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Analysis

Understanding the Amenity Impacts of Wind Development on an International Border[☆]

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ABSTRACT

Wind energy developments are often controversial. Concerns are often raised about negative impacts on local communities, including impacts on property values. Some of these negative impacts may be offset by compensatory payments made by wind developers. Community involvement in the planning and development process may also reduce negative perceptions associated with wind facilities. However, if the development is near a border between municipalities, states, or even countries, it is often the case that one or more jurisdictions will not be involved in the process or receive compensation, but will, nonetheless, face some costs or impacts from the development. We explore exactly this situation at the border between Canada and the United States in the Thousand Islands region where a wind farm is currently operating on the Canadian border island of Wolfe Island. Using a parcel-level hedonic analysis of property sales transactions, we find that properties in New York with a view of and/or in close proximity to the turbines significantly depreciated in value after construction of the turbines while no negative impacts were observed on properties in Ontario. We highlight a number of factors that could contribute to these differences in impacts on property values, which may also explain the variation in results that currently exists in the literature.

1. Introduction

Renewable energy sources are a steadily increasing portion of our global energy mix. Such energy sources are a global public good — by substituting for more pollution-intensive fossil-fuel sources they reduce global pollution of criteria pollutants, such as NOx, SOx, Mercury, and others, as well as greenhouse pollutants like CO_2.[2] The benefits of these reductions are generally spread over a large area and, in the case of greenhouse gases, over the entire planet. The costs of these reductions, however, are more likely to fall on a much smaller geographic area. In some cases, in fact, renewable energy facilities can be thought of simultaneously as global public goods and local public bads. As evidence of this, siting new renewable energy facilities, particularly wind farms, is often controversial, with local governments and/or residents putting up stiff resistance. Common local concerns about wind developments include visual and aural disamenities, potential human health impacts, and impacts on wildlife. These perceived amenity and health impacts are likely to be reflected in property values as bids for properties in close proximity to wind turbines may be reduced. Research on the impacts of wind turbines on property values is a growing area of the literature, but remains without consensus in the results regarding these impacts.

A number of recent studies using the hedonic pricing method (Rosen, 1974) have found evidence of significant negative impacts (Gibbons, 2015; Heintzelman and Tuttle, 2012; Jensen et al., 2014; Sunak and Madlener, 2012), while other studies have not found

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[1] Primary authorship of this paper was shared equally between Heintzelman and Vyn.

[2] The exact emissions reductions from a wind facility depends very much on what other energy sources are displaced, the focus of Kaffine et al. (2013).

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significant impacts (Hoen et al., 2011, 2015; Lang et al., 2014; Sims and Dent, 2007; Sims et al., 2008; Vyn and McCullough, 2014). These mixed results may occur due in part to issues inherent in the estimation of these impacts. Typically there are relatively few observations from which impacts are estimated for individual wind farms, which may affect the validity of the results or reduce the likelihood of finding statistically significant impacts. Hoen et al. (2015) addressed this issue by combining multiple sites around the U.S., which produced a large data set with many observations in close proximity to turbines. However, combining observations across multiple sites may obscure variation that may occur in the impacts across sites, which was demonstrated by Heintzelman and Tuttle (2012) where significant negative impacts were found at two sites but not at a third site. The mixed results in the literature may also suggest that there may not be a single, global answer to the question regarding impacts of wind turbines on property values; rather, the specific context for individual sites may influence whether significant impacts occur.

There are a number of factors related to context that may affect the nature of the impacts that wind turbines have on property values. The degree of local controversy related to wind development can potentially influence perceptions regarding the disamenity effects of wind turbines, which in turn could affect the willingness to pay for properties in close proximity to turbines. The impacts may be exacerbated by the presence of seasonal or vacation homes. Owners of these homes are likely to have more elastic preferences regarding changes in the amenities surrounding their property, and may be more likely to sell their property or less likely to buy a property due to an adverse change in amenities, which could contribute to a relatively greater impact on prices for these properties. Acting counter to these potential negative impacts are benefits that accrue through payments from developers to local landowners, through lease payments for use of the land, and to communities, through payments-in-lieu-of-taxes (PILOTs). Another potential influencing factor is public involvement in the approval and development process. If a community feels that they have not had sufficient input into this process, this can create considerable opposition to and negative perceptions of the turbines, which can be manifested in property value impacts, whereas if the community is involved throughout the process, residents may be less likely to hold negative perceptions of the turbines (Devine-Wright, 2005). As an extreme form of this, if the development happens near a border between communities, but is wholly contained within one community, the community without the development is unlikely to be consulted during the approval process and would not receive compensation from the developer. These neighboring communities, in other words, will bear some of the cost of the project with little prospect of receiving any benefits.

The factors discussed above are explored in this paper, using a unique setting in which a large wind farm was constructed on the Canadian island of Wolfe Island in the St. Lawrence River along the border between Canada and the United States. This setting is ideal for examining the impacts of these contextual factors, particularly the cross-border impacts and the influence of seasonal or vacation homes. While the wind turbines on Wolfe Island affect the viewshed for properties on both sides of the border, the development of this wind farm involved public consultation and compensation only on the Canadian side. In addition, many of the properties on the American side, particularly those with views of the turbines, are seasonal or vacation homes rather than primary residences.

We use a hedonic analysis and property sales data to examine and compare how property values on both sides of the border have been impacted by the Wolfe Island wind turbines. In this analysis, a difference-in-differences approach is used to compare transaction prices before and after approval or construction of the wind farm as well as between homes which can and cannot view the turbines, or are at varying distances from the turbines. We employ fixed effects to mitigate potential omitted variables bias as well as to control for property market trends and seasonality of prices. We find evidence of negative property value impacts on the American side after construction of the turbines for properties in close proximity to the turbines and/or with a view of the turbines. In contrast, we do not find evidence of significant negative impacts on the Canadian side.

2. Study Region

Wolfe Island, which is the largest island in the Thousand Islands region, is situated at the entrance of the St. Lawrence River in Lake Ontario, directly across the river from the community of Cape Vincent in the state of New York. The Wolfe Island wind farm was developed by Canadian Hydro Developers[3] , which initially submitted a proposal for construction of this wind farm on the western half of the island in July 2005 (Keating, 2006). The official plan and zoning bylaw amendments necessary to allow this project to move forward were passed by council in November 2006, and the project was officially announced on the Wolfe Island website in April 2007. Construction of the 86-turbine, 197.8 MW facility began in May 2008 and was completed in June 2009, at which time the wind farm became operational (Ontario Power Authority).

On the American side, we focus on Jefferson County, which sits at the northern edge of New York and borders both the St. Lawrence River and Lake Ontario. Throughout the past decade, wind energy has divided public opinion in the county. The region has been the targeted site for several recent American wind facility proposals, including in the Town of Cape Vincent and in the Town of Hounsfield, on Galloo Island in Lake Ontario, all of which have been highly controversial.

Newspaper coverage and letters to the editor in the New York media regarding the Wolfe Island facility clearly expressed Jefferson County residents' opposition to turbines due to negative aesthetic impacts. A Cape Vincent journalist feared that the turbines "will take away [the] image and… beauty of [his] township", deterring prospective seasonal residents who "contribute so much in taxes and expertise" (Radley, 2009). A Chaumont resident characterized the wind farm as "blight on landscape" (Lynne, 2009). Finally, a seasonal resident of Chippewa Bay described the waterfront view of facility nighttime lighting as "a jolt to the entire landscape and to [his] mind, … like a jab in the ribs" (Quarrier, 2009).

