Saving Unique Ecosystems by the Use of Economic Methods and Instruments : Is this possible?

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1. Introduction

Since the 1990s flood risk and the effects of flooding episodes have reemerged as an important natural hazard concern in central and northern Europe. These concerns have also been exacerbated as a result of widespread and increasing awareness of global climate change, and significant wetland loss due to rising sea levels. Global climate change and wetland loss are expected to increase the frequency and extent of floods in the future (Nichols et al., 1999). These floods are expected to cause significant changes in the current land use and population patterns. Contrary to floods of the past centuries, recent European floods have milder effects in terms of loss of human life. Nevertheless the economic costs of flooding are rapidly increasing as a result of increased costs of damages to infrastructure and production in primary, secondary and tertiary sectors, and disruptions to transport. The estimated costs of the damages of the floods of 1997 and 2001 are in the region of one billion USD for Poland, and 250 million USD, for the surrounding countries (Brakenridge et al, 1997, 2001). As a consequence of the increasing economic and social costs of floods, European governments have taken a more involved approach in flood risk reduction.

With these effects in mind and given the special circumstances in the Brobrek catchment, the central questions we seek to answer in this chapter are the following: What are the benefits for the general public from reducing flood risk, improving biodiversity and improving recreational river access? From which of the above characteristics does the Polish public derive the greatest improvement in welfare? Which are the necessary conditions for economically efficient policy making regarding the management of the aforementioned characteristics? In order to answer the aforementioned questions we apply economic and econometric techniques that constitute the state of the art among the existing valuation techniques. Specifically in this chapter we report the results of an economic valuation technique known as the Choice Experiment Method.

Economic valuation techniques are widely applied to inform policy making regarding decisions that involve environmental costs and benefits. These applications of economic theory are extremely useful since they can capture and estimate the benefits derived from the proposed policy changes. In our case, capturing the welfare effects of flood risk reduction, biodiversity increase and recreational river access is crucial for carrying out the appropriate cost benefit analyses to inform those projects and policies that maximise economic efficiency. Even though the costs of policies aimed to the aforementioned goals are relatively easy to calculate given specialized knowledge, the estimation of their economic benefits is a challenging task. This is due to the public good nature of improving these characteristics, since there are no markets or market prices that could be used for the estimation of the economic benefits that would arise from such projects or policy changes. Non-market valuation techniques, therefore, could be applied in order to estimate the economic benefits of flood risk reduction.

In the existing literature on the valuation of flood risk reduction, a number of non-market valuation techniques have been employed. These include the contingent valuation method, the hedonic pricing method and the aversive behaviour method. Shabman and Stephenson (1996) compare the results of these methods, applied to the valuation of a flood risk reduction project in Roanoke, Virginia, USA. Brouwer and van Ek (2004) and Brouwer et al. (2007) employ integrated impact assessment methods to estimate the benefits of flood risk reduction in the Netherlands and Bangladesh respectively, and conduct cost benefit analyses for various flood alleviation projects. Ragkos et al. (2006) employ the contingent valuation method to estimate the value of flood control for the Zazari-Cheimaditida Wetland in Greece.

This chapter is organized as follows: in section 2 we discuss the case study area. In section 3 we briefly present the a non-market valuation method, namely the choice experiment method that was applied in this case study. In section 4 we describe the survey used while sections 5 and 6 report the results. Section 7 concludes the paper with the policy implications.

2. The case study area

The case study reported in this chapter presents the results of a choice experiment carried out in the city of Sosnowiec with the purpose of estimating the benefits to be gained from flood risk reduction, biodiversity increase and improvement of recreational river access. The city of Sosnowiec is located in the Bobrek catchment, in the Upper Silesia Region of Poland. The region is an important industrial center located within the Upper Silesian Coal Basin. There are five rivers (Biala, Brynica, Jaworznik, Wielonka and Rawa) running through the wider area, making the region susceptible to flooding episodes

Among the main economic activities in the area are heavy industry and mining with some of the world's largest bituminous coalmines located in the region. The mines are concentrated close to the rivers, changing and eroding the riverbanks. Mining activities have been taking place in this area for over two centuries. Scientific evidence from Central Mining Institute, Silesian University, AGH University of Science and Technology, and Krakow University of Technology claim that mining industry has significantly deformed the local landscape and the riverbed, thereby rendering the region extremely vulnerable to floods even after light rainfalls. Given the size of the local communities, it is estimated that approximately 50,000 individuals may suffer the effects of a flood episode.

