Valuing Climate Change Mitigation in Coastal Environments Exposed to Extreme Natural Hazards: A choice experiment simulated for different time horizons

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Pedro Diaz, Phoebe Koundouri, Benedique Rulleau, Kyriaki Remoundou

Abstract: This paper contributes to the limited literature of monetary valuation of the effects of natural hazards. In particular, we focus on natural hazards caused by climate change and measure willingness to pay (WTP) to avoid relevant environmental and health risks in coastal environments. We also allow short, medium and long term for the effects of mitigation measures, in order to investigate differences and/or similarities in people's WTP for these different time horizons. A choice experiment is used and implemented in Stantander, Spain, a coastal region that faces a number of significant challenges due to climate change: (a) vulnerability to marine dynamics, with effects on its beaches (and their role as focal locations for social and touristic activities) as well as built environment and businesses, (b) loss of marine biodiversity and (c) increase in exposure to medusas and other dangerous and alien species present on the beaches, which result to restriction of bathing activities due to health risks. Finally, the empirical results from this paper provide useful insights with regards to the development of optimal (economically efficient, socially acceptable and environmentally sound) risk insurance schemes against extreme natural hazards.

Keywords: climate change, mitigation measures, choice experiment, coastal area, Spain

1. Introduction.

Climate change is expected to have major impacts, especially on coastal zone, effects such as sea level rise, possible changes in maritime storms, and increased salinity of water (IPCC, 2007). Key concerns include land loss, flooding, and implications for water resources. In this context, economic studies may be particularly useful to design climate mitigation policies since they may provide information on public's risk perception (e.g. O'Connor et al., 1999; Akter and Bennett, 2011) as well as on what drives the public WTP this public good and the most important motives for contributions (e.g. Lindsay, 1992). Some studies also focus on climate change impacts: impacts of sea-level rise on nonmarket lands (e.g. Ng and Mendelsohn, 2006), impacts of climate change on insurance (e.g. Richard, 1998; Botzen and van den Bergh, 2008) or on tourism (e.g. Phillips and Jones, 2006), impacts on flooding (e.g. Brouwer at al., 2004; Dawson et al., 2011)… Others relate to resilience (e.g. Wardekker et al., 2010). Some focus on the willingness to pay (WTP) of people for new climate conditions (e.g. Rehdanz, 2006). However, studies assessing the WTP for mitigation options remain seldom whereas they may help to better understand public's valuation of mitigating global climate change (e.g. Rajmis et al., 2009) and even more when dealing with coastal areas (e.g. Berk and Fovell, 1999; Longo et al., 2012; Polomé et al., 2005).

This paper contributes to the limited literature of monetary valuation of the effects of natural hazards. In particular, we focus on natural hazards caused by climate change and measure WTP to avoid relevant environmental and health risks in marine environments. We also allow different time horizons (short, medium and long term) for the effects of mitigation measures, in order to investigate differences and/or similarities in people's WTP for different time horizons. A choice experiment (CE) is used to elicit the relevant WTP for avoiding climate change challenges via the payment for mitigation measures, when these (the mitigation measures) opt to reduce environmental and health risks and take effect at different time frames. The experiment is implemented in Stantander, Spain, a coastal region that faces a number of significant challenges due to climate change: (a) vulnerability to marine dynamics, with effects on its beaches (and their role as focal locations for social and touristic activities) as well as built environment and businesses, (b) loss of marine biodiversity and (c) increase in exposure to medusas and other dangerous species present on the beaches, which result to restriction of bathing activities due to health risks. Our contribution to the literature, however, does not only concern the implementation of a choice experiment in marine environments endangered by extreme natural events. We also derive and measure the WTP to avoid the relevant environmental and health risks for different time horizons (five, thirty and sixty years). Finally, the empirical results from this paper provide useful insights with regards to the development of optimal (economically efficient, socially acceptable and environmentally sound) risk insurance schemes against extreme natural hazards.

The paper is structured as follows. In the first section, we provide information on our case study (Santander, Spain). In the second section, we set out the methodological issues. Then, we describe the present the descriptive statistics and the estimation results. In the last section, we conclude by discussing the implications of our findings.

2. The Case Study: Santander, Spain.

Santander is the capital city of the Region of Cantabria, Northern Spain. Its bay is the largest estuary on the North coast of Spain with an extension of 22.42 km², 9 km long and 5 km wide. It is characterized by pocket beaches and small inlets isolated between rocky headlands. The Bay is a member of The Most Beautiful Bays in the World Club.