Similar sentiments have been expressed by residents of Wolfe Island, where the construction of this wind farm generated considerable controversy and public opposition. Opponents of the wind turbines have expressed concerns regarding "the industrialization of this rural community" and how the turbines "forever change the landscape into something that doesn't fit here" (Fast et al., 2015). As with Cape Vincent, there are a considerable number of seasonal residences on Wolfe Island, many of which are waterfront properties. According to Fast et al. (2015) , summer cottages comprise about one-third of all residences on the island. As such, visual amenities play a significant role in the value of these properties, and owners of these properties have expressed concerns regarding potential negative impacts on property values arising due to the visual disamenities associated with wind turbines. As one seasonal resident stated, "why would I want to live there [with the turbines]?" (Fast et al., 2015) In one case, property owners brought an appeal to Ontario's Assessment Review Board to have the assessed value of their waterfront property reduced due to the devaluation caused by the wind turbines. This appeal was ultimately rejected due to a lack of evidence of negative impacts. But this case highlights the underlying concerns that exist among residents of Wolfe Island regarding impacts of wind

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[3] Canadian Hydro Developers was acquired by TransAlta in 2009.

turbines. However, not all residents of Wolfe Island were opposed to this project. As evident from interviews conducted by Fast et al. (2015) , there are a considerable number of area residents that were supportive of the project and of wind energy in general.

It is interesting to note that similar concerns and issues were raised by residents on both sides of the border despite the fact that public meetings and open houses were held for residents on the Canadian side throughout the application and development process. Public open houses for this project were first held in March of 2006, only a few months after the project was initially proposed. In October 2006, a public meeting was held to consider a proposed zoning by-law amendment applicable to all Wolfe Island lands optioned for a wind plant zone (this amendment was passed by council the following month). In March 2007, public open houses were held that included maps indicating the 86 turbine locations. Overall, public consultation focused only on residents of Wolfe Island, while residents of Cape Vincent had no involvement in this process. This difference in the level of involvement could potentially contribute to a difference in the nature of the resulting impacts on either side of the border. In addition, the Township of Frontenac Islands, which includes Wolfe Island, receives C$645,000 per year in payments from the developer, while no compensation is provided to Jefferson County. This could also contribute to a difference in impacts on property values.

3. Data and Methodology

3.1. Property Value Data

We estimate the impacts of the Wolfe Island wind farm on property values using data on 8279 single-family residential property transactions on both sides of the border: 6017 in Jefferson County, NY[4] , and 2262 across the border in Frontenac County, Ontario. Fig. 1 provides a map of the study area and transaction locations. Data on NY transactions between January 2004 and July 2013, inclusive, comes from the New York State Office of Real Property Taxation Services (NYSORPTS). This data includes sale price, sale date, and parcel identifying information. This transaction data is then merged with parcel and home characteristics data from the assessment process, also from NYSORPTS. We then bring in parcel shapefile (GIS) data which we acquired from the Jefferson County Assessor's Office. With this spatial data we calculate a number of distance and spatial variables in ArcGIS. Data on Canadian transactions comes from Ontario's Municipal Property Assessment Corporation (MPAC). This detailed data includes all open-market sales of residential properties in Frontenac County between September 2004 and July 2013, inclusive. An extensive set of property and structural variables is included in the MPAC data, while additional distance and spatial variables are calculated using ArcGIS. There are no sales in this data set of properties on which a turbine is located.

To ensure consistency in the estimation approach between the two sides of the border and to reduce the possibility of bias between the two sets of results, the same set of explanatory variables representing the parcel and structural characteristics are used. Variables accounting for parcel attributes include lot size and categorical variables for waterfront and seasonal properties as well as for the existence of a mobile home as the primary residence. The value associated with the residence on each parcel is accounted for by a set of variables that includes living area, finished basement area, age of the house, a house quality index (from 1 to 5), the numbers of bathrooms, bedrooms, and stories, and categorical variables for the existence of a fireplace, central air conditioning, and forced air heating. In addition to distance to the nearest turbine, other distance variables include the distances from each parcel to the nearest city, to the nearest town, and to the St. Lawrence River. As mentioned above, sets of year and month fixed effects variables are also included. All of these variables were included in both data sets, though in some cases slight adjustments were made in the merging process. For example, the house quality index variable is based on a 5-point scale in the NY data and on a 10-point scale in the ON data, which is accounted for by dividing the quality index by two for parcels in Ontario.

3.2. Wind Turbine Data

The Wolfe Island wind farm consists of 86 turbines built primarily on farmland properties but with residential properties interspersed within and around this area that may be impacted by the turbines. The locations of the turbines and of properties within the samples on both sides of the border that are in close proximity to the turbines are indicated in Fig. 2. The key variables specified to capture the visual and aural impacts of the wind turbines include a turbine visibility variable and a turbine proximity variable. We estimate separate models using each of these variables. The turbine proximity variable was specified based on the Euclidean distance from each parcel to the nearest turbine on Wolfe Island, calculated using ArcGIS. Previous studies that have accounted for turbine impacts on property values based on distance measures have used inverse distance (e.g., Heintzelman and Tuttle, 2012; Vyn and McCullough, 2014) and distance bands (e.g., Hoen et al., 2011, 2015). Both of these measures have potential shortcomings: the use of inverse distance involves estimating impacts at the mean distance from the turbines and, as such, may underestimate the potentially greater impacts in very close proximity to turbines, while the use of distance bands, which involves dividing up observations into bins of specified distances from turbines, can result in estimated impacts for each band that may be based on relatively few observations. Due to the relatively low number of observations in our data sets in close proximity to the turbines, the shortcoming associated with the use of distance bands is of greater concern. As a result, we use the inverse distance measure in our analysis (InvDistance). Given the distance-decaying nature of the visual and aural impacts of turbines, any impacts on property values are expected to be greater in closer proximity to the turbines, which would be reflected by a negative coefficient for the inverse distance variable.

Since proximity does not necessarily correspond with visibility, as view may be obstructed by landscape features, we also conducted field visits to all parcels that are potentially within visibility of the wind turbines (this potential was determined based on a combination of viewshed modelling in ArcGIS and distance to the nearest turbine — less than 5 miles). On these visits, it was determined whether the parcel (as viewed from the road) had a partial or full view of one or more of the turbines. These assessments were used to create a categorical variable indicating whether properties had a view (either partial or full) of the turbines (View).[5]

The field observations of the visual impacts of every transacted parcel with a potential view is a strength of this paper, similar to that of Hoen et al. (2011) and Hoen et al. (2015). It is superior to solely using viewshed analysis in ArcGIS, which generally relies on a number of assumptions about the height of different forms of land cover (trees) to estimate views, and cannot possibly include every potential

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[4] There were an additional 11 transactions that had to be omitted from the data set due to incomplete information.

