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When a Good Is a Bad (or a Bad Is a Good)—Analysis of Data from an Ambiguous Nonmarket Valuation Setting

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Abstract: This paper analyses data from a contingent valuation experiment carried out in a context with large degree of preference heterogeneity and valuation ambiguity. Despite this challenge, by implementing estimation of an unrestricted valuation function on pooled data from two elicitation formats, utilizing all preference information available from the survey, we are able to estimate welfare measures with an acceptable degree of statistical confidence. It turns out that an offshore wind farm, a priori believed to constitute a *bad* that people would be willing to pay to avoid, instead was a *good* that people would be willing to forego under compensation. This was true *on average* but not for all study participants. Two key determinants of preferences were spatial proximity to the proposed wind farm and perceptions of the visual impacts of wind turbines. Individuals who would be near and thought wind turbines are "ugly" had a mean willingness to pay to avoid the wind farm of about $508 per household per year. In contrast, those who would be far away and perceived wind turbines to be "beautiful" had a negative mean willingness to pay to avoid the wind farm of about −$595 per household per year.

Keywords: contingent valuation; willingness to pay; renewable energy; wind power; households; preference heterogeneity

1. Introduction

A lingering issue facing researchers seeking to value various nonmarket goods has been the statistical estimation of welfare measures in the negative range [1]. While robust applications invariably yield positive central tendency estimates, it is not uncommon to find a non-trivial portion of the population predicted to have negative valuation of the good under study [1–6]. Typically, this is considered an artefact of model specification or the statistical method employed. However, as noted by Haab and McConnell [1]: "*For most public goods, negative willingness to pay is not correct because the good can simply be ignored if it does not provide utility to the respondent*" (p. 253). Subsequently, in cases where theory clearly leads to an a priori expectation that the consumers' valuation is non-negative, various remedies have been proposed. These remedies include restricting functional form for indirect utility or the valuation function, pre-/post-estimation truncation or spiking at zero and non-parametric approaches [1,2,7,8].

In contrast to the clear-cut case of unambiguous *goods* described above, this paper deals with an empirical context characterized by a large degree of preference heterogeneity, with the possibility of both positive valuation and negative valuation of the good in question, to wit, an offshore wind farm. Unfortunately, this complexity was not fully recognized prior to the study implementation. A combination of the project's media attention, review of the existing research on wind power acceptance at the time (much of which focused on the so-called "not-in-my-backyard" (NIMBY) phenomenon) and results from local focus groups led designers to conclude that the wind farm would constitute a *net nonmarket economic bad* [9]. As discussed in the literature review (Part 2), this assumption is consistent with several other wind power valuation studies (e.g., Groothuis et al. [10]) but certainly not all (e.g., Koundouri et al. [11]). As it turned out, about 47% of the participants supported the project, 24% were against it, while 29% were uncertain about their position. This resulted in a dataset with a large degree of preference heterogeneity and associated valuation ambiguity [9].

In order to deal with this ambiguity, we exploit what is typically considered a problem, namely, negative welfare predictions [1], to estimate an unrestricted valuation function for the offshore wind farm. Despite the fact that the contingent valuation design did not include negative bids, or otherwise accounted explicitly for the possibility of positive wind farm preferences, we are able to estimate both central tendencies and variations with an acceptable degree of statistical confidence. The estimation is facilitated by utilizing responses to an additional survey question, which asked the participants whether they were in favour of the project. By interpreting this question as a zero-bid referendum, we implement a double-bounded interval-data model specification [12]. Specifically, if a participant indicated to be against the project but said "no" to paying \$$X$ to avoid it, his/her latent valuation is interpreted to be in the $(0, X)$ interval. On the other hand, if the participant stated to be a proponent of the wind farm and rejected the valuation scenario, his/her latent valuation is interpreted to be in the $(-\infty, 0)$ range. Estimation efficiency is enhanced further by pooling data from two (split-sample) elicitation formats into a general welfare framework.

The most specific insights from the empirical analysis come from conditioning on the respondents' spatial proximity to the proposed wind farm and their perceptions of the visual impacts of wind turbines in general. As such, this paper contributes to the literature on consumers' preferences for renewable energy investments, and, specifically, the heterogeneity of preferences that exists in the context of wind power projects. It also illustrates the robustness of the contingent valuation approach under employment of a tailored full-information strategy to dealing with preference ambiguity.

The rest of this paper is organized as follows: Section 2 reviews various aspects of the relevant valuation literature, Section 3 discusses the application and data for this paper, Section 4 presents analytical framework (theory and statistical method), while Section 5 goes through the estimation results. Finally, Section 6 offers some reflections and concluding remarks.

2. Previous Research

There are many published articles related to consumers' preference for renewable energy investments and acceptance of renewable energy projects [13–15]. There is also an overlapping literature on preferences for climate policies [16]. Here we narrow the focus to valuation research pertaining to wind power.

Table 1 offers summary of a sample of relevant articles in terms of valuation methodology, what is being valued, preference and property rights assumptions and estimated welfare measure. As can be observed, most studies explored a single method; either stated choice experiments [17–24] or contingent valuation [10,11,25–29]. Exceptions are Alvarez-Farizo and Hanley [30] who compared both choice experiments and contingent ranking and Landry et al. [31] who analysed revealed preference data, choice experiments and contingent behaviour responses. Last in the list is Jensen et al. [32], a recent revealed preference study, which finds negative impacts of wind turbine proximity on housing prices in Denmark.

Table 1. Summary of Sampled Wind Energy Valuation Literature.

