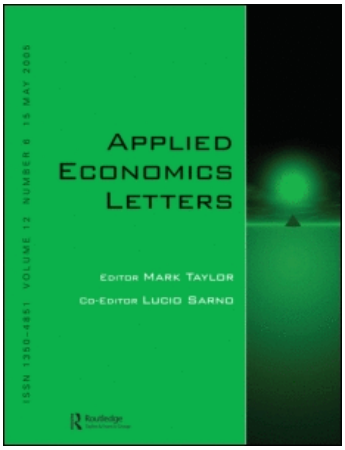

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Estimating the value of natural resources under legal constraints: an application to marine resources in Sicily

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In this article, we use the Contingent Evaluation methodology to develop an economic evaluation of natural resources in a protected marine area of Sicily. Assuming a nonnormal distribution for the ML estimation, the article shows that a variant of the stochastic utility model appears to capture well the dependence of the willingness to pay (WTP) on the socioeconomic characteristics of a sample of stakeholders of the natural resources in question. The estimates obtained are consistent and robust across different policy measures, no embedding or sequencing effects emerge and option values also appear to have been elicited in a consistent way. Once these values are added to the basic WTP, the income elasticities estimated fall in the range reported by other studies.

I. Introduction

Because of its richness in natural resources the Gulf of Castellammare, Sicily, is the theatre of many conflicting socioeconomic interests that over time have prompted several regional and national legal interventions.[2] On the one hand, several environmental policies which have been implemented through rules or regulations have heightened the conflicts among stakeholders. On the other hand, the same policies have made the Gulf a natural laboratory for biological and economic experiments. In this context, this article is based on the results of a research project aiming at developing estimates of the economic value of natural resources by examining the willingness to pay (WTP) of local stakeholders for several environmental policies regarding some of the natural resources (in a broad sense) of the Gulf: a protected land area, a possible sea park, the trail fishing ban and regulation of sea culture. The results obtained suggest that stakeholders attach sizable values to all the conservation policies examined, that their willingness to pay (WTP) is largely explained by a set of plausible socioeconomic characteristics, and that a significant role is played by option values.

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[1] Where you recall Marco Ventura's affiliation, or wherever you want The opinions expressed by the author do not necessarily reflect the position of the Institute.
[2] In 1981, the 'Zingaro Natural Park' was established by a regional law (98/81) as a strictly protected area, in 1990, another regional law (25/90) had banned the trail fishing in a limited area of the Gulf, in 2001 (decree 1339), the stopping of fishing for some months a year was introduced.

II. The Estimates

Consider the Random Utility Model first elaborated by Marschak (1960) and successively studied, improved and implemented by many authors, such as McFadden (1974, 1978, 1999, 2001), Train (1986, 1998, 2001) Train and McFadden (1978), Hausman *et al*. (1993).The model assumes that heterogeneity of choices made by economic agents is attributable to two different components: a systematic part, depending on the agent's observable socioeconomic characteristics (e.g. sex, age, income, family size etc.) and an unobservable random part.

On the basis of similar hypotheses, we investigated the preferences of a sample of agents by using a survey designed on the assumption that the WTP of each given agent could be considered as a latent process explained by observable and unobservable components. The survey was conducted by applying a questionnaire designed to elicit the WTP of agents for a range of environmental improvements or damage preventive actions by classes of payment. The interviewees, who comprised a cross section of users of the environmental resources of the gulf, were asked if they would agree to pay upon paying a given annual 'price' for a series of policy actions aimed at the conservation of the resources in question. These policy actions included: (i) an extension of the ban of trail fishing, (ii) support of a protected land area, (iii) institution of a protected sea park, (iv) the ban on sea culture. The interviews were conducted on a random sample of 200 subjects, stratified by type of employment, using as benchmark rules the principles suggested by the NOAA (National Oceanic and Athmospheric Administration) protocol (Portney, 1994), Diamond and Hausman (1994), Hausman Leonard McFadden (1993), McFadden and Leonard (1993). Using a payment card, the interviewee was asked a question on her WTP for a particular policy action. According to whether the interviewee responded 'yes' or 'no' to the question, the interviewer asked the same question for the next higher price or the next lower price on the payment card. As a consequence, for each series of questions, the WTP of the *i*th interviewed lies in an interval whose lower bound, WTP_{Li}, is given by the highest value to which he answered 'yes' and the upper bound, WTP_{Hi}, by the lowest value to which he answered 'no'.