[5] Since there are relatively few parcels with a view of the turbines, we use only a single variable to represent view rather than accounting separately for impacts on parcels with a full view and impacts on parcels with a partial view. As a result, any effects that we estimate using this measure will be an average of effects across these sub-categories of view, presumably over-estimating the effect for those with only a partial view of one turbine and under-estimating the effect for those with full views of multiple turbines.

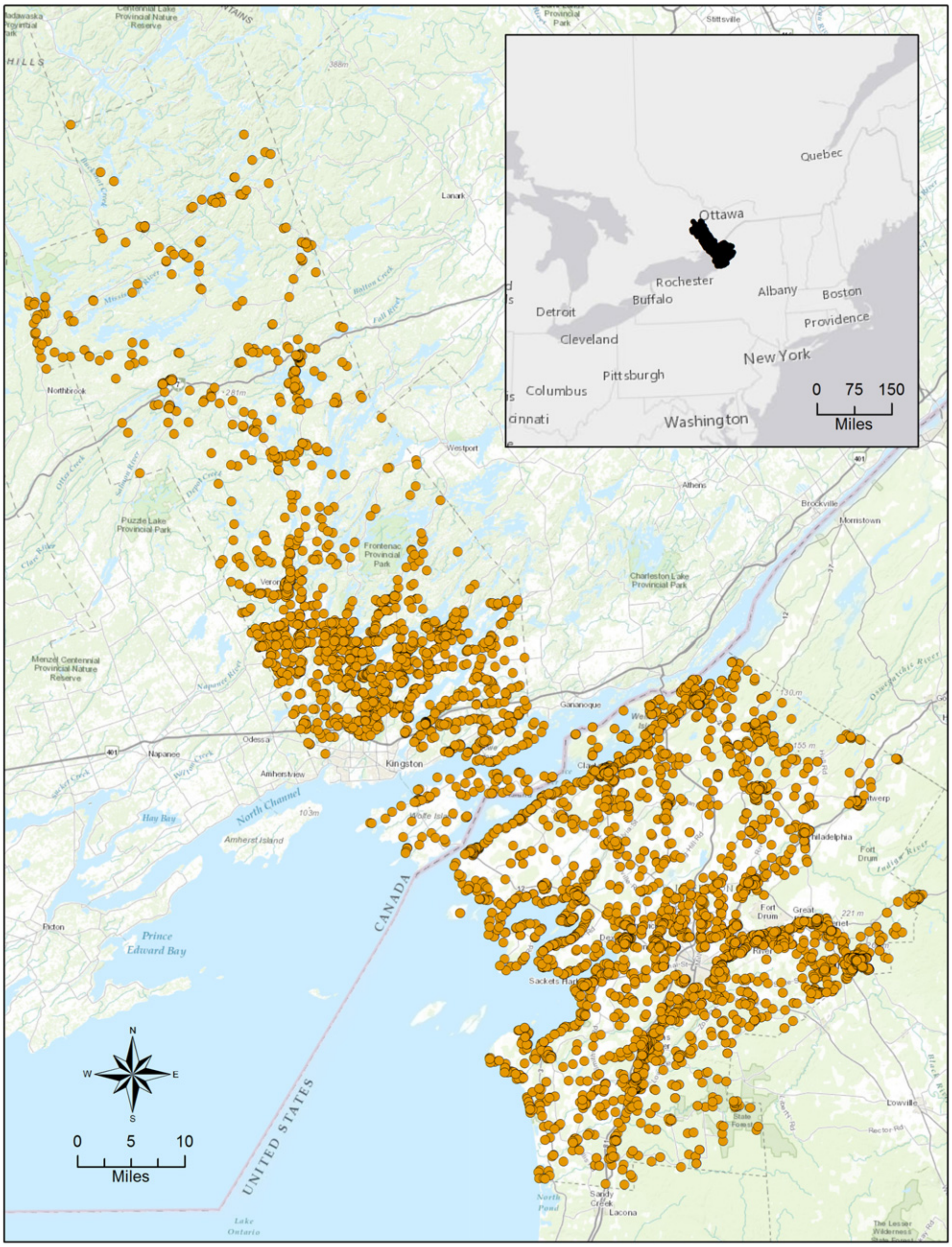

Fig. 1. Study area.

obstruction. Because of this, viewshed analysis will tend to overestimate turbine views, and we avoid this potential error with the field observations. It is important to note, however, that there could still be some error in this view variable. It is possible that some parcels with a view fell outside of our distance filter in determining which parcels to visit. That is, we may be underestimating the number of parcels with views of the turbines. Nonetheless, these parcels would be more than 5 miles from the turbines, and thus less likely to be impacted by the turbines.[6]

While turbine view is highly correlated with turbine proximity (0.6089), we believe it is important to conduct analysis using both factors, as they account for different aspects of the potential impacts of turbines, although not simultaneously. For example, turbine view accounts only for the visual impacts of turbines, while turbine proximity also accounts for aural impacts. Both of these factors have been utilized in previous studies, and are included here.

Since the data includes sales that occurred both before and after the wind farm was developed, it is necessary to account for the time period during which turbine impacts on property values are expected to occur. We specify a post-turbine period to account for sales that occurred after turbine construction on Wolfe Island was completed in June 2009 (Post-Turbine). In addition, we account for potential announcement effects by specifying an announcement period between April 2007, when the wind farm was first announced, and June 2009 (Announcement). Each of these time period variables is interacted with the visibility (View) and turbine distance (InvDistance) variables in order to specify the variables that account for the impacts of turbines on property values. However, given the difficulty

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[6] If we did mischaracterize some parcels with a view as not having a view, and those parcels were actually negatively impacted, we are likely to be underestimating the negative impacts in our analysis. If, on the other hand, these parcels were not negatively impacted, despite the view, than our results would be biased in the other direction.