Study	Method Employed	What Is Being Valued	Preference Assumption	Property Right	Welfare Measure
Groothuis, Groothuis, Whitehead (Energy Policy, 2008) [10]	Contingent valuation	Construction of windmills	Negative preferences	Status quo	Willingness to Accept
Kondouri, Kontouris, Remoundou (Energy Policy, 2009) [11]	Contingent valuation	Construction of wind farm	Positive preferences	Status quo	Willingness to Pay
Ek, Persson (Ecological Economics, 2014) [17]	Choice experiment	Wind farms, multiple attributes	Positive/Negative preferences	Renewable energy development	Willingness to pay/willingness to accept
Navrud, Bråten (Revue économie politique, 2007) [18]	Choice experiment	Renewable energy, multiple sources	No assumption	Status quo (import of coal-generated electricity)	Willingness to pay
Ladenburg, Dubgaard (Energy Policy, 2007) [19]	Choice experiment	Visual dis- amenities associated with coastal windmills	Negative Preferences	Renewable energy development	Willingness to Pay
Bergmann, Colombo, Hanley (Ecological Economics, 2008) [20]	Choice experiment	Renewable energy, multiple attributes	Positive/Negative preferences	No assumption	Willingness to pay/ willingness to accept
Meyerhoff, Ohl, Hartje (Energy Policy, 2010) [21]	Choice experiment	Wind power, multiple attributes	Negative preferences	Renewable energy development	Willingness to pay
Krueger, Parsons, Firestone (Land Economics, 2011) [22]	Choice experiment	Visual Dis-amenities, offshore wind turbines	Negative preferences	Expansion of coal and natural gas power	Willingness to pay
Borchers, Duke, Parsons (Energy Policy, 2007) [23]	Choice experiment	Renewable energy from different sources	Positive preferences	Status quo	Willingness to pay
Dimitropoulos, Kontoleon (Energy Policy, 2009) [24]	Choice experiment	Wind farms, multiple attributes	Negative preferences	Status quo	Willingness to accept
Whitehead, Cherry (Resource and Energy Economics, 2007) [25]	Contingent valuation	Purchase of green energy	Positive preferences	Status Quo	Willingness to Pay
Nomura, Akai (Applied Energy, 2004) [26]	Contingent valuation	Green energy	Positive preferences	Status quo	Willingness to pay
Boulatoff, Boyer (Applied Economics Letters, 2010) [27]	Contingent valuation	Wind farm	Positive/Negative Preferences	Status quo	Willingness to pay/willingness to accept
Preez, Menzies, Hosking (Journal of Energy in Southern Africa, 2012) [28]	Contingent valuation	Wind farm	Negative preferences	Renewable energy development	Willingness to accept
McCartney (Journal of Agricultural Economics, 2006) [29]	Contingent valuation	Wind farm	Positive/Negative Preferences	Renewable energy development	Willingness to pay
Álvarez-Farizo, Hanley (Energy Policy, 2002) [30]	Choice experiment/ Contingent ranking	Wind farm, multiple attributes	Negative preferences	Renewable energy development	Willingness to pay
Landry, Allen, Cherry, Whitehead (Resource and Energy Economics, 2012) [31]	Travel cost method & stated behaviour method	Change in recreational values from offshore wind development	No assumption	Renewable energy development	Consumer surplus, compensating variation
Jensen, Panduro, Lundhede (Land Economics, 2014) [32]	Hedonic pricing	Noise & visual impacts of wind turbines	No assumption	Renewable energy development	Change in housing prices

In regard to what is being valued, some of the studies focused exclusively on wind power from a multi-attribute perspective (e.g., Ladenburg and Dubgaard [19]) or from a renewable investment project perspective (e.g., Koundouri et al. [11]). Others investigated general preferences for expansion of renewable energy capacity, with wind power being one of the sources (e.g., Navrud and Bråten [18];

Borcher et al. [23]). A more market commodity perspective is found in Whitehead and Cherry [25] and Nomura and Akai [26], two studies that look at household preference for purchasing *green* electricity for their homes.

When it comes to preference assumptions, it should first be pointed out that choice experiments permit attributes to be estimated with both positive and negative parameters. Nevertheless, several authors postulate a priori expectations with respect to expected parameter sign for specific attributes. For example, Meyerhoff et al. [21] describes height of wind turbines, proximity to residential areas and reduction in red kite population as negative externalities. Among existing contingent valuation studies, Koundouri et al. [11] assumes positive preferences for the construction of a wind farm, whereas Groothuis et al. [10] and Preez et al. [28] assume negative preferences for wind power installations. In the studies by Whitehead and Cherry [25] and Nomura and Akai [26] there is an underlying presumption of non-negative preferences for green electricity consumption. Thus, many researchers have approached the valuation exercise with particular assumptions regarding the nature of preferences for wind energy projects; however, across studies, these restrictions are often contradictory.

In regard to property right perspective and empirical welfare measure, the former typically implies the latter. Moreover, these features connect to preference assumption. For example, when the objective is to value environmental damage from which the individual has a right to be protected, the appropriate property right perspective is status quo (no damage). This yields willingness to accept (*WTA*) as the theoretically correct welfare measure. On the other hand, if the individual does not have the right to be protected against environmental damage, or more generally, if what is to be valued is a new public good, then willingness to pay (*WTP*) emerges as the appropriate welfare measure. Among the contingent valuation studies on wind power in Table 1, Koundouri et al. [11] assumes property right in status quo (no development) and elicited *WTP* for a local wind farm. Groothuis et al. [10] and Preez et al. [28] also assume property right in status quo. However, since these studies conceptualized the siting of local wind turbines as a nonmarket economic bad, *WTA* elicitation formats are employed. Interestingly, McCartney [29] and Boulatoff and Boyer [27] explore both positive and negative wind farm preferences by using screening questions and a more flexible survey design.