According to the stochastic utility model, we assume that the expected WTP is linearly dependent on a vector of social and economical characteristics, x_i, and on a stochastic term with zero mean:

$$\begin{aligned}\mathrm{WTP}_i &= E(\mathrm{WTP}_i) + \varepsilon_i \\ &= \alpha + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_m X_m + \varepsilon_i \quad (1)\end{aligned}$$

In order to correct for heteroscedasticity, we also assume that the stochastic disturbance, ε_i has a SD that linearly depends on the same socioeconomic characteristics, $\sigma_i = c_{i1}X_1 + \cdots\cdots + c_{in}X_n$. While the survey does not provide point estimates for WTP_i, its results can be used to estimate the probability that it is comprised in a given interval. In particular, the probability that the $\mathrm{WTP}_{Li} \leq \mathrm{WTP}_i \leq \mathrm{WTP}_{Hi}$ is given by $\mathrm{Prob}(\mathrm{WTP}_i \leq \mathrm{WTP}_{Hi}) - \mathrm{Prob}(\mathrm{WTP}_i \leq \mathrm{WTP}_{Li})$, namely by $F(\mathrm{WIP}_{Hi}) - F(\mathrm{WTP}_{Li})$ where $F(.)$ is a probability distribution function (PDF).

The estimation procedure is closely related to the ordered logit and probit method, except for the fact that the cutoff points are given by the questionnaire design. A ML function is specified on the basis of the probabilities that the WTPs lie in the intervals specified by the survey. This function is maximized with respect to the vector β of coefficients of the socioeconomic variables according to Equation 1, under the nontrivial constraint that the WTP cannot take on negative values and ruling out any distribution function that admits negative values in the domain of the function. A lognormal distribution is attractive if all people have positive WTP, but in our case the probability function has a hump around zero. Among several alternative candidates, a χ^2 distribution was singled out and used as the null hypothesis for a Kolmogorov test based on the comparison with the empirical distribution,[3] with the result that for all the different WTPs elicited it is not possible to reject the null.

An ordered χ^2 ML estimate was thus carried out, with the matrix of observable variables partitioned into five blocks: (i) household income, (ii) personal, (iii) employment sector, (iv) environment and (v) education. Each block contains about 4–5 variables.

For each block estimation has been performed twice removing in the second step all variables with nonsignificant coefficients (Table 1).

The estimates appear robust as the estimated coefficients and their significance levels are only marginally affected by the removal of the

[3] This procedure suffers from two weaknesses: first, the alternative hypothesis does not allow to specify an alternative distribution, e.g. the normal, but it simply tests that the difference between the estimated parameters and the theoretical is nonsignificant, second, having arranged the WTP by classes one needs to take the central value of any class (or any other value within each class) to proxy a continuous distribution function and carry out the test. For a general description of empirical distribution function testing see D'Agostino and Stephens (1986).