Map 1: Bay of Santander in 1997 (source: NASA)

The city itself has a population of around 190,000 people while more than 260,000 are living in the Bay. Due to this anthropic pressure the morphology of the bay has suffered important changes in the last centuries. It is estimated that more than 50% of its original extension has been filled up, drying up a large amount of marsh area, to be used as grasslands, to expand the Port of Santander, and to create new industrial and residential areas together with the local airport (south of the Bay). At the moment work is going on to try and recover the seaside ecosystem in some areas of high ecological value. Besides most the large urban areas around the Bay include important industrial assets together with transportation and life-support systems that are endangered due to sea level rise and increasing storminess including higher waves and high winds. Long-term erosion and winds are expected to give way to flooding.

Actually, middle and eastern part of the spit for instance are fully exposed to the North-Western Cantabrian swell waves. The spit is severely affected by periodic flooding events resulting in important erosion processes. Furthermore, the spit is highly vulnerable to climate change, induced sea level rise and wave climate modification. The Santander Bay already suffered damage caused by severe weather conditions such as Storm Becky in November 2011 which seemed to be at least a twenty-year return period event. According to Mayor Iñigo de la Serna, estimated costs of material damage and the subsequent clean-up well exceeded 400.000 euros in Santander alone for this sole event. Across Galicia, costs are likely to have exceeded 4 million euros which is similar to the price-tag of the storm that plagued Northern Spain in 2008. Fortunately, human casualties were limited to only three injured.

In this paper we focus specifically on the following climate change challenges: First, on Santander's vulnerability to marine dynamics. This is typical in any coastal city and especially important in Santander due to its morphology that puts in close contact both settlements and marine environment. Issues such as high tides and extreme wave events have traditionally attracted public attention in the area. Second, we focus on Santander's beaches and their role as focal locations for social and touristic activities. Actually, Santander offers a lot of beaches and the most famous ones are the Magdalena beach and the Sardinero beach. Third, we focus on issues of the effects of climate change on marine biodiversity, which is related to overexploitation of fish resources, loss of biomass with respect to sellfish, changes in big fishing banks location, and foreign species intrusion. Fourth, we study the effects of exposure to medusas and other dangerous species present on the beaches, which result to restriction of bathing activities for limited periods of time due to health risks.

3. Methodology.

A CE exercise is implemented in this study to elicit respondents' preferences for different climate change mitigation strategies in different time frames. Grounded on Lancaster's theory of value (1966), CE describe the good under valuation in terms of its characteristics, attributes, and the levels these attributes take (Bennett and Blamey, 2001). One of the attributes is usually price, so that the marginal value of the other attributes can be evaluated in monetary terms. Accordingly, respondents are presented with a set of alternatives constructed from different combinations of the levels of attributes, and are asked to choose their most preferred.

Each alternative j in a choice set, under the random utility theory, has an associated utility level for each individual i represented by:

$$U_{ijt} = \beta \; X_{jt} + e_{ijt}$$

In this approach, the utility of a choice is comprised of a deterministic component (βX_{jt}) and an error component (e_{ijt}) and alternative j will be chosen over some other option k iff $U_j > U_k$. The exact specification of the econometric model to be estimated depends on the assumption regarding the functional form of the utility function and the distributional assumption of the error.

To analyse our choice data, we follow a random parameters logit model to allow for heterogeneity in preferences between respondents in the sample. In this class of models the coefficient vector for each individual is the sum of population mean and an individual variation. The stochastic part of the utility is correlated among alternatives, which means that the model does not exhibit the restrictive IIA property of the simple multinomial logit model. According to this specification the probability of an individual i choosing alternative j in a choice situation t is given by the following integral:

$$\Pr_{ijt} = \int \left(\frac{\exp \beta_i X_{jt}}{\sum_k \exp \beta_i X_{kt}} \right) f(\beta|\theta) d\beta$$

Where X is the vector of the attributes and β_i the vector ofthe associated coefficients. For all the considered attributes including the tax a triangular distribution is assumed in our analysis.