Finally, when it comes to choice experiments, it is generally considered appropriate to include a status quo option in the menu of choice alternatives [33]. An estimated positive parameter on an attribute implies the attribute is a "good" for which people have positive willingness to pay. In contrast, a negative parameter implies a "bad" with associated negative *WTP*. The latter is theoretically equivalent to a positive *WTA*. Preference heterogeneity can thus be identified by estimating random coefficient models, which use flexible distributions that support probability mass in both positive and negative value-ranges (see, for example, Bergmann et al. [20]; Ek and Persson [17]).

3. The Empirical Application

3.1. Brief Background

The data analysed in this paper comes from a contingent valuation study associated with the so-called *Cape Wind* project planned for the Northeast coast of the United States [9]. Initially proposed as far back as 2001, this wind farm would be one of the largest offshore wind farms in the world. The expected production capacity was originally estimated at 170-megawatt hours on average (454 megawatt hours at peak output). It would consist of 130 wind turbines spread out in a grid pattern across 24 square miles of the Nantucket Sound off the coast of Cape Cod, state of Massachusetts [34,35]. The wind turbines closest to shore would be located 4.7 miles outside Point Gammon in South Yarmouth. Further, wind turbines would be located 6 miles from Cotuit on Cape Cod, 9.3 miles outside Oak Bluffs on Martha's Vineyard and 13.8 miles outside Nantucket. The tallest point of the turbine blades would rise 440 feet above sea level, estimated to stand half to one inch above the horizon from six-mile distance.

The project has been highly contested from the time that it was first proposed. A strong opposition argued that the wind farm is damaging to the unique local environment and natural beauty of the Nantucket Sound. In addition to the possibility of negative visual impacts, opponents argued that fish species and migratory birds could be negatively affected by the development. Proponents on the other hand, argued that the wind farm would increase energy security, create jobs, reduce greenhouse gas emissions from fossil-based electricity production, and, contrary to the opponents claim, actually generate visual amenities. These conflicting views on Cape Wind were the subject of the public opinion study by Firestone and Kempton [36].

3.2. The Contingent Valuation Survey

The contingent valuation study was implemented through a *mail-mode* survey in the Fall of 2005 [9]. The survey was developed and implemented in accordance with most recommendations in Dillman [37], Arrow et al. [38] and Mitchell and Carson [39].

The survey administration involved multiple contacts to enhance the response rate: (1) mail-out of initial notification letter with invitation to take part in a survey, (2) first survey booklet with accompanying cover letter, (3) a reminder postcard to non-respondents and (4) mailing of second booklet to non-respondents with letter encouraging them to participate. Furthermore, the first mailing included a $1 token, while both booklets were accompanied by a self-addressed return envelope with pre-paid postage. The cut-off date for returning the survey was 15 January 2006.

The selected households (N = 2000) were drawn from the database of *Survey Sampling International* (SSI). Only households paying utility bills were deemed eligible, while businesses and organizations were excluded. A local sub-sample (N = 1000) was drawn from the counties of Barnstable, Dukes and Nantucket (often referred to as "Cape Cod and the Islands region") due to their close proximity to the proposed development site. The other sub-sample represented the overall state of Massachusetts (N = 1000). The purposes of the dual sampling were to inform the relevant market size (i.e., the affected population) while assessing the magnitude of any NIMBY effect. Furthermore, the state legislature is in charge of state-wide renewable energy standards and Massachusetts is the closest state governance to the proposed development area.

The survey instrument was developed through a series of steps that included review of literature and news articles, personal communication with government officials and stakeholder organizations, focus groups and pre-testing of the instrument on representatives of the general public and environmental economists.

In regard to the focus groups, four interviews with 8–12 participants in each were conducted at an early stage of survey development. In the interviews, participants were asked a set of pre-set questions, with discussions permitted to flow to other ideas and opinions so long as they were related to wind energy projects. While the participants differed in their attitudes and opinions, the consensus seemed to be that the proposed wind farm would detract from the area's natural beauty. Many participants also expressed concerns over fish and bird impacts, others over small plane and boating routes, among other things.

The final survey booklet was structured as follows: It first presented neutral background information about the Cape Wind project. Then followed questions about knowledge and support of the project and about experience with and attitudes towards wind turbines. An equal number of arguments from opponents and proponents, presented side-by-side, followed next. The order of the two sets of arguments were randomized across different versions of the booklet. The specific arguments were identified in the focus groups and were subsequently carefully tested and revised in order to minimize the likelihood of an emotional response or survey rejection. Then came the contingent valuation experiment, which had two different experimental treatments. One treatment, or scenario, involved payment to avoid the wind farm (*willingness to pay*, *WTP*), whereas the other scenario involved compensation for allowing its construction (*willingness to accept*, *WTA*). These two versions represent opposite property right structures with regard to environmental protection versus economic development [8,40]. In both scenarios, the valuation question was cast in single-bounded dichotomous-choice format, with change in the household's electricity bill being the payment vehicle.

A public ballot referendum was used to frame the question in the following way: Experts expect the cost of electricity will go up as the population in the area increases. Building the wind turbines could affect the price of your electricity bill. Suppose that everyone [on Cape Cod and the Islands/in Massachusetts] were asked to vote in the next public ballot. How would you vote on the following question?