Table 1. Ordered χ^2_{n-k} ML estimates

	Zingaro		Trail fishing		Sea park		Sea culture	
α	−326.767*	(168.2)	−241.925***	(14.85)	400.599	(331.1)	115.049	(353.4)
x_{18} monthly income	0.006***	(0.001)	0.004*	(0.001)	0.003*	(0.001)		
x_1 other interviewed income	38.473***	(6.110)	48.140***	(6.729)	32.769***	(7.572)		
x_{16} share of secondary income	−0.939***	(0.212)	−1.239***	(0.254)	−0.811***	(0.266)		
x_{19} seasonal concentration in income					−6.794**	(3.400)	12.319***	(3.671)
x_{20} number of rentiers	11.151***	(1.306)	7.301***	(1.653)	6.701***	(1.755)		
x_2 altruism			12.148**	(5.756)	27.542*	(14.27)		
x_6 year of birth					−0.325*	(0.169)		
x_{12} sex	14.297***	(2.534)	14.406***	(3.344)	19.199***	(3.061)	15.669***	(3.968)
x_{13} homeowner					−8.964**	(4.135)	−8.171*	(4.345)
x_{14} risk aversion	0.005***	(0.000)	0.004***	(0.000)				
x_{15} subjective discount rate	0.841***	(0.186)					1.124***	(0.285)
x_{22} household components	6.773***	(2.545)					3.655***	(1.357)
x_8 tourism			16.177***	(3.278)	16.120***	(3.410)	15.746***	(3.164)
x_9 public sector	−0.124***	(3.141)			−8.258**	(4.070)		
x_{10} fishing	−6.954**	(3.131)	7.874**	(3.597)				
x_{11} services	−0.012***	(3.518)			−10.202**	(4.982)	−17.304**	(7.327)
x_3 polluting job			15.036***	(3.393)			−7.589*	(4.548)
x_4 participation in environmental associations	12.067***	(2.340)			11.141***	(2.779)	19.508***	(3.074)
x_5 willingness to decrease working hours should his job pollute	15.313***	(2.385)	15.320***	(3.100)	16.579***	(3.405)	11.531***	(3.926)
x_7 wta compensation to forego from one working day			−0.040***	(0.012)				
x_{23} owning a degree	27.906***	(2.880)	20.048***	(3.285)	31.279***	(3.323)	33.261***	(4.464)
x_{24} high school degree								
x_{25} junior high school degree	22.076***	(5.513)	17.972***	(6.078)	29.054**	(13.69)		
H_0: joint significance of all coefficients	0.00		0.00		0.00		0.00	
Schwarz criterium (BIC)	4.25		3.37		2.97		2.50	
Pseudo R^2 di McFadden	0.25		0.18		0.28		0.24	

Notes: ***, ** and * Indicate 1, 5 and 10% significance levels, respectively.
SE in parentheses.
Significance of each regressor and of the whole regression has been tested through a LR test.

nonsignificant variables. Further, the estimated coefficients show the same signs for all the policy measures examined. The following variables play a positive role on the probability that the WTP falls in a higher class:

(1) The amount of monthly income, the presence of more than one income per household gained directly by the interviewed, or by any other household component.
(2) Greater sensitivity towards fellow workers or the environment, altruism, participation in environmental associations, willingness to decrease working hours should one's job pollute.
(3) Age, only for the protected sea area.
(4) Male gender.
(5) Employment in the tourism sector.
(6) Risk aversion.
(7) Subjective discount rate.
(8) Number of household components.
(9) Education.

On the other hand, the probability to fall in a higher WTP class decreases when:

(1) The interviewee is employed in the public sector, or in the service sector.
(2) The interviewee or his/her spouse are homeowners.
(3) The interviewee has a higher share of secondary income. There is an increase in the willingness to be compensated to forgo from working one day. This effect is significant only for trail fishing.

Differences among policy actions are found instead for the following variables:

(1) people with polluting jobs have a greater probability to fall in the highest payment class for the trail fishing section, while the opposite effect is recorded for the sea culture section.
(2) Being in the fishing sector increases the probability to pay more to keep the trail ban, and decreases it for the protected land area.
(3) People with income concentrated in one or more periods of the year are more likely to be willing to pay higher amounts to remove sea culture facilities and lower probability to be willing to pay higher amounts for a marine protected area.

The results obtained with the χ^2 ML estimation show that income is positively associated with WTP. At the same time, they also suggest that the socio-economic pattern and the mechanism of income formation are the most important determinants of WTP, far more important than monthly income per se. By the same token, intangible factors and social sensitivities play a non negligible role in determining the opinion of interviewed towards environmental resources. Quantifying: the elasticity of WTP with respect to income goes from a minimum of 0.3% for monthly income of 600€ to a maximum of 6-10% for higher incomes. This level is in line with the results from several WTO studies (Hanemann, 1994, p. 33), Kristrom and Riera (1996), Hokby and Soderqvist (2003), Pearce (2003).

