Consequentiality and Validity in Estimating Willingness to Pay

for Coastal Erosion Management

by

DREW WARREN

(Under the Direction of Craig Landry)

ABSTRACT

Stated preference survey data from North Carolina households is used to estimate willingness to pay for different types of coastal erosion management programs. Hypothetical bias is a known obstacle in performing valid contingent valuation studies. The incentive compatibility of the survey response depends on the respondent believing that their response will have real consequences that they are invested in financially and emotionally. Debriefing statements presented at the end of the survey are incorporated into micro-economic models of willingness to pay to test for consequentiality and validity. We find that respondents who do not believe that their response will affect policy decisions or that the state government can accomplish the goals of the management programs have a significantly lower willingness to pay. The results have important implications for improved survey design as well as opportunities for improving the messaging of local, state, and federal entities.

INDEX WORDS: Contingent Valuation, Validity, Consequentiality, Beach Erosion Management, Survey Design, Nonmarket Valuation

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CHAPTER 1

Background

Sandy beaches are dynamic, evolving ecosystems comprising two thirds of the world's ice-free coastline and providing a variety of ecosystem services (McLachlan and Brown, 2006). Beaches are subject to coastal change which encompasses a broad set of impacts including coastal erosion, shoreline change, extreme storms, and sea level rise. Coastal erosion resulting from the sea moving inland narrows the widths of beaches, disturbs ecological communities, and threatens to damage vast amounts of public and private property near human development. The United States suffers approximately $500 million dollars per year in coastal property loss and the federal government spends an average of $150 million dollars on shoreline erosion management programs (Climate Program Office, NOAA, 2021). The global effects of sea level rise and coastal erosion disproportionately impact the Southeastern United States and places such as Nags Head, North Carolina have already engaged in shoreline retreat (Landry and Whitehead, 2017). Intense storm events can remove the widths of beaches and dunes in a short period of time, and shoreline communities are having to carry out beach erosion management projects with increased frequency and with less support from the federal government.

As of 2014, approximately 40% of the U.S. population lives in coastal counties that are densely populated as coastal areas account for less than 10% of the total land within the contiguous United States (National Ocean Service, NOAA, 2014). Recurring intense hurricanes and floods in recent years have expanded public awareness on the negative impacts of coastal change and the necessity to prepare and adapt to extreme weather. Increased awareness and

importance given to the environmental and financial threats of coastal change drives innovative policies and management strategies to meet these challenges accordingly.

Beach nourishment (the addition of sand to extend beach width) can be a workable management strategy to protect against erosion and property damage. This is a type of "green infrastructure" that provides nature-based protection from severe storms without needing to build structures that interfere with coastal processes (U.S. Climate Resilience Toolkit, NOAA, 2021). North Carolina has already engaged in nourishment efforts along its coast for decades, with the first episode occurring in 1939 in Wrightsville Beach (Usher, 2021). Negative impacts on various species living in and near the sand has led to criticism of nourishment. Despite visually appearing to be an ecologically friendly management strategy, beach nourishment generally causes a short-term local extinction of flora and fauna as the fresh deposit of sand disrupts breathing, feeding, nesting, and other activities of invertebrates, fish, turtles, and other marine organisms (Speybroeck, 2006). There can be additional problems related to environmental and coastal processes if there is a mismatch in the sediment characteristics between the deposited nourishment sand and the original eroded beach sand and acquiring the correct type of sand has become expensive over the past century (Speybroeck, 2006).

The federal government provides most of the funding and the Army Corps of Engineers oversees management for nourishment projects. This past year, however, Onslow County, North Carolina decided to opt out of a nourishment project in coordination with Surf City due to concerns of environmental uncertainty as well as sharing the cost of the $1 billion project planned over a fifty-year period (Mcgrath, 2021). Nourishment remains the most prevalent method of mitigating beach erosion and is the most ecologically sound coastal defense alternative despite becoming financially unsustainable (Speybroeck, 2006).

Shoreline armoring (the construction of preventative barriers and structures) is another alternative that can hold back the sea and sediment and prevent the need for engaging in coastal retreat. The construction of seawalls, levees, jetties, and other structures has the advantage of creating a delineated barrier, but this strategy has come under increased scrutiny as an optimal solution. This is because preventative barriers obstruct coastal processes like natural water currents and the shifting of sand and this obstruction can exacerbate erosion and property damage in areas further down the coastline (U.S. Climate Resilience Toolkit, NOAA, 2021).

There are high fixed costs associated with installation, maintenance, and mitigating increased erosion that occurs adjacent to the barriers. North Carolina has engaged in shoreline armoring projects since the 1980s (despite pushback from the environmental community) until 2003 when the North Carolina General Assembly voted to ban hard structures being built on beaches (North Carolina Coastal Federation, 2021). There have been exceptions made under this ban including the prescription of several terminal groins (preventative barriers placed perpendicular to the coastline that are smaller than jetties) that have been approved in the last decade and further exceptions are expected to be made in the future.

Coastal retreat, the relocation of buildings and infrastructure away from eroding shorelines, is another option implemented preemptively or as a last resort to protect structures from coastal change. These measures are becoming more necessary in some regions that experience constant damages from storms that are increasing in frequency and severity. The removal of structures from the coast can benefit the public by dedicating the land to be open to the public or to become a protected area, providing lasting benefits such as creating habitat for wildlife, buffering homes and businesses against storms, and supporting recreation, tourism, and other amenities (U.S. Climate Resilience Toolkit, NOAA, 2021). Nourishment and armoring are

referred to as active management, whereas coastal retreat is a form of *passive* management as it involves adapting to the evolving coastline rather than hindering its evolution (Landry et al., 2020). Local communities and beachfront homeowners must make the unfortunate tradeoff between the costs of relocating buildings and the costs associated with damaged property.