Specifically, the *WTP* question regarding payment to avoid the wind farm was as follows: If the wind turbines are not built, electricity prices are likely to go up. Would you be willing to have your household's electricity bill go up by [$BID] per year so that the wind turbines would not be built? ___YES___NO. Similarly, the *WTA* question regarding payment for permitting the wind farm to be built was phrased as: If your household electricity bill would go down by [$BID] per year, would you be in favour of having the wind turbines built? ___YES___NO.

Randomized bid amounts were drawn from the $1 to $350 range, with each booklet version containing exactly one bid amount associated with either a *WTP* or *WTA* scenario. The bid range was developed from focus group feedback and pre-test results, with some adjustments made to ensure the credibility of the suggested utility bill changes.

The valuation question was proceeded by a response certainty question and questions probing reasons for either accepting or rejecting the bid. Finally, the survey booklet included standard questions eliciting socioeconomic and demographic information on the participants.

After accounting for non-deliverables, the overall response rate of the survey was approximately 50%. The usable data for the analysis in this paper includes 898 respondents (492 from the local sample and 406 from the state sample). A summary of the bid responses is given in Table 2. Descriptive statistics for key variables, including those employed in the econometric estimations, are provided in Table 3. Further details are provided in Steltzer [9]. Copies of the booklets and complete descriptive statistics from the survey can be obtained from the authors upon request.

Table 2. Summary of Bid Responses.

Bid Amounts	N_{WTP}	%YES *WTP*	N_{WTA}	%YES *WTA*
$1	36	47%	42	62%
2	46	35%	46	52%
5	42	38%	47	38%
10	46	35%	44	43%
25	46	46%	47	66%
50	51	25%	46	52%
75	45	18%	41	66%
100	44	30%	35	80%
200	44	23%	44	80%
$350	56	21%	50	78%
All Bids	456	31%	442	61%

Note: N = Number of observations. The correlation between bid amount and percentage "yes" to *WTP* question is −0.64, while the correlation between bid amount and percentage "yes" to *WTA* question is 0.70.

4. Analytical Framework

4.1. Theoretical Welfare Measures

As discussed above, the population's preferences regarding the Cape Wind project were elicited through a split-sample *WTP*/*WTA* design. Underlying both treatments was an assumption that the project would constitute a *net* economic bad in terms of its environmental impact. In the *WTP* format, implied property rights are in the new state, such that the population would have to pay to avoid the negative externalities associated with development. The relevant welfare measure is thus formally an *equivalent surplus* (ES) [41], which represents the maximum amount of money that an individual is willing to pay to avoid the negative impact. From optimization of the primal, i.e., maximization of utility subject to a budget constraint, the *ES* can be expressed implicitly in terms of a corresponding indirect utility function:

$$V(P, M - ES, q_0) = V(P, M, q_1) = V_1 \quad (1)$$

where P is a price vector for private goods, M is exogenous income, q_0 refers to status quo environmental quality and q_1 refers to the environmental quality if development takes place. The term V_1 indicates that the new state (i.e., after project implementation) constitutes the baseline utility level. For those people who indeed perceive Cape Wind to be a "bad", we have that $q_1 < q_0$ and $ES > 0$. However, for those who perceive Cape Wind to be a "good" the opposite is true: $q_1 > q_0$ and $ES < 0$. In this case, *ES* will be a negative *WTP*, which can be interpreted as a minimum *WTA* to forgo implementation of the project.

In the *WTA* format, property rights are implied to be in status quo, i.e., the population has the right to be compensated for any negative impact caused by the development. The relevant welfare measure is thus a *compensating surplus* (*CS*), which gives the minimum amount of compensation the individual is willing to accept to let the development take place [41]. The implicit indirect utility function representation of *CS* is:

$$V(P, M, q_0) = V(P, M + CS, q_1) = V_0 \quad (2)$$

where the term V_0 indicates that the initial utility level is the baseline. Similar to the above, opponents who perceive the project as a "bad" are captured by $q_1 < q_0$ and $CS > 0$. In contrast, for proponents: $q_1 > q_0$ and $CS < 0$, with the implied negative *WTA* being equivalent to positive *WTP* to have the wind farm built.

4.2. WTP-WTA Data Pooling

The empirical strategy in this paper is to estimate an unrestricted valuation function permitting both positive and negative values. We follow the direct estimation approach proposed by Cameron [42] (See Hanemann and Kanninen [7] and Haab and McConnell [43] for textbook treatments of various ways to handle dichotomous-choice (single-bounded and double-bounded) contingent valuation data). Let *HS* denote Hicksian surplus (*ES* or *CS*), then the general empirical model for latent valuation is given by:

$$HS_i = X_i\beta + \varepsilon_i \quad (3)$$

where X is a vector of measurable factors postulated to affect individual i's valuation, including income effects, status quo bias and other influences that might cause divergence between *WTP* to avoid the wind farm versus *WTA* compensation for permitting it to be built. Relating this valuation function to bid responses, the probability of a *yes* in the *WTP* scenario is equal to the probability that the latent valuation is greater than or equal to the price in the form of a bid amount (T):

$$\Pr(yes\ WTP) = \mathrm{Prob}(HS_i \geq T_i). \quad (4)$$

Similarly, the probability of a *yes* in the *WTA* scenario is equal to the probability that latent valuation is less than or equal to the offered compensation (the bid amount):

$$\Pr(yes\ WTA) = \mathrm{Prob}(HS_i \leq T_i). \quad (5)$$

Furthermore, from (5), the probability of *no* is one less the probability of *yes*, which can be expressed as:

$$\Pr(no\ WTA) = 1 - \mathrm{Prob}(HS_i \leq T_i) = \mathrm{Prob}(HS_i > T_i). \quad (6)$$

