Values in the Wind: A Hedonic Analysis of Wind Power Facilities*

Martin D. Heintzelman

Carrie M. Tuttle

March 3, 2011

Economics and Financial Studies

School of Business

Clarkson University

E-mail: mheintze@clarkson.edu

Phone: (315) 268-6427

*Martin D. Heintzelman is Assistant Professor, Clarkson University School of Business. Carrie M. Tuttle is a Ph.D. Candidate in Environmental Science and Engineering at Clarkson University. We would like to thank Michael R. Moore, Noelwah Netusil, and seminar participants at Binghamton University as well as the 2010 Thousand Islands Energy Research Forum and the 2010 Heartland Economics Conference for useful thoughts and feedback. All errors are our own.

ABSTRACT: The siting of wind facilities is extremely controversial. This paper uses data on 11,369 property transactions over 9 years in Northern New York to explore the effects of new wind facilities on property values. We use a repeat-sales framework to control for omitted variables and endogeneity biases. We find that nearby wind facilities significantly reduce property values. Decreasing the distance to the nearest turbine to 1 mile results in a decline in price of between 7.73% and 14.87%. These results indicate that there remains a need to compensate local homeowners/communities for allowing wind development within their borders.

1 Introduction

Increased focus on the impending effects of climate change has resulted in pressure to develop additional renewable power supplies, including solar, wind, geothermal, and other sources. While renewable power provides several environmental advantages to traditional fossil fuel supplies, there remain significant obstacles to large-scale development of these resources. First, most renewable energy sources are not yet cost competitive with traditional sources. Second, many potential renewable sources are located in areas with limited transmission capacity, so that, in addition to the costs of individual projects, large-scale development would also require major infrastructure investments. Finally, renewable power projects are often subject to local resistance.

Wind power is, by far, the fastest growing energy source for electricity generation in the United States, capacity and net generation having increased by more than 1,348% and 1,164%, respectively, between 2000 and 2009. No other sources of electricity have even doubled in capacity over that period. This sort of growth for wind energy is expected to continue into the future, although not at quite those high rates.[1] If additional steps are taken to combat global climate change, the demand for wind energy would only increase relative to these forecasts.

There are many outspoken critics who focus on the potential negative impacts of wind projects. These critics point to the endangerment of wildlife including bats, migratory birds, and even terrestrial mammals. Some critics also point to detrimental human health effects including abnormal heartbeat, insomnia, headaches, tinnitus, nausea, visual blurring, and panic attacks.[2]

There are also more mundane concerns about the aesthetics of these facilities. One oft-quoted critic, Hans-Joachim Mengel a Professor of Political Science at the Free University, Berlin, has likened Wind Turbines to “the worst desecration of our countryside since it was laid waste in the 30 Years War nearly 400 years ago.”[3] If wind turbines are perceived to have this manner of impact on local areas, they would have a strong negative impact on local property values.

To give an idea of how far-reaching we might expect the impacts to be, consider that estimated sound levels for a typical turbine at a distance of 1500 ft. are 50 dBA, equivalent to a normal indoor home sound level (Colby et al., 2009). In comparison, the Occupational Safety and Health Administration (OSHA) requires that sound levels for prolonged unprotected occupational exposures be less than 90 dBA. This exposure would be equivalent to standing next to a highway with heavy diesel trucks passing by for an 8-hour time period.[4] Typically, distances between wind turbines and receptors are regulated at the local level. The New York State Energy Research and Development Authority (NYSERDA) recommends turbine setbacks of 1000 ft. from the nearest residence (Daniels, 2005). These setbacks focus on general safety considerations such as turbine collapse instead of specific health impacts associated with noise or vibration. The National Environmental Protection Act and comparable New York State Environmental Quality Review legislation prescribe a general assessment process that does not define specific turbine setback requirements. Viewshed impacts are more far reaching but vary widely by property and depend on land cover and property elevations.

As a result of these potential effects, the siting of wind facilities is extremely controversial, and debate about siting has caused delays and cancellations for some proposed installations. Perhaps the most famous case is that of Cape Wind in Massachusetts. First proposed in 2001, this project, approved by the U.S. Department of Interior in April 2010, calls for the construction of 130 turbines, each with a maximum blade height of 440 ft., approximately 5 miles off the shore of Cape Cod between Cape Cod and Nantucket. In response, local activists have organized the "Alliance to Protect Nantucket Sound" to fight the proposal through the courts and other avenues. This is despite the fact that the primary local impact is expected to be the impacted view from waterfront properties.[5] In the case of terrestrial projects, the opposition can be even stronger. In Cape Vincent, NY, in Jefferson County, wind developers have been working since 2006 to construct two separate facilities that include 147 turbines. Cape Vincent is bordered to the north by the St. Lawrence River and Lake Ontario, within view of an eighty-six turbine wind farm on Wolf Island in Ontario, Canada, and within a short drive to the largest wind farm in New York State. The response to the proposal has been spirited with both pro- and anti-wind factions fighting to determine its fate. In October of 2010, a lawsuit was filed to nullify a town planning board's approval of a final environmental impact statement; the meeting at which it was approved had been disrupted by vocal protestors.[6] Recent reports in the popular media suggest that such controversy over wind turbines is widespread.[7]

At the individual level, property owners willing to permit the construction of turbines or transmission facilities on their property receive direct payments from the developer as negotiated through easement agreements. In terms of community benefits, wind developers claim that their projects create jobs and increase tax revenues by way of payment in lieu of taxes (PILOT) programs. PILOTs are a significant revenue source that can help offset overall town and school tax rates for all residents. These host community benefits are not unlike those made to communities that have permitted the construction of landfills within their municipal boundaries. In the case of Cape Vincent, a town appointed committee evaluated the economic impacts of the proposed facility and concluded that 3.9% of property owners would benefit directly from easement payments made by the developers.[8] Easement payments are negotiated with individual land owners and are not publically available so the magnitude and actual economic benefit to these property owners was not quantified. PILOT agreements between the developers and the Town were estimated at $8,000 per turbine or $1.17 million per year. In the opinion of some Cape Vincent property owners, local officials are negotiating PILOT agreements to the benefit of the municipality, individual property owners are negotiating individual easement agreements to offset their respective property impacts, and property owners in close proximity to turbines are left with no market leverage to offset the impacts that they believe turbines will have on their property values. This is the externality problem that is at the heart of the issue.

In moving forward with wind power development then, it is important to understand the costs that such development might impose. Unlike traditional energy sources, where external/environmental costs are spread over a large geographic area through the transport of pollutants, the costs of wind development are largely, but not exclusively, borne by local residents. Only local residents are likely to be negatively affected by any health impacts, and are the people who would be most impacted by aesthetic damages, either visual or audible. These impacts are likely to be capitalized into property values and, as a consequence, property values are likely to be a reasonable measuring stick of the imposed external costs of wind development.

The literature that attempts to measure these costs is surprisingly thin. To our knowledge, there are only two peer-reviewed hedonic analyses that examine the impact of wind power facilities on property values. Sims et al. (2008) and Sims et al. (2007) use small samples of homes near relatively small wind facilities near Cornwall, UK and find no significant effect of turbines on property values. The first of these studies has very limited data on homes, just home 'type' and price, and uses a cross-sectional approach. In addition, there is a quarry adjacent to the wind turbines, and other covarying property attributes which makes identification of the wind turbine effect very difficult. They actually do find a significant negative effect from proximity to the turbines but based on conversations with selling agents, attribute this instead to the condition and type of the homes. The second study uses a very small sample of only 201 homes all within the same subdivision and a cross-sectional approach. They focus specifically on whether homes can view the turbines and have very limited data on home attributes. Moreover, given the small geographic scope of the analysis, it is unlikely that there was sufficient variation in the sample to identify any effect; all of the homes were within 1 mile of the turbines.