In 1992 the Polish government facilitated the construction of concrete barriers on the rivers' banks in order to minimize the risk of flooding in the region. Mining industries were deemed responsible for protecting their mines by constructing spoil hips on the rivers' banks. This strategy, however, was not successful since it increased the speed of flowing water, thereby generating negative externalities for downstream communities. Moreover, recreational activities in the catchment became limited as a result of the blocking of the river access by the concrete barriers. Furthermore this policy was not successful in providing flood control as the extensive floods of 1997 and 2002 can attest.

The high economic and social costs of flooding episodes are borne mainly by the local residents, but also by the overall national economy, as well as by the nearby countries. Nevertheless, extensive flooding and the effects form mining activities have led to the creation of new wetland habitats that harbor important biodiversity riches in both flora and fauna species. Ecologists from Silesian University recognise these biodiversity riches and assert that they should be conserved. In addition, these habitats created by the overflown rivers are now of high recreational value and could potentially serve as attractive tourism location. A second aim of this choice experiment is therefore to investigate the local residents' valuation of the conservation of the biodiversity found in these habitats and also accessibility to the riverbanks to enjoy recreational activities in the area.

3. The Choice Experiment Method

In this section we briefly describe the theory underlying the choice experiment method and its applications. The choice experiment method has its theoretical grounding in Lancaster's model of consumer choice (Lancaster, 1966), and its econometric basis in random utility theory (Luce, 1959; McFadden, 1974). Lancaster's model of consumer choice proposed that consumers derive satisfaction not from goods themselves but from the attributes they provide. That is, a consumer that wants to buy a coat does not derive utility directly form the coat itself but from its constituent characteristics or attributes (like fabric, colour etc). Furthermore, when choosing among coats, the consumer will actually compare these characteristics in order to make a choice. In our case then the benefits from a river management strategy are derived by flood risk levels, biodiversity levels and river access levels. In the same fashion, when the consumer is called to choose among different river management strategies, he will compare among these attributes in order to choose his most preferred management strategy. If one of these attributes is monetary (eg price, tax level, tax rate) then the researcher can estimate the Willingness to Pay (WTP) of the individual for the other attributes. The WTP is the measure of value used for the attributes in question.

The random utility theory is the theoretical basis for integrating behaviour with economic valuation in the choice experiment method. According to random utility theory, the utility of a choice is comprised of a deterministic component and a random component which is independent of the deterministic part and follows a predetermined statistical distribution. According to the theory, the deterministic component can be observed by the researcher and depends on the characteristics of the good. However, the random component implies that predictions cannot be made with certainty. Choices made between alternatives will be a function of the probability that the utility associated with a particular wetland management option is higher than those for other options.

As already mentioned, the choice experiment method is a non-market valuation method. That is, the choice experiment method tries to circumvent the absence of markets and market prices for the goods to be valued by creating a hypothetical market in which it asks individuals to participate. The hypothetical market is created in the context of a carefully worded scenario which describes the market and its workings in the respondents. The choice experiment method is also a stated-preference method. In practice this amounts to asking individuals to make choices among different management strategies in a specially designed survey. The data collected by the method can then be analyzed using appropriate econometric techniques to estimate the effects of attributes on individual choice and the WTP for each of the attributes.

4. Survey Design and Administration

As indicated earlier, the choice experiment method is a stated preference method. That is, the choice experiment method derives the data for the estimation of the economic benefits from specifically designed surveys. In this section we describe the design of the survey as well as the procedure undertaken for the data collection.

