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Anabela Botelho

Lígia M. Costa Pinto

Patrícia Sousa

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Anabela Botelho

NIMA, University of Minho

Escola Economia e Gestao

Universidade do Minho, Gualtar

4710-057 Braga

Portugal

Phone: 351-253601930 Fax: 351-253601380

Email: botelho.anabela@gmail.com

Lígia M. Costa Pinto

(CORRESPONDING AUTHOR)

NIMA, University of Minho

Escola Economia e Gestao

Universidade do Minho, Gualtar

4710-057 Braga

Portugal

Email: ligiacpinto@gmail.com

Phone: 351-253601930 Fax: 351-253601380

Patrícia Sousa

NIMA, University of Minho

Escola Economia e Gestao

Universidade do Minho, Gualtar

4710-057 Braga

Portugal

Phone: 351-253601930 Fax: 351-253601380

Email: patriciacruzsousa@gmail.com

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Anabela Botelho, Lígia M. Costa Pinto, Patrícia Sousa*

Abstract

Wind energy is currently one the most important energy sources in the production of electricity. In this study, we use the CVM to elicit the monetary value attached to wind power's environmental impacts from three different groups of individuals: local residents, residents in a nearby town, and residents outside the area of a wind farm located in Portugal, one of the top 10 countries in the world with the highest cumulative wind power capacity to date. In each case, our empirical analysis employs a novel likelihood function that is constructed to be appropriate for the type of data collected. The main results are supportive of a NYMBY effect, but also indicate that the amount needed to compensate local residents for the negative impacts caused by the wind farm can be raised by the constitution of a compensation fund paid by non-residents, thereby overcoming the inefficiency caused by the NYMBY effect.

JEL: Q50, Q51, C29, Q40, Q58, Q53
Keywords: Contingent Valuation, uncertainty, renewable energy; Stochastic frontier models; Willingness to pay/accept; hypothetical bias

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[*]University of Minho and NIMA, Portugal. E-mail: botelho.anabela@gmail.com, ligiacpinto@gmail.com, patriciacruzsousa@gmail.com.

1. Introduction

Wind power is considered a “clean” energy source, environmentally friendly and sustainable when compared with other renewable energy sources (Saidur et al., 2011), and has presented the highest growth of the installed power level in the European Union (Sahin, 2004). Despite its well-known advantages, however, wind power is also associated with negative environmental impacts. The literature indicates that the most common environmental impacts of electricity production are related with the changes of the physical environment: visual impact, noise impact, impacts on fauna and flora (Álvarez-Farizo and Hanley, 2002; Menegaki, 2008; Bergmann et al 2006; Mendes et al 2002; Saidur et al. 2011). Given the growing importance that wind power has gained, a number of studies have resorted to the contingent valuation method (CVM) in order to compute the economic valuation of its environmental impacts. This method allows the measurement, in monetary values, of the impact on welfare resulting from a quantitative or qualitative change in environmental amenities by directly asking individuals about the maximum amount of income they are willing to pay (WTP) to avoid a decline in circumstances (or for an improvement in circumstances), or about the minimum amount of income they are willing to accept (WTA) for a decline in circumstances (or to forgo an improvement in circumstances). The CVM has the particularity of being applicable in project evaluations *ex-ante* and *ex-post*, so it can capture the use and non-use values of environmental goods and services (Pearce et al., 2006).

For example, Nomura and Akai (2004) asked a sample of individuals from the general Japanese population for their WTP for photovoltaic and wind energy sources, having found a WTP of $17 per month per household in the form of a flat monthly surcharge. On the other hand, Groothuis et al. (2008) asked residents in the Watauga County, North Carolina-USA, for their WTA a compensation for the potential construction of a wind farm in the county mountains, having found a yearly WTA of $23 per family. Turning to European countries, Koundouri et al. (2009) asked a sample of individuals from the Greek population residing in the Rhodes island for their WTP to build a wind farm in the southern part of the island, having found a mean WTP of €8.86 from the 70% of respondents who stated a positive WTP (30% of respondents stated a zero WTP). Hanley and Nevin (1999) asked a sample of local residents for their WTP and WTA for the development of a local wind farm (three turbines) in a remote community in North West Scotland, having found a mean WTP of £87 per year from the 78% of respondents who supported the development of the farm (the remaining respondents did not accept the construction of the wind farm, and out of these only one respondent would accept a compensation in the form of a minimum reduction of £140 per year in his annual electricity invoice). These studies illustrate that WTP/WTA values associated with wind power are highly case-specific, and maybe dependent upon the sampled population (local vs non-local).