There is less substantial information regarding the public's support for any strategy and how they might value one option over another. A 2018 survey of Virginia and North Carolina surfers who have intimate knowledge of their respective beaches found that they had neutral to somewhat negative opinions of beach nourishment projects taking place along their states' coasts (Usher, 2021). Negative opinions may arise due to different perceptions on the severity of coastal change, the extent to which government entities at local, state, and federal levels can achieve effective management, and how much of the project should be funded locally.

This paper uses primary survey data from North Carolina households providing information on use and non-use of coastal beaches, perceptions of coastal processes and changes, stated preference referendum votes for programs to manage coastal erosion, and post-valuation debriefing statements designed to test for consequentiality and validity (Landry et al., 2017). The debriefing statements are particularly valuable because estimating benefits using surveys is less straightforward if respondents do not believe their response will impact public policy or if they believe their government is incapable of achieving the goals of the coastal erosion management policy. This paper seeks to examine determinants of perceived consequentiality as well as perceived trust in government and the extent to which these determinants impact people's willingness to pay for different beach erosion management strategies including beach nourishment, shoreline armoring with nourishment, and coastal retreat and adaptation.

CHAPTER 2

Literature Review

Much of the literature on economic valuation related to beach resources and management deals with aspects related to geomorphic and atmospheric dynamics and how these conditions impact management strategies. Landry (2008) analyzes the scheduling of beach nourishment to identify optimal rotation times for restoring desired quantities of sand. McNamara et al. (2015) examines the effects of coastal storms, erosion rates, and federal replenishment subsidies on optimal beach rotation and the resulting changes in property values. Huang et al. (2007) examines the economic costs of wildlife being impacted by beach nourishment, which is valuable since there is less empirical work covering the external effects of beach management strategies on the surrounding environment. They find that failing to consider the negative impacts of erosion control programs can significantly exaggerate the benefits of these programs. The lack of empirical work on the external effects of erosion control projects may be a contributing factor in people's confidence in the ability of government agencies to put in place sustainable and effective management strategies.

Estimating the total benefits of non-market goods and services like erosion management projects that prevent future environmental damages can be less straightforward compared to estimating the costs of these projects. Landry et al. (2003) combined hedonic property methods with stated preference methods to determine the benefits of beach preservation and management projects, finding that wider beaches are favorable and that changes in property values are dependent on the rate of shoreline erosion and how local management costs change over time.

They also find that shoreline armoring is less favorable generally and that shoreline retreat is a less favorable strategy for people who live near the beach but more neutral for people who are visiting far from the beach. Landry et al. (2011) used hedonic property models to estimate the value of beach quality defined by beach and dune width, finding that beach quality does influence property values (limited by proximity to the shoreline) and they suggest that beach quality is a local public good by providing recreational potential (valued more by people living farther away from the beach) and protection of beachfront property (valued more by people living in close proximity to the beach).

Whitehead et al. (2008) used recreational demand models combining revealed and stated preference techniques for trip demand in North Carolina, estimating a consumer surplus of $90 per trip for North Carolina beaches which increases by $7 for wider beaches. Pendleton et al. (2012) uses a random utility approach to find that increased beach width is increasingly valuable to a certain extent, but the values of increasing width vary for different types of beach users engaging in different activities, and that the marginal value of beach width depends on the initial beach width. Landry et al. (2020) combines revealed and stated preference data from North Carolina households and finds significant welfare gains from shoreline retreat (median WTP of $22.20 per household per year), moderate support for beach nourishment (median WTP of $7.91), and significantly weaker values for shoreline armoring (median WTP of $0.09).

Stated preference methods using survey data can assist policy makers by directly gauging households' perceptions of coastal erosion and how much they would hypothetically value preventative measures like nourishment or armoring. Contingent valuation has developed as an increasingly refined technique in estimating the value of public goods and externalities using surveys (Mitchell and Carson 1989). The most prevalent theoretical difficulty with contingent

valuation is the presence of hypothetical bias which is the deviation between a survey respondent's hypothetical estimate and the estimate given by a respondent during a trial using real money or the result given by an incentive compatible revealed preference method (Carson et al., 2014). Studies have shown that on average the hypothetical willingness to pay estimate is greater than the willingness to pay estimate with real money, although there is debate as to what factors contribute to this deviation (Loomis, 2011). In the context of this study, respondents having negative opinions regarding governmental capability in managing coastal erosion could be one factor contributing to hypothetical bias that should be considered by coastal managers.

Eliciting a hypothetical willingness to pay value that is closer to the value of a treatment using real money requires that the agent's response has a nonzero probability of influencing an outcome that the respondent considers to be important (Carson and Groves, 2007). This type of "consequential" treatment would require that people filling out the survey be informed in some way that their answers will influence policy or other decisions that affect public welfare. The inclusion of consequential binary referendum questions was introduced to construct a hypothetical market or voting simulation that is incentive compatible (i.e., truth revealing) and has become the standard in contingent valuation (Carson and Groves 2007). Landry and Whitehead (2017) attempted to address hypothetical bias in their survey design by presenting a standard referendum question format and then presenting follow-up questions that allow for uncertainty by requiring the respondent to indicate their self-assessed certainty in their response to the follow up question. This is done because the hypothetical referendum only indicates whether a respondent values a policy above or below the specified dollar amount but there is little information elicited on actual willingness to pay (Landry and Whitehead, 2017).