III. The Option Value

The concept of option value of a natural resource was presented originally by Cicchetti and Freeman (1975) and refined by Schmalensee (1972 and 1975) and Bohm (1975). These authors interpret option value as something akin to a risk premium arising from a combination of the individual's uncertainty about his future demand for a site and uncertainty about its future availability. This kind of uncertainty concerns the potential future value of the park if it were preserved. More generally, we can think of the option value as a hypothetical risk premium under uncertainty to avoid a possible damage to a natural resource and estimate it as the WTP to avoid the risk of environmental damage. In the survey, the estimate was obtained by asking the interviewee his WTP to apply several policy instruments (a protected land area, a strengthened trail ban, a protected sea park) to avoid a damage that would severely affect the species in the area under two alternative regimes. These were respectively characterized by a probability distribution over two states of the world (one highly and one mildly unfavourable) and by an equivalent, average scenario without uncertainty. In the following tables (Tables 2–5), estimates of the two components (WTP and option value) of the value of the natural resources are given for policy instrument examined in the survey.

In all of the four sectors, it is not possible to accept the null of equality of means by sector of employment for the total value of the resources at least at 5% namely, evaluations given by different sectors are statistically significant. This conclusion does not hold, however, if one considers only the option value. Within each sector (Table 6) one cannot reject the null for the employees of the public, the service sector and for retirees. For the

Table 2. Mean value (WTP) assigned to the protected land area by employment sectors of the respondent

	WTP		Option value		Total		Ranking
Tourism	121.15	(18.41)	3.95	(11.19)	125.1	(23.72)	6
Fishing	144.78	(16.30)	12.94	(71.02)	157.72	(68.71)	3
Public sector	132	(21.84)	7.21	(26.31)	139.21	(37.15)	4
Industry and trade	122.23	(20.59)	1.48	(6.54)	123.71	(19.79)	7
Services	146.58	(21.44)	24.77	(106.48)	171.36	(95.35)	1
Nonemployed	135.41	(16.47)	3.5	(6.69)	138.91	(16.03)	5
Retired	136.46	(20.14)	25	(52.17)	161.46	(49.08)	2
Average	134.40	(21.35)	10.71	(54.85)	145.10	(55.85)	
H_0: equality of conditioned means (p-value)	0.000		0.6786		0.0072		

Note: Euros, SD in parentheses.

Table 3. Mean value (WTP) assigned to the 'trail ban' by employment sector of the respondent

	WTP*		Option value		Total		Ranking
Tourism	130.22	(17.41)	8.95	(31.58)	139.17	(40.40)	7
Fishing	144.00	(15.28)	5.94	(43.61)	149.95	(46.24)	4
Public sector	139.67	(15.20)	4.15	(11.10)	143.82	(18.58)	6
Industry and trade	143.88	(14.34)	5.90	(14.34)	149.79	(16.14)	5
Services	149.86	(17.97)	24.77	(106.34)	174.64	(98.88)	2
Nonemployed	154.60	(14.44)	10.50	(12.35)	165.10	(12.08)	3
Retired	154.71	(19.86)	24.20	(59.82)	178.91	(52.45)	1
Average	142.56	(17.71)	10.09	(48.11)	152.65	(49.40)	
H_0: equality of conditioned means (p-value)	0.00		0.6281		0.0353		

Notes: *WTP for keeping the trail ban. Euros, SD in parentheses.

Table 4. Mean value (WTP) assigned to the creation of a protected 'sea park' by employment sector of the respondent

	WTP		Option value		Total		Ranking
Tourism	134.98	(17.65)	6.18	(40.11)	141.16	(45.14)	7
Fishing	163.20	(15.83)	9.56	(34.46)	172.76	(37.41)	2
Public sector	142.93	(23.41)	4.39	(12.75)	147.33	(30.31)	6
Industry and trade	146.36	(23.97)	1.43	(4.78)	147.79	(23.21)	5
Services	160.08	(28.47)	22.73	(106.61)	182.81	(94.62)	1
Nonemployed	154.28	(19.67)	2.50	(6.35)	156.78	(16.45)	4
Retired	158.99	(29.90)	10.67	(30.35)	169.66	(33.32)	3
Average	151.01	(24.01)	8.32	(45.08)	159.27	(47.99)	
H_0: equality of conditioned means (p-value)	0.00		0.7734		0.0038		

Note: Euros, SD in parentheses.