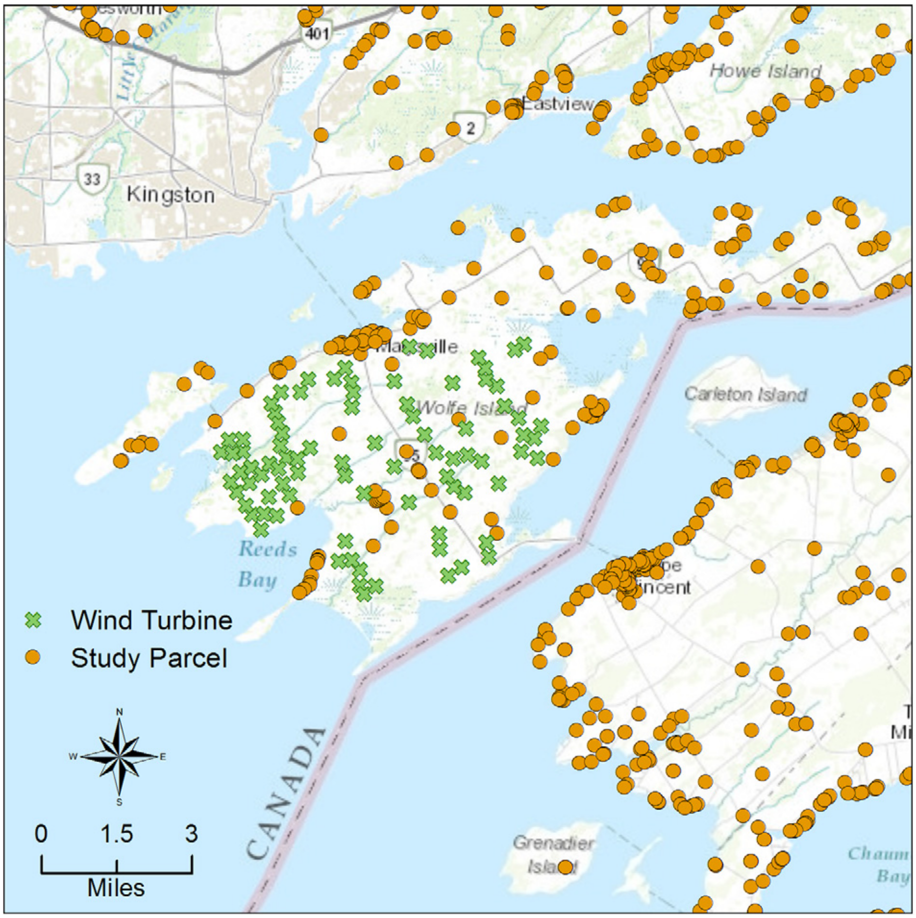

Fig. 2. Detailed map of Wolfe Island and environs.

in specifying the precise point in time at which impacts may begin to occur, we test the robustness of our results with alternate specifications of these time periods. Rather than using the post-construction date for the specification of the post-turbine period, we use the date that construction began: May 2008. During the construction period, while all turbines were not yet fully erected, the locations were known and the visual effects were becoming evident; hence, turbine impacts could conceivably have begun to occur during this period. We also use an alternate announcement effect period that begins following the approval of the zoning bylaw amendments in November 2006.

In the post-turbine period, the Ontario data includes 47 parcels within 5 miles of the nearest turbine and 19 parcels within 1 mile, while the New York data includes 58 parcels within 5 miles, the nearest of which is 1.86 miles from the turbines. There are 39 parcels in Ontario and 15 parcels in New York with a view of the turbines that were sold in the post-turbine period. These low numbers of observations from which to estimate the impacts of wind turbines represent a serious limitation of this study. This has been a recurring issue in the literature on the impacts of wind turbines.

Summary statistics for all variables for the two data sets are presented in Table 1. Notice that property values in our Ontario sample are considerably higher than in our New York sample. A higher proportion of homes in our NY sample are on the waterfront as compared to our ON sample, and a higher proportion are also seasonal in our NY sample. There are other variables with notable differences in means between the two samples, such as basement area, air conditioning, and distances to the nearest town and the nearest city. But for many of the remaining control variables, our samples are quite comparable.

With such a small number of properties that are potentially impacted by the turbines, especially based on the view specification, it is important to compare summary statistics between treated and control observations to determine how similar properties are across the two groups of observations. In Table 2, we compare variable means between the treated and control properties in both jurisdictions, where the treated samples includes sales of properties with a view of the turbines in the announcement and post-turbine periods.[7] The largest differences in means between the treated and control groups (aside from view and distance to turbines) are found for waterfront properties and for distance to the St. Lawrence River, which is not surprising given the location of the wind farm. These differences convey the importance of controlling for these variables in the analysis. Other notable differences in means exist for lot size and basement area, both of which are larger for the control groups, as well as for distances to the nearest town and city, primarily in the ON sample. However, for many of the remaining parcel and structural variables the means are quite similar between the treated and control groups in both jurisdictions.

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[7] Variable means comparisons were also conducted where the treated groups were specified to include properties within 5 miles of turbines sold in the announcement and post-turbine periods, the outcomes of which were similar in nature to those in Table 2. Variable means are very similar between treated and control properties within 5 miles of the turbines.

Table 1
Summary statistics.

		Ontario				New York			
Variable name	Variable description	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
Sale price	Sale price of the parcel, in Canadian $ for Ontario sales and in US $ for New York sales	241,150.40	122,104.90	25,000.00	1,600,000.00	142,004.90	101,407.80	3,500.00	2,000,300.00
View	= 1 if parcel has a view (full or partial) of the turbines	0.03	0.18	0	1	0	0.07	0	1
Distance	Distance to nearest Wolfe Island turbine, in miles	19.28	13.21	0.28	71.45	25.75	9.02	1.86	44.38
Announcement	= 1 if parcel sold between project announcement and completion of turbine construction	0.35	0.48	0	1	0.21	0.41	0	1
Post-turbine	= 1 if parcel sold following completion of turbine construction	0.59	0.49	0	1	0.41	0.49	0	1
Waterfront	= 1 if parcel is on the waterfront	0.05	0.22	0	1	0.12	0.32	0	1
Seasonal	= 1 if parcel is seasonal	0.06	0.24	0	1	0.1	0.3	0	1
Mobile	= 1 if residence is mobile home	0.01	0.11	0	1	0.04	0.19	0	1
Lot size	Size of the parcel, in acres	4.18	14.48	0.06	300.56	6.54	25.41	0.01	391.43
Living area	Living area of the house, in square feet	1493.10	587.71	101	4839.00	1557.52	598.32	136	6074.00
Basement area	Finished basement area, in square feet	221.04	385.94	0	4091.00	71.47	276.6	0	2600.00
Stories	Number of stories in the house	1.26	0.4	1	3	1.46	0.44	1	3
Quality	House quality index (1–5)	2.89	0.39	0.5	4	2.94	0.54	1	5
Age	Age of the house, in years	42.45	37.29	0	190	67.5	52.45	0	225
Bathrooms	Number of bathrooms	1.51	0.7	0	4.5	1.43	0.58	0	5.5
Bedrooms	Number of bedrooms	2.92	0.82	0	9	2.99	0.94	0	9
Fireplace	= 1 if at least one fireplace exists in the house	0.29	0.45	0	1	0.17	0.38	0	1
Air	= 1 if house has central air conditioning	0.23	0.42	0	1	0.02	0.14	0	1
Forced air	= 1 if the house has forced air heat	0.72	0.45	0	1	0.7	0.46	0	1
Town	Distance to the nearest town, in miles	13.8	10.29	0	57.02	1.61	1.51	0	8.25
City	Distance to the nearest city (population > 50,000), in miles	17.02	16.49	0	81.32	2.9	3.03	0	17.88
St. Lawrence	Distance to the St. Lawrence River, in miles	14	12.52	0.01	62.36	7.17	6.77	0	26.45
	Observations	2262				6017			

3.3. *Methodology*

Hedonic analysis is a well-accepted form of revealed preference (as opposed to stated preference) non-market valuation in the field of environmental economics. This approach is derived from Rosen (1974) and others.[8] Essentially, Rosen (1974) lays out a model of buyers and sellers with preferences over the attributes of a compound good, like housing. In this case, he derives a hedonic price function showing that, under certain assumptions, the market price of a house will be a function of its attributes. One can then estimate this hedonic function using data on a set of homes with varying prices and attributes, where the estimated coefficients represent the marginal willingness-to-pay for changes in these individual attributes. The strength of this approach is that it allows for the estimation of the value of marginal changes in attributes that are otherwise not bought and sold on markets, such as environmental amenities.

