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Estimating preferences for controlling beach erosion in Sicily

This study applied discrete-choice experiments to estimate preferences for a program aimed at reducing the retreatment of the sandy beach at "Lido di Noto", a renowned Sicilian bathing resort close to Noto (Italy). Econometric analysis of data was based on Multinomial Logit (MNL), Latent Class (LC) and Mixed Logit (MXL) models. Findings shown that users appreciated the advancement of the current coastline through nourishment, and negatively perceived the construction of emerged sea barriers. MXL and LC models revealed that preferences were heterogeneous.

1. Introduction

Humans' actions and natural processes are increasing at alarming rate the erosion of worldwide coastlines (Luijendijk *et al.*, 2018). This phenomenon is causing a considerable reduction in the provision of many coastal ecosystems services, and posing a significant threat on several human activities, in particular on seaside tourism economy of many locations and regions (EEA, 2006; Phillips and Jones, 2006; World Travel Tourism Council, 2016).

To face with coastal erosion problem, various defence alternatives exist (National Research Council, 2007). Each alternative varies in terms of aesthetic impact, beach loss, access restriction, biological impacts, and socio-economic dimensions. Generally active defence schemes, such as engineered (or hard) structures, natural (or soft) structures, or a mixture of them, are adopted (APAT, 2007). Examples of hard interventions are typically groins, sea barriers, breakwaters and sea walls. Typical soft measures are the beach nourishment, the generation of gravel beaches, and the planting of sea-grass on the sea bottom.

Knowing in advance users' preferences for the different protection schemes is focal to design efficient coastal conservation policy and management plans, and to avoid undesirable effects on beach users and seaside tourism economy.

Discrete Choice Experiments (DCE) is now the most common approach to elicit preferences due to its ability to handle simultaneously an array of several changes relative to the "business-as-usual" status (Hoyos, 2010; Mahieu *et al.*, 2014; Train, 2003; Johnston *et al.*, 2017; Hanley and Czajkowski, 2017).

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In this paper, DCE method is executed to elicit preferences for alternative erosion control programmes of "Lido di Noto", a renowned seaside resort located in South East part of Sicily, at seven kilometres away from the municipality of Noto, an UNESCO world heritage site. In recent years, the "Lido di Noto" has been hugely affected by erosion, losing about 53,000 m^2 of sandy beach in the period 1988-2014, with a coastline retreatment of 47 metres.

A random sample of local users of the beach is asked to choose among different coastal defence actions. Hypothetical interventions consist in building sea barriers, and in nourishing the beach. Econometric analysis of data is based on Multinomial Logit (MNL), Latent Class (LC) and Mixed Logit (MXL) models (McFadden, 1974; Swait, 1994; Swait and Sweeney, 2000; McFadden and Train, 2000; Boxall and Adamowicz, 2002; Train, 2003; Hensher *et al.*, 2015). Last two models allow to verify if in the sample preferences varies respectively in a 'lumpy' and in a "smooth" way (Beharry-Borg and Scarpa, 2010).

Findings show that users appreciate the advancement of the current coastline through nourishment, and negatively perceive the construction of emerged sea barriers. The mostly chosen defence program is based on a coastline's advancement of the current coastline through nourishment equal to 60 meters, and on the construction of sub-emerged sea barriers. MXL and LC models reveals that in the sample preferences are heterogeneous.