However, while recognizing that the advantages of wind power are largely global in nature, and that the disadvantages are primarily local (e.g., land use, noise and visual pollution), these studies have not focused on the potentially different valuations attached to the environmental impacts of wind power by those living close to wind farms vis-à-vis the general population or those living at greater distances. This stands in contrast with theoretical work hypothesizing that the local negative environmental impacts of wind power lead to a “not-in-my-backyard” (NYMBY) effect which, in turn, leads to an inefficient allocation of resources that could be overcome if those who receive the benefits of wind power compensate those living on the site for bearing the external costs (O’Hare, 1977; Kunreuther et al., 1987). While NYMBY effects, and the concomitant calls for compensations in order to encourage the placement of a “locally undesirable land use”, are generally theoretically accepted, some authors have pointed out that wind farms may benefit the local population through the generation of income and employment in ways that outweigh the external costs borne locally (e.g., Hanley and Nevin, 1999). To date, however, no study has empirically evaluated the relative strength of these competing hypotheses with respect to wind power.

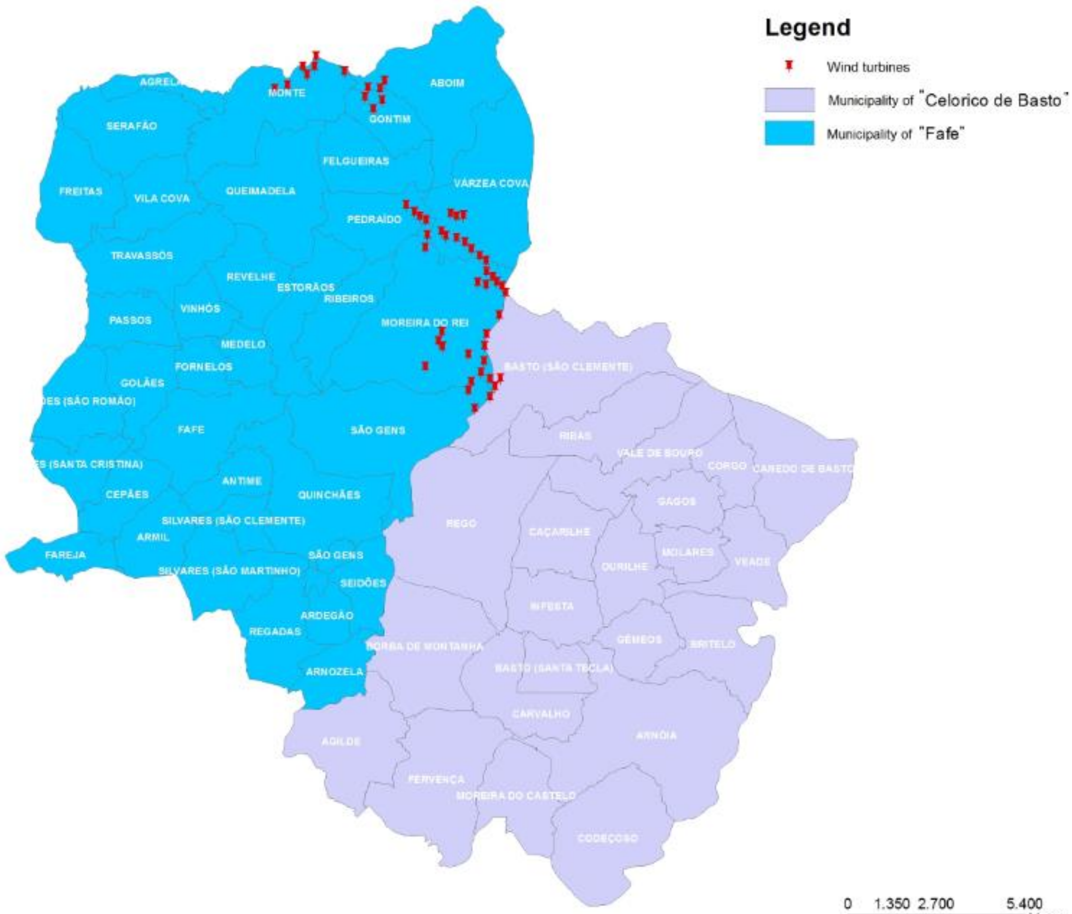
In the present study, we directly address this issue by eliciting the monetary value attached to wind power’s environmental impacts from three different groups of individuals: local residents, residents in a nearby town, and residents outside the area of the wind farm. The chosen study-site is the wind farm of *Terras Altas de Fafe* located in the north of Portugal. Due to its geographic and geomorphologic characteristics favouring the production of wind energy, along with high investment levels on this energy source, Portugal (a small European Union (EU) country with about 10 million inhabitants) is placed amongst the top 10 countries in the world with the highest cumulative wind power capacity at the end of 2012 (GWEC, 2013). In addition, while wind energy investments at the EU level are mostly offshore, all wind energy to date in Portugal is produced onshore (Azau, 2011). These features make of wind farms located in Portugal particularly well suited for an assessment of their environmental impacts since the general population has some degree of familiarity with this energy source.