4. Survey design and data collection.

The questionnaire was structured as follows: first the interviewed was asked to unveil his perceptions regarding climate change and its seriousness for the world as a whole and Santander in particular as well as any actions taken to mitigate it. Among others, respondents were also asked their opinion regarding their perceived impacts of climate change on the beaches and ecosystems in Santander in different time frames. In the second section the choice cards were presented to respondents who were asked to state their preferred option from three management options. We developed three different versions of the questionnaire each referring to a different time frame for the changes suggested under the scenario (five years, thirty years and sixty years respectively). In each version a short text first presented the situation in Santander and the expected changes under a management policy. The payment was a year tax lasting for five, thirty and sixty years respectively depending on the version. The individuals who showed reluctance to support any protection policy were invited to explain themselves. Finally, the third section focuses in the socioeconomic condition of the respondents.

Table 2 presents an example of a choice card whereas table 3 presents the attributes and their levels used in the analysis.

Table 2: Example of Choice Card.

	Alternative1	Alternative2	Alternative3 (no policy action)
Biodiversity	Medium	High	Low
Number of days beaches are closed because of Medusa Portuguesa outbreaks	5	15	15
Beach Size	High	Low	Low
Additional annual cost to your household for the next five years	125	50	0
I prefer			

Table 3: Atributes and their levels.

Attribute	Levels
Biodiversity	• Low: The area for shell fishery is altered by climate change and is not suitable for this type of fisheries anymore. The Bay of Santander is no longer a stop for migrating birds and invertebrates • Medium: The shell fishery area is preserved but reduced and the Bay is no longer a stop for migrating birds and invertebrates • High: Current level of biodiversity is preserved
Number of days beaches are closed because of Medusa Portugessa outbreaks	• 5 days per year • 10 days per year • 15 days per year
Beach Size (recreation)	• Low: The four main beaches in Santander will reduce from 3kn long that are now to pocket ones. Pocket beaches and beaches located at the flood prone Somo split will disappear due to erosion. • High: Renurishment of the main beaches in Santander and pocket beaches will preserve their size throughout the year
Additional annual cost to your household	• 0 euros per year • 50 euros per year • 75 euros per year • 100 euros per year • 125 euros per year • 150 euros per year

The target population is composed of all the persons over eighteen years old living in one of the cities of the Santander bay area. The sampling was based on two quotas: one reflecting gender and age distribution in the population and one based on the repartition of the inhabitants between the different municipalities. The later procedure was used in order to reflect site specificities: people working in services and retired ones are more present in the urban City of Santander, while Camargo, Astillero and Medio Cudeyo are characterized by the presence of industrial activities and the remaining areas by agricultural and cropping activities. Tourist activities cover the whole territory.

Interviews were conducted by a well-trained team and each person was presented with the questionnaire accompanied with the choice cards. They were conducted in specifically-chosen locations, such as commercial centers, industries, schools, etc. Each interviewee was given a paper questionnaire and asked to fill it. A team member was present in order to provide the needed information and guarantee a correct interpretation of the questions. The administration of the survey lasted about 15 minutes. At the end, a total of 300 people were interviewed and 266 questionnaires are usable for the econometric analysis.

5. Results.

5.1. Descriptive Statistics.

Table 4 presents the main characteristics of the study sample across timelines of public intervention in the valuation question. Significant differences between subgroups are only observed for the household size (at a 10% level) and for the education level (at a 1% level).

Table 4: Descriptive statistics of the sample

	5 years	30 years	60 years	Total
Number of respondents	83	96	87	266
Personal characteristics				
Age (mean)	43	41	41	42
Female (% of women)	59.0	48.9	52.9	53.4
Occupation (% full time)	69.9	68.1	57.5	64.7
Number of people per household (mean)*	3.2	3.6	3.0	3.3
Children (% of household with children)	55.4	55.3	49.4	53.4
Education (% with university degree)***	10.8	13.8	57.5	27.3
Income (% with monthly household income under €2,000) [1]	68.3	65.8	64.7	66.2
Politics (mean score on a scale for 1 – extreme left – to 10 – extreme right)	5.8	6.2	6.1	6.0
Distance of the house from the beach (mean, in km)	2.9	9.4	2.9	5.1
Environmental risks currently facing Santander				
Recreation (mean score)	2.9	3.2	3.2	3.1
Wildlife (mean score)	3.5	3.8	3.9	3.7
Tourism (mean score)	3.4	3.2	3.2	3.3
Health (mean score)	3.3	3.2	2.9	3.1
Consequences of Climate Change				
Increase in frequency and extend of floods...				
... in the next five years	2.4	2.3	2.1	2.3
... in the next thirty years	3.4	3.3	3.1	3.3
... in the next sixty years	3.8	3.6	3.9	3.8
Increase in frequency and extend of storms...				
... in the next five years	2.9	2.9	2.6	2.8
... in the next thirty years	3.4	3.5	3.3	3.4
... in the next sixty years	3.8	3.8	3.8	3.8
Reduction of the size of the beach				
... in the next five years	2.6	2.7	2.7	2.7
... in the next thirty years	3.6	3.6	3.7	3.6
... in the next sixty years	4.2	4.0	4.1	4.1
Intergenerational or contribution questions				
Future generations	4.5	4.5	4.5	4.5
Intergenerational equity	4.3	4.1	4.3	4.2
Financial contribution	3.7	3.4	3.6	3.6
Enjoy the present	2.2	2.0	2.2	2.1