Under the restriction of non-divergence between *WTP* and *WTA*, baseline equivalence between Equations (4) and (6) is thereby established, which forms the basis for pooling data from the two scenarios. Practically speaking, this involves coding *yes*-response data in the *WTP* scenario and *no*-response data in the *WTA* scenario with the value 1, while *WTP no*-responses and *WTA yes*-responses is coded with a zero value. Statistical discrimination between *WTP* and *WTA* is allowed by including an indicator variable for elicitation format in the *X*-vector. We explore parsimonious specifications of $X_i\beta$ using the variables summarized in Table 3, with the most complete specification being:

$$HS_i = \beta_0 + \beta_1 DUMNEUTRAL_i + \beta_2 DUMBEAUTY_i + \beta_3 HHINC_i + \beta_4 AGE_i + \beta_5 EDU_i + \beta_6 DUMWTP_i + \varepsilon_i \quad (7)$$

Table 3. Key Summary Statistics (N = 898).

Variable	Description	Mean	St. Dev.	Min	Max
DUMUGLY	0–1 Indicator of wind turbines perceived as "ugly" (yes = 1)	0.22	0.42	0	1
DUMNEUTRAL	0–1 Indicator of wind turbines perceived as neither "ugly" nor "beautiful" (yes = 1)	0.47	0.50	0	1
DUM BEAUTY	0–1 Indicator of wind turbines perceived as "beautiful" (yes = 1)	0.31	0.46	0	1
HHINC	Household annual gross income (USD)	81,071.24	47,464.65	7500	175,000
AGE	Respondent Age (years)	56.60	14.68	16	95
EDU	Years of Schooling	15.21	2.74	4	20
DUMWTP	0–1 Indicator for *WTP* versus *WTA* scenario (*WTP* = 1)	0.51	0.50	0	1
DUMSTATE	0–1 Indicator for state (versus local) sub-sample (state = 1)	0.45	0.50	0	1
DUMINFAVOR	0–1 Indicator for "in favour" of project (in favour = 1)	0.47	0.50	0	1

4.3. Improve Statistical Efficiency with Additional Preference Information

The survey design did not include the idea of negative valuation of avoiding the wind farm, in other words, the possibility that people instead have a positive *WTP* to build it. Moreover, the contingent valuation question itself does not provide information regarding whether a respondent falls into this category. For example, a *no*-response on question regarding willingness to pay, say $10, simply gives the information that the respondent's latent *WTP* is less than $10. Nevertheless, by recognizing the potential for negative valuation, the probability of such response can be characterized as: $pr(-\infty < WTP < \$10)$. Without non-negativity bounds placed on Equations (3) and (7), negative welfare estimates are indeed possible. Hence, by exploiting what is usually considered a problem (e.g., as discussed in Haab and McConnell [43]), it becomes possible to utilize the data from this imperfectly designed contingent valuation survey.

In order to enhance statistical precision further, we combine into the analysis responses to a pre-valuation preference question, which elicited whether or not the respondent supported the proposed wind farm project or not. The exact phrasing of the question was as follows: *Based on what you know, are you in favour of building wind turbines in Nantucket Sound? __YES__NO__ Not Sure.* While there are various ways to utilize the preference information embedded in this question, we interpret it here as equivalent to a *zero-bid* referendum question. As pointed out by an anonymous referee, this is a non-trivial assumption. Nevertheless, we believe this assumption is reasonable since there was no mentioning of costs to individuals or society in the context of the question. Moreover, in an earlier version of the paper, we estimated regression models without using the responses to this question. These regressions yielded welfare estimates of similar magnitude as those reported in this paper but with much less statistical precision, i.e., higher standard errors. As can be seen by the descriptive statistics for the variable DUMINFAVOR in Table 3, about 47% of the respondents reported to favour the project, while 24% were opposed to the project Opposition was 9% in the state and 37% in the local sub-sample, respectively. It was also permissible for the respondents to indicate uncertainty ("not sure") on this question, which was the case for 29% of the sample.

This zero-bid interpretation helps to identify narrower intervals for the latent valuation. In the *WTP* version, the following intervals are identified:

(i) *In favour* (and *no* to payment amount): $(-\infty < WTP < 0)$
(ii) *Not in favour* together with *no* to payment amount implies $(0 < WTP < T)$,
(iii) *Not in favour* together with *yes* to payment amount implies $(T \leq WTP < \infty)$.
(iv) Similarly, in the *WTA* version:
(v) *In favour* (and *yes* to compensation amount) implies $(-\infty < WTA < 0)$,
(vi) *Not in favour* together with *no* to compensation amount implies $(T < WTA < \infty)$,
(vii) *Not in favour* together with *yes* to compensation amount implies $(0 < WTA \leq T)$.

For the respondents who indicated they were uncertain regarding whether or not they were in favour of the Cape Wind Project, a *no*-response to the *WTP* question suggests: $(-\infty < WTP < T)$, whereas *yes* implies: $(T \leq WTP < \infty)$. Analogously, *yes* to the *WTA* question can be interpreted as: $(-\infty < WTA \leq T)$, while *no* suggests: $(T < WTA < \infty)$.