2. Material and Methods

2.1. Description of the site

The wind farm of *Terras Altas de Fafe* is presently composed of 53 wind turbines of 2 MW (MegaWatt) power. It is located in the in the district of Braga, Portugal, in the municipalities of Celorico de Basto and Cabeceiras de Basto (Figure 1), and has an extension of about 20 Km. The substation occupies an area of 8300 m^2, and the foundation of each turbine occupies an area of 150 m^2, with each turbine consisting of a multiplier and an electric generator located on the top of the tower. The towers, made of carbon steel, have a height that varies between 60 and 78 meters, and each of the blades is 39 meters long. The farm started its operation in 2004 with one wind turbine connected to the network. In 2005, 39 more wind turbines were connected to the network, and the remaining 13 were connected in 2008. The turbines were manufactured by Gamesa, G87 model, giving a total power of 106 MW. The estimated annual production is 213 GWh (Giga Watt Hour), a production that approaches the energy consumed by the residents (about 90000) of the municipalities of Fafe, Celorico de Basto and Cabeceiras de Basto (ECOSSISTEMA and ARQPAIS, 2003).

Figure 1 - Municipalities of Fafe and Celorico de Basto with the location of wind turbines of the wind farm *Terras Altas de Fafe*



Source: CAOP, 2013

2.2. Data collection

Three surveys were designed and applied to three different groups of individuals: local residents (LR), residents in the nearby town of Fafe (RN-residents nearby), and residents outside the area of the wind farm (NR-non-residents). The surveys comprised common questions collecting demographic data, and respondents' beliefs and perceptions about the benefits of wind energy production and its environmental impacts. The surveys also included a common informative text introducing the topic, with indication of the renewable energy sources used to produce electricity, prior to the valuation question. The valuation question differed between the surveys, but in all cases the payment vehicle was the households' electricity bill. Respondents in the group of NR were asked how much they would be willing to pay (in euros) per year for the constitution of a compensation fund for local people affected by the impacts of construction and operation of the wind farm. Respondents in the group of RN were asked their annual willingness to pay (in euros) to prevent the construction of a wind farm. In both cases, respondents were shown the images in Figure 2 with a pre and post landscape change in order to clarify the proposed hypothetical scenario. Although the WTP question is the preferred format in contingent valuation studies, the WTA format is more appropriate when the status quo defines perceived property rights (Groothuis et al., 2007). Given the already existence of the wind farm *Terras Altas de Fafe*, respondents in the group of LR were asked the minimum amount of money (in euros) they would accept annually as compensation for the impacts imposed by the wind farm. After answering the valuation question, respondents in all of the groups were asked to rate the degree of difficulty/uncertainty they experienced in stating their values.