Incentive compatibility is contingent on respondents thinking that their response could influence decision making and that they care about the outcome of the decision. This requires that the survey is constructed in a way that the respondent's dominant strategy is to reveal their preferences truthfully (Carson et al., 2014). These conditions must be met to confidently apply economic theory in stated preference methods. However, as stated before, respondents might agree that their survey response answers will impact management decisions but if they have negative opinions regarding government capability, they still may exhibit hypothetical bias (i.e., stating a willingness to pay measure that is lower than the respondent's true willingness to pay valuing the erosion management project).

(Czajkowski et al. (2017) outlines the two major empirical challenges of addressing incentive compatibility as being the reality that respondents' stated beliefs might not be line with the real choice they would make in the given scenario as well as the challenge of attempting to make respondents believe in real consequences following from giving a survey response. They find surveys including consequentiality scripts emphasizing the role of surveys in formulating policy lead to meaningful increases in elicited willingness to pay. Groothuis et al. (2017) finds that respondents have a higher willingness to pay if they perceive the survey to be consequential. The main objective of this paper is to analyze public support and willingness to pay for coastal erosion management and analyze to what extent agreeing or disagreeing with statements that capture consequentiality affect willingness to pay for management programs.

CHAPTER 3

Survey

In fall of 2013, a survey was conducted with North Carolina households to assess a proposed governmental program that would manage erosion on all North Carolina beaches by implementing different management strategies including beach renourishment, shoreline armoring, a combination of renourishment and armoring, and shoreline retreat (Landry and Whitehead 2017). This is an internet survey collected through a contract with *Online Sampling Solutions, Inc* that garnered a 61% response rate. This study is concerned with recreation demand and existence value of beaches and beach visitors are over sampled in the design. Households that do not visit the beach are included as well, but because of the oversampling of beach visitors it is less likely that the sample is representative of the general population of North Carolina. The survey population has a disproportionately higher income but overall compares favorably with population data from the U.S. Census (Landry et al., 2020).

Table 1 – Descriptive statistics

Variable	Observations	Mean	Std. dev.	Min	Max
Income	863	91.318	54.728	10	275
Household size	1,005	2.318	1.082	1	10
Male (y/n)	1,005	0.425	0.495	0	1
Children (y/n)	1,005	0.339	0.790	0	1
Environmental organization (y/n)	1,005	0.073	0.259	0	1
Erosion is a problem (y/n)	1,005	0.808	0.394	0	1
Support the proposed plan (y/n)	1,005	0.266	0.442	0	1
At least high school education	1,005	0.687	0.464	0	1
Beach house owner (y/n)	1,005	0.053	0.224	0	1

The survey begins by presenting a short introduction to describe the resource management problem being studied:

"Beaches provide for storm protection and coastal recreation. Wind, waves, currents, storms, and changing sea levels have contributed to the erosion of coastal beaches. About 75% of North Carolina beaches have eroded an average of 2.7 feet per year in the past 20 years. Between 1% and 2% of the North Carolina coastline has no dry sand at high tide."

Subjects are first questioned on their knowledge of coastal change including rising sea levels and frequency and severity of hurricanes. Next, subjects are asked about their attitudes towards local, state, and federal governments' management of coastal beach erosion, with respect to both the monetary resources and the technical assistance and oversight of government entities. Information is then collected on the respondents' frequency and type (day versus overnight) of trips taken to the North Carolina coast in the past and expected trips in the future. Those who reported at least one trip to the coast in the past 24 months are assigned as beach users. Data was collected in late fall after the peak summer season when the most trips are taken.

After acclimating the respondent to the objectives of the study and obtaining information on beach use and environmental perceptions, the contingent valuation section begins by presenting brief summaries of the management options including nourishment (replenishment), armoring, retreat, and status quo (no action) as well as the potential negative impacts of these options which are shown in Appendix A. Respondents are asked how strongly they would favor or oppose each of these approaches. Next, respondents answer various questions concerning the importance of beach width, the protection of coastal development, and the ways in which management programs would be financed.

The survey randomly assigns one of three management options to the respondent who must indicate yes, no, or undecided regarding their willingness to support the management plan at a randomly assigned price. One third of the sample was assigned to either beach nourishment, shoreline armoring with beach nourishment, or shoreline retreat and adaptation and the respondent must decide between their assigned management option or the status quo of no management program being implemented. The beach width (50-foot increase versus 150-foot increase) and environmental effects related to erosion management (minimal impacts versus negative impacts associated with the management strategy) are also randomized amongst respondents and pictures are displayed that show the assigned beach width (Landry et al., 2020).

The willingness to pay section of the survey follows the structure of a "close ended" contingent valuation survey where respondents are asked if they would hypothetically accept or reject a predetermined amount as payment for the use and existence of the resource (Cameron and James, 1987). The payment vehicle is framed in the survey as an increase of 2 cents per $100 value in annual beach property taxes in addition to an increase in state income taxes where the bid amount is randomly assigned as either $4, $28, $49, $81, or $114 per household per year. There is additional text purposefully designed to enhance incentive compatibility shown in Appendix B.

Following the contingent valuation questions there are five post-valuation debriefing statements shown in Appendix C. 70% of respondents agreed that a statewide referendum is a good way to express preferences about coastal erosion policy. 67% of respondents agreed that their responses will be shared with North Carolina policy makers. 55% agreed that their responses could affect environmental policy decisions. 78% of respondents indicated that they understood all the information presented. 27% of respondents indicated they are confident in the

ability of the state government to successfully carry out the goals of the erosion management program. Statements A, B, and E stated below are of most importance in estimating validity and consequentiality effects, as responses to these statements may hinder eliciting incentive compatible responses.