2. Related works

In this section, we mention only stated preference studies. Systematic literature review evidences that Contingent Valuation is the most used method to quantify individual welfare effects related to coastal erosion. Silberman and Klock (1988) estimate use and existence values of a beach nourishment program in New Jersey (USA). Lindsay *et al.* (1992) explore the determinants of visitors' willingness to pay (WTP) for seawall construction and beach nourishment projects in New Hampshire and Maine (USA). Silberman *et al.* (1992) estimate users and non-users benefits for a beach nourishment project in New Jersey (USA). Whitmarsh *et al.* (1999) assess the value of enjoyment by residents and visitors of the seafront area in Hampshire (UK). Landry *et al.* (2003) elicit the users' WTP for beach erosion management alternatives in Georgia (USA). Shivlani *et al.* (2003) investigate visitors' WTP for beach nourishment in three different sites in South Florida (USA). Alberini *et al.* (2005) estimate residents' WTP for a public program for the preservation of lagoon through the beach nourishment and the construction of infrastructures in the island of S. Erasmo (Italy). Lamberti and Zanuttigh (2005) quantify the WTP of residents, day-visitors and tourists for different defence techniques and beach materials in Lido di Dante (Italy). Koutrakis *et al.* (2011) compare the beach users' WTP for Mediterranean beaches protection in Greece, Italy and France. Reimann *et al.* (2012) measure the WTP of Estonian population for preserving different seashore types. Rulleau and Rey-Valette (2013) estimate WTP of full-time and secondary residents, tourists and day trippers for the implementation of protection measures in some French Mediterranean coastal areas. Logar and van den Bergh (2014) estimate WTP of beach visitors for preventing beach erosion in Crikvenica (Croatia). Castaño-Isaza *et al.* (2015) estimate the tourists' WTP to prevent the loss in beach width in the Caribbean. Landry and Whitehead (2015) assess the WTP of beach users and non-users for beach replenishment, shoreline armoring, and coastal retreat in North Carolina (USA). Dribek and Voltaire (2017) measure the WTP of residents and tourists in Tunisia for the implementation of a beach protection project. Chang and Yoon (2017) assess the WTP for a restoration project in Korea. Only a few studies use Discrete Choice Experiment (DCE) to identify preferences for coastal erosion options. Huang *et al*. (2007) value several beach erosion control programs in New Hampshire and Maine (USA). Each program is based on eight technical attributes: beach preservation; property protection; visible structure; restricted beach access; hazards to swimmers; alteration of wildlife habitat; erosion of a neighbouring beach; water quality deterioration. Phillips (2011) investigates beach visitors' preferences for alternative coastal erosion management schemes based on six technical attributes: the presence and extent of hard protection structures; the minimum width of the beach at high tide; the width of reserve/picnic area behind the beach; the maximum distance to nearest beach access; the number of existing properties which would need to be removed in a managed retreat policy; the relative risk of flood damage to public and private property. Remoundou *et al*. (2015) elicit residents' preferences for impacts on marine and coastal ecosystem caused by climate change in Santander (Spain). As technical attributes, they use: marine biodiversity effects; number of days during which beaches are closed due to jellyfish blooms; effects on beaches size due to sea level rise and erosion. More recently, Matthews *et al*. (2017a; 2017b) extract visitors' preferences for Coromandel peninsula (New Zealand) and value alternative coastal erosion management plans using virtual reality scenarios. Their DCE study is based on two technical attributes: removing the front row of properties and restoring the nature dune system or building a seawall; development of headland.

3. Materials and Method

3.1 Experimental design

To design alternative beach erosion control schemes, we considered three attributes. The first attribute was the building of sea barriers, made up of natural boulders. For this attribute, we assumed two levels: emerged or submerged. The second attribute consisted in the nourishment of the beach. Three levels composed this attribute, involving different metres of advancement of coasts (20, 40 or 60 metres). The third attribute was a voluntary and *una-tantum* monetary donation composed by five levels, from 10 euros to 50 euros (see Table 1).

Choice sets were made up through an Orthogonal Optimal in the Difference (OOD) fractional factorial design (Street *et al.*, 2005). This design, also known as

Table 1. Attributes and levels of the experimental design.

Attributes	Levels
Barriers (in natural boulders)	1. Emerged 2. Submerged
Beach nourishment (coastline's advancement in meters)	1. 20 2. 40 3. 60
Voluntary monetary donation (*una tantum*) (euros)	1. 10 2. 20 3. 30 4. 40 5. 50

D-optimal design, respects the orthogonality principle, and ensures that attributes common across alternatives never take the same level over the experiment (Kanninen, 2002). D-optimal designs produce lower standard errors compared to orthogonal designs. This justify the use of smaller sample size for D-optimal designs respect orthogonal designs, for achieving the same level of statistical significance in estimation (Bliemer and Rose, 2011). In this study, the final sample size was composed by 182 individuals. The OOD design produced 180 choice tasks, blocked in 20 blocks. This statistical design is quite similar to designs adopted by Greene et al. (2006), Hensher and Rose (2007) and Puckett and Hensher (2009).