The three surveys were implemented during the months of May and June 2012. The surveys for participants in the groups of RN and LR were implemented through personal interviews, while those for participants in the group of NR were implemented by email. In total, 204 survey responses were obtained, with 65, 60, and 74 of them pertaining to the NR, RN, and LR groups, respectively.

Figure 2 – Manipulated photographs

2.3. Statistical Methods

In order to assess the individuals' valuations for the impacts caused by wind farms, the analysis employs a likelihood function that is constructed to be appropriate for the type of data collected. Following standard economic theory, we start by assuming that individuals' WTP/WTA is explained by the model

$$p_i^* = \mathrm{f}(x_i; \gamma) \tag{1}$$

where x_i is a vector of explanatory variables, and γ is a vector of location parameters to be estimated. Assuming that individuals have a true value for the good under consideration but do not know it with certainty, we modify the deterministic model in (1) as

$$p_i^T = p_i^* + v_i \tag{2}$$

where v_i is a stochastic error that may render p_i^T larger or smaller than p_i^*. A common assumption in empirical work concerned with estimation of valuation functions from continuous (open-ended), cross-section data is to specify the error component in (2) as normally distributed with zero mean and standard deviation (σ_v) given by the observations. Behaviorally, this assumption implies that lower uncertainty levels concerning the desired p_i^* are captured by smaller values of σ_v, and, in the limit, when $\sigma_v \rightarrow 0$, the stochastic model in (2) collapses to the deterministic model in (1). This behavioral interpretation about the sources of the random error in (2) is consistent with the individuals' difficulty to specify exactly their values when facing a continuous valuation question as reported in the literature (Kriström, 1993; McFadden, 1994), and provides an economic rationale for modeling the variance of the idiosyncratic error term v_i as a function of information elicited from individuals concerning their degree of uncertainty about their stated WTP/WTA.

In addition to respondents' uncertainty about their true values for changes in environmental amenities, a further concern associated with the use of the CVM is whether hypothetical statements are equivalent to real values. While it is commonly accepted that hypothetical WTA values overstate real WTA values (Bishop and Heberlein, 1979), the direction of any misstatements of hypothetical WTP values is unclear. For example, and depending upon the degree of respondents' knowledge of or familiarity with the good, Crocker and Shogren (1991) and Hoehn and Randall (1997) provide theoretical accounts for systematic over or understatements of hypothetical WTP values compared with true (real) values. As first noted by Hofler and List (2004), accommodating the possibility that stated values systematically differ from true values may be accomplished by employing the stochastic frontier methodology to the CVM data. This methodology, first developed by Aigner, Lovell and Schmidt (1977) in the context of production function models, consist in adding a one-sided error term to (2), which yields the model

$$p_i^H = p_i^T + u_i \tag{3}$$

where p_i^H denotes observed hypothetical values, and p_i^T are seen as unobservable, but estimable, "frontier values". The error term u_i is a measure of the gap between hypothetical and true values for the *i*th individual, and may be positive (≥0), meaning that hypothetical values overstate true values, or negative (≤0), meaning that hypothetical values understate true values. To complete the specification, a particular probability distribution for the stochastic structure u must be chosen. A common choice is to assume that u is normally distributed with zero mean, standard deviation σ_u, and truncated at zero, i.e., a half-normal distribution. Because the dependent variable in (3) is nonnegative, the model is estimated by taking the natural logarithm of the hypothetical valuations.