Under the common assumption that $\varepsilon_i \sim N(0, \sigma^2)$, this leads to a special case of the doubled-bounded interval-data model [12,43], with the *zero* bid playing the role as a *lower bid* (T_L), either first or second bid, in a two-bid sequence. For those in favour of the project such that $(-\infty < HS \leq 0)$, where *HS* is either *WTP* or *WTA*, *zero* is equivalent to a second (lower) bid in a sequence of two contingent valuation questions yielding no-response to both amounts. It can be shown that the probability of *no-no* (*NN*) is equal to:

$$\Pr(NN) = \Phi\left(\frac{T_2 - X\beta}{\sigma}\right) \tag{8}$$

where $T_2 = T_L = 0$. This Probability (8) also captures the uncertain respondents who said either "no" to the *WTP* amount or "yes" to the *WTA* amount. In this case, $T_2 = T$, not zero. Similarly, for those against the project but with valuation less than the bid amount, such that $(0 < HS < T)$, *zero* can be interpreted as first (lower) bid in a two-bid sequence resulting in a *yes-no* (*YN*) response pattern. The probability of *yes-no* can be expresses as:

$$\Pr(YN) = \Phi\left(\frac{T_2 - X\beta}{\sigma}\right) - \Phi\left(\frac{T_1 - X\beta}{\sigma}\right) \tag{9}$$

where $T_1 = T_L = 0$ and $T_2 = T_H$ (that is, T, the bid amount presented on the survey). Finally, the cases above wherein the latent valuation is given by $(T < HS < \infty)$ can be interpreted as a two-bid sequence resulting in *yes-yes* (*YY*). This probability can be written as:

$$\Pr(YY) = \Phi\left(\frac{X\beta - T_2}{\sigma}\right) \tag{10}$$

The log-likelihood function for the interval-data model, which is maximized to obtain parameters (β, σ), is given by:

$$\sum_i D_i^{NN} \ln \Pr_i(NN) + D_i^{YN} \ln \Pr_i(YN) + D_i^{NY} \ln \Pr_i(NY) + D_i^{YY} \ln \Pr_i(YY) \tag{11}$$

where, $(D_i^{NN}, D_i^{YN}, D_i^{NY}, D_i^{YY})$ represent indicator variables capturing the relevant case for the individual.

Interestingly, our application lacks respondents in the *no-yes* (*NY*) classification. In principle, this could be project proponents who would reject the zero-payment but would accept a sufficiently high *negative* follow-up bid: $T_2 < 0$, that is, compensation for foregoing the project. Missing observations in this response category is a direct result of the study design. Nevertheless, as demonstrated next, our data still contain sufficient information for the estimation of welfare measures with acceptable degree of statistical confidence.

5. Econometric Estimation

5.1. Basic Results

Table 4 provides maximum likelihood estimates and Hicksian Surplus (*HS*) statistics. Maximum likelihood estimations were executed in *Stata* 13.1 using the *doubleb* module. Confidence intervals for *HS* are computed by the delta method using Stata's *nlcom* (non-linear combinations of estimators) command. Estimations were performed for the full sample, the Massachusetts ("State") sub-sample and the Cape Cod and Islands ("Local") sub-sample, respectively, under four different specifications. Model 1 is an intercept-only specification, model 2 adds perceptions of the visual impact of wind turbines, model 3 adds demographics, whereas model 4 includes both these sets of covariates. Results for specifications using the *DUMWTP* variable in Equation (7) are presented in Section 5.3 below.

First observe that estimated mean *HS* is negative across all specifications using full sample data. Based on model 4, the mean welfare measure for the full sample is −\$134 per household per year with 95% confidence interval from −\$201 as lower bound to −\$66 as upper bound. This suggests that the "average" respondent has a negative *WTP* to avoid the wind farm (or a negative *WTA* for allowing it), consistent with the proportions observed in the zero-bid referendum question. Conceptually, this is equivalent to a positive *WTA* for not implementing the project (or a positive *WTP* for implementing it). In other words, Cape Wind is on average valued as a "good," not a "bad," among the survey respondents.

This finding runs counter to the a priori expectations underlying study design, which was based on the presumption that the nonmarket impacts of the offshore wind farm would in net be considered a "bad". Furthermore, this finding is even more pronounced for the state sub-sample, with mean *HS* estimated at −\$317 per household per year (based on model 4). As regards to the local sub-sample, however, the estimations are not able to statistically establish whether mean *HS* is different from zero. Taken together, the different results for the two sub-samples strongly suggest the presence of NIMBY effects in the context of the proposed Cape Wind project.

When it comes to the explanatory variables in the estimated valuation function, the visual perception variables (*DUMNEUTRAL* and *DUMBEAUTY*) have statistically significant negative coefficients in all specifications. Moreover, the *DUMNEUTRAL* coefficient is smaller in absolute magnitude than the *DUMBEAUTY* coefficient. Since the baseline constitutes those who perceive wind turbines to be visually displeasing (*DUMUGLY* = 1), these results are as expected: A more positive perception of the aesthetic impacts of wind turbines is associated with a lower *WTP* to avoid them, or, in this case, rather, a higher *WTP* to obtain them. As regards the demographic variables, only *HHINC* shows sign of statistical significance. The estimated coefficients are positive, suggesting that *HS* is increasing in income. Note, however, that *HHINC* is not significant in the local sub-sample models.

Table 4. HS Function Estimation Results - Pooled *WTP-WTA* Double-Bounded Interval-Data Model.