B) I believe the results of this survey will be shared with North Carolina coastal policy makers

C) I believe the results of this survey could affect decisions about coastal beach erosion policy in North Carolina

E) I have confidence in the ability of North Carolina state government to achieve the goals of the coastal beach erosion policy

Table 2 – Debriefing statistics

Debriefing statement	Observations	Mean	Std. dev.	Min	Max
Support referendum	1,005	0.702	0.457	0	1
Results will be shared	1,005	0.674	0.469	0	1
Results will affect policy	1,005	0.546	0.498	0	1
Understand information	1,005	0.780	0.414	0	1
Confidence in state gov	1,005	0.274	0.446	0	1

The survey concludes by asking demographic questions including the respondent's gender, number of children, education, household income, environmental organization membership, beach home ownership, political affiliation, and ethnicity.

CHAPTER 4

Methods

Stated preference survey data is used to estimate willingness to pay for beach erosion management programs and test to what extent agreeing or disagreeing with the debriefing statements affects willingness to pay. We begin with a simple probit regression where the dependent variable is the probability of voting for the proposed management plan and paying the increased annual tax amount P(for) presented in the hypothetical scenario found in Appendix C. Acceptance of the bid by the respondent indicates they are indifferent between voting for or against the policy at this level (Landry and Whitehead 2017).

The baseline model is performed first to ensure that coefficients for the parameter estimates in the model are in line with expectations before estimating willingness to pay values. Dummy variable parameters for the debriefing statements are added to the original baseline model and this new probit regression is used to estimate willingness to pay values. The third debriefing statement on whether the respondent believes their decision will impact policy and the fifth debriefing statement pertaining to the respondent's confidence in the North Carolina state government's ability to carry out the erosion management policy successfully are most crucial in determining to what extent consequentiality impacts willingness to pay. We hypothesize that respondents who do not believe their response will impact policy and do not have faith in the state government (i.e., responding disagree or strongly disagree to these debriefing statements) would be less willing to accept the proposal and have a lower overall estimated willingness to pay value.

Table 3 – Baseline probit regression

Y=Acceptance of proposal	Parameter Estimate	Std. err.	P>|z|	95%	C.I.
Tax	-0.008	0.001	0.000	-0.010	-0.005
Income	0.001	0.001	0.142	-0.000	0.003
Coastal retreat treatment	0.191	0.115	0.097	-0.034	0.416
Shoreline armoring treatment	-0.078	0.117	0.504	-0.308	0.152
Given beach width is 250 feet	0.006	0.094	0.947	-0.178	0.190
Beach house owner (y/n)	-0.013	0.208	0.950	-0.420	0.394
Environmental Impact treatment	-0.515	0.095	0.000	-0.701	-0.329
Male (y/n)	0.174	0.096	0.070	-0.010	0.363
Children (y/n)	0.096	0.057	0.091	-0.015	0.207
At least high school education	0.171	0.107	0.109	-0.038	0.381
Erosion is a problem (y/n)	0.702	0.134	0.000	0.439	0.966
Support the proposed plan (y/n)	0.798	0.105	0.000	0.592	1.004
Intercept	-0.917	0.198	0.000	-1.306	-0.529

Observations: 863 Pseudo R^2: 0.1547 Log likelihood = -476.329

After performing the baseline probit models, we use the delta method to calculate the confidence intervals. The models have less than 1,000 observations from dropping those who did not prefer to state their household income level. To estimate the impacts of debriefing statement responses on willingness to pay, two separate probit models are estimated for each debriefing statement, resulting in ten total models augmenting the baseline model. Observations are isolated to either agree and strongly agree or disagree and strongly disagree with each of the five respective debriefing statements. The delta method for calculating willingness to pay and confidence intervals is used for each augmented model. Five separate probit models are also estimated to examine the determinants of perceived consequentiality and if the consequentiality statements are correlated with one another. The ten augmented willingness to pay models are repeated three more times isolating the observations for each of the three erosion management policies (beach nourishment, shoreline armoring with nourishment, coastal retreat and adaptation).

Table 4 – Probit regression with debriefing dummy variables

Y=Acceptance of proposal	Parameter Estimate	Std. err.	P>|z|	95%	C.I.
Tax	-0.009	0.001	0.000	-0.012	-0.006
Income	0.002	0.001	0.134	-0.000	0.003
Coastal retreat treatment	0.335	0.133	0.012	-0.073	0.596
Shoreline armoring treatment	-0.172	0.133	0.196	-0.433	0.089
Given beach width is 250 feet	0.009	0.107	0.931	-0.220	0.201
Beach house owner (y/n)	0.867	0.278	0.002	-0.323	1.411
Environmental Impact treatment	-0.641	0.108	0.000	-0.854	-0.429
Male (y/n)	0.104	0.110	0.344	-0.112	0.321
Children (y/n)	0.082	0.063	0.196	-0.042	0.206
At least high school education	0.189	0.124	0.127	-0.054	0.433
Erosion is a problem (y/n)	0.711	0.151	0.000	0.415	1.008
Support referendum	0.254	0.130	0.051	0.002	0.510
Results will be shared	-0.021	0.139	0.878	-0.294	0.251
Results will affect policy	0.175	0.132	0.185	-0.083	0.432
Understand information	0.151	0.162	0.359	-0.166	0.468
Confidence in state gov	0.712	0.134	0.000	0.450	0.974
Intercept	-0.886	0.264	0.001	-1.383	-0.348