In 2003, Sterzinger et al. released a report through the Renewable Energy Policy Project (REPP) which used a series of 10 case studies to compare price trends between turbine viewsheds and comparable nearby regions and found, in general, that turbines did not appear to be harming property values. This analysis, however, was not a true hedonic analysis. Instead, for each project they identified treated property transactions as being within a 5 mile radius of the home and a group of comparable control transactions outside of that range. They then calculated monthly average prices, regressed these average prices on time to establish trends and then compared these trends between treatment and control groups. They did not control for individual home characteristics or any other coincident factors.

Hoen (2006) also focuses on the view of wind turbines, and collects data for homes within 5 miles of turbines in Madison County, NY. His sample is also small, 280 transactions spread over 9.5 years, and he uses a cross-sectional approach. He fails to find a significant impact from homes being within viewing range of the turbines. Hoen et. al (2009) use a larger sample of 7,500 homes spread over 24 different regions across the country from Washington to Texas to New York that contain wind facilities and again find no significant effect. They look at transactions within 10 miles of wind facilities and use a variety of approaches, including repeat sales. However, they limit themselves to discontinuous measures of proximity based on having turbines within 1 mile, between 1 and 5 miles, or outside of 5 miles, or a similar set of measures of the impact on scenic view, and they again find no adverse impacts from wind turbines. In addition, by including so many disparate regions within one sample they may be missing effects that would be significant in one region or another.

There is also a small literature using stated preference approaches to value wind turbine disamenities. Groothuis, Groothuis, and Whitehead (2008) asked survey respondents about the impact of locating wind turbines on Western North Carolina ridgetops and found that on average households are willing-to-accept compensation of $23 to allow for wind turbines, although retirees moving into the area require greater compensation. Similarly, Krueger, Parsons, and Firestone (2011) surveyed Delaware residents about offshore wind turbines and find that residents would be harmed by between $0 and $80 depending on where the turbines are located and whether the resident lives on the shore or inland.

This paper improves upon this literature using data on 11,369 arms-length residential and agricultural property transactions between 2000 and 2009 in Clinton, Franklin, and Lewis Counties in Northern New York to explore the effects of relatively new wind facilities. We use a repeat-sales fixed effects analysis to control for the omitted variables and endogeneity biases common in hedonic analyses, including the previous literature on the impacts of wind turbines. We find that nearby wind facilities significantly reduce property values. To be specific, decreasing the distance to the nearest turbine to 1 mile results in a decline in price of between 7.73% and 14.87% on average. In addition we confirm that census block-group fixed effects models are subject to endogeneity bias and that this bias inflates the negative impacts of turbines on property values by about 35%. These results are consistent across continuous functional specifications of the proximity effect. However, attempts to control for dis-continuities through a series of dummy and count variables representing the presence of turbines at various distances are insignificant.

Section 2 provides background information on wind development and on the study area. Section 3 provides detailed information on our data and empirical approach. Section 4 provides analytical results and Section 5 concludes the paper by discussing the implications of our study and guidance for further research in this area.

2 Background and Study Area

New York State is a leader in wind power development. In 1999, New York had 0 MW of installed wind capacity, but by 2009 had 14 existing facilities with a combined capacity of nearly 1300 MW, ranking it in the top 10 of states in terms of installed capacity.[9] New York also appears to have more potential for terrestrial wind development than any other state on the east coast.[10] This is borne out by the fact that there are an additional 28 wind projects in various stages of proposal/approval/installation in the state. [11]

New York has also been badly affected by the environmental impacts of traditional energy sources. The Adirondack Park, the largest park of its sort in the country, in particular, has been severely impacted by acid deposition and methyl mercury pollution (Banzhaf et al., 2006). In that sense, the state has much to gain from transitioning away from fossil sources of energy and towards renewable sources like wind. New York, however, has relatively little potential to develop solar, geothermal, or other renewable sources. Existing wind developments are spread throughout the state, with clusters in the far west, the far north, and in the northern finger lakes region. The largest projects, however, are in what is often referred to as ‘The North Country,’ and are in the three counties - Clinton, Franklin and Lewis Counties - which make up our study area, shown in Figure 1, together with the outline of the Adirondack Park and the location of the wind turbines in this area.

Northern New York is dominated by the presence of the Adirondack Park. The Adirondack Park was established in 1892 by the State of New York to protect valuable natural resources. Containing 6.1 million acres, 30,000 miles of rivers and streams, and over 3,000 lakes, the Adirondack Park is the largest publically protected area in the United States and is larger than Yellowstone, Everglades, Glacier, and Grand Canyon National Park combined. Approximately 43% of the Park is publically owned and constitutionally protected to remain “forever wild” forest preserve. The remaining acreage is made of up private land holdings. There are no wind facilities within the borders of the Park, but as you can see in Figure 2, the facilities in our study are very close. There are six wind farms in our study area, as summarized in Table 1.[12]

Table 2 presents a comparison of the counties in our study area to the New York State and United States averages for population density and per capita income. As that table shows, our study area is a very rural, lightly populated area of small towns and villages that is also less affluent than the state average. The largest population center in our study area is Plattsburgh, NY with a 2000 population of about 18,000.

3 Data and Methodology

Our data consists of a nearly complete sample of 11,369 residential and agricultural property transactions in the Clinton, Franklin and Lewis Counties from 2000-2009. Of these there are 1,955 from Lewis, 3,255 from Franklin, and 6,159 from Clinton counties. Each observation constitutes an arms-length property sale in one of the three counties between 2000 and 2009. Parcels that transacted more than once provide a greater likelihood of observing specific effects from the turbines on sales prior to and after installation. In total, 3,890 transactions occurred for 1,903 parcels that sold more than once during the study period.

Transacted parcels were mapped in GIS to enable us to calculate relevant geographic variables for use in the regressions. Turbine locations were obtained from two different sources. In Lewis County, a GIS shapefile was provided by the County which contained 194 turbines. According to published information on the Maple Ridge wind project, there are 195 turbines at the facility (Maple Ridge Wind Farm). Noble Environmental Power would not provide any information on their turbine locations so 2009 orthoimagery was utilized to create a GIS shapefile with the turbine locations in Franklin and Clinton counties.

Turbine locations in combination with several other datasets were merged using ESRI ArcView GIS software and STATA data analysis and statistical software to form the final dataset. Transacted parcels were mapped in GIS to determine the distance to the nearest turbine. Then buffers, ranging in size from 0.1 to 3.0 miles, were created around each parcel polygon and these were spatially joined with the turbine point data to compute the number of turbines located within these various distances from the parcels. Buffer distances are used as a proxy to estimate the nuisance effects of the turbines (i.e., viewscapes and noise impacts). The distance to turbines and number of turbines by parcel were exported from GIS and combined with the other parcel level details in STATA. Table 3 summarizes the datasets that were used in the analysis and their sources. Table 4 provides summary statistics for many of the variables included in our analysis.

3.1 Methodology

Our analytical approach to estimating the effects of wind turbines on property values is that of a repeat sales fixed-effects hedonic analysis. We are attempting to estimate the 'treatment' effect of a parcel's proximity to a wind turbine. There are a number of difficulties in measuring the effect of turbines. First and foremost, there is a question of when a turbine should be said to 'exist.' The obvious answer is that turbines exist only after the date on which they become operational. However, there is a long approval process associated with development of these projects and local homeowners presumably will have some information about where turbines will be located some years before they actually become operational. To deal with this issue, we run our regressions with three different assumptions about the date of existence - the date the draft environmental impact statement was submitted to the New York State Department of Environmental Conservation, the date the final environmental impact statement was approved, and the date at which the turbines became operational.