The hedonic method is quite powerful because any amenity which is valued by consumers and associated in some way with housing markets can, in theory, be valued through this method under the right conditions. A limitation of this approach, however, is that the hedonic method can only estimate what are called “use” values of homeowners or renters, and not broader societal values. For instance, the hedonic method could estimate the value of having a healthy ecosystem to residents in a local area, but cannot estimate the value to society-at-large of a particular ecosystem.

As in any econometric exercise, there are a number of empirical issues that are common in hedonic analyses. First, one must take care in choosing the functional form. Traditionally, based on Cropper et al. (1988), the log-linear or log-log forms are preferred. We use a log-log form for our analysis. However, to ensure that this selection of functional form does not bias the results, we also tested the sensitivity of the results to a log-linear functional form, which has also been used in recent studies on the impacts of wind turbines on property values. We found that the nature of the results of our primary variables of interest was consistent between the log–log and log–linear forms, which suggests that our results are not particularly sensitive to the selection of functional form.

Kuminoff et al. (2010) also advocate for the inclusion of spatial fixed effects, temporal controls, and quasi-experimental identification to control as best as possible for omitted variables bias, which is endemic to applications of the hedonic method. Omitted variables bias arises when one or more factors that are correlated with both the dependent variable and one or more included explanatory variables are omitted from the specification. In this case, the analysis will assign explanatory power which properly belongs with the omitted variable to included variables, resulting in biased estimates of the effects of those variables. Given the large number of factors which are both unobservable to the analyst and correlated with property values (local neighborhood attributes, for instance), this has serious implications for hedonic analysis. Similarly, given that we are trying to

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[8] See Taylor (2003) and Freeman III et al. (2014) for comprehensive treatments of the hedonic method in environmental economics.

Table 2
Variable means and standard deviations for treated and control properties, based on turbine view.

	Ontario				New York			
	Treated		Control		Treated		Control	
Variable name	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Sale price	330,567.80	250,096.00	238,880.50	116,275.10	209,351.40	194,272.30	141,757.70	100,858.10
View	1	0	0.01	0.09	1	0	0	0.03
Distance	2.25	2.17	19.72	13.09	2.88	0.63	25.84	8.92
Announcement	0.3	0.46	0.36	0.48	0.32	0.48	0.21	0.41
Post-Con	0.7	0.46	0.58	0.49	0.68	0.48	0.41	0.49
Waterfront	0.52	0.5	0.04	0.19	0.45	0.51	0.12	0.32
Seasonal	0.21	0.41	0.06	0.24	0.14	0.35	0.1	0.3
Mobile	0.02	0.13	0.01	0.11	0.05	0.21	0.04	0.19
Lot size	2.52	5.6	4.23	14.63	0.99	1.88	6.56	25.45
Living area	1473.43	509.86	1493.60	589.65	1583.86	654.26	1557.42	598.16
Basement area	102.71	243.97	224.05	388.43	0	0	71.73	277.07
Stories	1.34	0.36	1.26	0.4	1.41	0.39	1.46	0.44
Quality	2.79	0.41	2.89	0.39	3.18	0.73	2.94	0.54
Age	50.04	44.69	42.25	37.07	81.68	55.8	67.44	52.43
Bathrooms	1.43	0.64	1.52	0.7	1.45	0.6	1.43	0.58
Bedrooms	2.82	0.94	2.93	0.82	2.91	1.11	2.99	0.94
Fireplace	0.23	0.43	0.29	0.45	0.45	0.51	0.17	0.37
Air	0.13	0.33	0.24	0.43	0	0	0.02	0.14
Forced air	0.61	0.49	0.72	0.45	0.73	0.46	0.7	0.46
Town	7.46	3.17	13.96	10.35	1.47	1.36	1.61	1.51
City	9.14	5.65	17.22	16.62	1.39	1.37	2.9	3.04
St. Lawrence	0.24	0.41	14.35	12.48	0.05	0.03	7.19	6.76

identify the impact of a feature which changes over time (the Wolfe Island turbines are built mid-sample period), if we fail to adequately control for trends over time, we may similarly bias our estimates of the turbine impacts.

Fixed effects approaches help overcome these issues. By implicitly including a large number of spatial dummy variables, fixed effects allows each area (township or census block, for instance) to have its own intercept term, accounting for time invariant factors which affect property values in these areas. The smaller the level of the fixed effects, the less likely one is to have an omitted variables problem (as more and more spatial factors will be subsumed in the fixed effect). However, fixed effects also rely on within unit variation to identify the effects of remaining variables. This often means that as the level of the fixed effects gets smaller, the analyst loses power to identify effects. Thus, it is important to carefully balance these effects when interpreting results and choosing a level of fixed effects. In our case, we found that the use of fixed effects at the township level provided an appropriate balance, as our preliminary analysis indicated that the ability to identify effects was diminished with the use of fixed effects at the census block level. In addition, differences exist

Table 3
Regression results for full sample and 20mile sample — turbine view.

	Full sample						20 mile sample					
	Ontario			New York			Ontario			New York		
Variable	Coefficient		Std. Error	Coefficient		Std. Error	Coefficient		Std. Error	Coefficient		Std. Error
View	0.017		0.017	0.031		0.044	0.006		0.006	0.181	*	0.094
Announcement	−0.02		0.029	−0.081		0.06	−0.045		0.04	−0.163	**	0.071
Post-Turbine	0.034		0.044	−0.15	**	0.069	−0.005		0.063	−0.136		0.137
View*Announcement	0.008		0.056	0.181	***	0.056	0.047		0.034	0.068		0.077
View*Post-Turbine	−0.037		0.048	−0.185	***	0.052	−0.001		0.027	−0.289	**	0.101
Waterfront	0.615	***	0.025	0.557	***	0.065	0.624	***	0.023	0.555	***	0.073
Seasonal	−0.038		0.028	0.137	***	0.038	−0.03		0.041	0.076		0.064
Mobile	−0.375	***	0.049	−0.154	***	0.042	−0.52	***	0.028	−0.14	**	0.048
Ln(Lot Size)	0.074	***	0.01	0.017		0.012	0.067	***	0.006	0.024		0.02
Ln(Living Area)	0.392	***	0.017	0.563	***	0.049	0.406	***	0.029	0.484	***	0.129
Ln(Basement Area)	0.005		0.002	0.005		0.007	0.002		0.003	0.017		0.018
Stories	−0.056	**	0.015	0.003		0.037	−0.069	**	0.012	−0.038		0.073
Quality	0.298	***	0.019	0.294	***	0.017	0.315	***	0.027	0.237	***	0.015
Ln(Age)	−0.089	***	0.008	−0.097	***	0.017	−0.084	***	0.007	−0.05		0.033
Bathrooms	0.057	***	0.011	0.098	***	0.019	0.048	**	0.01	0.135	***	0.033
Bedrooms	−0.003		0.008	−0.002		0.016	0.004		0.011	0.027		0.032
Fireplace	0.041	**	0.013	0.148	***	0.021	0.04		0.014	0.126	**	0.051
Air	0.012		0.009	0.114	**	0.047	0.013		0.014	0.239	***	0.038
Forced Air	0.043	***	0.005	−0.113	***	0.019	0.034	*	0.009	−0.103	*	0.053
Ln(Town)	−0.163		0.079	−0.057		0.041	−0.18		0.108	−0.012		0.047
Ln(City)	0.046		0.075	0.01		0.044	0.1		0.103	0.016		0.04
Ln(St. Lawrence)	−0.047	***	0.01	−0.195	***	0.028	−0.028		0.014	−0.15	**	0.064
Number of observations	2262			6017			1620			1569		
Adjusted R^2	0.7823			0.3969			0.7673			0.4284		

Table 4
Regression results for full sample and 20mile sample — turbine distance.