Respondents were asked for three times to choose the preferred coastal defence scheme included in each choice set composed by two alternatives made up by the combination of the different attributes and levels, and the *status quo* alternative. The survey was administered in the face-to-face mode in four Sicilian municipalities (Augusta, Avola, Melilli and Noto) closer to "Lido di Noto". Interviews were conducted in February and March 2015. Table 2 reports summarises main statistics of the sample.

3.2 Econometric analysis

To estimate preferences, we used MNL, LC and MXL models. In all models, we assumed that individual utility was linearly depending on the barrier typology (emerged vs. submerged), the coastline's advancement of coasts through the nourishment of the beach, and the monetary attribute. The Alternative Specific Constant (ASC) was assigned to the status quo. The MNL model (McFadden, 1974) assumes homogeneous preferences among the population, ignores the panel nature of data, and relies on Independence of Irrelevant Alternatives (IIA) principle (Train, 2003; Hensher *et al.*, 2015). The LC model, also called Panel Logit with Finite Mixing (Swait, 1994; Swait and Sweeney, 2000; Boxall and Adamowicz, 2002), assumes that respondents' behaviour depends on observable attributes and on latent heterogeneity varying with unobserved factors. Individuals are as-

Table 2. Summery statistics of the sample (n = 182).

Variable	Description	Mean	Standard deviation	Mini-mum	Maxi-mum
Gender	User's gender: 1 if male, 0 if female	0.55	0.50	0.00	1.00
Distance	Distance, in km, between user's residence and the beach	29.72	21.99	0.00	75.50
Age	User's age in years	37.01	11.71	18.00	69.00
Married	User's marital status: 1 if married, 0 if other	0.63	0.48	0.00	1.00
Education	User's education level, in years	12.34	3.20	5.00	18.00
Employed	User's employment status: 1 if employed, 0 otherwise	0.48	0.50	0.00	1.00
Knowledge	1 if the user declare that he/she knows that the beach is at risk of erosion, 0 otherwise	0.93	0.25	0.00	1.00
Visits	Number of visits in the last summer season	24.39	37.29	0.00	90.00
Local	1 if user is the owner or tenant of a residence in Lido di Noto	0.16	0.37	0.00	1.00
Environmentalist	1 if user is an environmentalist	0.05	0.23	0.00	1.00

signed to a finite number of C classes based on their choice patterns. Preferences are variable among classes, but are strongly homogeneous within each class. The optimal number of classes is not automatically determined by the model itself but it is derived through appropriate information criteria (Scarpa and Thiene, 2005). The MXL model, or Panel Logit with Continuous Mixing (Revelt, and Train, 1998; McFadden and Train, 2000; Train, 2003), assumes that taste preferences continuously vary across individuals. Consequently, estimation imposes assumptions on the distributions of parameters across individuals. In this study, a log-normal distribution was assumed for the monetary coefficient; remaining random parameters followed a normal distribution (Hensher and Greene, 2003; Hoyos, 2010).

As it concerns estimates of marginal willingness to pay (MWTP), we adopted the standard "preference space" framework (Train and Weeks, 2005; Scarpa *et al.*, 2008). In the LC model, we estimated individual-specific MWTP using the formula proposed by Boxall and Adamowicz (2002):

$$MWTP_{nk} = \sum_{S} Q^{*}_{ns}\left(-\frac{\beta_{sk}}{\beta_{sc}}\right) \tag{1}$$

where Q^{*}_{ns} is the probability of membership for respondent n of belonging in segment s and β_{sk} and β_{sc} are respectively the coefficient estimates for the attribute and for the cost in segment *s*. In the MXL model, the individual-specific MWTP was estimated using the following formula (Beharry-Borg and Scarpa, 2010):

$$MWTP_{nk} = -\frac{\beta_k +_k^r \sigma_k}{\beta_c +_c^r \sigma_c} \tag{2}$$

where: $\eta^r{}_k$ is the r-*th* random draw from the distribution of coefficient for the *k* attribute, with mean equal to β_k and standard deviation equal to σ_k; $\eta^r{}_c$ is the r-*th* random draw from the distribution of coefficient cost attribute, with mean equal to β_c and standard deviation equal to σ_c. In this application, we did 10.000 draws.