	MODEL 1: INTERCEPT ONLY						**MODEL 2: VISUAL PERCEPTIONS**					
	Full Sample		**State Sub-Sample**		**Local Sub-Sample**		**Full Sample**		**State Sub-Sample**		**Local Sub-Sample**	
VARIABLE	**Est.**	**Sig.**	**Est.**	**Sig.**	**Est.**	**Sig.**	**Est.**	**Sig.**	**Est.**	**Sig.**	**Est.**	**Sig.**
INTERCEPT	−166.033	0.000	−373.980	0.002	24.670	0.460	443.090	0.000	224.055	0.022	511.329	0.000
DUMNEUTRAL							−643.145	0.000	−615.124	0.002	−568.617	0.000
DUMBEAUTY							−896.722	0.000	−819.013	0.001	−838.172	0.000
HHINC												
AGE												
EDU												
Sigma	610.616	0.000	531.380	0.000	594.696	0.000	465.454	0.000	489.878	0.000	427.744	0.000
Number of obs.	898		406		492		898		406		492	
Wald Stat.							39.42		10.94		28.70	
Prob > Chi2							0.0000		0.0042		0.0000	
Mean *HS* [95% CI]	−$166.03	[−249,−83]	−$373.91	[−613,−135]	$24.67	[−41,90]	−$134.19	[−202,−66]	−$316.28	[−522,−110]	−$12.89	[−68,43]
	MODEL 3: DEMOGRAPHICS						MODEL 4: FULL SPECIFICATION					
	Full Sample		**State Sub-Sample**		**Local Sub-Sample**		**Full Sample**		**State Sub-Sample**		**Local Sub-Sample**	
VARIABLE	**Est.**	**Sig.**	**Est.**	**Sig.**	**Est.**	**Sig.**	**Est.**	**Sig.**	**Est.**	**Sig.**	**Est.**	**Sig.**
INTERCEPT	−322.413	0.104	−525.840	0.097	344.702	0.169	381.258	0.023	228.325	0.418	668.787	0.003
DUMNEUTRAL							−634.277	0.000	−608.455	0.002	−557.761	0.000
DUMBEAUTY							−888.518	0.000	−813.631	0.001	−825.998	0.000
HHINC	0.002	0.005	0.001	0.175	0.002	0.031	0.001	0.069	0.000	0.710	0.001	0.083
AGE	1.587	0.382	0.075	0.977	−1.680	0.478	−0.116	0.938	−0.345	0.892	−2.451	0.202
EDU	−5.709	0.582	2.589	0.858	−23.614	0.100	−0.925	0.915	−1.133	0.936	−7.054	0.524
Sigma	607.726	0.000	534.427	0.000	579.864	0.000	463.479	0.000	489.900	0.000	419.001	0.000
Number of obs.	898		406		492		898		406		492	
Wald Stat.	8.29		2.41		6.23		39.57		10.94		28.59	
Prob > Chi2	0.0405		0.4918		0.1008		0.0000		0.0527		0.0000	
Mean *HS* [95% CI]	−$166.78	[−250,−83]	−$374.29	[−615,−134]	$29.75	[−35,95]	−$133.65	[−201,−66]	−$316.94	[−523,−111]	−$7.27	[−62,48]

5.2. Conditioning on Visual Perceptions

As observed above, the variables capturing attitudes towards whether wind turbines in general provide aesthetic amenities or dis-amenities are important determinants of valuation. Table 5 explores this further by computing *HS* conditional on visual perceptions using the maximum likelihood results from Model 4. As can be seen, this adds further precision to predicted welfare measures.

Table 5. Simulated Hicksian Surplus by Sub-Sample & Visual Perceptions.

Full Sample	**N**	**Mean**	**St. Err.**	**95% CI**	
HS ALL	898	−$133.655	34.493	−$201	−$66
HS-UGLY	200	$436.933	72.090	$296	$578
HS-NEUTRAL	424	−$197.345	47.036	−$290	−$105
HS-BEAUTY	274	−$451.585	83.781	−$616	−$287
State Sample	**N**	**Mean**	**St. Err.**	**95% CI**	
HS ALL	406	−$316.943	105.316	−$523	−$111
HS-UGLY	55	$218.602	98.404	$26	$411
HS-NEUTRAL	206	−$389.852	129.609	−$644	−$136
HS-BEAUTY	145	−$595.029	186.819	−$961	−$229
Local Sample	**N**	**Mean**	**St. Err.**	**95% CI**	
HS ALL	492	−$7.271	27.984	−$62	$48
HS-UGLY	145	$508.112	93.132	$326	$691
HS-NEUTRAL	218	−$49.649	40.023	−$128	$29
HS-BEAUTY	129	−$317.886	79.982	−$475	−$161

Note: Welfare measures are computed by the delta-method based on Model 4. Welfare estimates are reported in 2005 dollars. The multiplier for converting estimates to 2017 dollars is 1.25 Source: http://www.usinflationcalculator.com/inflation/consumer-price-index-and-annual-percent-changes-from-1913-to-2008/.

Focusing on the 95% confidence intervals for the full sample, we now observe that people who perceive wind turbines as ugly (*UGLY*, N = 200, 22%) have a statistically positive mean *HS* (between $296 and $578). People who are neutral with respect to the visual aesthetics (*NEUTRAL*, N = 424, 47%) have a statistically negative *HS* (−$290 to −$105), while people who perceive them as beautiful (*BEAUTIFUL*, N = 274, 31%) have an even stronger negative mean *HS* (−$616 to −$287).

Again we observe clear differences between people living close to the proposed project versus those from the larger state area. However, it is noteworthy that when conditioning on visual perceptions, both local and state respondents who think wind turbines are ugly have positive *WTP* to avoid the wind farm (or positive *WTA* for allowing it). In the case of offshore wind farms, then, there appear to be potentially competing private and public use values (e.g., energy security versus viewsheds), correlated with proximity to the farm's location, that ultimately determine the desirability of the project.

5.3. Additional Robustness Checks

The above analysis was based on specifications without the *DUMWTP* variable from Equation (7). Here, we re-estimate all twelve models from Table 4 with this variable added to the specification. Table 6 summarizes the results in terms of its estimated coefficient and implied 95% confidence interval for the difference between *WTP* and *WTA*.