In addition, given the uncertain and possibly diverse physical/aesthetic impacts of turbines, it is difficult to know how to measure proximity. Is it distance to the turbine, whether or not the turbine can be seen, whether or not the turbine can be heard/felt, or all of the above? For all of these factors, it is reasonable to suspect that distance would work as a proxy measure. That is, homes closer to turbines will be more likely to see the turbines and more likely to hear or feel vibrations from the turbines. So, all of the measures that we employ will be distance based, starting with the simplest - the inverse of the distance to the nearest turbine.[13] This inverse distance measure is also calculated with the date of the turbines' existence in mind. So, distance will decrease (inverse distance will increase) for all parcels after new turbines come into existence. Unlike some of the previous studies of these effects, we are dealing with very large facilities, so that if a parcel is near at least one turbine it is likely near many turbines. To account for this, we employ simple dummy variables for the presence of at least one turbine within various distances from the parcel as well as count variables for the number of turbines within those distances. This enables us to test for any 'density' effects. These variables also potentially change over time as new turbines are sited. Table 5 presents summary statistics for the various measures of the effect of wind turbines that we employ.

In addition to these various measures of the proximity of homes to wind turbines, we include a number of other covariates. These include distance to the nearest major road, the value of any personal property included in the transaction, whether or not the home is in a 'village,' which would imply higher taxes, but also higher services and proximity to retail stores and restaurants, in addition to standard home characteristics including number of bedrooms, bathrooms, half-baths, the square footage of the house, the age of the home, and the size of the lot. We also include parcel level land cover data which tells us the share of each parcel in a number of different land cover categories (woodland, pasture, crops, water, etc.). To capture possible information asymmetries between buyers and sellers we include a dummy variable for whether or not the buyer was already a local resident or moving in from outside of 'the North Country.' This is particularly important since there is good reason to believe that local residents would have more information about the future location of turbines, and about any associated disamenities than someone moving into the area. Finally we include a series of relatively subjective measures of construction quality and property classification (mobile homes, primary agriculture, whether or not the home is winterized, etc.) that come from the NYSORPS (New York State Office of Real Property Services) assessment database.

3.1.1 Empirical Issues

As Greenstone and Gayer (2009), amongst others, lay out, omitted variables bias is a major concern in any hedonic analysis. Put simply, there are almost innumerable factors that co-determine the price of a property, and many or most of these factors are unobservable to the researcher. If any of the unobserved factors are also correlated with included factors, then the resulting coefficient estimates will be biased. Fixed effects analysis, by implicitly including a large series of dummy variables representing small geographic areas, or, better yet, individual parcels, captures the effects of any of these unobserved factors that are constant or similar across the geographic scale of the fixed effects. For instance, if homes in a particular census block are especially attractive because of some unobservable factor then the fixed effects analysis would implicitly pick up the effect of this amenity on the price of homes in that census block.

The smaller the geographic scale of the fixed effects, the tighter the controls will be for omitted variables bias. The tradeoff, however, is that since variation in the remaining observable explanatory variables can only be observed within the scale of the fixed effects, a smaller geographic scale means less variation and less power with which to estimate these remaining coefficients. That is, if we are interested in the distance from each parcel to the nearest major road, the statistical power to measure this comes only from variation in this distance within the scope of the fixed effects (ie. the census block). Presumably, since homes within a census block are all close to each other, they will all be a similar distance to the nearest road and thus there is limited variation with which to measure this effect. In a repeat sales analysis, since parcel location and most other characteristics are assumed to be fixed, one can only estimate the effects of time-variant factors. However, this level of analysis provides the cleanest measures of these effects.[14]

Equally concerning in attempting to accurately estimate the effects of a discrete change in landscape, like the construction of a wind turbine, is endogeneity bias. This bias has a similar effect as omitted variables bias but a slightly different cause. Endogeneity bias enters when the values of the dependent and one or more independent variables are co-determined. In the case of hedonic models, if property values determine the location of some facility, and that facility also impacts property values, we have endogeneity bias. In our case we do need to be concerned about this since it is likely that, ceteris paribus, wind turbines will be sited on lower-value, cheaper land. Then, if this is not corrected, we might falsely conclude that wind turbines negatively impact property values or, at least, overstate any negative impacts, simply because wind turbines are placed on cheaper land. This selection effect would cause us to confuse correlation with causation.

To control for these selection effects we use repeat sales, parcel level, fixed effects analysis. While census block level fixed effects will do something to control for this effect since lower value census blocks will be more attractive for the siting of turbines, if selection of sites for affordability occurs within census blocks, that is, if the cheapest parcels within a block are more likely to have or be near a turbine, then endogeneity bias would still be present. Therefore, the best available correction for endogeneity is parcel-level fixed effects. If there is some characteristic of a parcel that makes it cheaper, and that makes it attractive for turbines, the parcel-level fixed effects control for this selection effect.[15]

Finally, we have to be concerned about spatial dependence and spatial autocorrelation. There is no doubt that homes that are close to each other affect each other's prices (spatial dependence) and that unobserved factors for one home are likely to be correlated with unobserved factors for nearby homes (spatial autocorrelation). Both of these factors would bias our results if not corrected. We correct for these issues using fixed effects, again, for the first and error clustering for the second. The fixed effects analysis is akin to employing a spatial lag model with a spatial weights matrix of ones for pairs of parcels within the same geographic area, the scale of the fixed effects, and zeros for pairs of parcels in different areas. Likewise, the error clustering allows for correlation of error terms for parcels within an area and assumes independence across areas. This is akin to employing a spatial error model with the spatial weights matrix as described just above to control for spatial autocorrelation.[16] In this way it also controls for heteroskedasticity (Wooldridge, 2002).

Formally, we estimate two regression equations. The first uses census block or block group fixed effects:

$$\ln p_{ijt} = \lambda_t + \alpha_j + z_{ijt}\beta + x_{ij}\delta_{jt} + \eta_{jt} + \epsilon_{ijt} \tag{1}$$

where p_{ijt} represents the price of property i in group j at time t; λ_t represents the set of time dummy variables; α_j represents the group fixed effects; z_{ijt} represents the treatment variables - the different measures of the existence/proximity of turbines at the time of sale; x_{ijt} represents the set of other explanatory variables; and η_{jt} and ϵ_{ijt} represent group and individual-level error terms respectively. This specification is adapted from Heintzelman (2010a, 2010b) and follows from Bertrand, Duflo, and Mullainathan (2004) and Parmeter and Pope (2009).

The second regression equation uses the repeat sales approach:

$$\ln p_{it} = \lambda_t + \alpha_i + z_{it}\beta + \epsilon_{it} \tag{2}$$

where λ_t represents year dummies, α_i represents parcel fixed effects, z_{it} represents time varying parcel level characteristics, and ϵ_{it} is the error term. In effect, this analysis regresses the change in price over time on the change in any time-variant factors. In our case these time varying factors are the proximity of turbines, the age of any home on the parcel, and the year in which the sale takes place.