Observations: 662 Pseudo R^2: 0.1898 Log likelihood: -370.6727

Table 5 – Marginal effects after probit regression

Variable	dy/dx	Std. error	P<|z|	Mean
Tax	-0.004	0.0006	0.000	60.124
Income	0.0006	0.0004	0.134	93.29
Coastal retreat treatment	0.133	0.052	0.012	0.335
Shoreline armoring treatment	-0.068	0.052	0.193	0.352
Given beach width is 250 feet	-0.004	0.043	0.931	0.493
Beach house owner (y/n)	0.323	0.087	0.000	0.053
Environmental Impact treatment	-0.250	0.041	0.000	0.497
Male (y/n)	0.041	0.043	0.343	0.467
At least high school education	0.075	0.049	0.124	0.707
Children (y/n)	0.032	0.025	0.196	0.356
Erosion is a problem (y/n)	0.264	0.050	0.000	0.818
Support referendum	0.100	0.050	0.048	0.736
Results will be shared	-0.008	0.055	0.878	0.719
Results will affect policy	0.069	0.051	0.183	0.560
Understand information	0.060	0.063	0.345	0.860
Confidence in state gov	0.278	0.050	0.000	0.282

CHAPTER 5

Results

Baseline parameter estimates that do not incorporate debriefing statements are presented in Table 3 and parameter estimates including the debriefing statements are presented in Table 4. The results are consistent with and without the inclusion of debriefing statements showing negative results for tax coefficient and positive results for the income coefficient. Results for all five debriefing statement coefficients besides question B are positive indicating a relationship between increased probability of acceptance of the bid with increased agreeableness to the debriefing statements other than B, although question E is the only debriefing statement that is statistically significant.

The baseline WTP measures and debriefing adjusted WTP measures are presented in Table 6. We find a baseline WTP estimate of $44 using the simple probit regression and $43 with the Delta Method estimate. Running separate models using observations of either agree and strongly agree or disagree and strongly disagree for all five statements causes significant differences in WTP measures, especially for those that were expected to impact validity. WTP is $59 for respondents who agree that the survey will be shared with North Carolina policy makers and $23 for those who disagree. WTP is $75 for respondents who agree that the results could affect policy decisions regarding erosion management and a negative mean willingness to pay that is insignificantly different from zero. Respondents having confidence in the state government's ability to implement effective erosion policy state a significantly higher WTP of $113 whereas those who disagree have a WTP of $18, less than half of the baseline estimate.

Table 6 – Willingness to pay measures accounting for debriefing statement responses

Debriefing statement response	WTP ($)	Lower Bound	Upper Bound
Baseline willingness to pay	42.821	37.564	48.077
Support referendum agree	60.942	61.742	64.563
Support referendum disagree	13.851	-24.788	38.665
Results will be shared agree	58.488	60.153	60.614
Results will be shared disagree	22.702	-1.026	39.396
Results will affect policy agree	74.782	68.095	81.469
Results will affect policy disagree	1.121	-34.791	33.082
Understand information agree	51.085	49.451	55.724
Understand information disagree	34.569	25.870	47.888
Confidence in state gov agree	112.804	89.117	129.960
Confidence in state gov disagree	18.301	3.991	32.438

Table 7 – Determinants of supporting referendum

Y=Acceptance of proposal	Parameter Estimate	Std. err.	P>|z|	95%	C.I.
Income	0.001	0.0009	0.194	-0.000	0.003
Coastal retreat treatment	0.143	0.120	0.234	-0.092	0.380
Shoreline armoring treatment	0.128	0.120	0.286	-0.107	0.365
Given beach width is 250 feet	-0.053	0.097	0.590	-0.244	0.139
Beach house owner (y/n)	-0.633	0.220	0.004	-1.065	-0.201
Environmental Impact treatment	0.087	0.098	0.371	-0.104	-0.219
Male (y/n)	-0.073	0.110	0.344	-0.112	0.321
Children (y/n)	0.082	0.063	0.467	-0.270	0.124
At least high school education	-0.104	0.113	0.358	-0.324	0.117
Erosion is a problem (y/n)	0.300	0.123	0.015	0.059	0.541
Results will be shared	0.354	0.114	0.002	0.131	0.577
Results will affect policy	0.492	0.112	0.000	0.273	0.712
Understand information	0.535	0.121	0.000	0.297	0.773
Confidence in state gov	0.531	0.134	0.000	0.269	0.794
Intercept	-0.771	0.203	0.000	-1.170	-0.372

Observations: 863 Pseudo R^2: 0.1587 Log likelihood: -438.509

The five models estimating determinants of perceived consequentiality show that the consequentiality statements (labelled “Results will be shared”, “Results will affect policy”, and “Confidence in state gov”) are correlated with one another. Tables 8, 9, and 11 show significant positive relationships between agreeing with these three statements.

Table 7 shows that beach house owners are significantly less likely to be in favor of a statewide referendum for expressing preferences about erosion management policies whereas those who think erosion is a problem are more likely to be in favor of such a referendum. Tables 8 and 9 show that respondents with at least a high school education are more likely to think that their answers will be shared with North Carolina coastal policy makers but less likely to think that their answers will affect policy decisions. Those who believe erosion is a problem are more likely to think that their response has an impact on coastal beach erosion policy decisions. Male respondents and respondents with at least a high school education were significantly more likely to state that they understand all the information on the proposed erosion policy according to the results from Table 10. Table 11 shows that respondents who own beach homes and respondents who have children in their household are more likely to have confidence in the ability of the state government to achieve the goals of the erosion management policy whereas male respondents were significantly less likely to agree with this statement.

