies for which restoration works are planned:

$$H^1_0: \quad \alpha_j = \alpha_k \text{ for all } j \neq k \quad (2)$$

Rejection of the first hypothesis implies that the labelled water bodies are valued significantly different and the water bodies have a distinct value of their own, i.e. not captured by the alternative characteristics embodied in the choice attributes, which is not directly transferable.

The preference parameters in Equation (1) are allowed to vary across individuals, hence β_i with a density function $f(\beta)$. The parameters associated with the choice attributes are furthermore also assumed to be alternative specific. This brings us to the second hypothesis:

$$H^2_0: \quad \beta^x_j = \beta^x_k \text{ for all } j \neq k \quad (3)$$

Rejection of the second hypothesis implies that the restoration characteristics related to the two water bodies are valued significantly different, making the utility functions non-transferable.

The vector β^y in Equation (1) measures the influence of the socio-demographic characteristics Y_i of the beneficiaries of the restoration works on choice behavior, and is generally expected to be the same for both alternatives. However, this does not apply to one of the main issues of interest in this study, i.e. the distance D_i survey participants i live from each labelled water body alternative j and k. The third hypothesis tested in this study is that the distance-decay effects differ for the two water bodies: