Choice-based valuation of natural resources in the protected area of the Evros Delta

Emmanouilides C.J.[1], Tsiantikoudis S.[2], Arabatzis G.[2]

[1]Department of Economics, Aristotle University of Thessaloniki, Greece, e-mail: cemman@econ.auth.gr
[2]Department of Forestry and Management of the Environment and Natural Resources, Democritus University of Thrace, Greece, e-mail: stsianti@fmenr.duth.gr, garamp@fmenr.duth.gr

Abstract. The paper investigates the economic valuations individuals make about natural resources in the protected area of the Evros river delta in North-East Greece. A choice experiment is conducted to quantify in monetary terms the value of natural resources, focusing on four key aspects associated with a healthy local ecosystem, (a) the withdrawal of saline soils, (b) the decrease in the use of nitrates and phosphates, (c) the protection of habitats, and (d) transfer of labor to eco-friendly human activities. We apply choice models to analyze the preference structure of residents for alternative scenarios of ecosystem's evolution in a ten years horizon. The main focus of the modeling approach is inference about welfare valuations and their relationship with the characteristics of the participants to the choice experiment and their perceptions about the importance of ecosystem services. We derive welfare estimates and detect a number of significant linear and non-linear effects that may inform environmental protection and regional development policies.

Keywords: choice modeling, choice experiment, protected areas.

1. Introduction

Healthy ecosystems play a vital role in maintaining high levels of human well-being through the provision of a variety of benefits or services to people (Millennium Ecosystem Assessment - MEA 2005). These services include the provision of food, freshwater, energy and raw materials; regulation of climate conditions and of water quality, control of waste and extreme events such as flooding and diseases; recreation, educational, aesthetic and other cultural benefits (MEA 2005). Ecosystems in protected areas located in the vicinity of residential sites are routinely deteriorating due to human activities. Intensive farming near the limits of protected areas in river deltas may severely affect ecosystem health. The usually saline cultivated soils are not productive, thus inducing intensive use of pesticides and fertilizers by local farmers, and waste of freshwater for irrigation. This results to contamination, loss of precious natural resources, and a consequent degradation of the ecosystem. Saline soils are poor providers of income to farmers and of food for animal and plant species. A solution to the problem is the flooding of soils with freshwater that under effective management is expected to reduce pollution by agro-

In: M. Salampasis, A. Matopoulos (eds.): Proceedings of the International Conference on Information and Communication Technologies

for Sustainable Agri-production and Environment (HAICTA 2011), Skiathos, 8-11 September, 2011.

chemicals, increase biodiversity, facilitate livestock farming, and provide sustainable income to local inhabitants by eco-friendly economic activities, such as eco-tourism, organic farming, etc.

In this paper we employ stated choice methods (e.g. Louviere et al. 2000) to assess the economic value of natural resources associated with ecosystem health in the protected area of the Evros River Delta, in North-East Greece. This particular study area suffers from inefficiencies in natural resources' use, associated ecosystem degradation and economic losses for the local society that are typical to many other sites in the Mediterranean. Such a choice-based valuation can be informative to the design of policies that aim to achieve environmental sustainability and improve social welfare. In the following section we describe the methodology, then we present the choice modeling results, assess the impact of measured variables on welfare estimates, and finally conclude with a discussion of the findings.

2. Methodology

Valuation of the natural resources in the protected area of the Evros Delta is conducted using a discrete choice experiment (CE). CE is a well known stated preference method (e.g. Louviere et al. 2000) used for the study of individual preferences that cannot be revealed through direct observation of actual choice behavior in an existing market process. Such experiments have been widely used in marketing, transportation research, and more recently in environmental and ecological economics. Among others, Louviere et al. (2000), Hensher et al. (2005), and Train (2009) provide extensive reviews of the CE methodology.

2.1 Design and data collection

The study focuses on four key issues pertaining to the sustainable management of Evros Delta natural resources; (a) the withdrawal of saline soils through freshwater flooding, (b) the decrease in the use of nitrates and phosphates via more efficient regulation, (c) the protection of natural habitats, and (d) transfer of labor to eco-friendly human activities. These are represented in the CE as the attributes of a hypothetic good that reflects the health status of the Evros Delta ecosystem. These attributes were determined through review of the relevant literature, extensive consultation and interviewing of domain experts, scientists and local people. Their measurement levels were decided via thorough pilot testing. Table 1 presents the attributes and their levels. The first attribute, SALT, is the covered area of the Evros Delta by saline soils, with baseline the current value ("status quo" - SQ). The second attribute is the usage level of agro-chemicals, the third is the protection level of the flora and fauna habitats, and the fourth is the degree of human labour transfer to ecosystem-sustaining activities. Finally there is a cost attribute that is the amount to be paid in ten annual instalments as part of the municipal tax by residents for improving the state of the ecosystem.

To reduce the large number (324) of possible choice alternatives for the given number of attributes and their measurement levels we used a factorial design that allows estimation of two-way attribute-attribute interactions. The number of profiles in the design is 32. They are orthogonally split into 4 blocks of 8 profiles. In each profile, individuals were asked to choose one among three alternative scenarios for

the state of the Evros Delta ecosystem in a 10 years horizon. Two of them are "management" scenarios (MSs) that represent an improved future state of the ecosystem with respect to the third scenario, that of "unmanaged" situation or "status quo" (SQ).

Table 1. Attributes and levels

Attribute	*Definition*	*Levels*
SALT	Reduction of saline soils (in acres)	0 (SQ), 10000, 15000, 25000
NIT	Decrease (%) in use of nitrates and phosphates	0 (SQ), 15%, 25%, 30%
BIO	Biodiversity protection level (% of species protected)	<50% (SQ), 50%, >50%
EMP	Employees in eco-friendly activities	0 (SQ), 45, 60, 110
COST	Cost (€)	0 (SQ), 12, 15, 22, 40

The survey was carried out in the area of the Evros Delta in North-East Greece, during April-September 2008. The sampling unit of the survey is households. Data are collected with interviews with an adult household member. The total sample size is 388.

2.1.1 Sample characteristics – Measured variables

The key individual specific variables (ISVs) that were measured and used in the choice modeling task are classified for descriptive purposes into two broad categories: (a) *Socio-demographic* variables, such as age, gender, marital status, education level and occupation of the respondent, household size, presence of kids in the household, membership to environmental groups and annual net household income, and (b) *Perceptions* regarding the importance of ecosystem services. Definitions of the corresponding variables, their measurement scales and descriptive sample statistics are shown in Tables 2a and 2b, respectively.

Table 2a. Socio-demographic variables. Definitions and descriptive statistics

Quantitative Variables	*Definition*	*Mean*	*Median*	*Std. Dev.*	*Min*	*Max*
HHSIZE	Size of household	3.38	3.00	1.05	1.00	6.00
NKIDS	Number of kids	1.23	1.00	0.92	0.00	4.00
INCOME	Annual net household income (,000 €)	12.93	12.5	6.87	0.25	32.50
Qualitative Variables	*Definition and levels*	*Frequency*	*Percent (%)*			
AGE**	Age of respondent in years					
	1 = 18 to 30	91	23.45			
	2 = 31 to 40	115	29.64			
	3 = 41 to 50	107	27.58			
	4 = 51 to 60	51	13.14			
	5 =more than 60	24	6.19			
GENDER*	Gender					
	0 = Male	240	61.86			
	1 = Female	148	38.14			
MARIT*	Marital status					
	0= Single	88	22.68			
	1 = Married/Cohabiting	280	72.16			
	2 = Widowed	13	3.35			
	3 = Divorced	7	1.80			
KIDS*	Have kids					
	0 = No	106	27.32			
	1 = Yes	282	72.68			

Base: N = 388. * Operationalised as dummies, ** Treated as quantitative, for computational ease

Table 2a. - continued

Qualitative Variables	*Definition and levels*	*Frequency*	*Percent (%)*
EDUC**	Education level		
	1 = Primary school	54	13.92
	2 = Secondary school	55	14.18
	3 = Higher technical school	32	8.25
	4 = High school	136	3.51
	5 = College	22	5.67
	6 = Technical Institution degree	42	10.82
	7 = University degree	44	11.34
	8 = Postgraduate degree	3	0.77
OCCUP*	Occupation		
	1 = Farmer	85	21.91
	2 = Housekeeping	27	6.96
	3 = Private sector employee	86	22.16
	4 = Public sector employee	77	19.85
	5 = Self-employed – technical	67	17.27
	6 = Self-employed – science/engineering	16	4.12
	7 = Entrepreneur	5	1.29
	8 = Student	13	3.35
	9= Unemployed	12	3.09
FARM*	1st or 2nd occupation related to farming		
	0 = No	180	46.39
	1 = Yes	208	53.61
ENV*	Environmental group membership		
	0 = No	368	94.84
	1 = Yes	20	5.16

Base: N = 388. * Operationalised as dummies, ** Treated as quantitative, for computational ease

Table 2b. Perceptions of importance. Definitions and descriptive statistics

Variables						
	Definition and levels	***Mean***	***Median***	***Std. Dev.***	***Min***	***Max***
IMP*	Importance of ecosystem services					
	(0 = null, 1=low, 2= moderate, 3=high importance)					
	1 = Leisure and recreation for locals (CU)	2.24	2.00	0.74	0.00	3.00
	2 = Employment opportunities (PR)	2.62	3.00	0.69	0.00	3.00
	3 =Protection and conservation of flora and fauna (RE)	2.77	3.00	0.64	0.00	3.00
	4 = Protection of air, water and soil from pollution (RE)	2.78	3.00	0.63	0.00	3.00
	5 = Tourist attraction (CU)	2.47	3.00	0.68	0.00	3.00
	6 = Investment opportunities (PR)	2.44	3.00	0.80	0.00	3.00
	7 = Landscape of high aesthetic value (CU)	2.76	3.00	0.50	0.00	3.00
SCORES	Importance scores for classes of services					
SCCU	Cultural: (IMP1 + IMP5 + IMP7)*2/3	4.99	5.33	0.93	0.00	6.00
SCPR	Provisioning: IMP2 + IMP6	5.06	6.00	1.24	0.00	6.00
SCRE	Regulating: IMP3 + IMP4	5.55	6.00	1.15	0.00	6.00

Base: N = 388. * In parenthesis is the type of ecosystem service (CU = cultural, PR = provisioning, RE = Regulating)

Variables measuring respondents' perceptions about the importance of ecosystem services where grouped into three classes (i.e. *regulating, provisioning,* and *cultural*) following the classification of the Millenium Ecosystem Assessment work programme initiated by the U.N. in 2001 (e.g. see MEA, 2005; Boyd and Banzhaf, 2007). Then, for each respondent, total class scores were derived by summing the values of the corresponding services variables. The relevant definitions and statistics are shown in Table 2b.

Protest bidders pose a well known problem in discrete choice analysis (e.g. Meyerhoff, J. and Liebe, L., 2008). Using a set of appropriate questions asking zero

bidders to provide reasons for choosing the status quo scenario, we classified 5.4 % of the respondents as protest bidders. These were excluded from further analyses, reducing thus, the effective sample size to *N=367*.

2.2 Choice modeling methodology

Modeling of individual choices proceeds with a random utility model (RUM) specification; Assume a stochastic indirect utility function for the choice of individual *i, i=1,...,N (N=367)* among three alternatives $j \in \{0,1,2\}$ (0 for the SQ scenario, 1 and 2 for the MSs) at choice instance *t=1,...,T (T=4)*

$$U_{ijt} = V_{ijt}\left(\mathbf{x}_{ijt}, \mathbf{w}_i, \boldsymbol{\beta}_i, \boldsymbol{\beta}\right) + e_{ijt} \qquad (1),$$

where $V_{ijt}(.)$ is the deterministic utility and e_{ijt} the random utility component associated with choice *j*. $\mathbf{x}_{ijt} = \left\{x_{ijt}^{(k)}\right\}_{k=1}^{K}$ is a vector of *K* choice attributes (here, *K=5*), $\mathbf{w}_i = \left\{w_i^{(l)}\right\}_{l=1}^{L}$ is a vector of *L* individual characteristics that are invariant across choices and choice occasions, $\boldsymbol{\beta}_i = \left\{\beta_i^{(k)}\right\}_{k=1}^{K}$ is a vector of individual specific random preference parameters, and $\boldsymbol{\beta}$ a vector of fixed parameters capturing the effects of individual characteristics and of interactions between attributes on choice. Then, setting the choice outcome $y_{it} \in \{j = 0,1,2\}$, under the common assumption of *iid* extreme value type I distributed random utilities, the conditional probability of choosing alternative *j* has the mixed logit model form (e.g. Longford 1993, Train 2009)

$$\pi_{ijt} = \Pr\left(y_{it} = j \middle| \mathbf{x}_{ijt}, \mathbf{w}_i, \boldsymbol{\beta}_i, \boldsymbol{\beta}\right) = \frac{\exp\left(V_{ijt}\right)}{\sum_{m=1}^{3}\exp\left(V_{imt}\right)} \qquad (2).$$

Assuming linearity in the parameters of the deterministic utilities and allowing for two-way interactions between attributes and between attributes and individual observed characteristics, as well as for higher order polynomials of quantitative characteristics, deterministic utility is specified as

$$V_{ijt} = \beta_0^{(j)} + \sum_{k=1}^{K}\beta_i^{(k)}x_{ijt}^{(k)} + \sum_{k=1}^{K}\sum_{\substack{k'=1 \\ k'\neq k}}^{K}\beta^{(kk')}x_{ijt}^{(k)}x_{ijt}^{(k')} + \sum_{k=1}^{K}\sum_{l=1}^{L}\sum_{r=1}^{R(k,l)}\beta^{(rkl)}x_{ijt}^{(k)}\left(w_i^{(l)}\right)^r \qquad (3),$$

where *R(k,l)* is the maximum order of polynomial interactions of the attribute *k* with individual-specific variable $w^{(l)}$.

Under specification (3), the vector of fixed parameters is $\boldsymbol{\beta} = \left\{\beta_0^{(j)}, \beta^{(kk')}, \beta^{(rkl)}\right\}$, where $\beta_0^{(j)}$ is an alternative specific constant capturing the average effects of omitted variables, $k, k' = 1,...,K \ \left(k \neq k'\right)$ and $l = 1,...,L$. Random parameters $\beta_i^{(k)}$ follow

some specific, usually continuous, probability distribution, say $f_k\left(\beta^{(k)}\right)$, with mean $\beta^{(k)}$ and variance σ_k^2. For simplicity, random parameters are assumed uncorrelated with each other. Simpler model forms employed in the analysis are derived from expression (3) through constraints imposed on the parameters.

Mixed logit model estimation is performed with maximum likelihood (ML) methods. Likelihood is maximized with numerical integration over the random coefficients' distributions using a variety of available methods, including: (a) discrete approximations of the hypothesized parametric continuous distributions $f_k\left(\beta^{(k)}\right)$ (e.g. as a finite mixture of normals – Train (2008), mass point methods such as Gaussian quadrature for the normal – e.g. Longford (1993), Emmanouilides and Davies (2007), etc.), and (b) simulation methods (e.g. Train 2009), that are most commonly used in recent years. Here, we adopt the latter approach.

In contrast to a fixed parameter specification of the random utility model, i.e. same across individuals preferences for choice attributes, $\beta_i^{(k)} \equiv \beta^{(k)}$, the random coefficient specification (3) handles heteroscedasticity and serial correlation in repeated choices made by individuals, and allows for non-proportional substitution patterns across alternatives (e.g. Train, 2009). Notice also that the specified random coefficients model allows for two additive sources of possible correlations between choices of the same individual; (a) correlations due to observed effects, introduced in the model through the interactions between attributes and individual characteristics, and (b) correlations due to unobserved preference heterogeneity, accounted for by the individual-specific random parameters. Both are assumed time-invariant (i.e. constant across choices of the same individual), implying a temporally stable structure of individual preferences.

2.3 Estimation of the monetary value of attributes

Given estimates of parameters in the utility function (3), marginal willingness to pay (WTP) for a unit improvement of a non-cost attribute *k* can be computed as

$$WTP^{(k)}\left(\mathbf{w}_i, \beta_i^{(k)}, \beta_i^{(C)}\right) = \left[\frac{\partial V / \partial x^{(k)}}{\partial V / \partial C}\right]_i = -\frac{\left(\beta_i^{(k)} + \sum_{\substack{k'=1 \\ k' \neq k}}^{K-1} \beta^{(kk')} x_{ijt}^{(k')} + \beta^{(kC)} C_{ijt} + \sum_{l=1}^{L} \sum_{r=1}^{R(k,l)} \beta^{(rkl)} \left(w_i^{(l)}\right)^r\right)}{\left(\beta_i^{(C)} + \sum_{k'=1}^{K-1} \beta^{(k'C)} x_{ijt}^{(k')} + \sum_{l=1}^{L} \sum_{r=1}^{R(C,l)} \beta^{(rCl)} \left(w_i^{(l)}\right)^r\right)} \quad (4).$$

Equation (4) is derived by decomposing (3) into terms that involve cost (*C*) and non-cost attributes ($x^{(k)}$, *k=1,...,K-1*), and computing the derivatives involved in (4). *R(k,l)* denotes the maximum order of polynomial interactions of the non-cost attribute *k* with individual-specific variable $w^{(l)}$ and *R(C,l)* the maximum order of polynomial interactions of variable *w(l)* with the cost attribute. Note that the presence of interactions between the cost and other attributes renders willingness to pay for attribute *k* dependent on the levels of other attributes, *k'*, and cost, *C*. Interactions of attributes with individual characteristics (observed heterogeneity) and the random coefficients of the choice attributes (unobserved heterogeneity) both render willingness to pay individual-specific. Estimates of the individual random parameters

are computed during the simulated likelihood estimation procedure, and then are used to derive individual WTP values. Finally, the estimated expected willingness to pay for attribute *k* is

$$E\left(WTP^{(k)}\right)=\int_{\mathbf{w}_i\in\mathbf{W}}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}WTP^{(k)}\left(\mathbf{w}_i,\beta_i^{(k)},\beta_i^{(C)}\right)f\left(\mathbf{w}_i\right)f_k\left(\beta_i^{(k)}\right)f_C\left(\beta_i^{(C)}\right)d\beta_i^{(k)}d\beta_i^{(C)}d\mathbf{w}_i \quad (5),$$

where **W** denotes the multidimensional space of observed individual characteristics and $f\left(\mathbf{w}_i\right)$ the corresponding distribution function. Note that random coefficients are assumed independent from observed characteristics. $WTP^{(k)}\left(\mathbf{w}_i,\beta_i^{(k)},\beta_i^{(C)}\right)$ is given by (4). Integral (5) is analytically intractable and is evaluated numerically. Asymptotic confidence intervals for the expected WTP can be derived with Monte Carlo simulations using the estimated variance-covariance matrix of model coefficients under the assumption of asymptotic multivariate normality (MVN) of maximum likelihood estimates. Alternatively, at the expense of computational cost (that is considerable for the random coefficient models) non-parametric confidence intervals can be derived using resampling methods such as the bootstrap (e.g. Efron and Tibshirani, 1998). The delta method (e.g. Greene 2003) is another option, based again on asymptotic normality of ML estimators. As expected, it provides similar results to the MVN Monte Carlo approach.

2.4 Effects of individual characteristics on WTP

Given a non-trivial functional form for the WTP, such as (4), we are interested to assess the effects of individual characteristics on the WTP for choice attributes. Conditional on parameter estimates of the choice model, these effects can be estimated using the first order partial derivative of the WTP function for an attribute *k* with respect to the characteristic of interest, while keeping all other characteristics constant. A reasonable representative evaluation point for these effects in the multivariate space of individual characteristics and random coefficients is the point defined by the mean sample values; Denote $\left\langle w^{(l')}\right\rangle$ the average sample value of characteristic $w^{(l')}$, $l'\neq l$, $\beta^{(k)}$ the mean of the k^{th} non-cost attribute random coefficient $\beta_i^{(k)}$, and $\beta^{(C)}$ the mean of the cost random coefficient, $\beta_i^{(C)}$. Then, willingness to pay for attribute *k*, as a function of $w^{(l)}$, evaluated at the mean of other individual characteristics $w^{(l')}$ and of random coefficients, can be written (using (4)) as

$$\left\langle WTP^{(k)}\left(w^{(l)}\right)\right\rangle=-\frac{\left(\beta^{(k)}+\sum_{\substack{k'=1\\k'\neq k}}^{K-1}\beta^{(kk')}x^{(k')}+\beta^{(kC)}C+\sum_{r=1}^{R(k,l)}\beta^{(rkl)}\left(w^{(l)}\right)^r+\sum_{l'=1,l'\neq l}^{L}\sum_{r=1}^{R(k,l')}\beta^{(rkl')}\left\langle w^{(l')}\right\rangle^r\right)}{\left(\beta^{(C)}+\sum_{k'=1}^{K-1}\beta^{(k'C)}x^{(k')}+\sum_{r=1}^{R(C,l)}\beta^{(Cl)}\left(w^{(l)}\right)^r+\sum_{l'=1,l'\neq l}^{L}\sum_{r=1}^{R(C,l')}\beta^{(rCl')}\left\langle w^{(l')}\right\rangle^r\right)} \quad (6),$$

Of course, in the absence of random coefficients and of interactions between attribute and individual specific characteristics, (6) reduces to the most common and simplest

form for WTP, i.e. $WTP^{(k)} = -\beta^{(k)} / \beta^{(C)}$. Denote the maximum polynomial order as *R(l) = max{ R(k,l), R(C,l) }*, and

$$a_0 = \beta^{(k)} + \sum_{\substack{k'=1 \\ k' \neq k}}^{K-1} \beta^{(kk')} x^{(k')} + \beta^{(kC)} C + \sum_{l'=1, l' \neq l}^{L} \sum_{r=1}^{R(k,l')} \beta^{(rkl')} \left\langle w^{(l')} \right\rangle^r,\ a_r = \beta^{(rkl)},\ r = 1,...,R(l),\ l = 1,...,L\ ,\forall r > R(k,l),\ a_r \equiv 0,$$

$$b_0 = \beta^{(C)} + \sum_{\substack{k'=1 \\ k' \neq k}}^{K-1} \beta^{(k'C)} x^{(k')} + \beta^{(kC)} C + \sum_{l'=1, l' \neq l}^{L} \sum_{r=1}^{R(C,l')} \beta^{(rCl')} \left\langle w^{(l')} \right\rangle^r,\ b_r = \beta^{(rCl)},\ r = 1,...,R(l),\ l = 1,...,L\ ,\forall r > R(C,l),\ b_r \equiv 0,$$

Then, after some algebra, the first derivative of $\left\langle WTP^{(k)}\left(w^{(l)}\right)\right\rangle$ with respect to $w^{(l)}$ can be written as

$$\frac{\partial}{\partial w^{(l)}} \left\langle WTP^{(k)}\left(w^{(l)}\right)\right\rangle = -\frac{\sum_{r=1}^{R(l)} \sum_{s=r}^{R(l)} (s-r+1)\left(a_{r-1} b_s - a_s b_{r-1}\right)\left(w^{(l)}\right)^{r-1}\left(w^{(l)}\right)^{s-1}}{\left(b_0 + \sum_{r=1}^{R(l)} b_r \left(w^{(l)}\right)^r\right)} \qquad (7).$$

Replacing population parameters in (7) with their sample estimates from the choice model one can derive estimates for the marginal effects of individual specific variables on WTP for attribute *k*. Note that in the absence of interactions between choice attributes (cost and non-cost), parameters $\beta^{(kk')}, \beta^{(kC)}$ and $\beta^{(k'C)}$ equal to zero, simplifying the above relationships for α_0 and b_0. Asymptotic confidence intervals for the marginal effects can be derived using one of the available methods briefly discussed in section 2.3.

3. Choice modeling results

We model the CE data using a sequence of increasingly complex logit model specifications. We start with a fixed parameter specification of an additively separable indirect utility function (3) that is assumed to include only main choice attribute effects (model termed FPL1). Then we add interactions between choice attributes and interactions between individual characteristics and choice attributes, allowing for higher order polynomials of quantitative variables (model termed FPL2). All possible two-way interactions are considered, and selection of effects to include in each specification is based on standard AIC (Akaike Information Criterion) minimizing stepwise variable selection procedures. For both fixed parameter logit models we estimate its random coefficient (i.e. mixed logit) version by allowing the main effects of choice attributes to vary randomly across individuals assuming independent normal or log-normal distributions. These parametric distributions, despite their drawbacks that are extensively discussed in the literature (e.g. see Train, 2009), is the common choice for the modeler.

3.1. Model estimation

To estimate the FPL and RPL models, we employed the publicly available maximum simulated likelihood GAUSS code of Kenneth Train (http://elsa.berkeley.edu/~train), modified for use in the R statistical computing environment (http://cran.r-project.org/). For RPL model estimation we tried sequentially several starting values, intermediate optimization solutions, number of points for the simulation of random coefficient distributions, and alternative

optimization algorithms to reach a final solution. Note that LIMDEP, a more standard software for the estimation of RPL models, failed to estimate the more complex RPL2 model. Finally, for each estimated model, marginal WTP for the non-cost choice attributes are computed using the methodology of the previous section. The covariates we used to specify the indirect utility function (3) are defined in section 2.1.1.

The variable selection procedure suggests a final model specification without attribute-attribute interactions. Testing all alternative combinations of independent normal and log-normal distributions for the random coefficients, and employing the minimum AIC as the selection rule, we reached the conclusion that for both models - with (RPL1) and without ISVs (RPL2) - the data support log-normally distributed main effects for the COST attribute, normally distributed main effects for the EMP attribute, and fixed main effects for the BIO, SALT and NIT attributes. That is, unobserved preference heterogeneity in the target population is empirically supported for both employment and cost, but not for the biodiversity, saline soils and nitrate use reduction attributes. The results show that any heterogeneity in preferences for the BIO, SALT, and NIT attributes is fully captured by the modeled covariates.

McFadden's R^2 ranges from 0.27 for the FPL1 model to 0.43 for the RPL2 model, indicating good model fit for the choice models employed. Likelihood ratio (LR) tests are clearly in favor of the more complex RPL model specifications. Overall, the more complex RPL2 model is statistically superior as it achieves significantly better values of both the likelihood function and the AIC. Note also that the estimated standard errors of the random coefficients are statistically significant, justifying the conclusion of random unobserved preferences for the EMP and COST attributes. Estimation results for the RPL2 model are shown in Table 3.

Table 3: Estimated RPL2 Model

Variables	Estim.	S.E.	p-val	Variables	Estim.	S.E.	p-val	Variables	Estim.	S.E.	p-val
Attributes (Fixed)				**Attributes (Random)**				**Interactions of COST**			
ASC-SQ (β_0)	-0.835	0.237	0.000	EMP				COST:INCOME	0.009	0.005	0.058
BIO	4.547	1.408	0.001	distribution	Normal			COST:GENDER	-0.044	0.012	0.000
SALT	-0.146	1.360	0.282	mean	0.019	0.034	0.554	COST:ENV	-0.053	0.017	0.002
NIT	-0.057	0.045	0.198	scale	0.055	0.007	0.000				
				COST							
				distribution	Lognormal						
				mean	-3.472	0.370	0.000				
				scale	1.422	0.241	0.000				
Interactions of BIO				**Interactions of NIT**				**Fit Statistics**			
BIO: SCRE	-0.707	0.388	0.069	NIT:SCPR	0.008	0.004	0.038	Sample size	1468		
BIO: SCRE**2	0.077	0.047	0.100	NIT:INCOME	-0.007	0.003	0.031	Log Likelihood	-923.787		
BIO: SCPR	0.127	0.066	0.055	NIT:EDUC	0.080	0.045	0.074	McFadden's R^2	0.427		
BIO:AGE	-1.714	0.983	0.081	NIT:EDUC**2	-0.022	0.013	0.094	AIC	1921.574		
BIO:AGE**2	0.600	0.390	0.124	NIT:EDUC**3	0.002	0.001	0.099	BIC	2076.717		
BIO:AGE**3	-0.067	0.046	0.143								
BIO:HHSIZE	-2.007	1.062	0.059	**Interactions of EMP**							
BIO: HHSIZE**2	0.734	0.355	0.039	EMP:SCPR**2	0.001	0.000	0.087				
BIO: HHSIZE**3	-0.082	0.036	0.025	EMP:SCCU**2	-5.7×10^{-5}	4.2×10^{-4}	0.317				
				EMP:AGE	-0.002	0.002	0.261				
Interactions of SALT				EMP:HHSIZE	0.019	0.018	0.302				
SALT:INCOME**3	2.4×10^{-4}	1.8×10^{-4}	0.196	EMP:HHSIZE**2	-0.003	0.002	0.104				
SALT:AGE	-0.009	0.013	0.480								
SALT:HHSIZE	0.070	0.046	0.128								
SALT:HHSIZE**2	-0.008	0.007	0.244								
SALT:EDUC	0.177	0.097	0.069								
SALT:EDUC**2	-0.053	0.027	0.053								
SALT:EDUC**3	0.005	0.002	0.044								

In all four models, the estimated main effects of the attributes are statistically significant and have the correct signs; Biodiversity protection (BIO), decrease of saline lands coverage (SALT), reduced usage of agro-chemicals (NIT), and employment in eco-friendly activities (EMP), are positively related to the probability of selecting a choice scenario with ecosystem improvements. Also, in the main

effects models (FPL1 and RPL1), after appropriate measurement scale adjustments that allow for direct comparisons, the estimated attribute coefficients have the ordering $\beta_{EMP} > \beta_{BIO} > \beta_{NIT} > \beta_{SALT}$. This indicates a higher average preference level for the EMP attribute, followed in turn by the BIO, NIT and SALT attributes. Consequently, mean WTP for an attribute's level change follows the same ordering; it is highest on average for a level change in the EMP attribute, than for a level change in BIO, NIT and SALT attributes. This preference ordering persists in the FPL2 and RPL2 specifications. The cost coefficient is consistently negative in all estimated models.

3.1. Welfare estimates

Table 4 presents estimates from each model of the average WTP for the four investigated attributes (measured in the original scale shown in Table 1), using equation (6), and the corresponding 95% confidence intervals. The latter are derived in two ways, (a) under the MVN assumption for the joint distribution of estimated parameters, and (b) non-parametrically using empirical bootstrap estimates from 1000 bootstrap samples[1].

Table 4: Estimated expected WTP and 95% confidence intervals

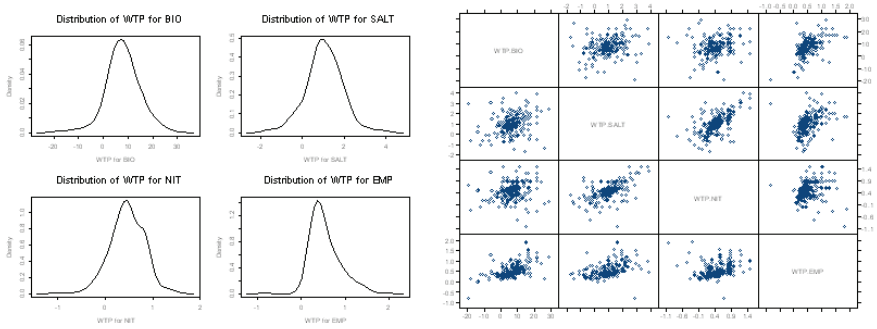
Attributes	*Model*			
	FPL1	RPL1	FPL2	RPL2
BIO	8.26 (5.57,11.84) [(1)]	4.80 (3.77,5.93) [(1)]	7.70 (5.41,10.27) [(1)]	7.01 (5.81,8.39) [(1)]
	8.42 (5.59,12.45) [(2)]	5.39 (4.39,6.79) [(2)]	7.51 (5.25,9.41) [(2)]	7.11 (5.95,8.68) [(2)]
SALT	0.79 (0.35,1.20) [(1)]	0.95 (0.69,1.22) [(1)]	0.89 (0.57,1.24) [(1)]	1.07 (0.88,1.36) [(1)]
	0.81 (0.34,1.29) [(2)]	0.84 (0.56,1.13) [(2)]	0.87 (0.74,1.18) [(2)]	0.94 (0.66,1.30) [(2)]
NIT	0.43 (0.23,0.67) [(1)]	0.34 (0.27,0.42) [(1)]	0.42 (0.27,0.60) [(1)]	0.33 (0.20,0.50) [(1)]
	0.44 (0.25,0.68) [(2)]	0.34 (0.25,0.45) [(2)]	0.44 (0.27,0.66) [(2)]	0.34 (0.23,0.49) [(2)]
EMP	0.55(0.44,0.74) [(1)]	0.40 (0.32,0.48) [(1)]	0.49 (0.39,0.60) [(1)]	0.36 (0.24,0.51) [(1)]
	0.56 (0.43,0.75) [(2)]	0.44 (0.36,0.56) [(2)]	0.46 (0.36,0.62) [(2)]	0.36 (0.27,0.49) [(2)]

[(1)] Multivariate normal estimates, [(2)] Bootstrap estimates

For each model, WTP estimates based on the MVN assumption and non-parametric bootstrap estimates do not differ significantly. Point estimates range from 4.80 to 8.42€ per protection level change for the BIO attribute, from 0.79 to 1.07€/1000 acres for the SALT attribute, from 0.33 to 0.44€ per 1% change for NIT, and from 0.36 to 0.56€/employee for the EMP attribute. From the best fitting RPL2 model, the average marginal WTP for BIO is estimated at about 7€ per level change, 1.07€/1000 acres for SALT, 0.33€ per 1% change for NIT, while for the EMP attribute at about 0.36€/employee. Figure 1 depicts the distribution of estimated individual WTP for each one of the four attributes from the best fitting RPL2 model, together with projections of their bivariate joint distributions. The correlations between them range from 0.25 (for the pair BIO-NIT) to 0.62 (for the pair SALT-NIT). These positive and statistically significant (*p-value* < *0.001* for all six pairs) correlations between valuations for the four attributes are due to the common effects of individual characteristics.

[1] For the RPL2 model the number of bootstrap samples was reduced to 500 due to the computational effort

Figure 1. Distribution of individual WTP values for the choice attributes – RPL2 model



4. Effects of ISVs on welfare estimates

The marginal effects of ISVs' on the WTP for the four attributes, while controlling for the effects of other variables, are computed using the estimation results for the best fitting RPL2 model and the methodology of section 2 (eq. 7). Each variable's effect is evaluated at the mean values of the other covariates. The accompanying 95% confidence intervals for the average marginal ISV effects are based on the asymptotic MVN assumption for the ML parameter estimates. Table 5 presents the results.

Table 5: Significant marginal effects of individual characteristics on WTP[(1)]

Variable	BIO			SALT		
Name	Mean	p-value[(3)]	95% CI	Mean	p-value[(3)]	95% CI
Perceptions of importance						
SCPR	0.836	<0.001	(0.677,1.031)	-	-	-
SCCU	-	-	-	-	-	-
SCRE	-4.093[(2)]	<0.001 (0.002)	(-5.048,-3.317)	-	-	-
Socio-demographics						
INCOME	1.807[(2)]	<0.001 (<0.001)	(0.993,3.274)	0.087[(2)]	0.014 (<0.001)	(0.012,0.177)
AGE	-3.125[(2)]	<0.001 (0.019)	(-3.852,-2.532)	0.115	<0.001	(0.093,0.142)
HHSIZE	-3.503[(2)]	<0.001 (<0.001)	(-4.319,-2.838)	0.159[(2)]	<0.001 (<0.001)	(0.129,0.196)
EDUC	-	-	-	0.251[(2)]	<0.001 (<0.001)	(0.203,0.309)
GENDER	-2.082	<0.001	(-3.301,-1.246)	-0.238	<0.001	(-0.355,-0.141)
ENV	-2.304	<0.001	(-3.559,-1.423)	-0.264	<0.001	(-0.386,-0.160)

Variable	NIT			EMP		
Name	Mean	p-value[(3)]	95% CI	Mean	p-value[(3)]	95% CI
Perceptions of importance						
SCPR	0.051	<0.001	(0.041,0.063)	0.0009	<0.001	(0.0007,0.0011)
SCCU	-	-	-	0.010[(2)]	<0.001 (<0.001)	(0.008,0.013)
SCRE	-	-	-	-	-	-
Socio-demographics						
INCOME	-0.063[(2)]	<0.001 (<0.001)	(-0.111,-0.026)	0.114[(2)]	<0.001 (<0.001)	(0.064,0.198)
AGE	-	-	-	-0.024	<0.001	(-0.030,-0.020)
HHSIZE	-	-	-	-0.012[(2)]	<0.001 (0.017)	(-0.015,-0.010)
EDUC	-0.019[(2)]	<0.001 (0.507)	(-0.023,-0.015)	-	-	-
GENDER	-0.113	<0.001	(-0.189,-0.060)	-0.132	<0.001	(-0.199,-0.083)
ENV	-0.125	<0.001	(-0.203,-0.068)	-0.145	<0.001	(-0.214,-0.095)

[(1)] Average derivative (in euros per unit increase of variable's level) from the RPL2 model. Averaging is across individuals and variable values.
[(2)] Marginal effect is non-linear (see Figure 5). Reported values refer to the average linear effect.
[(3)] Observed significance level for the one sided linear alternative hypothesis (i.e. H_a: *linear effect* > 0 or H_a: *linear effect* < 0). When the estimated marginal effect appears to be non-linear, the reported p-values given in parentheses refer to the F-test for the null hypothesis of linear effect.

Figures 2a-d show (a) the estimated average (i.e. evaluated at the mean values of other covariates and random coefficients) effects, of each quantitative ISV, together with (b) a smooth local regression fit of each quantitative ISV on the estimated

individual-level WTP values from model RPL2[2]. Due to space limitations, we restrict the discussion to some selected main results.

Figure 2a. Effects of ISVs on WTP values for BIO

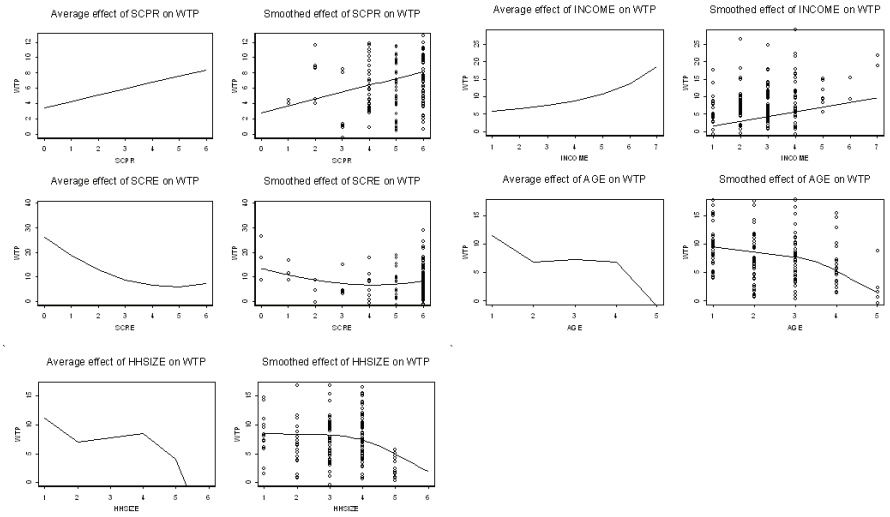


Figure 2b. Effects of ISVs on WTP values for SALT

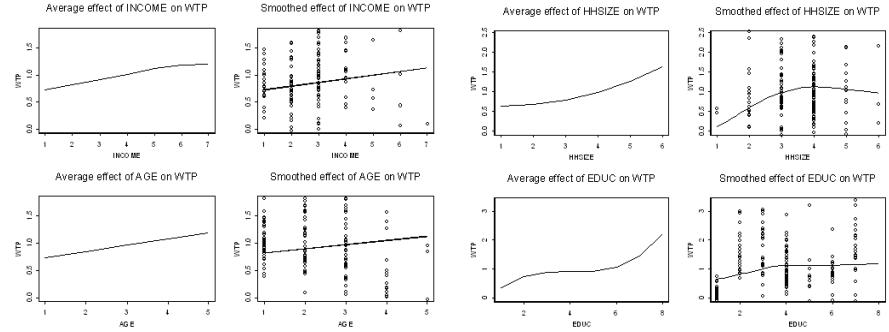
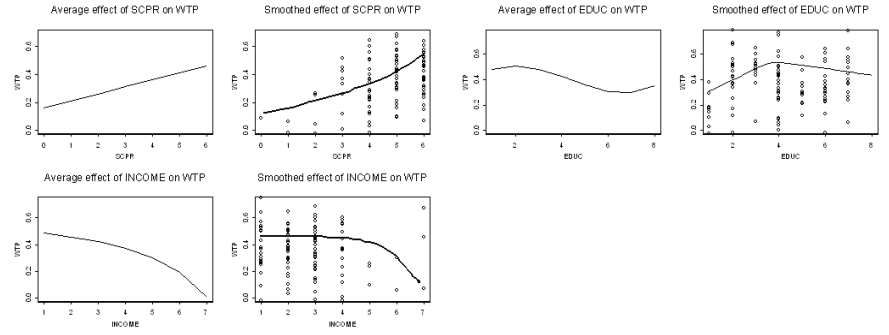
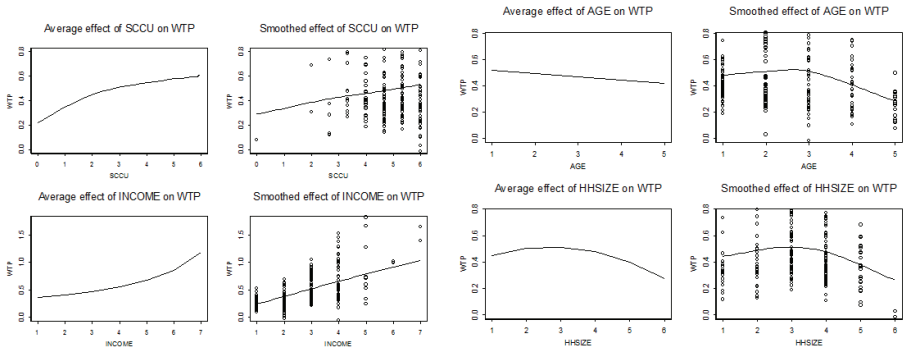


Figure 2c. Effects of ISVs on WTP values for NIT



[2] Results from model FPL2 are qualitatively the same.

Figure 2d. Effects of ISVs on WTP values for EMP



4.1 Perceptions of ecosystem services importance

Perceived importance scores for ecosystem services have a variety of linear and non-linear effects on individuals' economic valuations of the four attributes; For *provisioning services* (SCPR), WTP for the BIO attribute increases linearly from 3.4 (score = 0) to 8.4€ (score=6). The average derivative is 0.84€/scale unit. SCPR has also statistically significant linear effects on the WTP for the NIT and EMP attributes, though of small magnitudes. For *cultural services* (SCCU), WTP for the EMP attribute increases almost linearly from 0.29 (score = 0) to 0.53€ (score=6), with an average derivative of 0.01€/scale unit. SCCU does not appear to affect significantly WTP for the other three attributes. For *regulating services* (SCRE), WTP for the BIO attribute initially decreases fast from 26.3 (score = 0) to 6.5€ (score=4), and then increases slightly to 8.3€ (score=6). The average derivative is -4.1€/scale unit. We did not detect significant effects of SCCU to the WTP for the other three attributes.

4.2 Socio-demographic variables

Income has a non-linear effect on WTP for all four attributes. For biodiversity protection improvements, WTP increases in an almost quadratic manner from about 5.6€ for low income values (2500€/year) to a maximum of 18.7€ per level change for the highest income values (32500€/year). The average WTP derivative is 1.8€ per 5000€ of income. For reductions of saline soils coverage (SALT), expected WTP appears to be a piecewise linearly increasing function of income, with a positive and statistically significant average derivative value of 0.09€. WTP increases from 0.7 € for the lowest incomes to 1.3€ for the highest ones. Also, income has a significant positive quadratic effect on the WTP for the transfer of labor to eco-friendly activities (EMP). The average derivative is 0.11€.

Age has a non-linear negative effect on the WTP for biodiversity improvements (BIO). Average rate of WTP change for BIO with age is -3.1€ per age band (approximately 10 years wide). WTP for SALT is linearly increasing with age (average derivative 0.12€), while WTP for EMP is linearly decreasing (average derivative -0.02€). Age does not appear to affect WTP for NIT, when controlling for the effects of other covariates.

Household size (HHSIZE) is positively related with the WTP for the SALT attribute. The average derivative value is 0.16€/person. HHSIZE has an overall negative non-linear relationship with the WTP for the BIO attribute; WTP remains almost constant at about 8€ for small to medium sized families (1 to 3 persons) and then reduces fast to zero for the largest families in our sample. Education level has a statistically significant and sizeable positive non-linear relationship with WTP for saline soils reduction (average derivative is 0.25€ per attainment level). It is worth noting that female respondents tend to systematically be willing to pay less for all four attributes than male respondents. Participants to environmental groups exhibit a similar pattern of reduced WTP for all attributes studied, as compared to other population members.

5. Concluding comments

We conducted a choice experiment to value four key attributes associated with ecosystem health in the Evros Delta protected area. Choice models were used to obtain monetary estimates for the preferences of residents about ecosystem-preserving human activities, biotope protection, and interventions that reduce soil salinity and concentration of agro-chemicals, and their relationship to agents' characteristics. Methodologically, we derived non-trivial equations for the estimation of individual characteristics' marginal effects on welfare valuations (results of section 2.4). These valuations were found to be strongly related to individuals' demographics and perceptions of ecosystem services' importance. Our empirical results may well inform decision makers towards designing and targeting efficient economic policies for improving the management of protected areas in river deltas at the Mediterranean coast.

References

1. Boyd, J. and Banzhaf, S. (2007), "What are ecosystem services? The need for standardized environmental accounting units", *Ecological Economics*, Vol. 63(2-3), pp. 616-626.
2. Emmanouilides, C. J and Davies R. B. (2007), "Modelling and Estimation of Social Interaction Effects in New Product Diffusion", *European Journal of Operational Research*, Vol. 177(2), pp. 1253-1274.
3. Efron, B. and Tibshirani, R. (1998). *An Introduction to the Bootstrap*. Boca Raton, FL: Chapman & Hall/CRC.
4. Greene, W. H. (2003). *Econometric Analysis.* 5th ed., pp. 913f.
5. Hensher, D.A., Rose, J.M., and Greene, W.H. (2005). *Applied choice analysis: A primer*. Cambridge University Press. Cambridge, UK.
6. Longford, N.T. (1993). *Random coefficient models*. Clarendon Press, Oxford, UK.
7. Louviere, J.J., Hensher, D.A. and Swait, J. (2000). *Stated choice methods: analysis and applications*. Cambridge University Press, Cambridge, UK.
8. Meyerhoff, J. and Liebe, L., (2008), "Do Protest Responses to a Contingent Valuation Question and a Choice Experiment Differ?", *Environmental Resource Economics,* 39, pp. 433-446.

9. Millennium Ecosystem Assessment, 2005. Ecosystems and Human Well-Being: Synthesis. Island Press, Washington, DC.
10. Train, K.E. (2008), "EM Algorithms for nonparametric estimation of mixing distributions", *Journal of Choice Modelling*, 1(1), pp. 40-69
11. Train, K.E. (2009). *Discrete Choice Methods with Simulation*. 2nd Edition, Cambridge University Press, Cambridge, UK.