4. Results and discussion

Table 3 reports estimates of the MNL model. Results shown that all coefficients had a sign coherent with expectations, and were significant, even if at different significance level. The alternative specific constant (*ASC-status quo*) was equal to -2.28 and highly significant ($p<0.001$). This finding indicated that users strongly preferred to leave the status quo towards actions protecting the beach from erosion. The donation coefficient (*donation*), as expected, was negative and significant ($p<0.05$). The sign for attribute concerning the coastline's advancement (*Beach nourishment*) was positive and statistically significant ($p<0.001$). This result indicate that beach nourishment provided visitors with higher recreational benefits, as previously shown in other studies (Landry *et al.*, 2003; Shivani *et al.*, 2003; Lamberti and Zanuttigh, 2005; Landry and Whitehead, 2015). Phillips (2011) in particular found similar linearity, even if the advancement on the beach width in his study was lower respect to the level assumed in our application. The sign of the coefficient related to emerged barriers was negative and significant ($p<0.001$). This finding, which was consistent with Phillips (2011) and Blakemore et al. (2008), indicate that users of beach did not appreciate the visual impact of emerged barriers.

To select the optimal number of classes in the LC model, we estimated the Log-Likelihood (LL), the Bayesian Information Criterion (BIC), the Aikake Information Criterion (AIC) and the Consistent Aikake Information Criterion (CAIC) (Scarpa *et al.*, 2007). The LC model with the best performance is composed by three classes (see Table 4).

Table 5 reports estimates for LC model. Classes 1, 2 and 3 included respectively 48%, 27% and 25% of the respondents. Individual belonging in all classes negatively perceived the status quo, even if respondents in class 2 shown a higher awareness for the defence of the beach. As it concerns defence schemes, individuals in class 1 preferred the adoption of beach nourishment. Utility of individuals in class 2 was positively driven by sub-merged barriers. Emerged barriers were more appreciated by individuals in class 3.

Table 3. MNL estimates.

Attribute	Parameter	Standard Error (S.E.)
ASC - Status quo	-2.2810***	0.4550
Donation	-0.0142*	0.0051
Beach nourishment	0.0314***	0.0047
Emerged barriers	-0.3319**	0.1263
Log-likelihood	-375.7896	
AIC	759.5792	
BIC	781.2060	

n. of observations: 1,647; * p<0.05, ** p<0.01, *** p<0.001.

Table 4. Criterion to select the optimal number of classes for the LC model.

	LL	BIC	AIC	CAIC	R^2
1 Class	-373.5522	767.9204	755.1044	771.9204	0.1695
2 Classes	-325.8559	698.5478	669.7117	707.5478	0.5645
3 Classes	***-287.8447***	***648.5455***	***603.6894***	***662.5455***	***0.7653***
4 Classes	-277.0355	652.9471	592.071	671.9471	0.8238

Table 5. LC estimates with three classes.

Attribute	Class 1		Class 2		Class 3		Wald	p-value
	Parameter	S.E.	Parameter	S.E.	Parameter	S.E.		
ASC - Status quo	-2.14	12.112	-10.384	12.189	-2.192***	0.53	17.863	0.000
Donation	0.011	0.027	0.197*	0.086	-0.02*	0.011	8.213	0.042
Beach nourishment	0.188**	0.068	-0.047	0.049	-0.014[(a)]	0.011	13.811	0.003
Emerged barriers	-0.895	1.259	-8.56**	3.487	0.893***	0.25	20.381	0.000

[(a)] p<0.10, * p<0.05, ** p<0.01, *** p<0.001.

To identify factors influencing the class membership, we estimated three separate binary multivariate logit models, as suggested by Landry and Whitehead (2015). Table 6 shows estimates of such models. Results indicated that class 1 groups individuals living in more distance villages from the beach, less informed about erosion, and most active users of the site. Class 2 was not statistically influenced by any socio-demographic characteristics. Class 3 was composed by unemployed and older individuals living closer to the "Lido di Noto".

Table 6. Logit model estimates of characteristics influencing class membership.