Table 8 – Determinants of thinking answers will be shared

Y=Acceptance of proposal	Parameter Estimate	Std. err.	P>|z|	95%	C.I.
Income	0.0006	0.001	0.539	-0.001	0.002
Coastal retreat treatment	-0.146	0.125	0.243	-0.391	0.099
Shoreline armoring treatment	-0.086	0.125	0.491	-0.332	0.160
Given beach width is 250 feet	0.094	0.101	0.352	-0.104	0.292
Beach house owner (y/n)	0.163	0.246	0.507	-0.645	1.319
Environmental Impact treatment	-0.029	0.100	0.770	-0.227	-0.168
Male (y/n)	0.161	0.103	0.122	-0.043	0.364
Children (y/n)	-0.017	0.063	0.783	-0.141	0.107
At least high school education	0.206	0.114	0.074	-0.120	0.429
Erosion is a problem (y/n)	0.103	0.130	0.427	-0.151	0.357
Support referendum	0.362	0.112	0.001	0.143	0.581
Results will affect policy	1.104	0.109	0.000	0.829	1.255
Understand information	0.420	0.126	0.001	0.173	0.666
Confidence in state gov	0.523	0.139	0.000	0.250	0.796
Intercept	-0.973	0.211	0.000	-1.385	-0.560

Observations: 863 Pseudo R^2: 0.2368 Log likelihood: -408.674

Table 9 – Determinants of thinking answers will affect policy

Y=Acceptance of proposal	Parameter Estimate	Std. err.	P>|z|	95%	C.I.
Income	0.0006	0.001	0.548	-0.001	0.002
Coastal retreat treatment	0.042	0.121	0.731	-0.196	0.280
Shoreline armoring treatment	0.134	0.121	0.268	-0.103	0.370
Given beach width is 250 feet	0.041	0.098	0.671	-0.150	0.233
Beach house owner (y/n)	0.325	0.241	0.178	-0.148	0.798
Environmental Impact treatment	-0.132	0.098	0.175	-0.324	-0.059
Male (y/n)	-0.086	0.101	0.395	-0.283	0.112
Children (y/n)	-0.020	0.061	0.751	-0.141	0.101
At least high school education	-0.270	0.113	0.017	-0.491	0.048
Erosion is a problem (y/n)	0.228	0.129	0.078	-0.026	0.481
Support referendum	0.517	0.112	0.000	0.297	0.736
Results will be shared	1.086	0.111	0.000	0.878	1.303
Understand information	0.570	0.133	0.000	0.408	0.887
Confidence in state gov	0.648	0.122	0.000	0.408	0.887
Intercept	-1.617	0.227	0.000	-2.063	-1.170

Observations: 863 Pseudo R^2: 0.2581 Log likelihood: -439.245

Table 10 – Determinants of understanding the survey

Y=Acceptance of proposal	Parameter Estimate	Std. err.	P>|z|	95%	C.I.
Income	0.0008	0.001	0.466	-0.001	0.003
Coastal retreat treatment	0.346	0.134	0.010	-0.609	0.085
Shoreline armoring treatment	-0.279	0.135	0.040	-0.545	0.013
Given beach width is 250 feet	0.074	0.106	0.482	-0.282	0.133
Beach house owner (y/n)	0.171	0.277	0.536	-0.371	0.713
Environmental Impact treatment	0.130	0.106	0.222	-0.077	-0.338
Male (y/n)	0.289	0.111	0.009	-0.072	0.506
Children (y/n)	0.014	0.067	0.832	-0.116	0.145
At least high school education	0.313	0.116	0.007	-0.084	0.540
Erosion is a problem (y/n)	0.071	0.133	0.596	-0.191	0.332
Support referendum	0.501	0.116	0.000	0.272	0.730
Results will be shared	0.394	0.123	0.001	0.153	0.634
Results will affect policy	0.492	0.126	0.000	0.246	0.737
Confidence in state gov	0.244	0.146	0.095	-0.042	0.530
Intercept	-0.288	0.206	0.162	-0.692	0.116

Observations: 863 Pseudo R^2: 0.1644 Log likelihood: -363.620

Table 11 – Determinants of trust in state government

Y=Acceptance of proposal	Parameter Estimate	Std. err.	P>|z|	95%	C.I.
Income	-0.003	0.001	0.005	-0.005	-0.001
Coastal retreat treatment	-0.180	0.124	0.146	-0.422	0.063
Shoreline armoring treatment	-0.260	0.124	0.035	-0.502	0.018
Given beach width is 250 feet	0.020	0.101	0.841	-0.218	0.177
Beach house owner (y/n)	0.563	0.222	0.011	0.128	0.998
Environmental Impact treatment	-0.031	0.101	0.755	-0.229	0.166
Male (y/n)	-0.315	0.105	0.003	-0.521	-0.109
Children (y/n)	0.168	0.062	0.007	-0.046	0.290
At least high school education	-0.144	0.112	0.198	-0.364	0.075
Erosion is a problem (y/n)	0.180	0.142	0.205	-0.099	0.459
Support referendum	0.501	0.134	0.000	0.238	0.764
Results will be shared	0.509	0.138	0.000	-0.237	0.780
Results will affect policy	0.659	0.121	0.000	-0.423	0.896
Understand information	0.151	0.152	0.142	-0.075	0.521
Intercept	-1.600	0.247	0.000	-2.085	-1.115

Observations: 863 Pseudo R^2: 0.1749 Log likelihood: -412.799

Table 12 – Willingness to pay measures (beach nourishment)

Debriefing statement response	WTP ($)	Lower Bound	Upper Bound
Baseline willingness to pay	34.569	16.718	52.421
Support referendum agree	57.841	55.883	59.798
Support referendum disagree	-27.803	-195.050	145.443
Results will be shared agree	53.840	45.746	61.333
Results will be shared disagree	18.864	-16.888	54.617
Results will affect policy agree	122.809	32.966	212.651
Results will affect policy disagree	-68.968	-255.489	117.553
Understand information agree	56.176	51.592	60.761
Understand information disagree	34.164	1.090	67.239
Confidence in state gov agree	144.240	71.730	216.751
Confidence in state gov disagree	-1.784	-44.476	40.907

The baseline WTP on average is lower for respondents who were assigned either nourishment or armoring policy options (see Tables 12 and 13) and higher for those who were assigned the coastal retreat policy option (see Table 14). Overall, these models follow a similar pattern of high WTP for agree responses and lower WTP for disagree responses.