4 Results

We present our results beginning with the coarsest scale of fixed effects, the census block-group, before refining this approach by using census block and then parcel-level fixed effects. Keep in mind that these results are subject to endogeneity bias because of the selection effects discussed above. In Table 6, we display results of estimating Equation 1 including one wind variable at a time with each of the other covariates.[17] The rationale for this is that, except for the distance variable, these measures are not exclusive of one another, and are thus highly collinear. All of the results presented here assume that turbines exist at the date the Final Environmental Impact Statement (EIS) is issued. This accounts for the fact that local residents and most other participants in real estate markets will be aware of at least the approximate location of turbines before they are actually constructed. In fact, most of the turbine locations would be known, if not publically, well before this since developers typically negotiate with individual landowners before moving forward with regulatory approvals. Our results are quite robust to adjusting the date of 'existence' forwards to the date of the draft EIS. If we adjust this date backwards to the date of the permit being issued the results are qualitatively similar, but we lose significance - likely because we then have even fewer post-turbine transactions in the 'treatment' group.

First, notice that the covariate results are largely as would be predicted. Homeowners in this region prefer larger homes, more bathrooms and fireplaces, and to be close to major roads. The road result may be counter-intuitive, but remember the rural character of our study area; distance to a major road is a measure of the relative isolation of a parcel. Homeowners also take into account the value of included property, and appear to prefer to be outside of established villages. This may be a tax story as those homeowners in outlying areas face considerably lower property taxes. However, homes outside of villages generally have larger lots. Lot size is, unusually, not a significant factor. This may be because of the large size of most parcels in our sample, but also may be related to the inclusion of the village identifier.[18] Local buyers pay about 9% less than others.[19] Residents appear to not value additional bedrooms, but since we are controlling for house size, this result is likely because, ceteris paribus, more bedrooms means smaller bedrooms. Not surprisingly, parcels with more dedicated agricultural land are priced lower, controlling for acreage, and homes with open water or wetlands are more valuable. These measures are partially proxying for a home being waterfront. The presence of multiple families, including apartments, or mobile homes on a parcel also reduce the price, while 'estates' receive a premium.[20] Strangely, homes classified as having 'excellent' construction quality appear to sell for less than those with average quality in the block-group model while selling for more in the census block model. The negative, insignificant, result is likely to due to the small number of homes with this classification and omitted variables bias that is corrected for in the census block model. Meanwhile, minimum and economy quality homes sell at substantial discounts of about 50.5% and 27% respectively relative to average quality homes. Finally, age has a negative but diminishing impact as older homes, all else equal, will sell for less.

The wind results are also broadly consistent with intuition. At the block-group level, the existence of turbines between up to 1 and 3 miles away negatively impacts property values by between 15.6% and 31%, while having at least one turbine on the parcel reduces prices by 65%. The significance of this last result is surprising given that only 3 parcels in our sample contain turbines at the time of sale and thus may be spurious. Effects for turbines at other distances are also negative though insignificant, and this is likely, and in part, because of a lack of variation in these variables; only 39 of the observations in our sample have turbines within 0.5 miles at the time of sale (about 0.3%). We also find that the marginal turbine has a negative effect at all ranges and is significant in the same ranges as above. At the block level we see many of the same effects, with turbines in the 0.1 mile range also having significant effects. At both scales, the ln(inverse distance) measure is significant and negative. We will discuss the interpretation of this coefficient in Section 5.

Table 7 contains results from using two additional sets of variables to represent the effects of wind turbines. These are dummy variables and count variables representing the existence of turbines within concentric rings around each parcel.[21] The ln(inverse distance) measure is also included as a covariate, and, as above, it is negative and significant. These measures show less consistent results than those above. At very small distances there appears to be a positive effect with the sign switching between positive and negative at larger distances. These results are robust to excluding the ln(inverse distance) variable. One reason for the inconsistent and generally insignificant results for these estimates is that even though these measures are not dependent on one another, there is still a high degree of collinearity between the number of turbines within each of the ranges.

All of the results in Table 6 and Table 7, however, are subject to endogeneity bias. If it is true that lower value parcels are more likely to contain or be near wind turbines due to selection effects, than these estimates would overstate the negative impact of turbine proximity. Tables 8 and 9 present results from the estimation of Equation 2 that control for these selection effects using parcel-level fixed effects. Specifically, Table 8 presents results from using each turbine measure individually in regressions with only year and month dummies and the age of the home and Table 9 presents results from using the distance measure with the concentric circle turbine dummies and count variables. Here we see a consistent negative impact from proximity to the nearest turbine, and little other significance. We do find a significant positive impact from having turbines within 0.1 miles when proximity measures are included individually, and weakly significant positive impacts for turbines between 0.5 and 1 mile away as well as negative impacts for turbines between 1 and 1.5 miles away in the concentric circle model. These results are plausible if homes very close to existing turbines expect that future wind development may be possible on their parcels, which would necessitate easement payments.

The coefficient on age is now positive and significant. This sign reversal might be explained by the fact that, in the repeat-sales framework, this variable represents the change in age, or the number of years between sales for a parcel. We are controlling for the dynamics of the real estate market through year and month dummy variables, but this may be acting as an additional control for general appreciation over the sample period.

Throughout all of these regressions, however, the ln(inverse distance) measure is strongly significant and negative, which indicates that wind turbines are negatively impacting property values in a way that is declining over the distance from the turbines. Notice that the effects are somewhat larger in the block-group model than in the census block or repeat sales models. This is suggestive of endogeneity bias in the block-group model.

We would expect there to be systematic differences in the effects of wind turbines across the counties in our sample. In particular, the turbines in Lewis County were installed in 2004-2005 and those in Clinton and Franklin County were only installed in 2008-2009. So, homeowners in Lewis County have more experience with the turbines and, in addition, we observe more post-turbine transactions in Lewis County with which to identify impacts. Table 10 reports repeat sales results by area - Lewis County vs. Clinton/Franklin Counties. We combine Clinton and Franklin Counties since the turbines in these counties were installed at very close to the same time and the wind farms are nearly adjacent to one another. We see that proximity effects are still negative, but not significant in Lewis County, which is somewhat surprising, but may result from the small number of observations, or from the fact that familiarity with the turbines has diminished their impact. Meanwhile, proximity effects are negative and strongly significant in Clinton/Franklin Counties. In both areas there continue to be unexplained significant impacts from turbines within some concentric circles.

Another interesting way to segment the data is along the dimension of whether or not the buyers in a transaction are local residents (from the five counties that make up the North Country). The idea is that local buyers might be more aware of the effects of turbines, particularly after the fact, and also more likely to know about turbine locations and potential locations. In Table 11 we see that the proximity effect is more than halved for local buyers vs. non-local buyers.[22] This suggests that non-local buyers are more wary of turbines and their effects than local residents which may also be a function of familiarity.

5 Discussion and Conclusions

The results in this study appear to indicate that proximity to wind turbines does have a negative and significant impact on property values. Importantly, the best and most consistent measure of these effects appears to be the simple, continuous, proximity measure, the ln(inverse distance) to the nearest turbine. The estimated coefficient on this variable is consistently negative and significant. One reason for this consistency is that, unlike the dummy and count variables, the distance measure changes for nearly every parcel in our dataset between transactions, as long as new turbines are sited in the interim. In contrast, changes in the count/dummy variables are comparatively rare. Also, as we have already mentioned, the count and dummy variable measures are highly collinear and so it is difficult to effectively estimate effects using those variables.