	Full sample						20 mile sample					
	Ontario			New York			Ontario			New York		
Variable	Coefficient		Std. error	Coefficient		Std. error	Coefficient		Std. error	Coefficient		Std. error
InvDistance	−0.132	***	0.019	−1.276	***	0.276	−0.134	**	0.016	−1.119	***	0.191
Announcement	−0.018		0.029	−0.088		0.065	−0.043		0.035	−0.193	**	0.075
Post-Turbine	0.031		0.047	−0.129	*	0.076	−0.01		0.065	−0.096		0.138
InvDistance*Announcement	0.004		0.036	0.183		0.279	0.023		0.01	0.313	**	0.121
InvDistance*Post-Turbine	0.014		0.036	−0.334		0.219	0.035	**	0.007	−0.447	**	0.149
Waterfront	0.552	***	0.021	0.55	***	0.061	0.562	***	0.011	0.555	***	0.072
Seasonal	−0.036		0.028	0.13	***	0.04	−0.038		0.035	0.061		0.066
Mobile	−0.376	***	0.05	−0.154	***	0.042	−0.521	***	0.027	−0.14	**	0.048
Ln(Lot Size)	0.074	***	0.01	0.018		0.012	0.067	***	0.006	0.023		0.021
Ln(Living Area)	0.388	***	0.019	0.562	***	0.049	0.402	***	0.034	0.478	***	0.13
Ln(Basement Area)	0.005		0.002	0.004		0.007	0.002		0.003	0.014		0.016
Stories	−0.053	**	0.013	0.001		0.037	−0.063	**	0.007	−0.047		0.078
Quality	0.297	***	0.018	0.296	***	0.017	0.314	***	0.026	0.243	***	0.015
Ln(Age)	−0.089	***	0.008	−0.097	***	0.017	−0.085	***	0.007	−0.047		0.033
Bathrooms	0.056	***	0.012	0.098	***	0.019	0.046	**	0.009	0.137	***	0.034
Bedrooms	−0.003		0.008	−0.001		0.016	0.005		0.011	0.029		0.033
Fireplace	0.039	**	0.011	0.148	***	0.022	0.038	*	0.012	0.125	**	0.052
Air	0.014		0.008	0.114	**	0.047	0.015		0.012	0.239	***	0.036
Forced Air	0.042	***	0.006	−0.115	***	0.019	0.033	*	0.01	−0.105	*	0.051
Ln(Town)	−0.124	*	0.057	−0.06		0.043	−0.116		0.083	−0.019		0.052
Ln(City)	−0.006		0.037	0.003		0.043	0.026		0.066	−0.006		0.027
Ln(St. Lawrence)	−0.045	***	0.009	−0.208	***	0.024	−0.033		0.019	−0.155	**	0.056
Number of observations	2262			6017			1620			1569		
Adjusted R^2	0.7959			0.4074			0.7708			0.4335		

in the specification of the American census blocks and the closest Canadian equivalent, the homogeneous neighborhood which would undermine our ability to compare results across the border.

We include year fixed effects to account for sample-wide trends as well as month fixed effects to account for seasonality in real estate prices. This is particularly important given the turbulent real estate markets of the late 2000s.[9] Our quasi-experimental identification stems from the fact that we have transactions taking place both before and after the turbines were built and in areas that are at varying distances and with varying views of the turbines. We include clustered error terms at the same level as our fixed effects. This allows error terms to be correlated across transactions in the same local area (i.e., townships) while requiring them to be independent across local areas. This generalization helps to control for spatial autocorrelation and is a simplified form of spatial econometrics.

With all of this in mind, our specification follows Heintzelman and Tuttle (2012) and takes the general form:

$$\ln(P_{ijt}) = \lambda_t + \alpha_j + \beta_1 wind_i + \beta_2 wind_t + \beta_3 wind_{it} + \beta_4 \ln(\mathbf{x}_{it}) + \eta_{jt} + \epsilon_{ijt} \tag{1}$$

where λ_t represents the time (year and month) fixed effects, α_j represents local area fixed effects, $wind_i$ represents the proximity to or view of wind turbines for parcel i, $wind_t$ represents the time period, t, in which turbine impacts are expected to occur, $wind_{it}$ represents the interaction term between proximity to or view of wind turbines for parcel i with time period t, $\mathbf{x}_{it}$ is a vector of other parcel and structural characteristics[10], as described above, and η_{jt} and ϵ_{ijt} represent spatial area and individual specific error terms. The model represented in Eq. (1) is estimated separately for real estate markets in Ontario and New York, which permits determining whether the turbine impacts differed between the two locations. For each location, the data includes a considerable number of sales well beyond the viewshed of the wind farm that would not be impacted by the turbines, which comprise a control group.

One of the assumptions of the hedonic model is that all included observations comprise a single market. However, our samples include observations up to 71 miles away from the turbines on the Ontario side and up to 44 miles away on the New York side. While we account for the influence of unobserved factors through the use of spatial fixed effects, the possibility remains that including sales from such extensive geographic areas may bias the results. To address this potential issue, we also estimate Eq. (1) for samples comprised only of sales within 20 miles of the turbines, which include 1620 sales in Ontario and 1569 sales in New York. The results for these samples are compared with those of the full samples in the following section.

4. Results

Table 3 presents the results of our analysis for the regressions in which turbine impacts are accounted for by visibility, while Table 4 presents the results for the regressions based on distance to the nearest turbine. Each table includes the results of both the full sample and the sample restricted to properties within 20 miles of the wind turbines.

In Table 3, the key variables of interest are the interaction terms that indicate how turbine view impacts property values in

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[9] It is important to note that real estate markets in Northern New York and in Ontario were relatively insulated from this turmoil, and there is no dramatic crash in prices following the financial crisis in our sample. Nonetheless, it is important to control for these possible impacts.

[10] Not all parcel and structural characteristics are logged. We follow general rules of thumb outlined by Wooldridge (2006) in determining the variables to represent in log form. For example, categorical variables and continuous variables comprised of relatively small integer values are not logged.

Table 5
Results for robustness checks — turbine view.

