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Review

Valuing the visual impact of wind farms: A calculus method for synthesizing choice experiments studies

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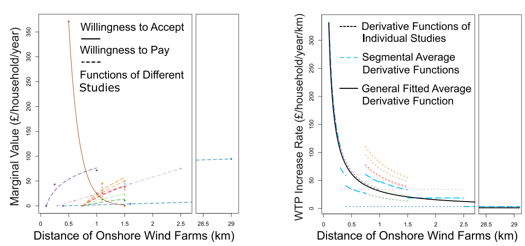
HIGHLIGHTS

- A new meta-analysis method was proposed to synthesize choice experiment studies.
- Willingness to Pay for wind farms further away followed natural logarithm curves.
- Public preferences for wind farm size and turbine height were divergent.
- Our results can be used for future spatial modelling and benefit transfer studies.
- Future meta-analysis on wind farm disamenity should include non-linear terms.

GRAPHICAL ABSTRACT



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ABSTRACT

Despite the great potential of mitigating carbon emission, development of wind farms is often opposed by local communities due to the visual impact on landscape. A growing number of studies have applied nonmarket valuation methods like Choice Experiments (CE) to value the visual impact by eliciting respondents' willingness to pay (WTP) or willingness to accept (WTA) for hypothetical wind farms through survey questions. Several meta-analyses have been found in the literature to synthesize results from different valuation studies, but they have various limitations related to the use of the prevailing multivariate meta-regression analysis. In this paper, we propose a new meta-analysis method to establish general functions for the relationships between the estimated WTP or WTA and three wind farm attributes, namely the distance to residential/coastal areas, the number of turbines and turbine height. This method involves establishing WTA or WTP functions for individual studies, fitting the average derivative functions and deriving the general integral functions of WTP or WTA against wind farm attributes. Results indicate that respondents in different studies consistently showed increasing WTP for moving wind farms to greater distances, which can be fitted by non-linear (natural logarithm) functions. However, divergent preferences for the number of turbines and turbine height were found in different studies. We argue that the new analysis method proposed in this paper is an alternative to the mainstream multivariate meta-regression analysis for synthesizing CE studies and the general integral functions of WTP or WTA against wind farm attributes are useful for future spatial modelling and benefit transfer studies. We also suggest that future multivariate meta-analyses should include non-linear components in the regression functions.

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Contents

1. Introduction

As one of the most mature renewable energy technologies, wind energy has developed rapidly around the world (GWEC, 2017; Leung and Yang, 2012). In the UK, for example, the onshore wind installed capacity has tripled between 2009 and 2016 while offshore wind installed capacity has increased by six times (BEIS, 2017). Despite the great potential to mitigate carbon emission and air pollution, onshore and offshore wind farms could also cause negative environmental impacts such as noise, wildlife loss and visual disamenity (Dai et al., 2015; Saidur et al., 2011). Although wind energy is generally supported by the public, construction of new wind farms is often confronted with opposition from local communities (Bell et al., 2005; Bell et al., 2013). Studies have been devoted to understanding the public perception and acceptance of wind farms and the underlying determinants (Fast, 2013; Thayer and Freeman, 1987; van der Horst, 2007; van der Horst and Toke, 2010; Warren et al., 2005; Warren and McFadyen, 2010; Wolsink, 2000). The visual impact on landscapes has been identified as one of the most important determinants of local opposition to wind farms (Johansson and Laike, 2007; Pasqualetti, 2011; Wolsink, 2007).

From the economic view, visual impact is an environmental externality which is difficult to be valued in the current market. To help policy makers and planning authorities to take better account of visual impact when assessing the costs and benefits of wind farms, a growing number of non-market valuation studies have been conducted to estimate the monetary value of the visual impact of wind farms using the methods of Hedonic Pricing (Gibbons, 2015; Heintzelman and Tuttle, 2012; Hoen et al., 2011; Lang et al., 2014; Sims et al., 2008; Sunak and Madlener, 2016), Contingent Valuation (Bigerna and Polinori, 2015; du Preez et al., 2012; Groothuis et al., 2008; McCartney, 2006; Mirasgedis et al., 2014; Riddington et al., 2010) and Choice Experiment (Alvarez-Farizo and Hanley, 2002; Aravena et al., 2006; Ek and Matti, 2015; García et al., 2016; Strazzera et al., 2012). Hedonic Pricing studies reveal the implicit value of visual impact by investigating the relationship between house prices and the proximity to wind farms. As Knapp and Ladenburg (2015) summarized, results from the literature were mixed in terms of whether wind farms exhibited significantly negative effects on nearby house prices.

Contingent Valuation and Choice Experiment (CE) studies use survey questions to construct hypothetical markets for eliciting participants' willingness to pay (WTP) or willingness to accept (WTA) compensation for the landscape/scenery change due to wind farms. While the former makes relatively simple, direct estimation for a single wind farm project, CE studies describe multiple wind farms as different combinations of defined attributes at different levels (e.g. distance from the wind farm to residential areas, the number of turbines in the wind farm) and ask participants to state their preferences for different wind farms through a rigorously designed recursive procedure. By setting one of the wind farm attributes to be monetary values (e.g. surcharge or discount of household electricity bills), CE studies can estimate the marginal values (WTP or WTA) of non-monetary attributes, i.e. how much participants are willing to accept or pay for specified change in the attributes (marginal WTP and WTA are simply referred to as WTP and WTA hereafter).

With the growing number of non-market valuation studies on wind farm externalities, several reviews and meta-analyses have been found in the literature. Strazzera et al. (2012), Ladenburg and Lutzeyer (2012) and Knapp and Ladenburg (2015) tabulated valuation results from different studies and provided narrative reviews, while Mirasgedis et al. (2014), Bigerna and Polinori (2015) and Mattmann et al. (2016) applied multi-variate meta-regression analysis to identify explanatory variables for the variation among different valuation results. These reviews and meta-analyses have provided useful insights, for example, that offshore wind farms are generally preferred than onshore wind farms (Mattmann et al., 2016; Mirasgedis et al., 2014) and WTA estimates are statistically larger than WTP estimates (Bigerna and Polinori, 2015; Mirasgedis et al., 2014). Furthermore, people significantly prefer locating wind farms further away from housing (Bigerna and Polinori, 2015; Mirasgedis et al., 2014), but there is a distance decay effect, i.e. the marginal benefit of moving wind farms away decreases with distance (Knapp and Ladenburg, 2015; Ladenburg and Lutzeyer, 2012).

Notwithstanding the useful insights, those reviews and meta-analyses have limitations. For instance, Mirasgedis et al. (2014) and Bigerna and Polinori (2015) did not include two important wind farm attributes that are closely related to the level of visual impact, i.e. the number of turbines in the wind farm and the height of turbines.