The magnitude of the proximity effect depends on how close a home is to a turbine and is very important since any decision-maker will need to understand both how large the discount is and how far it extends away from the turbines. Since it is a log-log specification, the estimated coefficient represents the elasticity of price with respect to the inverse of the distance to the nearest turbine. So, a coefficient of $-\beta$ implies that a 1% increase in the inverse distance (a decrease in distance to the nearest turbine) decreases the sale price by β%. Inverse distance declines as distance increases, so this tells us that the impacts of wind turbines similarly decay. Using the estimated coefficients above, we can calculate the percentage change in price from a given change in distance. These results are presented in Table 12 for a selection of representative βs from the models above. The double log/inverse distance specification enforces that the relationship between percentage price declines and distance be convex. To test for the robustness of this assumption we also tried quadratic and cubic distance specifications which would allow for a concave rather than convex relationship. The quadratic specification confirmed the convex shape of the relationship since the linear term was positive and significant and the quadratic term was negative and significant. The quadratic and cubic terms in the cubic specification were not significant.[23]

From the repeat sales model we see that the construction of turbines such that for a given home the nearest turbine is now only 0.5 miles away results in a 10.87%-17.77% decline in sales price depending on the initial distance to the nearest turbine and the particular specification. For the average property in our sample that sells for $106,864, this implies a loss in value of between $11,616 and $18,990. At a distance of 1 mile (about 20% of our sample), we see declines in value of between 7.73% and 14.87% resulting in losses for the average home of between $8,261 and $15,891. Failing to properly control for selection effects, as in the block-group fixed effects analysis, results in price declines that are about 35% higher than those estimated from the repeat sales model.

From a policy perspective, these results indicate that there remains a need to compensate local homeowners/communities for allowing wind development within their borders. Existing PILOT programs and compensation to individual landowners are implicitly accounted for in this analysis since we would expect these payments to be capitalized into sales prices, and still we find negative impacts. This suggests that landowners, particularly those who do not have turbines on their properties and are thus not receiving direct payments from wind developers, are being harmed and have an economic case to make for more compensation. That is, while the 'markets' for easements and PILOT programs may be properly accounting for harm to those who allow parcels on their property, it appears not to be accounting for harm to others nearby. This is a clear case of an uncorrected externality. If, in the future, developers are forced to account for this externality through increased payments this would obviously increase the cost to developers and make it that much more difficult to economically justify wind projects.

This study does not say anything about the societal benefits from wind power and should not be interpreted as saying that wind development should be stopped. If, in fact, wind power is being used to displace fossil-based electricity generation it may still be that the environmental benefits of such a trade exceed the costs. However, in comparing those environmental benefits, we must include not only costs to developers (which include easement payments and PILOT programs), but also these external costs to property owners local to new wind facilities. Property values are an important component of any cost-benefit analysis and should be accounted for as new projects are proposed and go through the approval process.

Finally, this paper breaks with the prior literature in finding any statistically significant property-value impacts from wind facilities. We believe that this stems from our empirical approach which controls for omitted variables and endogeneity biases. Future studies which expand this sort of analysis to wind and other renewable power facilities in other regions are imperative to understanding the big picture of what will happen as these technologies grow in prominence.

References

[1] Spencer Banzhaf, Dallas Burtraw, David Evans, and Alan Krupnick. Valuation of natural resource improvements in the adirondacks. *Land Economics*, 82(3):1–43, 2006.

[2] Marianne Bertrand, Esther Duflo, and Sendhil Mullainathan. How much should we trust differences-in-differences estimates? *Quarterly Journal of Economics*, 119:249–275, February 2004.

[3] W. David Colby, Robert Dobie, Geoff Leventhall, David M. Libscomb, Robert J. McCunney, Michael T. Seilo, and Bo Sondergaard. Wind turbine sound and health effects: An expert panel review. American Wind Energy Association, 2009.

[4] Katherine Daniels. Wind energy: Model ordinance options. NYSERDA, October 2005.

[5] Michael Greenstone and Ted Gayer. Quasi-experiments and experimental approaches to environmental economics. *Journal of Environmental Economics and Management*, 57:21–44, 2009.

[6] Peter A. Groothuis, Jana D. Groothuis, and John C. Whitehead. Green vs. green: Measuring the compensation required to site electrical generation windmills in a viewshed. *Energy Policy*, 36:1545–1550, 2008.

[7] Robert Halvorsen and Raymond Palmquist. The interpretation of dummy variables in semilogarithmic equations. *American Economic Review*, 70(3):474–475, June 1980.

[8] Martin D. Heintzelman. Measuring the property value effects of land-use and preservation referenda. *Land Economics*, 86(1), February 2010a.

[9] Martin D. Heintzelman. The value of land use patterns and preservation policies. *The B.E. Journal of Economics Analysis and Policy (Topics)*, 10(1), 2010b. Article 39.

[10] Ben Hoen. Impacts of windmill visibility on property values in madison county, new york. Master's thesis, Bard Center for Environmental Policy, Bard College, Annandale-on-Hudson, NY, April 2006.

[11] Ben Hoen, Ryan Wiser, Peter Cappers, Mark Thayer, and Gautam Sethi. The impact of wind power projects on residential property values in the united states: A multi-site hedonic analysis. Technical Report LBNL-2829E, Ernest Orlando Lawrence Berkeley National Laboratory, Environmental Energy Technologies Division, December 2009.

[12] Andrew D. Krueger, George R. Parsons, and Jeremy Firestone. Valuing the visual disamenity of offshore wind power projects at varying distances from the shore: An application on the delaware shoreline. *Land Economics*, 87(2):268–283, May 2011.

[13] Chris Parmeter and Jaren C. Pope. Quasi-experiments and hedonic property value methods. In John A. List and Michael K. Price, editors, *Handbook on Experimental Economics and the Environment*. Edward Elgar Publishing, 2011.

[14] Sally Sims and Peter Dent. Property stigma: Wind farms are just the latest fashion. *Journal of Property Investment and Finance*, 25(6):626–651, 2007.

[15] Sally Sims, Peter Dent, and G. Reza Oskrochi. Modelling the impact of wind farms on house prices in the uk. *International Journal of Strategic Property Management*, 12:251–269, 2008.

[16] George Sterzinger, Frederic Beck, and Damian Kostiuk. The effect of wind development on local property values. Analytical report, Renewable Energy Policy Project, May 2003.

[17] Jeffrey M. Wooldridge. *Econometric Analysis of Cross Section and Panel Data*. The MIT Press, 2002.

Tables and Figures

Figure 1: Study Area

Facility	County	Capacity (MW)	Turbines	Startup Year
Maple Ridge	Lewis	320	194	2006
Noble Chateaugay	Franklin	106.5	71	2009
Noble Belmont	Franklin	21	14	N/A
Noble Altona	Clinton	97.5	65	2009
Noble Clinton	Clinton	100.5	67	2008
Noble Ellenburg	Clinton	81	54	2008

Table 1: Study Area Wind Facilities

Geographic Area	**2008 Median Income ($)**	**2000 Pop. Density (ppl/sq. mi.)**	**2008 Median Value Owner-Occupied Homes ($)**
United States	52,029	86.8	119,600
New York State	55,980	401.9	148,700
Clinton	49,988	76.9	84,200
Franklin	40,643	31.4	62,600
Lewis	41,837	21.1	63,600

Table 2: Study Area Demographics (SOURCE: U.S. Census)

Description of Dataset	Source
Turbine Locations, Lewis County	Lewis County
Turbine Locations, Clinton & Franklin Counties	2009 Orthoimagery
2000-2009 Property Sales	NYS Office of Real Property Services (NYSORPS)
2009 Parcel Layer	Clinton, Franklin and Lewis Counties
2009 Parcel Level Details	NYSORPS
80-Meter Wind Potential	AWS Truepower
Census Blocks	NYS GIS Clearinghouse
Elevations	Cornell U. Geospatial Info. Repository
Land Cover	USGS
Streets	NYS GIS Clearinghouse