	10 Mile sample				Alternate post-turbine period				Alternate announcement period			
	Ontario		New York		Ontario		New York		Ontario		New York	
Variable	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
View	0.012	0.026	0.403***	0.022	0.005	0.009	0.181*	0.095	−0.053***	0.005	0.176*	0.094
Announcement	−0.109	0.164	−0.227	0.115	−0.048	0.042	−0.169*	0.079	−0.241***	0.023	−0.066	0.211
Post-Turbine	−0.054	0.251	0.252	0.521	−0.026	0.052	−0.247*	0.133	−0.196**	0.031	−0.032	0.287
View*Announcement	0.064	0.045	−0.181*	0.048	0.064	0.041	0.052	0.083	0.167**	0.026	0.055	0.076
View* Post-Turbine	−0.003	0.052	−0.484**	0.05	0.003	0.03	−0.288**	0.101	0.07	0.026	−0.283**	0.1
Number of observations	471		309		1620		1569		1620		1569	
Adjusted R^2	0.7983		0.5735		0.7464		0.4009		0.7425		0.4002	

the announcement and post-turbine periods (View* Announcement; View* Post-Turbine). For the full sample models, we find negative and significant impacts from turbine construction for homes in NY with a turbine view. The estimated coefficient for this variable indicates that the values of homes in NY with a view of the turbines have, on average, been reduced by 16.9% following construction of the turbines[11] . Conversely, no significant impact is observed in ON in either period. It is also evident from the results that sale prices across the NY sample decreased in the post-turbine period relative to prices prior to this period, but this decrease was significantly greater for parcels that had a view of the turbines. A positive impact is found in NY during the announcement period, but conceivably during this time home buyers in New York may not have been aware of the proposed wind farm or the location of the turbines to be constructed, or at the very least may not have been aware of the impending impact on their viewshed. This positive impact may also be the result of an omitted variable related to water view on the NY side.

The property type has a major impact on sale price in both NY and ON. Waterfront properties sell at a substantial premium on both sides of the border, while seasonal homes sell for a premium in the full NY sample.[12] The negative coefficient for ON may be due to the prevalence of more rustic seasonal homes in the northern, mainland area of Frontenac County, which are used more for hunting and fishing purposes than as vacation homes. The lower values for these properties may offset to some degree the higher values of seasonal vacation homes on Wolfe Island, resulting in an insignificant estimate. In general, the seasonal homes in the NY study area are more likely to be vacation homes located on particularly attractive parcels, or in attractive locations, resulting in a price premium.

The results of the remaining control variables are fairly consistent between the two models, although there are some differences between ON and NY. As expected, living area, house quality, number of bathrooms, and the existence of a fireplace positively impact sale prices, while prices are inversely related to the age of the house, the distance to the St. Lawrence River, and the existence of a mobile home on the property. Lot size positively impacted prices in ON but did not significantly impact prices in NY, while the existence of air conditioning had a positive impact in NY but no significant impact in ON. The existence of forced air heating was positively related to sale price in ON but negatively related to sale price in NY.

The results of the specification in which turbine impacts are accounted for by distance to the nearest turbine are reported in Table 4. This specification is less susceptible to the small numbers problem highlighted above since every parcel has a distance to the nearest turbine and as such can contribute to the estimation of turbine impacts. The key variables of interest are the interaction terms between the inverse of the distance to the nearest turbine and each of the announcement and post-turbine periods (InvDistance* Announcement; InvDistance* Post-Turbine). We find some similarities between the results of this specification and those based on turbine view, but also some differences. In the full sample model, the estimated impact of proximity to turbines in the post-turbine period in NY is negative but not statistically significant, which differs from the result for turbine view. However, the full sample model result for ON is consistent with that of the turbine view model, with no significant impact observed. Similarly, the result of the 20 mile sample model for NY, which indicates a significant negative impact in the post-turbine period, is consistent with the turbine view model. This result indicates that parcels in closer proximity to turbines have experienced reductions in value relative to those at greater distances from the turbines. A positive impact is observed in the 20 mile sample model for ON in the post-turbine period, which is unexpected. While this impact is relatively low in magnitude (3.6%), it is significant at the 5% level. Inverse distance to turbine is negative and significant in both samples, indicating that real estate prices were relatively lower in areas close to the wind farm even before the turbines were constructed. Hence, the positive impact observed in ON in the post-turbine period may offset to some degree this negative impact in the pre-turbine period. The results for the control variables are quite consistent with those of the turbine view models.

In general, the results with respect to the turbine variables are relatively consistent between the full sample model and the 20 mile sample model. In particular, the direction of the estimated impacts for each of the turbine variables is consistent between the two models, while some slight differences in significance are observed. The full sample model provides the benefit of a larger control group from which to compare the treated properties, but the 20 mile sample may include a set of control properties that, while smaller in size, may be a more relevant set of properties (i.e., more likely to represent a single real estate market); as such, the estimated impacts of turbines on the treated properties may be more accurate. Overall, the results of both the view and distance specifications suggest that negative impacts associated with the Wolfe Island turbines have only occurred to any observable extent for properties on the NY side.

Given the potential issues inherent in the model specification for this analysis, it is important to conduct robustness checks to test the sensitivity of our primary results. We address two issues through our robustness checks. First, we further restrict our samples geographically to account for the potential bias that can occur if the assumption of a single market that underlies the hedonic model does not hold. In our study areas this assumption may not necessarily hold due to differences in the composition of residential property types and usage across each area. For example, on both sides of the border, the

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[11] This figure is derived based on coefficient interpretation for categorical variables in semi-log equations (see Halvorsen and Palmquist, 1980)

[12] NYSORPTS defines seasonal homes as those "Dwelling units generally used for seasonal occupancy; not constructed for year-round occupancy (inadequate insulation, heating, etc.)." MPAC is less specific about this definition for seasonal homes.

Table 6
Results for robustness checks — turbine distance.

	10 Mile sample				Alternate post-turbine period				Alternate announcement period			
	Ontario		New York		Ontario		New York		Ontario		New York	
Variable	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
InvDistance	−0.102*	0.015	−1.321	0.968	−0.133**	0.017	−1.125***	0.206	−0.133**	0.015	−1.225***	0.204
Announcement	−0.096	0.146	−0.379*	0.122	−0.043	0.034	−0.212**	0.081	−0.111*	0.031	−0.131	0.185
Post-Turbine	−0.055	0.257	0.309	0.475	−0.023	0.044	−0.214	0.143	−0.076	0.031	−0.023	0.267
InvDistance*Announcement	0.012	0.01	0.85	0.872	0.021	0.016	0.433**	0.189	0.021**	0.004	0.488**	0.155
InvDistance* Post-Turbine	0.025	0.03	0.013	0.431	0.031*	0.009	−0.419**	0.165	0.034**	0.004	−0.343*	0.18
Number of Observations	471		309		1620		1569		1620		1569	
Adjusted R^2	0.802		0.5736		0.7464		0.4009		0.7425		0.4002	

areas that would be most affected by the wind turbines (i.e., Wolfe Island and Cape Vincent), have proportionally more waterfront properties relative to the other areas of their respective counties, and are also used to a greater extent for vacation purposes. Such differences could potentially introduce bias into our estimates of the turbine impacts. To address this potential bias, we consider a specification that restricts our samples to parcels within 10 miles of the turbines, which include 471 parcels in the ON sample and 309 parcels in the NY sample.

Second, as described above in our data section, due to the uncertainty around the time at which turbine impacts could conceivably begin to occur, we test alternate specifications of the post-turbine and announcement periods, using the 20 mile sample models. For the alternate post-turbine period specification we use the date that turbine construction began (May 2008), rather than the date construction was completed (June 2009) as the date following which impacts would be expected to occur. We specify the alternate announcement period to begin following approval of zoning bylaw amendments (November 2006) rather than using the date that the project was officially announced (April 2007).