Table 5. Mean value (WTP) assigned to the ban of sea culture by the respondent sector of employment

	WTP*	Sea culture		Ranking
Tourism	146.10	(17.49)		7
Fishing	162.01	(11.80)		5
Public sector	154.25	(22.15)		6
Industry and trade	164.93	(14.98)		4
Services	183.72	(26.05)		1
Nonemployed	169.61	(18.80)		3
Retired	174.44	(18.58)		2
Average	161.70	(21.30)		
H_0: equality of conditioned means (p-value)	0.0000			

Notes: *WTP to withdraw the licenses for sea culture in the gulf. In this case the option value does not appear because the damage is already in place. Euros, SD in parentheses.

Table 6. Equality test for the resources by employment sectors

	H_0: equality of conditioned means for total value of the resources (p-value)
Tourism	0.0468**
Fishing	0.0925*
Public sector	0.1721
Industry and trade	0.0000***
Services	0.9514
Nonemployed	0.0007***
Retired	0.6801
Average	0.0018***

Note: ***, ** and * respectively represent rejection of the null at 1, 5 and 10% levels, respectively.

Table 7. SURE estimates of two equations whose dependent variables are the (log of the) two OV components

	Protected land area	Trail fishing	Sea park
α			
Log of monthly income	0.590*** (0.181)	0.330* (0.180)	0.43*** (0.145)
R^2 of eq. WTP to avoid a mean damage	0.13	0.13	0.19
R^2 of eq. mean of WTP to avoid damage	0.17	0.17	0.21
Joint significance of all coefficients (p-value)	0.00	0.00	0.00

Notes: *** and * respectively represent rejection of the null at 1 and 10% levels, respectively.
SE in parentheses. Other significant regressors are: sex, education, altruism, and willingness to reduce working hours in response to environmental damage. A constrained system has been estimated after accepting a Wald test of equality of some common coefficients in both equations.

fishing sector it is possible to reject at 10%, for tourism at 5% and for the remaining sectors at 1%.

One step further now is to analyze the determinants of the Option Value (OV) and income elasticity. For this purpose a SURE estimate has been run for the (log of the) two components of the OV (WTP of the mean and mean of the WTP to avoid an environmental damage) since errors are highly correlated. For brevity, Table 7 reports only the coefficients we are interested in, the (log of) monthly income where the dependent variable is the log of the WTP for mean damage, i.e. the certain component of the OV, as a proxy of the WTA, in line with Adamowicz *et al*. (1993), Cummings *et al*. (1986), NOAA (1993), Chanel *et al*. (2006).

Income elasticities to prevent environmental damages are estimated to be between 0.3 and 0.6. This range of estimation agrees with the results of meta-estimates by Kristrom and Riera (1996), who found income elasticities for environmental improvement for a number of European data sets to be less than one, Similar results are also supported by Hokby and Soderqvist (2003) and Pearce (2003).

IV. Concluding Remarks

In this article, we have presented an application of the CV method to the evaluation of natural resources in Sicily. Relying on the CV methodology, WTP estimates have been obtained from a small sample of interviews of relevant stakeholders, by maximizing a nonnormal ML function, with the following noteworthy results: (i) WTPs appear to be of reasonable sizes and significantly variable across individuals, (ii) individual differences are significantly, but only partly explained by the socioeconomic characteristics of the respondents, (iii) in accordance to other studies, WTP estimated income elasticities are lower than one, (iv) option values appear to be small, but non trivial components of total WTPs and (v) the high values attached to a possible ban of licenses for sea culture suggests that people are confident in the success of government intervention and hold a positive view of the effect of the environmental measures taken in the area.

The main policy implication of these findings is that the value assigned to environmental policies on the part of interested economic agents is sufficiently high to warrant both government intervention and a measure of private participation.

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