Under these assumptions, the relevant log-likelihood function is given by Aigner *et al*. (1977) and by takes the form

$$lnL^+ = \sum_i \{(1/2)\ln(2/\pi) - \ln(\sigma) + \ln \Phi(s\varepsilon_i\lambda/\sigma) - (1/2)(\varepsilon_i/\sigma)^2\} \tag{4}$$

where $\Phi(.)$ is the standard normal cumulative distribution function, $\sigma = (\sigma_v^2 + \sigma_u^2)^{1/2}$, $\lambda = \sigma_u/\sigma_v$, $\varepsilon_i = \ln p_i^H - p_i^*$, and s takes the value of 1 (-1) if $u_i \geq 0$ ($u_i \leq 0$).

The logarithmic transformation of the dependent variable, however, rules out the possibility of zero valuations. Thus, the model must be further revised to account for this possibility. One option to do so consists in viewing the sample as representing two separate groups: one group that does not value the change in environmental amenities and reports a zero valuation, and a second group that has a positive WTP/WTA for the change in the environmental amenities. Statistically, this amounts to introducing a spike to the probability distribution of valuations falling at a value of zero, which can be represented by a single parameter ρ, the height of which yields the probability of having a zero valuation.

The log-likelihood function for the resulting mixture model takes the form

$$lnL = \begin{cases} \sum_i \ln \rho, & p_i^H = 0 \\ \sum_i \{\ln(1-\rho) + lnL^+\}, & p_i^H > 0 \end{cases} \tag{5}$$

where ρ is parameterised as a function of x_i, and specified as $\rho = exp(\theta)/(1 + exp(\theta))$, $\theta = \text{f}(x_i; \alpha)$, thereby restricting ρ to take values within the unit interval as is expected for a probability.

Maximum-likelihood estimation of this model allows us to compute the predicted WTP/WTA values for each individual in the sample conditional on x_i, while taking into account both the individual's degree of uncertainty about her/his stated values, and the individual's estimated gap between stated and true values. Letting (1-$\hat{\rho}_i$) stand for the *i*th individual' predicted probability of having a positive WTP/WTA, and $\tilde{p}_i$ stand for the exponential of her/his log-scale predicted valuation *conditional* on having a positive valuation, then the overall predicted WTP/WTA for the individual is given by

$$\hat{p}_i = (1 - \hat{\rho}_i) \times \tilde{p}_i \tag{6}$$

3. Results and Discussion

3.1. Specification tests

Prior to the estimation of the full model in (5), we investigated, for each group of participants, whether $u_i \geq 0$ or $u_i \leq 0$ using the using the one-sided generalized likelihood-ratio test constructed by Gutierrez, Carter and Drukker (2001) following the maximum likelihood estimation of the model in (4). If we specify $u_i \geq 0$, this is a test of H0: $\sigma_u^2 = 0$ against H1: $\sigma_u^2 > 0$, and rejection of the null hypothesis indicates that hypothetical values overstate real values, whereas failure to reject the null hypothesis indicates that (i) hypothetical values are not different from real values (so that the stochastic frontier model reduces to an OLS model with normal errors), or (ii) hypothetical values understate real values. Application of the test to the LR data yielded a likelihood-ratio test statistic equal to 26.62 with a p-value<0.0001, indicating that, as expected, the hypothetical WTA values from the local residents exceed their true WTA values. The null hypothesis, however, was not rejected in the case of the WTP data for the NR and RN participants. In order to investigate whether this result is due to (i) or (ii), we re-estimated the model specifying $u_i \leq 0$ for these data. The resulting likelihood-ratio test statistics were 14.46 (p-value<0.0001) and 9.15 (p-value<0.0001) for the NR and RN participants, respectively, allowing us to reject the null hypothesis and conclude that their stated values fall short of their true WTP values. These results accord with the theory of Hoehn and Randall (1997), which suggests that hypothetical WTP values are systematically below true values when respondents' are unfamiliar with the good as one expects to be the case for non-local residents.