Table 3: Data Sources

	Clinton		Franklin		Lewis	
Variable	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Sale Price ($)	$122,645	$83,603	$120,466	$354,556	$81,740	$63,207
Building Age (years)	37	41	49	109	50	42
Living Area (sq. ft.)	1,609	611	1,447	643	1,538	690
Lot Size (acres)	5.9	39.3	6.8	25.6	9.0	27.2
Distance to Nearest Major Road (Feet)	1,549	2,493	1,861	3,189	6,094	6,628
Value of Included Personal Property ($)	$63	$965	$324	$6,995	$204	$2,678
Buyer from Local Area	0.913	0.282	0.790	0.407	0.684	0.465
Home in established Village	0.049	0.215	0.395	0.489	0.261	0.439
Full Bathrooms	1.615	0.647	1.312	0.618	1.287	0.630
Half Bathrooms	0.332	0.495	0.226	0.441	0.229	0.431
Bedrooms	3.134	0.936	2.829	1.051	2.929	1.140
Fireplaces	0.306	0.544	0.245	0.484	0.167	0.416
Excellent Grade Building Quality	0	0	0	0	0.0005	0.023
Good Grade Building Quality	0.031	0.173	0.019	0.137	0.013	0.112
Average Grade Building Quality	0.833	0.373	0.584	0.493	0.639	0.480
Economy Grade Building Quality	0.136	0.342	0.381	0.486	0.317	0.465
Minimum Grade Building Quality	0.001	0.028	0.016	0.127	0.031	0.174
Single-Family	0.859	0.348	0.755	0.430	0.677	0.468
Single-Family +Apt	0.001	0.025	0	0	0	0
Estate	0.0002	0.013	0.003	0.058	0	0
Seasonal Residences	0.032	0.175	0.111	0.314	0.181	0.385
Multi-Family Properties	0.054	0.226	0.046	0.209	0.043	0.203
Acreage/Residences with Ag Uses	0.043	0.202	0.054	0.226	0.054	0.225
Mobile Home(s)	0.0003	0.018	0.002	0.039	0.006	0.075
Other Residential Classes	0.007	0.081	0.012	0.107	0.011	0.106
Primarily Agricultural Use	0.005	0.071	0.018	0.135	0.029	0.168
Percent of Parcel Forested	0.202	0.324	0.269	0.353	0.319	0.371
Percent of Parcel Open Water	0.011	0.077	0.031	0.127	0.024	0.123
Percent of Parcel Fields/Grass	0.160	0.293	0.139	0.277	0.292	0.356
Percent of Parcel Wetlands	0.041	0.147	0.068	0.172	0.067	0.170
Percent of Parcel Developed	0.444	0.448	0.226	0.369	0.134	0.293
Percent of Parcel Open	0.141	0.256	0.268	0.344	0.164	0.290
Observations	6,159		3,255		1,955	

Table 4: Summary Statistics by County

	Clinton			Franklin			Lewis		
Variable	Mean	Std. Dev.	Max.	Mean	Std. Dev.	Max.	Mean	Std. Dev.	Max.
Distance to Nearest Turbine (miles)	11.2	4.2	28.9	24.1	15.0	53.5	9.4	6.4	26.7
Inverse Distance to Nearest Turbine	0.1	0.4	18.0	0.2	1.5	81.1	0.2	0.8	24.4
Number of Turbines on Parcel	0.001	0.046	3	0.000	0.018	1	0.001	0.023	1
Number of Turbines w/in 0.1 Miles	0.002	0.089	6	0.002	0.066	3	0.003	0.071	2
Number of Turbines w/in 0.25 Miles	0.007	0.212	13	0.005	0.137	6	0.027	0.347	10
Number of Turbines w/in 0.5 Miles	0.023	0.457	18	0.037	0.505	19	0.054	0.584	12
Number of Turbines w/in 1 Mile	0.092	1.437	42	0.219	1.578	39	0.194	1.774	26
Number of Turbines w/in 1.5 Miles	0.206	2.803	65	0.503	3.236	70	0.465	3.594	53
Number of Turbines w/in 2 Miles	0.357	4.423	103	0.879	5.355	92	0.853	5.887	82
Number of Turbines w/in 3 Miles	0.721	7.665	162	2.084	10.773	152	2.265	11.439	114
At least 1 Turbine on Parcel	0.0003	0.018	1	0.0003	0.018	1	0.001	0.023	1
At least 1 Turbine w/in 0.1 Miles	0.001	0.028	1	0.001	0.030	1	0.002	0.045	1
At least 1 Turbine w/in 0.25 Miles	0.002	0.048	1	0.002	0.046	1	0.009	0.096	1
At least 1 Turbine w/in 0.5 Miles	0.004	0.062	1	0.013	0.113	1	0.012	0.110	1
At least 1 Turbine w/in 1 Mile	0.006	0.079	1	0.032	0.175	1	0.020	0.142	1
At least 1 Turbine w/in 1.5 Miles	0.008	0.092	1	0.036	0.187	1	0.027	0.162	1
At least 1 Turbine w/in 2 Miles	0.012	0.107	1	0.041	0.197	1	0.033	0.179	1
At Least 1 Turbine w/in 3 Miles	0.019	0.138	1	0.057	0.232	1	0.104	0.305	1
Number of Turbines between 0 and 0.5 Miles	0.022	0.427	16	0.037	0.494	18	0.053	0.573	11
Number of Turbines between 0.5 and 1 Miles	0.069	1.028	25	0.182	1.183	20	0.141	1.234	17
Number of Turbines between 1 and 1.5 Miles	0.114	1.444	31	0.284	1.766	31	0.271	1.939	27
Number of Turbines between 1.5 and 2 Miles	0.152	1.737	42	0.377	2.247	34	0.388	2.499	35
Number of Turbines between 2 and 3 Miles	0.364	3.633	87	1.205	5.866	64	1.413	6.131	54
At Least 1 Turbine between 0 and 0.5 Miles	0.004	0.062	1	0.013	0.113	1	0.012	0.110	1
At Least 1 Turbine between 0.5 and 1 Miles	0.006	0.079	1	0.032	0.175	1	0.020	0.142	1
At Least 1 Turbine between 1 and 1.5 Miles	0.008	0.092	1	0.036	0.187	1	0.027	0.162	1
At Least 1 Turbine between 1.5 and 2 Miles	0.012	0.107	1	0.041	0.197	1	0.033	0.179	1
At Least 1 Turbine between 2 and 3 Miles	0.019	0.138	1	0.057	0.232	1	0.104	0.305	1