Different questions in the questionnaire were used in order to assess residents' perception of the floods risk. Regarding the environmental risks they consider to be the most serious problems currently facing Santander, floods and marine pollution are cited first by about 30% of interviewees, shortly followed by air and water pollution (20%). They also believe that some assets are nowadays threatened because of climate change and sea level rise in Santander: on the scale from 1 to 5, the mean score of recreation is 3.10, the mean score of health is 3.14. The mean score of tourism is a little higher, ranging 3.25 while that of wildlife reaches 3.74, showing a ranking in perceived assets at risk.

We can pay attention to the timeline by asking residents if they agree with the statements that the frequency and extend of floods and storms in Santander will increase in the next five, thirty or sixty years and that, unless action is taken the size of the beach will be significantly reduced in the same

[1] According to the Instituto Nacional de Estadística (National Statistics Institute), the average annual income of Spanish households reaches €25,732 in 2009 i.e. €2,144 per month

time horizons (Table 4). Results show that storms are residents' main concern in the short run, shortly followed by the fact that the size of the beach may be reduced due to climate change and sea level rise. In the long run (sixty years time horizon), the scores are very high and seem to be much more similar across concerned assets. However, about one third of respondents fully agree with the previsions regarding floods and storms against about one half regarding beach size.

Finally, on the same Likert scale, the majority of the respondents think that current generations should protect the environment to ensure that future generations can continue to enjoy benefits of the goods it provides (mean score equals 4.52). On the same order of idea, intergenerational equity should be an important consideration for policy-making for the interviewees (mean score equals 4.24). A small majority of them affirm that they would financially contribute to actions aiming to mitigate climate change even if benefits are to be received by future generations (mean score equals 3.55) but only a few say that they prefer enjoying the present and not spend a big part of my time worrying about the future (mean score equals 2.13). The bequest value of the environment may thus be considered as an important issue.

The statistic tests do not show that the gender has a systematic significant influence on the answers. However, women are more concerned by the impact of climate change on floods in 60 years, by its impact on storms and beach size in 30 and 60 years. Men are also significantly more willing to enjoy the present. Regarding beach size, they only differentiate themselves for the sixty years timeline. Finally, intergenerational equity is a significantly more important issue for them than for the others. The willingness to financially contribute to mitigation options presents a U-curve when linked to the education level. The mean score of the willingness to enjoy the present significantly decreases with the education level (it equals respectively 3.50 and 2.08 for the "less than primary school" category and for postgraduates) while the mean score of the recreation as one of the most serious problems currently facing Santander increases with the education level (respectively 1.67 and 3.42). Finally, one can note that neither the number of people in the household nor the distance of the house from the beach has a link with the answers. In the same order of idea, the level of income does not influence on the perception of the future impacts of climate change in Santander or on the four intergenerational or contribution questions.

5.2. Estimation Results.

The majority of the attributes are statistically significant in all versions. Results suggest that people value positively improvements in biodiversity and recreational opportunities in all the considered time frames. However, differences in preferences between the different time frames are evident for the health attribute that seems to only be significant in the short run. This may be due to the fact that reducing the risk is not perceived realistic for the long-run. As expected, price has a negative sign in all versions. In the five years version it seems that improving biodiversity to medium is valued most followed by high biodiversity and recreation. In the thirty years version people value more the high biodiversity followed by recreation. Finally, in the sixty years version high biodiversity is considered more important followed by medium biodiversity.

Table 5 summarizes the results of the econometric analysis for each time frame.

Table 5: Results of the econometric analysis for each time frame.