3.2. Conditional statistical analysis

Along with the average sample values ($\bar{X}$) for the explanatory variables considered in the statistical analysis, Table 1 provides maximum likelihood estimates of the full model in (5). Following the results of the testing procedure above, the estimated model specifies $u_i \leq 0$ for the NR and RN data, and specifies $u_i \geq 0$ for the LR data. All estimates for the α parameter represent the calculated marginal effect of the associated covariate on the probability of having a zero WTP/WTA. The reported estimates for the γ parameter are the marginal effects on the natural logarithm of a positive WTP/WTA.

Explanatory variables include the respondents' age (*Age*), gender (*Male*, a dummy variable taking the unit value for males), educational level (*HigherE*, a dummy variable taking the unit value for respondents with a higher education degree), and the per capita income of the respondent' household (*IncPC* in euros). Also included in the model are explanatory variables pertaining to the respondents' perceptions concerning the noise impacts of wind energy (*Noise*, a dummy variable taking the unit value if the respondent judges this impact negatively), its visual impacts (*Visual*, a dummy variable taking the unit value if the respondent judges this impact negatively), and its impacts on global climate change (*Climate*, a dummy variable taking the unit value if the respondent judges this impact positively). Further explanatory variables pertain to respondents' beliefs about whether wind energy produces dangerous emissions or toxic solids (*Emission*, a dummy variable taking the unit value if the respondent believes it does), about whether production of wind energy contributes positively to job creation (*Jobs*, a dummy variable taking the unit value if the respondent believes it does), and about whether wind energy benefits the population in general (*BenPop*, a dummy variable taking the unit value if the respondent believes it does). In order to control for respondents' uncertainty about their stated WTP/WTA values, the (log of) variance of the idiosyncratic error term ($\ln\sigma_v^2$) is modeled as a function of the variable *Uncert*, a categorical variable ranging from zero (if the respondent found it very easy/very certain answering the valuation question) up to 3 (if the respondent found it difficult/uncertain answering the valuation question).

The results in Table 1 show that respondents in the NR group with a higher education degree and those who believe that wind energy produces dangerous emissions or toxic solids are less likely to state a zero WTP for the compensation fund (or, equivalently, more likely to state a positive WTP). However, while having a higher education degree exerts a negative effect on the WTP amount conditionally on stating a positive value, believing that wind energy produces dangerous emissions or toxic solids exerts a positive effect on the stated WTP amount. Likewise, older individuals and those believing that production of wind energy contributes positively to job creation are willing to pay higher monetary amounts for the compensation fund. On the other hand, income exerts a negative effect on mean WTP, although the magnitude of this effect is negligible. Unexpectedly, respondents who judge the noise and visual impacts negatively are, on average, willing to pay less for the compensation fund than their counterparts who do not judge these impacts negatively. At odds with these findings, the results show that respondents in the RN and LR groups who judge the visual impacts negatively are more likely to state positive WTP and WTA amounts, respectively. These results are in line with Ladengurg and Dubgaard (2007)'s finding that there is a positive WTP to reduce visual disamenities from wind farms. The most important factors affecting the conditional WTP of respondents in the RN group are the belief that that wind energy produces dangerous emissions and the belief that wind energy contributes positively to reduce global climate change, with both of them exerting a positive effect on individuals WTP. In turn, the most important factor affecting the conditional WTA of respondents in the LR group is the belief that wind energy benefits the population in general, with those believing it does requiring a lower monetary amount as compensation for the impacts imposed by the wind farm.