Table 5: Summary Statistics for Wind Turbine Variables in 2009

	Block-Group		Census Block	
Variable†	coef	p-value	coef	p-value
ln(Inverse Distance to Nearest Turbine)	-0.068***	0.000	-0.046***	0.000
At least 1 Turbine on Parcel	-1.057***	0.000	-0.428***	0.000
At least 1 Turbine w/in 0.1 Miles	-0.239	0.700	0.110	0.774
At least 1 Turbine w/in 0.25 Miles	-0.057	0.542	0.186	0.311
At least 1 Turbine w/in 0.5 Miles	-0.179	0.153	0.027	0.853
At least 1 Turbine w/in 1 Mile	-0.298***	0.000	-0.230*	0.099
At least 1 Turbine w/in 1.5 Miles	-0.339***	0.000	-0.272**	0.038
At least 1 Turbine w/in 2 Miles	-0.372***	0.000	-0.325***	0.006
At Least 1 Turbine w/in 3 Miles	-0.170**	0.013	-0.099	0.167
Number of Turbines on Parcel	-0.528***	0.000	-0.214***	0.000
Number of Turbines w/in 0.1 Miles	-0.307	0.237	-0.041	0.834
Number of Turbines w/in 0.25 Miles	-0.043	0.344	0.048	0.344
Number of Turbines w/in 0.5 Miles	-0.026	0.116	0.015	0.295
Number of Turbines w/in 1 Mile	-0.015***	0.000	-0.003	0.669
Number of Turbines w/in 1.5 Miles	-0.007***	0.001	-0.002	0.616
Number of Turbines w/in 2 Miles	-0.006***	0.000	-0.003	0.303
Number of Turbines w/in 3 Miles	0.004***	0.000	-0.002	0.216
Distance to Nearest Major Road (Feet)	-0.000***	0.000	-0.000***	0.000
Value of Included Personal Property ($)	0.000***	0.001	0.000***	0.000
Buyer from Local Area	-0.127***	0.002	-0.128***	0.000
Home in established Village	-0.231***	0.000	-0.245***	0.000
ln(Lot Size)	0.010	0.177	0.008	0.554
Living Area (sq. ft.)	0.000***	0.000	0.000***	0.000
Building Age (years)	-0.002***	0.000	-0.002***	0.000
Building Age Squared	0.000***	0.000	0.000***	0.000
Full Bathrooms	0.150***	0.000	0.124***	0.000
Half Bathrooms	0.175***	0.000	0.156***	0.000
Bedrooms	-0.006	0.468	-0.002	0.874
Fireplaces	0.219***	0.000	0.196***	0.000
Excellent Grade Building Quality	-0.041	0.470	0.485***	0.000
Good Grade Building Quality	0.132	0.176	0.161***	0.010
Economy Grade Building Quality	-0.315***	0.000	-0.291***	0.000
Minimum Grade Building Quality	-0.704***	0.000	-0.685***	0.000
Single-Family +Apt	-1.114***	0.000	-1.022**	0.022
Estate	1.620***	0.000	1.339***	0.000
Seasonal Residences	-0.030	0.285	-0.079	0.103
Multi-Family Properties	-0.219***	0.000	-0.232***	0.000
Acreage/Residences with Ag Uses	-0.148**	0.024	-0.128**	0.041
Mobile Home(s)	-0.947***	0.001	-0.817**	0.023
Other Residential Classes	0.023	0.897	0.028	0.830
Primarily Agricultural Use	0.071	0.328	0.050	0.723
Percent of Parcel Forested	-0.039	0.495	-0.058	0.197
Percent of Parcel Open Water	1.184***	0.000	0.992***	0.000
Percent of Parcel Fields/Grass	-0.116***	0.000	-0.142***	0.002
Percent of Parcel Wetlands	0.111***	0.000	0.152**	0.016
Percent of Parcel Developed	0.080***	0.002	0.048	0.158
Constant	10.242***	0.000	10.403***	0.000
Number of Observations	11,368/11,369		11,368/11,369	
Adjusted R^2	0.322-0.326		0.297-0.299	
Year and Month Dummies	Yes		Yes	
Clustered Errors	Yes		Yes	
note: *** p<0.01, ** p<0.05, * p<0.1				

† - The turbine proximity variables above the horizontal line were included individually in regressions with the set of covariates listed below the horizontal line. Estimates presented for these covariates are from the ln(inverse distance) regression but are representative. The range of model Adjusted R^2s are presented.

Table 6: Regression Results - Block-Group and Block Fixed Effects

Variable†	Block-Group coef	Block-Group p-value	Census Block coef	Census Block p-value
ln(Inverse Distance to Nearest Turbine)	-0.070***	0.000	-0.048***	0.000
Number of Turbines between 0 and 0.5 Miles	0.107***	0.002	0.158***	0.008
Number of Turbines between 0.5 and 1 Miles	-0.064***	0.001	-0.053*	0.087
Number of Turbines between 1 and 1.5 Miles	0.085*	0.094	0.095**	0.016
Number of Turbines between 1.5 and 2 Miles	-0.062**	0.025	-0.085**	0.017
Number of Turbines between 2 and 3 Miles	0.006	0.225	0.008	0.208
Number of Observations	11,368		11,368	
Adjusted R^2	0.327		0.300	
Year and Month Dummies	Yes		Yes	
Clustered Errors	Yes		Yes	
ln(Inverse Distance to Nearest Turbine)	-0.070***	0.000	-0.048***	0.000
At Least 1 Turbine between 0 and 0.5 Miles	0.327***	0.006	0.517**	0.043
At Least 1 Turbine between 0.5 and 1 Miles	0.154	0.519	0.064	0.864
At Least 1 Turbine between 1 and 1.5 Miles	-0.003	0.995	0.049	0.905
At Least 1 Turbine between 1.5 and 2 Miles	-0.448	0.186	-0.524*	0.059
At Least 1 Turbine between 2 and 3 Miles	0.132	0.205	0.154*	0.053
Number of Observations	11,368		11,368	
Adjusted R^2	0.327		0.300	
Year and Month Dummies	Yes		Yes	
Clustered Errors	Yes		Yes	
note: *** p<0.01, ** p<0.05, * p<0.1				

† - These sets of six proximity variables were included together with the full set of covariates shown in Table 6.

Table 7: Regression Results - Block-Group and Block Fixed Effects

Variable	coef	p-value
ln(Inverse Distance to Nearest Turbine)	-0.050***	0.001
At least 1 Turbine on Parcel	-	-
At least 1 Turbine w/in 0.1 Miles	1.559***	0.000
At least 1 Turbine w/in 0.25 Miles	0.143	0.605
At least 1 Turbine w/in 0.5 Miles	0.022	0.911
At least 1 Turbine w/in 1 Mile	-0.023	0.842
At least 1 Turbine w/in 1.5 Miles	-0.037	0.739
At least 1 Turbine w/in 2 Miles	0.007	0.940
At Least 1 Turbine w/in 3 Miles	-0.057	0.469
Number of Turbines on Parcel	-	-
Number of Turbines w/in 0.1 Miles	1.559***	0.000
Number of Turbines w/in 0.25 Miles	0.108	0.440
Number of Turbines w/in 0.5 Miles	0.011	0.706
Number of Turbines w/in 1 Mile	0.004	0.687
Number of Turbines w/in 1.5 Miles	0.001	0.850
Number of Turbines w/in 2 Miles	-0.000	0.977
Number of Turbines w/in 3 Miles	-0.000	0.889
Number of Observations	3,890	
Adjusted R^2	0.229-0.231	
Year and Month Dummies	Yes	
Clustered Errors	Yes	
note: *** p<0.01, ** p<0.05, * p<0.1		

Table 8: Regression Results - Repeat Sales

Variable	coef	p-value
ln(Inverse Distance to Nearest Turbine)	-0.059***	0.000
Building Age	0.112***	0.000
Building Age Squared	-0.000	0.263
Number of Turbines between 0 and 0.5 Miles	0.030	0.440
Number of Turbines between 0.5 and 1 Miles	0.036*	0.097
Number of Turbines between 1 and 1.5 Miles	0.009	0.577
Number of Turbines between 1.5 and 2 Miles	-0.035	0.153
Number of Turbines between 2 and 3 Miles	0.006	0.261
Constant	6.831***	0.000
ln(Inverse Distance to Nearest Turbine)	-0.059***	0.000
Building Age	0.112***	0.000
Building Age Squared	-0.000	0.265
At Least 1 Turbine between 0 and 0.5 Miles	0.180	0.416
At Least 1 Turbine between 0.5 and 1 Miles	0.209*	0.054
At Least 1 Turbine between 1 and 1.5 Miles	-0.403**	0.028
At Least 1 Turbine between 1.5 and 2 Miles	0.303	0.154
At Least 1 Turbine between 2 and 3 Miles	-0.004	0.976
Constant	6.835***	0.000
Number of Observations	3,890	
Adjusted R^2	0.214	
Year and Month Dummies	Yes	
Clustered Errors	Yes	
note: *** p<0.01, ** p<0.05, * p<0.1		