The results of the robustness checks are provided in Tables 5 (turbine view) and 6 (turbine distance). The results of the 10 mile sample model for turbine view are similar to those of our primary models, with a negative impact on property values in the post-turbine period in NY and no significant impacts in ON. In addition, there is evidence of a negative impact in the announcement period in NY. The results of this model for turbine distance indicate no evidence of significant impacts of turbines in either ON, which is consistent with the full sample model, or NY, which is consistent with the 20 mile sample model. The results of the alternate post-turbine and announcement period specifications are also similar to those of our primary specifications for both view and distance, particularly for the post-turbine interaction variables. One difference from the primary specifications is that positive impacts are observed in the announcement period in ON for both view and distance. Overall, the results of the robustness checks support the results of our primary models, where evidence of negative impacts on property values in the post-turbine period are found only in NY.

5. Discussion and Conclusions

There are two main contributions of this paper. First, it provides evidence that impacts of wind turbines on property values vary depending on the context. Second, it identifies some factors that may contribute to the occurrence of significant impacts and explain the variation in the results of the literature related to this issue. This paper also adds to the growing amount of evidence that wind facilities can have significant economic impacts on property values. In our particular context, with a unique setting in which two communities separated by an international border are affected by the same wind farm, we find evidence that property values are negatively impacted by wind turbines, but only on one side of the border.

This finding implies that there are some contextual factors that influence whether property values in a local area are negatively impacted by wind turbines. The finding of negative impacts on property values in New York but not in Ontario, despite the fact that many properties on Wolfe Island are located in among the turbines, is somewhat surprising given that concerns were raised on both sides of the border. However, this may reflect the cross-border difference in the level of involvement in the project development process. In addition, as indicated in Fast et al. (2015) , there are a fair number of residents, both long-time residents and newcomers, on Wolfe Island that are quite supportive of the wind farm. Those who support the wind farm are less likely to be concerned about impacts on property values and may not reduce their willingness-to-pay for properties with a view of or in close proximity to the turbines. If a large enough proportion of residents and potential homebuyers support the wind farm and believe it benefits the community, this may reduce the likelihood or magnitude of impacts on property values. In addition, the township of Frontenac Islands receives an annual payment of C$645,000 from the developer that may also be working counter to negative impacts on property values. These factors could also contribute to the observed positive impact in ON in the post-turbine period.

It is evident from the results of the primary models and robustness checks that negative impacts of wind turbines on properties in NY are more likely to be attributable to turbine view rather than to proximity to turbines. There is more robust evidence in the results for NY of significant negative impacts in the post-turbine period for turbine view. This is not surprising, given the types of properties in NY that are potentially impacted by the Wolfe Island wind turbines. Many of these properties are vacation homes and waterfront homes, for which a considerable amount of value tends to be derived from an aesthetic view. As such, it is more likely that turbine view will contribute to a negative property value impact than proximity to turbines, since properties in close proximity to turbines do not necessarily have a direct view of them.

While there are also many vacation homes and waterfront homes on Wolfe Island, these properties do not appear to be impacted by the view of the turbines in the same way that similar properties are impacted on the NY side. This could be due to a key difference in how the turbines affect the viewshed, particularly for waterfront properties, between the two sides of the border. On Wolfe Island, the view of the water for most waterfront properties is not obstructed by the turbines, as the turbines are located in-land from these properties (i.e., "behind" the waterfront properties). As such, there may not be much of an impact on the amenity value associated with the view from these properties. Conversely, on the NY side the turbines factor quite prominently into the view of the water for many of the waterfront properties, which may contribute to a greater impact on the values of these properties.

There are limitations in this study that should be acknowledged. First, as noted by Hoen et al. (2015), the use of inverse distance to account for turbine impacts involves estimating this impact at the mean distance from the turbines, which can hamper the ability to generate accurate impacts in close proximity to the turbines. This issue could potentially be avoided through the use of discrete distance bands. However, this approach may be unable to detect significant impacts within specified bands if the number of affected sales is relatively low, which is the case in our study. In fact, the low number of treated observations on both sides of the border represents a major limitation of this study, as it may impede the ability to detect significant impacts or to generate accurate estimates of these impacts. In addition, across the models estimated in the primary analysis and the robustness checks there are some changes in significance for some of the primary variables of interest, which may be cause for concern. Due to these issues, the results of this study regarding the impacts of the Wolfe Island wind turbines on surrounding property values should be viewed with considerable caution.

Interestingly, however, the finding of significant negative impacts on property values on the NY side occurred despite the fact that there were fewer sales with a view of the turbines than on the Ontario side. This suggests that the lack of evidence of negative impacts on the Ontario side is not necessarily due to a lack of observations. However, the possibility remains that parcels that are impacted the most by the turbines were not sold or were unable to be sold. Unfortunately, data is not available to examine this issue; as such, this represents an important caveat to our study results.

Despite these limitations, this paper provides an interesting case study that can add to the growing body of literature on this issue, particularly with respect to understanding the variation in results in the literature. Given that variation has even occurred among recent studies (Gibbons, 2015; Hoen et al., 2015) that have overcome the issue of low numbers of observations that plagued prior studies, it is worthwhile to identify factors that could influence the likelihood that wind facilities will impact property values. The unique setting of our study has enabled us to highlight some contextual factors that could contribute to differences in estimated impacts.

First, the quality of the view prior to construction of wind turbines may influence the nature of any observed impacts. Related to this factor, impacts could vary across different types of properties. For example, vacation homes and waterfront properties, for which the view is likely to be an important amenity, could be impacted to a greater degree than other types of properties. Subsequently, the likelihood of observing negative impacts would be greater in areas with a relatively high proportion of such properties. This may have been the case in our study, where many of the affected properties on the NY side were waterfront properties, for which the turbines had a greater impact on the view amenity relative to that of waterfront properties on the ON side.

Another factor influencing the nature of potential impacts could be the level of involvement or public participation that local residents have in the planning and development process for wind facilities. The amount of involvement may influence perceptions of wind energy, where a lack of involvement may contribute to negative perceptions (Devine-Wright, 2005) . In this study, we compared two jurisdictions affected by the same wind farm, one of which was involved in the process and one that was unable to participate in the process and did not receive any compensation from the developer. This difference may have contributed to the difference in observed impacts between the two jurisdictions.

However, while we have identified a number of factors that may have contributed to the observed differences in impacts between the two jurisdictions, we should stress that these explanations, though plausible, remain speculative, as we are unable to isolate these factors in order to test the extent to which each factor contributed to the differences in estimated impacts. Future research on settings with similar contextual factors is needed to support these conjectures.

This study reinforces the notion that the nature of the impacts of wind turbines on property values depends on the specific context of each wind facility, which helps to rationalize the varied results in the literature. In our case, we have impacts that differ across two communities impacted by the same facility. This implies that, in general, researchers should not expect there to be one single answer to the question of how wind farms affect property values, and that the lack of consensus in the literature is not necessarily problematic. Instead, making any forecast of anticipated impacts will require a more careful comparison to communities with similar contextual factors that have already been studied. As in any benefits transfer process, finding a proper comparison site is the critical task when using results from one community to predict outcomes for another. Given that the rationale we provide for the differences observed in our study is primarily conjecture, future research could focus on better identifying and understanding the contextual factors that contribute to an increased likelihood of observing negative property value impacts from wind facilities.

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