The first step in choice experiment design is to define the environmental good to be valued in terms of its attributes and their levels. It is essential to identify the attributes that the public considers important regarding the proposed policy change, as well as those levels that are achievable with and without the proposed policy change. The good to be valued in this choice experiment study is the river management strategy. Following discussions with scientists from the Central Mining Institute, the Silesian University, the AGH University of Science and Technology and the Krakow University of Technology, and drawing on the results of focus group discussions with the local population, three attributes were chosen: surface and underground flooding risk, biodiversity found in the habitats and access to the river. All three of these attributes were specified to have two levels. The payment vehicle was a percentage change in the local taxes paid by the households. Percentage change on the household's present level of tax level was preferred over fixed changes in the tax levels, since the former allows for a continuous monetary variable. Furthermore, higher and lower tax levels than the status quo level were considered in order to understand whether the households are willing to pay to have higher/lower levels of these attributes or willing to accept compensation to let go higher/lower levels of these. Finally, taxation was preferred as a payment vehicle over voluntary donations since households may have the incentive to free-ride with the latter (Whitehead, 2006). Table 1 defines the attributes, their levels and the status quo.

Table [1] Here

A large number of unique river management strategies can be constructed using these attributes and their levels. Using experimental design techniques (Louviere et al., 2000) an orthogonalization procedure was used that resulted in 32 pairwise comparisons of river management strategies. These were randomly blocked into four versions, each containing eight choice sets consisting of two river management strategies and an opt-out alternative, which represented the status quo. Inclusion of the status quo or another baseline scenario is important for the welfare interpretation of the estimates and for their consistency with demand theory (Louviere et al., 2000; Bennett and Blamey, 2001; Bateman et al., 2003).

The choice experiment survey started with the enumerators reading a statement identifying the current issues in the area regarding flood risk, biodiversity conservation and use of the river for recreational activities. Subsequently the households were presented with a description of the attributes used in the experiment and were asked to state their preferred river management strategy among three such strategies through eight choice sets. Figure 1 presents an example of a choice set.

Figure [1] Here

The choice experiment survey was implemented in March and April 2007 in the city of Sosnowiec, located in the Bobrek catchment, with in house face-to-face interviews. Time and budget constraints allowed for a sample of 200 households from the local population. A quota sample was collected and the survey was administered to be representative of the local population in terms of income and geographical distribution (i.e., distance from the river). Those household members who took part in the survey were by and large those who were main household decision makers and/or heads of the households. In total 96 percent of those approached, i.e., 192 households were interviewed, resulting in1536 choices.

In addition to the choice experiment, the survey also collected social, demographic and economic data, including the respondents' age, gender, education, household income and local tax paid by the household, as well as information on whether the household uses the river for recreational activities and flooding episodes that have effected the household in the past decade. Descriptive statistics for the key variables are presented in Table 2.

Table [2] Here

The average respondent is 46 years old while 51.5% of the sample is female. 46.3% of the respondents are in full time employment. Regarding the educational level, 26% have university or higher education. The average household consists of 2.8 persons while it is located at 462 meters from the river bank. 70.8% of the households have at least one child. Among the households that were interviewed, 13% were flooded in the past decade while these households were flooded on average of 2.52 times over the last decade,

5. Results

The data for econometric analysis were coded according to the levels of the attributes. Attributes with two levels (i.e., flood risk, biodiversity level, river access) entered the utility function as binary variables, effects coded as 1 to indicate low level of flood risk, high level of biodiversity and easy river access, and -1 to indicate high level of flood risk, low level of biodiversity and difficult river access (Adamowicz *et al.*, 1994; Louviere *et al.*, 2000). The attribute with five levels (i.e., percentage increase in local tax) was entered in cardinal-linear form, and then multiplied by the households' actual level of local tax, in order to calculate the level of this attribute for each household. Since this choice experiment involves generic instead of labelled options, the alternative specific constants (ASC) were set equal to 1 when either river management strategy A or B was chosen and to 0 when the households chose the status quo (Louviere *et al.*, 2000). A relatively more positive and significant ASC indicates a higher propensity for households to take no action to manage the river.

Retaining the assumption that observable utility function follows a strictly additive form, a conditional logit model for the choice of river management strategy was estimated using LIMDEP 8.0 NLOGIT 3.0. The model was specified so that household choice was only affected by the ASC and the four attributes of the choice experiment. The results of the conditional logit model for the pool of 192 households are reported in first column of Table 3.

Table [3] Here

The results in Table 3 indicate that all attributes are highly significant determinants of river management strategy choice for the pooled sample. Furthermore, the estimated coefficients have the expected signs. These indicate that households prefer low flood risk, high biodiversity and easy river access. Consistent with demand theory, the coefficient of the monetary attribute is negative indicating that households choose alternatives with lower tax rates to alternatives with higher tax rates. The positive and significant alternative specific constant captures other factors affecting choice that are not included in the model and can also be interpreted as an indicator of status quo bias.

In order to further examine the behaviour of different groups of households and subsequently to estimate their valuation of each one of the attributes, split sample conditional logit models were estimated for the following two household types: (i) non-flooded in the past ten years and (ii) flooded in the past ten years. These are reported in columns 2 to 3 of Table 3.

Statistical tests indicate that the impacts of attributes on the choices of flooded and non-flooded households are different. Hence flooded and non-flooded households have distinct preferences for river management attributes. For those households whose houses have not been flooded all of the river management attributes are significant determinants of river management strategy choice. They prefer those river management strategies, which provide low flood risk, high levels of biodiversity and easy access to the river. The sign on the coefficient on the monetary attribute is negative as expected a priori. Coefficient on the flood risk attribute is the largest in magnitude, implying that this is the most important determinant of choice for the household. This is followed by river access and biodiversity. For those households whose houses were flooded at least once in the past ten years, flood risk reduction and water access are significant determinants of river management strategy choice. These households prefer those river management strategies with low flood risk, however with difficult river access. Their valuation of the biodiversity attribute as well as the coefficient of the monetary attribute are statistically insignificant, the latter possibly due to the small size of this sub sample.

6. WTP Estimates

Using the estimates reported earlier we can calculate the increase in welfare derived from improving each of the attributes. In this section we report the estimated marginal

WTP which is the measure of welfare applied by economists when valuing non-marketed goods.

Table 4 reports the estimated marginal WTP for each river management strategy attribute for the pool and for the two household types introduced in the previous section.

Table 4 Here

As revealed by the WTP estimates for the pooled sample, on average households are WTP significant positive amounts for improving all attributes. They are WTP the highest in order to reduce the risk of flooding to a low level, their WTP for easy river access is less than half of their WTP for low flood risk, whereas their WTP for high levels of biodiversity is less than quarter of their WTP for low flood risk. Across the household types, ranking of the attributes, as well as households' valuation of these differ significantly. Flooded households are WTP highest for low flood risk, however their valuation is insignificant. These households are followed by non-flooded households. High biodiversity levels and easy access to the river are valued most highly by non-flooded households, whereas for flooded households' WTP are insignificant. This indicates that the ecological and recreational aspects of the problem are valued more by households that have not been flooded in the past. This is intuitive since for households that have been flooded in the past may be relatively more concerned with avoiding further floods.

5. Policy implications

Following the flooding episodes of 1997 and 2004 the Polish authorities embarked on an attempt to reduce flood risk in the Upper Silesia region. The application of the choice experiment method introduced in this chapter focused on the estimation of the benefits that the local population derives from the reductions of flood risk in the area. Furthermore, we explored the welfare implications of improving biodiversity and recreational river access.

The results presented reveal that there are significant welfare improvements from flood risk reduction, which dominate welfare improvements from both improving river accessibility for recreational reasons and conserving high levels of biodiversity. This can be translated as the locals' preferences for use values derived from flood reduction relative to use and non-use values from recreation or biodiversity conservation. Aggregation over the population of Sosnowiec shows that local residents are willing to incur an increase in local taxation of 2,693,416 zloty per year to reduce flood risk.

In order to evaluate whether reducing flood risk and improving the other attributes is an economically efficient option, it is important to appropriately compare between the costs and benefits of the proposed policy measures. The economic literature has developed an important instrument for this purpose, the Cost Benefit Analysis. In broad terms, under a Cost Benefit Analysis the aggregate increase in welfare is compared with the overall increase in costs through time. If the aggregated benefits over time exceed the aggregated costs over time then the project is considered to be economically meaningful. Thus, in order to fully evaluate the net benefit of improving river management, it is necessary in a latter stage to perform a cost benefit analysis.

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Tables and figures

Figure 1. Example choice set

Assuming that the following three river management strategies were the only choices you had, which

one would you prefer?			
Management strategy Characteristics	Management strategy A	Management strategy B	Neither Management strategy: Status Quo
Flood risk	Low	Low	High
Biodiversity	Low	High	Low
River access	Difficult	Easy	Difficult
Council tax	5% decrease	5% decrease	Same as now
I prefer (Please tick as appropriate)	Management strategy A	Management strategy B	Neither management strategy

Table 1: Attributes, Levels and their Definitions

Attribute Name	Definition and Levels
Flood Risk	This attribute refers to the risk of flooding in the area. Levels are **HIGH**: This is the case where no measures are taken and it also reflects the current flood risk level. Danger of flooding is imminent in case of rainfall. No barriers of any kind are built to protect the area from flooding. **LOW**: Both underground and surface barriers are set in place. To avoid past mistakes, the material is proposed to be wood for the surface barriers and concrete for the underground ones. Flooding danger is minimal.
River Access	This attribute refers to public's access to the river for recreational purposes. Levels are: **EASY**: Canalization of the river is very similar to the natural one. Materials such as concrete will not be used. Access to the river's will be possible and easy for everyone. **DIFFICULT**: Rivers will be canalized by forming vertical walls, the same measure that has been used a few years ago. Concrete will be used and it will be impossible for locals to access the river. At the moment access to the river is difficult.
Biodiversity	This attribute refers to the number of different species of plants and animals, their population levels, number of different habitats and their size in the river ecosystem in the next 10 years. The levels are: **LOW**: Due to the present regulation, companies are allowed to create spoil hips from the remnants of their mining activities. This poses a threat to the newly formed habitats, which are being filled with litter. As a result the current biodiversity levels are low and if the current situation prevails, biodiversity will reach a minimum level **HIGH:** As a result of reclamation activities on the existing spoil heaps especially afforestation in the rivers, biodiversity will reach a higher level in 10 years
Local Tax	This is the local, municipal tax paid by every household in the area. The levels are 10% less than the present level, 5% less than the present level, same as the present levels, 5% more than the present level, and 10% more than the present level.

Table 2. Descriptive Statistics of Respondents and their households, Sample Size=192

Socioeconomic Variables	Sample Mean	Population Average
Respondent characteristics		
Age (in years)	46	37.3**
% in full time employment	46.3	
% of female	51.5	51.5*
% with a University degree	26	
Household characteristics		
Household size	2.8	
Distance from the river in meters	462	-
Local tax (in zloty) paid by the household	183.9	
Monthly gross household income (in zloty)	2478.1	1175
% of Households with at least one Child	70.8	
Number of children living in households with children	0.9	
% own a car	64.5	
% visited the wetland	54.6	-
% houses flooded	13	
% flooded households that were compensated by the government, insurance company or mining industry	28	
Number of flood episodes flooded households suffered in the last decade	2.52	
Total damages to the household from floods in the last decade (in zloty)	7115.8	

*World bank gender Statistics ** CIA World Factbook

Table 3. Conditional Logit Model Results for pool, non-flooded, flooded, user and non-user households

	Pool	Non Flooded	Flooded
Variable		Coefficient (St. Error)	
ASC	0.381***	0.344***	0.965***
	(0.105)	(0.105)	(0.316)
Flood Risk	0.343***	0.278***	0.862 ***
	(0.043)	(0.043)	(0.131)
Biodiversity	0.076**	0.067*	0.009
	(0.04)	(0.04)	(0.11)
River Access	0.137***	0.175***	-0.217**
	(0.042)	(0.042)	(0.123)
Tax Rate	-0.029***	-0.029***	-0.012
	(0.003)	(0.003)	(0.014)
No of observations	1536	1336	200
Log Likelihood Function	-1498.707	-1319.578	-159.2430
ρ^2	0.112	0.10	0.28

*** 1% significance level; ** ; 5% significance level, and * 10% significance level with two-tailed tests.

Table 4 Marginal WTP for river management scenario attributes for pool, non-flooded, flooded, user and non-user households (zloty/household) and 95% C.I.

Attribute	Pool	Non-Flooded	Flooded
Flood Risk	23.9***	19.6***	140
	(20.6-27.4)	(15.9-22.4)	(-16-296)
Biodiversity	5.3***	4.8**	0.8
	(2.8-7.8)	(2.1-7.5)	(-15.82-19.02)
River Access	9.6***	12.1***	-34.2
	(7.1-12.1)	(9.4-14.7)	(-85.4--16.9)

*** 1% significance level; **; 5% significance level, and * 10% significance level with two-tailed tests.