In all models, the *DUMWTP* coefficient is negative, suggesting that *WTA* is higher than *WTP*. This is generally consistent with much of the existing literature (see, Carson and Hanemann [8] for a discussion). However, the coefficient is only statistically significant—at least at the 10% level, in five cases. Moreover, looking at the 95% confidence intervals indicates statistical difference in only two cases, namely, model 2 and model 4 estimated for the full sample. This means that the pooled models with a single *HS* welfare estimate cannot be rejected in 10 out of 12 cases.

Table 6. *WTP* vs. *WTA* Results.

	DUM*WTP*		DIFF (*WTP*-*WTA*)	
Specification	**Est. Coeff.**	***p*-Value**	**Lower 95%**	**Upper 95%**
Model 1-Full	−99.289	0.068	−206	7
Model 1-State	−137.590	0.097	−300	25
Model 1-Local	−38.514	0.565	−170	93
Model 2-Full	−104.743	0.023	−195	−14
Model 2-State	−122.533	0.128	−280	35
Model 2-Local	−77.706	0.153	−184	29
Model 3-Full	−92.826	0.086	−199	13
Model 3-State	−135.921	0.104	−300	28
Model 3-Local	−27.272	0.677	−156	101
Model 4-Full	−100.038	0.029	−190	−10
Model 4-State	−121.921	0.129	−279	36
Model 4-Local	−68.971	0.197	−174	36

Note: Lower and upper bounds on difference between *WTP* and *WTP* are computed from standard errors on estimated coefficients on the variable DUM*WTP*.

6. Discussion and Concluding Remarks

This paper analysed data from a contingent valuation study designed under the assumption that a proposed offshore wind farm project would constitute a *net* economic bad. As it turns out, more of the study participants were in favour of the proposed project than against it. This resulted in negative average welfare estimates. A negative *WTP* can be interpreted as the equivalence of a positive *WTA* for *not* implementing the project. Similarly, a negative *WTA* can be interpreted as a positive *WTP* to build the wind farm.

The welfare estimates were found to depend on the population area, with the local sub-sample being less positive (more negative) towards the wind farm than the state sub-sample. This result is consistent with a NIMBY-effect. Perceptions related to the visual impact of wind turbines were also found to be important in both sub-samples. Participants who viewed wind turbines as *ugly* exhibited positive *WTP* to avoid the development project. At the extremes, individuals who would be near and thought wind turbines are *ugly* had a mean willingness to pay to avoid the wind farm of about $508 per household per year. In contrast, those who would be far away and perceived wind turbines as *beautiful* had a negative mean willingness to pay to avoid the wind farm of about −$595 per household per year. Our finding that wind turbine aesthetics affects people's acceptance and valuation of wind energy development projects is consistent with results found in the existing literature [10,20–22,24,28,31]. Our finding is consistent with Jensen et al. [32], which used the hedonic pricing method. This study finds that housing prices in Denmark are negatively affected by the visibility of and noise from wind turbines. An interesting recent study that lends further support to this result is Krekel and Zerrahn [44]. This study utilizes well-being data and finds a negative, albeit spatially restricted and temporally diminishing, effect in Germany. Knapp and Ladenburg [45] provide a recent review of the role of spatial relationships on people's preferences for wind power.

In regard to wind energy investments in general (both offshore and on land), an overall question remains as to whether they generate a *net positive nonmarket* impact or a *net negative nonmarket* impact [46]. On the one hand, wind power developments may contribute to reductions in greenhouse gas emissions, increased energy security, and, for some, be associated with aesthetically pleasing architectural constructions, all of which may generate positive nonmarket values. On the other hand, the trade-offs seem to be negative environmental impacts associated with road construction, power lines, impaired nature views and displacement of wildlife and recreation [47]. Our review of the existing valuation research on wind power does not provide a ubiquitous answer. Preference assumption, property right perspective, analytical approaches and the empirical findings vary a great deal. More research is clearly needed.

Finally and related to the above discussion, our contingent valuation study was carried out in a context with large degree of preference heterogeneity and valuation ambiguity. This complexity stands in contrast to previous nonmarket environmental valuation research in the areas of natural damage assessment and environmental policy management. In such settings, the tension is typically between economic development on one side and protection against negative environmental impacts not captured by markets on the other. Hence, the methodological issue discussed in the introduction that "*. . . negative willingness to pay is not correct because the good can simply be ignored if it does not provide utility to the respondent*" [1] is clearly a valid one. In contrast, when one cannot freely ignore the valuation object in question, as in the case of long-lasting changes to natural environments associated with construction of wind turbines, then this assumption is not correct. With increased focus on global climate change threats, a new valuation frontier seems to lie in the nexus between natural protection and climate policies, which both involve benefit and cost aspects not reflected fully in the market place. In this nexus, preference heterogeneity and valuation ambiguity are inevitable and, subsequently, it will not always be possible to postulate that a good is a *good* or a bad is a *bad*. One possible response to this challenge would be to rely more on choice experiments. This multi-attribute approach permits estimation to inform whether specific attributes constitute a good or a bad and the extent to which preferences across different people include both positive and negative values [20]. However, such multi-attribute perspective is not always desirable, nor feasible. In assessing the overall social desirability of a new wind development project, the researcher may prefer to value the net impact of the project. This makes contingent valuation a more natural approach. Boulatoff et al. [27] and McCartney [29] are examples of studies that have attempted to implement designs that are more flexible. New complexities in modern valuation contexts necessitate further methodological adaptations. The bottom line is that the contingent valuation method continues to play an important role in bringing forth critical information otherwise not available to policymakers [48,49].

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