Table 1 – Maximum likelihood estimates of the full model in equation (5)

		NR			RN			LR		
Parameter	Variable	Estimate	SE	$\bar{X}$	Estimate	SE	$\bar{X}$	Estimate	SE	$\bar{X}$
α	Age	-0.01	0.01	27.1	-2×10^{-4}	5×10^{-3}	36.4	-0.01^{*}	3×10^{-3}	41.6
	Male	0.18	0.15	0.37	-0.18	0.16	0.33	-0.05	0.07	0.47
	HigherE	-0.28^{*}	0.13	0.74	-0.07	0.16	0.25	-6×10^{-3}	0.09	0.11
	IncPC	3×10^{-4}	3×10^{-4}	515.3	2×10^{-4}	3×10^{-4}	418.9	9×10^{-5}	1×10^{-4}	399.6
	Noise	-0.13	0.20	0.25	-0.29	0.30	0.12	-0.12	0.13	0.86
	Visual	-0.13	0.16	0.10	-0.29^{*}	0.10	0.85	-0.36^{*}	0.15	0.70
	Emission	-0.41^{*}	0.12	0.66	0.30	0.19	0.63			
	Climate	0.14	0.17	0.74	0.18	0.20	0.82	0.05	0.07	0.65
	BenPop							0.08	0.06	0.78
	Jobs	-0.06	0.15	0.35	0.06	0.14	0.35	-0.11	0.07	0.45
γ	Age	0.04^{*}	0.01	28.11	0.01^{*}	5×10^{-3}	39.8	4×10^{-3}	6×10^{-3}	43.08
	Male	-1.61^{*}	0.17	0.27	-0.66^{*}	0.32	0.39	-0.10	0.17	0.51
	HigherE	-0.40^{*}	0.17	0.88	-0.60^{*}	0.21	0.28	0.06	0.31	0.10
	IncPC	$-9\times10^{-4*}$	2×10^{-4}	506.4	-7×10^{-4}	3×10^{-4}	463.0	2×10^{-4}	2×10^{-4}	414.3
	Noise	-0.44^{*}	0.19	0.27	-0.66	0.60	0.11	-0.16	0.26	0.90
	Visual	-0.80^{*}	0.17	0.62	-1.34	0.88	0.94	0.11	0.18	0.76
	Emission	1.03^{*}	0.28	0.88	1.12^{*}	0.40	0.50			
	Climate	-0.03	0.11	0.69	1.25^{*}	0.28	0.78	0.12	0.16	0.64
	BenPop							-0.42^{*}	0.16	0.76
	Jobs	0.72^{*}	0.13	0.38	0.10	0.21	0.33	-0.11	0.15	0.49
	Constant	2.22^{*}	0.44		1.84^{*}	0.82		2.99^{*}	0.80	
$\ln\sigma_v^2$	Uncert	3.41^{*}	1.08	2.08	0.78	523.47	2.22	0.03	0.23	1.63
	constant	-9.14^{*}	2.26		-27.78	138.11		-1.37^{*}	0.41	
N			65			60			74	

Notes: SE (N) is standard-error (sample size); Descriptive statistics ($\bar{X}$) in the α (γ) panel are for the whole sample (sample with positive valuations only); BenPop (Emission) is dropped from the NR and RN (LR) models due to no variability in the respective samples; * is statistically significant at better than the 0.05 significance level.

Turning to the effect of respondents' uncertainty about their stated values, the results in the bottom panel of Table 1 show that the variance of the idiosyncratic error term is, as expected, a positive function of the degree of uncertainty of respondents in the NR group. Although the direction of the effects conform to *a priori* expectations, they are not statistically significant in the cases of the RN and LR groups. These results suggest that adjusting the conventional variance estimate of the idiosyncratic error term in valuation functions should not be ignored, particularly if respondents live further way from wind farms, and are, therefore, less familiar with their impacts.

3.3. Predicted participation and valuation by group of participants

Having estimated the full model, and generated the relevant participation (1-$\hat{\rho}_i$) and conditional (on stating positive values) valuation predictions, each individual's predicted WTP/WTA is computed using equation (6). Descriptive statistics for these predicted values by group of participants are shown in Table 2.