Table 13 – Willingness to pay measures (shoreline armoring)

Debriefing statement response	WTP ($)	Lower Bound	Upper Bound
Baseline willingness to pay	30.955	18.825	43.084
Support referendum agree	37.811	24.774	50.848
Support referendum disagree	28.393	4.944	51.841
Results will be shared agree	30.014	13.512	46.516
Results will be shared disagree	28.651	8.678	48.623
Results will affect policy agree	78.109	67.783	88.434
Results will affect policy disagree	27.026	6.443	47.609
Understand information agree	26.293	9.730	42.856
Understand information disagree	51.858	45.209	58.507
Confidence in state gov agree	78.996	68.298	89.694
Confidence in state gov disagree	64.795	62.114	67.477

Table 14 – Willingness to pay measures (coastal retreat)

Debriefing statement response	WTP ($)	Lower Bound	Upper Bound
Baseline willingness to pay	72.295	65.210	79.380
Support referendum agree	100.438	73.755	127.121
Support referendum disagree	-49.743	-348.198	248.711
Results will be shared agree	7.229	-34.217	48.675
Results will be shared disagree	4.828	-65.050	74.705
Results will affect policy agree	101.108	72.081	130.134
Results will affect policy disagree	41.083	15.588	66.577
Understand information agree	93.736	71.262	116.210
Understand information disagree	31.280	-16.399	78.960
Confidence in state gov agree	108.571	68.445	148.697
Confidence in state gov disagree	60.064	58.105	62.024

Table 13 shows that none of the mean WTP estimates for observations assigned shoreline armoring are zero, even though this sample has the lowest baseline estimate. The “support referendum disagree” WTP is insignificantly different from zero for the baseline, nourishment, and coastal retreat samples. The “results will be shared disagree” WTP is insignificantly different from zero for the baseline estimate and the “results will affect policy disagree” WTP is insignificantly different from zero for the baseline and nourishment model.

CHAPTER 6

Discussion

We expect that a nonzero percentage of respondents disagree with each debriefing statement, and indeed the final debriefing statement shows a disagree response rate of 73%. We also expect that respondents may have limited knowledge about environmental resources and the WTP measure elicited will be based on incomplete information (Blomquist and Whitehead, 1998). However, significant disparity in WTP measures between those who agree or disagree with certain statements may allude to obstacles related to validity and consequentiality.

For example, the hypothetical scenario gauging acceptance of the management plan, presented in Appendix B, explicitly states to the reader that the results of the study will be shared with North Carolina coastal policy makers. However, 23% of respondents disagreed with this statement when answering debriefing statement B which was only a few questions later. This could indicate disbelief by the respondent or that they did not fully understand all the information even if they agreed that they understood all the information in the debriefing section.

Disagreeing with statement B implies a belief that answers given in the survey will not have real consequences which could impact WTP validity. Survey validity can be improved if disclaimers regarding which governmental departments or research groups will be using the survey data are presented to the respondent at the beginning of the survey and then restated before gauging acceptance.

It is possible that respondents who disagree with debriefing statements B, C, and E are violating incentive compatibility. If the respondent disagrees with statement C, this implies that

they do not believe their responses regarding the hypothetical scenario presented could make real life impacts on coastal erosion policy decisions and the WTP estimate incorporating their response may be less valid. If the respondent disagrees with statement E, this implies that they do not think government entities can achieve the goals of the erosion management policy regardless of the tax amount. This means the respondent might not be indicating their true willingness to pay for the program and the results suggest that they could be willing to pay more if they believe their decision will impact beach erosion management programs implemented by a government entity that they believe would follow through with the proposed plan.

The high disagree response rate for statement E may be a result of increasing delays and uncertainties in coastal erosion management programs like beach nourishment in recent years. Respondents might also think that the federal government should take most of the responsibility in achieving the management objectives. Including more specific questions asking which governmental level should bear more responsibility in managing coastal erosion would give insight on who should be funding erosion management.

Overall, the 23%, 45%, and 73% disagree response rates for statements B, C, and E, respectively, could be impacting the validity and consequential nature of the final WTP measures. This can be addressed in the WTP estimations themselves by dropping observations in the survey dataset that are suspected of violating incentive compatibility before running the probit regression used to estimate WTP. Future surveys can provide more information for the respondent at the beginning on how much is currently being spent on beach erosion management and how much of the funding and oversight comes from local, state, and federal levels.

CHAPTER 7

Conclusion

Coastal communities face enormous management challenges in accommodating future development and growing populations while adapting to increasing rates of erosion, major storms, and sea level rise. Assessing the perceived values of households in coastal zones regarding environmental resources and the protection and maintenance of those resources is critical in developing management strategies that reflect the interests and wellbeing of the households in that area. Estimating micro-economic models of demand and willingness to pay for coastal erosion management programs that are valid and reliable for policy makers requires that the survey responses are incentive compatible.