Variable	LC1		LC2		LC3	
	Parameter	S.E.	Parameter	S.E.	Parameter	S.E.
Distance	0.022*	0.009	-0.001	0.009	-0.028*	0.010
Age	-0.015	0.014	-0.009	0.017	0.028[(a)]	0.015
Employed	0.268	0.319	0.398	0.364	-0.808*	0.408
Knowledge	-1.459[(a)]	0.761	1.555	1.067	0.785	1.012
Visits	0.010[(a)]	0.006	-0.003	0.006	-0.011	0.008
Local	0.600	0.536	-0.753	0.704	-0.108	0.656
Environmentalist	0.866	0.670	-1.144	1.045	-0.171	0.811
Constant	0.897	0.934	-2.245*	1.130	-1.618	1.261
Correctly classified cases (in %)	61.54		75.82		78.02	
Log pseudo-likelihood	-118.229		-96.867		-89.563	
Wald Chi^2	14.2*		7.64		13.3[(a)]	

LC1 = 1 if the user belongs to LC1, 0 otherwise; LC2 = 1 if the user belongs to LC2, 0 otherwise; LC3 = 1 if the user belongs to LC3, 0 otherwise. Standard Error were estimated using Huber-White sandwich estimator.
[(a)] p<0.10, * p<0.05, ** p<0.01, *** p<0.001.

Table 7 displays estimates of the MXL model. Findings shown heterogeneity for all attributes and the *ASC - Status quo*. The parameters of the distributions (e.g. mean and standard deviation of random coefficients) were significantly different from zero for all random variables. Preferences for beach nourishment were less heterogeneous, while heterogeneity was prominent for the status quo, the cost attribute and for the emerged barriers.

Table 8 displays MWTP estimates. LC MWTP values were not reported because the cost coefficient was not significant for class 1, and had a positive sign for class 2. In the MNL model, MWTP for coastline's advancement through nourishment equalled to 3.01 €/meter. Emerged barriers were negatively valued: the loss of utility amounted to 31.85 €. In the MXL model, the mean of MWTP for beach nourishment and emerged barriers were lower than analogue measure estimated through MNL. Particularly, the mean of MWTP for coastline's advancement through nourishment equalled to 0.09 €/meter and was significantly lower than the estimate reported for the MNL. However, the sign was positive for the whole distribution. Similarly, the MXL estimates produced lower values in MWTP compared to MNL also for the attribute related to emerged barriers: the loss of utility estimated with the MXL for the presence of emerged barrier amount to -4.08 € vs. 31.85 € in the MNL. For this attribute, the MWTP had a negative part-worth for two-thirds of users and a small positive part-worth for the remainder. Findings, that are consistent with Phillips (2011), highlight how failure to account for preference variation can bias results.

Table 7. MXL estimates.

Attribute	Parameter	Estimate	S.E.
ASC - Status quo	Mean of coefficient	-32.5278*	13.9496
	Standard deviation of coefficient	11.9946*	5.0834
Donation (neg.)	Mean of ln(-coefficient)	-7.1252***	1.4958
	Standard deviation of ln (-coefficient)	3.1558***	0.5012
Beach nourishment	Mean of coefficient	0.1245***	0.0284
	Standard deviation of coefficient	0.15557***	0.0362
Emerged barriers	Mean of coefficient	-1.4642**	0.4814
	Standard deviation of coefficient	3.2315***	0.7182
Final Log-likelihood	-299.1359		
AIC	614.2718		
BIC	657.5255		

* p<0.05, ** p<0.01, *** p<0.001.
Number of observations: 1,638; number of individuals: 182; random draws: 1,000.

Table 8. Estimates of MWTP.

	Beach nourishment (in euro/meter)	Emerged barriers (in euro)
MNL		
Mean	3.01	-31.85
95% C.I.	-0.22 ¸ 6.05	-73.91 ¸ 10.22
MXL		
Mean	0.09	-4.08
Standard deviation	0.01	7.28
25th percentile	0.08	-9.36
75th percentile	0.10	0.65

95% C.I. calculated with Delta method.

5. Conclusion

This DCE study produce findings that are generally consistent with empirical evidence provided by similar studies. Users of "Lido di Noto" seaside resort are willing to support erosion control of the beach. Their utility generally increases with the advancement of the current coastline through nourishment, and decreases when beach erosion is controlled by the construction of emerged barriers. The most appreciated defence program implies a coastline's advancement of the current coastline equal to 60 meters and on the construction of sub-emerged barriers.

The analysis was limited to local users and did not take into account passive use values. Despite these limits, the DCE study provides useful insights that can be used by policy and decision makers to design defence schemes in harmony with preferences of communities, and to appraise the social profitability of public investments to control erosion and restore beach.

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