Table 2 – Mean (standard-deviation) predicted participation and valuation by group of participants

Group	(1-$\hat{\rho}_i$)	$\hat{p}_i$
NR	0.40 (0.26)	9.76 (12.11)
RN	0.30 (0.17)	2.30 (0.81)
LR	0.80 (0.21)	13.59 (5.63)

The results in Table 2 show that the predicted participation in a compensation fund by respondents in the NR group is 40%, while the probability that respondents in the RN group are willing to pay some amount to prevent the construction of the wind farm is 30%. The comparison of these two predicted probabilities suggests that individuals are more willing to pay to compensate damages to the local population than to prevent the construction of a wind farm, which may indicate that they are sensitive to the environmental impacts caused but still want wind energy to be used to produce electricity. As expected, the predicted probability that respondents in the LR group are willing to receive some amount as compensation for the impacts caused by the wind farm is substantially higher, at about 80%.

The predicted mean WTP amount for the compensation fund by respondents in the NR group is €9.76, while the predicted mean WTP amount to prevent the construction of the wind farm by respondents in the RN group is significantly lower at about €2.30. Notice, however, that a direct comparison between these two values cannot be made since the valuation questions differed among the groups. Notwithstanding, and in line with the results concerning the participation decisions, these results indicate that individuals are willing to pay a substantially higher amount to compensate the local residents than to prevent the construction of the wind farm, suggesting that it is seen by RN respondents as a desirable endeavour despite the negative impacts caused to local residents. As expected, the predicted mean WTA amount required by LR respondents as compensation for the impacts caused by the wind farm is of a higher magnitude than any of the WTP amounts, at about €13.59. However, the application of several multi-independent-samples testing procedures indicate that the conditional predicted mean WTP by NR respondents and the conditional predicted mean WTA by LR respondents are not statistically different at conventional significance levels, suggesting that the amount needed to compensate local residents for the negative impacts caused by the wind farm could be raised by the constitution of a compensation fund paid by non-residents.

4. Conclusion

In the present study, we use the CVM to elicit the monetary value attached to wind power's environmental impacts from three different groups of individuals: local residents, residents in a nearby town, and residents outside the area of a wind farm located in continental Portugal, one of the top 10 countries in the world with the highest cumulative wind power capacity. We estimate the WTP of non-residents for a compensation fund for local residents, the WTP of residents in a nearby town to prevent the construction of a wind farm, and the willingness to accept of local residents as compensation for environmental impacts caused by the wind farm. In each case, our empirical analysis employs a likelihood function that is constructed to be appropriate for the type of data collected. The results indicate that the WTP of residents in a nearby town is positive but substantially lower than the WTP (WTA) of non-residents (local residents), suggesting that although aware of the negative impacts caused to the local population, residents in the nearby town still view the wind farm as a desirable endeavour. Importantly, the results also indicate that any benefits brought about by wind farms are not enough to offset any external costs borne by local residents, supporting a NYMBY effect. Interestingly, however, our results also reveal that the amount needed to compensate local residents for the negative impacts caused by the wind farm can be raised by the constitution of a compensation fund paid by non-residents, thereby overcoming the inefficiency caused by the NYMBY effect.

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CVs

Lígia M. Costa Pinto is a Professor at the department of Economics at the University of Minho and a full researcher at the Microeconomics Research Unit (NIMA). Her research interests have focused on the economic valuation of environmental impacts, applications of experimental methods, discrete choice experiments, contingent valuation, and more recently Life cycle costing. She has participated in several research projects in the fields of health economics, experimental CO2 markets, renewable energies, and agricultural economics.

Patricia Sousa has a master's degree in Industrial Economics and Business from the University of Minho and is a Research Fellow at Microeconomics Research Unit (NIMA). Her master thesis focused on the identification and valuation of the environmental impacts of wind farms and deserved a grade of 17/20. Her research interests has focused on the economic valuation of environmental impacts of renewable energies using discrete choice experiments and the contingent valuation method.

Anabela Botelho is a Professor at the department of Economics at the University of Minho and a full researcher at the Microeconomics Research Unit (NIMA). Her research interests have focused on experimental economics and econometric modeling. In addition she has developed several applications in the fields of environmental economics, health economics and labor economics. She has participated in several research projects in the fields of health economics, experimental CO2 markets, renewable energies, and agricultural economics.