Attribute	60 years version	30 years version	5 years version
Biodiversity medium	0.899*** 0.274	0.995*** 0.202	1.260*** 0.217
Biodiversity high	1.608*** 0.244	1.776*** 0.26	1.037*** 0.211
Health risk	0.021 0.0315	0.011 0.026	-0.114*** 0.029
Recreation	0.788*** 0.231	1.241*** 0.251	0.613*** 0.165
Price	-0.021*** 0.003	-0.048*** 0.005	-0.060*** 0.007

Based on the above estimations the marginal WTP for each attribute in each version is calculated as:

$$WTP = \frac{\beta_{attribute}}{\beta_{price}}$$

Table 6 displays the results of the WTP estimation for the three versions of our study. Standard errors are proposed in parenthesis. They are calculated using the Krinsky-Robb method.

Table 6: WTP Estimation

Attribute	60 years version	30 years version	5 years version
Biodiversity medium	45.08 (16.95)	20.85 (4.71)	21.22 (4.38)
Biodiversity high	80.12 (18.15)	37.27 (6.43)	17.49 (3.97)
Health risk	1.12 (1.67)	0.24 (0.54)	-1.93 (0.55)
Recreation high	40.10 (14.90)	26.24 (5.64)	10.45 (2.84)

Estimated WTP for all attributes are statistically significant with the exception of the health attribute that is only statistically significant in the five years version. The negative sign on the health attribute shows that people are actually willing to accept to suffer health risks in the Bay of Santander from the presence of jelly fishes.

It should be noted that the above values correspond to year estimates of the WTP. To allow for comparisons the present value of the amounts is calculated assuming a 3% discount rate (table 7).

Table 7: Present values of the WTP estimates (r = 3%)

Attribute	60 years version	30 years version	5 years version
Biodiversity medium	1245.4	408.7	97.2
Biodiversity high	2214	730.5	80.1
Health risk	0	0	-8.84
Recreation high	1107	514.3	47.9

From the above table it is evident that the present value for biodiversity and recreation increase with time horizons. People therefore seem to acknowledge and positively value long run benefits from biodiversity and recreation. For biodiversity this could be an indication of the existence of a non-use value component relating to the possibility of inheriting biodiversity for the benefit of the future generations. This is highly stated in the non-market valuation literature (Bateman et al., 2002). Recreation seems to also have an option value for future use besides its current value. Hence, our results suggest that people understand and the long-run nature of the effects of climate change as well as the long-run nature of the mitigation strategies to hedge against climate related risks. Their WTP is responsive which suggests that people hold values for insurance schemes to hedge against these risks.

Zero WTP values to hedge against long-run health risks associated with jellyfish outbreaks may again be an indication that people do not perceive the health risk as realistic. Evidence from focus groups and pretesting of the survey also provided evidence that for a part of the Santander citizens' health risks in the Bay of Santander do not constitute a real threat.

6. Conclusions.

In this paper we employ a CE to value the effects of climate change on the coastal ecosystem of the Santander Bay, Spain. We follow a split-sample approach and elicit the value people place on improvements in biodiversity and recreational opportunities and decreases in the health risks associated with the presence of alien jelly species in the short, medium and long run. Results suggest that people value positively benefits in terms of increased biodiversity and recreation opportunities in all the considered time frames. On the other hand people do not seem to be willing to pay to hedge against health risks relating to the presence of alien jelly fishes in the long-run. We speculate that this results from the fact that people do not perceive health risks as realistic which should be taken into consideration in the design of efficient insurance schemes.

The present value of the monetized benefits is also elicited under the assumption of 3% for the discount rate. Results suggest that the present value of future biodiversity and recreation related benefits increases with the time frame. Therefore results under this study provide evidence of the presence of a strong non-use component in the total economic value of biodiversity and recreation. This could relate to the presence of bequest values and/or option values associated with the possibility of deriving benefits in the future.

Our results provide useful insights for the design of optimal (economically efficient, socially acceptable and environmentally sound) risk insurance schemes to hedge against extreme natural hazards in the Bay of Santander. They suggest that people can understand the long-run nature of climate change related hazards and are willing to pay to prevent those risks for their benefit but also the benefit of the future generations. Moreover, the monetary estimations under this exercise could inform the appraisal of a long-run cost-benefit analysis to investigate whether different planned mitigation measures are economically efficient. Finally, our results suggest that there is a great heterogeneity of preferences with respect to the attributes of a mitigation strategy which in turn suggest that any insurance scheme should take this heterogeneity into account if socially equitable and thus acceptable schemes are to be adopted.

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