We examine changes in willingness to pay for beach erosion management programs when incorporating debriefing statements that test for consequentiality and running separate models with observations that either agree or disagree with those statements. The results show evidence that respondents who do not believe their response will impact policy and do not have faith in the state government to carry out the management program successfully have a significantly lower willingness to pay. There are opportunities for improved survey formatting and preference elicitation design. In addition, governmental agencies can create platforms for improved messaging and publicity with respect to their coastal erosion management efforts as well as platforms that allow for increased public input on the implementation and financing of erosion management programs so that we may collectively formulate strategies that improve economic well-being, human livability, and environmental sustainability.

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Appendix A - Management options

Beach nourishment involves adding sand to the beach to increase beach width and build dunes. The beach will still erode over time so sand must be added about every 3 to 5 years to maintain width.

Beaches that have been nourished provide for greater storm protection for coastal communities and provide for recreational and leisure benefits for all visitors.

Potential negative environmental impacts from **beach nourishment** include**:**

- ● disruption of ocean-bottom habitats, which can affect turtles, fish communities, and small creatures like clams and crabs
- ● increased cloudiness and changes in sand movement in coastal water
- ● burial of beach organisms and alteration of sand texture on the beach, which can affect plants, turtle nesting, shorebird habitat, and small creatures like clams and crabs Most of these effects are short term, but can present *longer term problems if incompatible sand is mined from the wrong areas offshore*.
  Once completed, *beach nourishment can provide additional beach habitat for coastal animals and plants*, such as sea turtles, shorebirds, dune mice, dune plants, and small creatures like clams and crabs.

  Shoreline armoring uses concrete and rocks to protect coastal buildings, roads, and utilities. This process often erodes the beach and can increase erosion at other nearby beaches. **Beach nourishment** can be used to maintain beaches where this erosion occurs

  Potential negative environmental impacts from **beach nourishment** include**:**

● disruption of ocean-bottom habitats, which can effect turtles, fish communities, and small creatures like clams and crabs

- ● increased cloudiness and changes in sand movement in coastal waters
- ● burial of beach organisms and alteration of sand texture on the beach, which can affect plants, turtle nesting, shorebird habitat, and small creatures like clams and crabs Most of these effects are short term, but can present *longer term problems if incompatible sand is mined from the wrong areas offshore*.
  The negative impacts of shoreline armoring are more permanent and include:

  - disruption of continuous beach - loss of beach habitat.

Beaches would be wide, but could be interrupted by seawalls, rocks, and concrete. These negative impacts can be minimized through beach nourishment and careful project management.

Retreat and adaptation involves moving vulnerable buildings, roads and utilities out of harm's way to adapt to the changing shoreline. This approach allows the beach to evolve naturally. Shoreline retreat and adaptation would be paid for by a public program that provides funds to move buildings, roads, and infrastructure out of harm's way and to offer partial compensation to those that lose their land. Retreat would only be implemented when shoreline erosion gets severe enough to require adaptation. Some debris can be temporarily left on the beach during the retreat. Parts of the beach may be inaccessible at times as buildings and infrastructure are moved.

Potential negative environmental impacts of **shoreline retreat and adaptation:**

- ● Temporary disruption of continuous beach
- ● Temporary loss of beach habitat
- ● Temporary presence of debris on some parts of the beach

Most of these effects appear to be short term. There are no negative impacts after the debris is removed. Negative environmental impacts can be minimized through careful project management.

The **status quo** is no state program. Coastal communities would pursue limited amounts of beach nourishment with some shoreline armoring. Beach erosion would continue.

Overall coastal beach width would continue to decline, leading to loss of beach area for recreation and beach habitat.

Appendix B - Text in the survey designed to enhance incentive compatibility:

Imagine that you have the opportunity to vote on the proposed coastal erosion management plan, _____. If more than 50% of North Carolina households vote for the plan then it would be put into practice.

Sometimes when people are asked to evaluate a proposed policy like this one, it is easy for them to say they support a policy either because they are not being asked to pay at the same time, or they don't think they will have to pay based on their response.

We want you to only respond with what you actually think you would do given the beach impacts and the estimated cost to your household.

Also consider your personal income and current payment obligations. If you vote for the policy then you would have _____ less to spend on other things each year. If you pay property taxes on a beach house you would have even less to spend on other things each year.

There is no right or wrong answer but results from this study will be shared with North Carolina coastal policy makers.

The first blank was filled with their assigned policy scenario ('nourish', 'armor', or 'retreat'), and the second blank was filled with their randomly assigned bid ($4, $28, $49, $81, $114). Immediately following their polychotomous choice, they were asked to state their level of certainty in their response:

If you could vote today and you knew that property taxes on beach houses would go up and your household's state taxes would go up by _____ each year, would you vote for or against the _____ plan that targets maintaining beaches at _____ feet?

____ For

____ Against

____ Undecided

Appendix C - Post-valuation debriefing statements

Please Indicate your disagreement or agreement with the following statement.	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
A) A statewide referendum is a good way for citizens to express their preferences about coastal erosion policy to the North Carolina state government	1	2	3	4	5
B) I believe the results of this survey will be shared with North Carolina coastal policy makers	1	2	3	4	5
C) I believe the results of this survey could affect decisions about coastal beach erosion policy in North Carolina	1	2	3	4	5
D) I understand all of the information presented to me on the proposed coastal beach erosion policy	1	2	3	4	5
E) I have confidence in the ability of North Carolina state government to achieve the goals of the coastal beach erosion policy	1	2	3	4	5