Table 9: Regression Results - Repeat Sales

	Lewis		Clinton/Franklin	
Variable	coef	p-value	coef	p-value
ln(Inverse Distance to Nearest Turbine)	-0.063	0.402	-0.069***	0.000
Building Age	0.126***	0.000	0.113***	0.000
Building Age Squared	-0.000	0.532	-0.000	0.306
Number of Turbines between 0 and 0.5 Miles	-0.439***	0.000	0.033	0.249
Number of Turbines between 0.5 and 1 Miles	0.279***	0.005	0.015	0.338
Number of Turbines between 1 and 1.5 Miles	0.011	0.902	0.005	0.710
Number of Turbines between 1.5 and 2 Miles	-0.029	0.296	-0.021	0.112
Number of Turbines between 2 and 3 Miles	0.005	0.831	0.006**	0.046
Constant	4.809***	0.000	7.021***	0.000
ln(Inverse Distance to Nearest Turbine)	-0.058	0.477	-0.070***	0.000
Building Age	0.120***	0.000	0.114***	0.000
Building Age Squared	-0.000	0.667	-0.000	0.308
At Least 1 Turbine between 0 and 0.5 Miles	0.420	0.402	-0.016	0.901
At Least 1 Turbine between 0.5 and 1 Miles	-0.450	0.102	0.253**	0.045
At Least 1 Turbine between 1 and 1.5 Miles	5.004***	0.000	-0.165	0.351
At Least 1 Turbine between 1.5 and 2 Miles	0.611*	0.066	0.053	0.776
At Least 1 Turbine between 2 and 3 Miles	-0.117	0.645	0.038	0.730
Constant	5.004***	0.000	7.002***	0.000
Number of Observations	630		3,260	
Adjusted R^2	0.250-0.261		0.206	
Year and Month Dummies	Yes		Yes	
Clustered Errors	Yes		Yes	
note: *** p<0.01, ** p<0.05, * p<0.1				

Table 10: Regression Results by County - Repeat Sales

Variable	Local Buyer coef	p-value	Non-Local Buyer coef	p-value
ln(Inverse Distance to Nearest Turbine)	-0.054***	0.001	-0.131**	0.020
Building Age	0.107***	0.000	0.176***	0.000
Building Age Squared	-0.000	0.338	-0.001	0.305
Number of Turbines between 0 and 0.5 Miles	0.004	0.924	.	.
Number of Turbines between 0.5 and 1 Miles	0.022	0.431	.	.
Number of Turbines between 1 and 1.5 Miles	-0.000	0.984	.	.
Number of Turbines between 1.5 and 2 Miles	-0.003	0.907	2.046	0.251
Number of Turbines between 2 and 3 Miles	-0.003	0.715	-0.027	0.460
Constant	6.988***	0.000	5.719***	0.000
ln(Inverse Distance to Nearest Turbine)	-0.056***	0.001	-0.131**	0.020
Building Age	0.108***	0.000	0.176***	0.000
Building Age Squared	-0.000	0.341	-0.001	0.305
At Least 1 Turbine between 0 and 0.5 Miles	0.039	0.799	.	.
At Least 1 Turbine between 0.5 and 1 Miles	0.141	0.255	.	.
At Least 1 Turbine between 1 and 1.5 Miles	-0.080	0.556	.	.
At Least 1 Turbine between 1.5 and 2 Miles	0.049	0.815	1.424	0.153
At Least 1 Turbine between 2 and 3 Miles	-0.009	0.958	-0.460	0.460
Constant	6.961***	0.000	5.824***	0.000
Number of Observations	3,315		575	
Adjusted R^2	0.207		0.306	
Year and Month Dummies	Yes		Yes	
Clustered Errors	Yes		Yes	
note: *** p<0.01, ** p<0.05, * p<0.1				

Table 11: Regression Results by Buyer Location - Repeat Sales

Distance to Nearest Turbine (Miles)	Repeat Sales Only ln(Inverse Distance)	Repeat Sales ln(Inverse Distance) w/ Dummies	Block-Group FE ln(Inverse Distance) w/ Dummies
Initial Distance=25 Miles	$\beta = -0.050$	$\beta = -0.059$	$\beta = -0.070$
0.1	24.12	27.80	32.06
0.25	20.57	23.79	27.56
0.5	17.77	20.61	23.95
1	14.87	17.30	20.17
2	11.86	13.84	16.21
3	10.06	11.76	13.79
Initial Distance= 15 Miles			
0.1	22.16	25.59	29.58
0.25	18.51	21.46	24.92
0.5	15.64	18.18	21.19
1	12.66	14.77	17.27
2	9.58	11.21	13.15
3	7.73	9.06	10.65
Initial Distance= 5 Miles			
0.1	17.77	20.61	23.95
0.25	13.91	16.20	18.92
0.5	10.87	12.70	14.89
1	7.73	9.06	10.65
2	4.48	5.26	6.21
3	2.52	2.97	3.51

Table 12: Percentage Price Declines for Selected Models and Distances

Notes

[1]Data on the recent and future expected growth of wind energy are derived from the Energy Information Administration of the U.S. Department of Energy (http://www.eia.doe.gov).

[2]These symptoms are described by Nina Pierpont in her book on the topic, *Wind Turbine Syndrome* published in 2009.

[3]Renee Mickelburgh et al., "Huge protests by voters force the continent's governments to rethink so-called green energy", Sunday Telegraph (London), April 4, 2004, p. 28.

[4]http://www.pachamber.org/www/products/publications/pdf/OSHA\%20Handbook\%20pgs287-291.pdf

[5]See the DOI's Cape Wind Fact sheet (http://www.doi.gov/news/doinews/upload/04-28-10-Cape-Wind-Fact-Sheet-MMS-approved.pdf) for details on the regulatory process surrounding the project.

[6]"WPEG sues Cape Vincent; Petition asks judge to nullify approval of impact statement," *Watertown Daily Times*, October 28, 2010.

[7]"Not on My Beach, Please," *The Economist*, August 19, 2010.

[8]"Cape Vincent Wind Turbine Development Economic Impact - Final Report", Submitted by Wind Turbine Economic Impact Committee, Town of Cape Vincent, NY, October 7, 2010.

[9]Department of Energy (http://www.windpoweringamerica.gov/wind_installed_capacity.asp).

[10]Department of Energy (http://www.windpoweringamerica.gov/wind_maps.asp).

[11]NYS Dept. of Environmental Conservation (http://www.dec.ny.gov/docs/permits_ej_operations_pdf/windstatuscty.pdf).

[12]The Final Environmental Impact Statement for the Noble Belmont project in Franklin County was completed in conjunction with the Noble Chateaugay project. Construction for the combined project consisting of 85 turbines was initiated in 2008. While 71 turbines were brought online in 2009, site work for the additional 14 turbines was completed but the

turbines themselves were never installed. Since the turbine bases are visible from ortho-imagery and the project environmental review was completed as a single project, these locations have been included in our analysis.

[13]We measure the linear distance rather than road network distance since the effects are not a matter of travel to or from the turbines, but instead simple proximity.

[14]In our particular study area, there are 92,960 total parcels, 1,997 census blocks, and 17 census block groups, which implies that, on average, there are 46.55 parcels per block, 5,468.24 parcels per block group. The average census block has an area of just under 2 square miles, and the average census block group, about 232 square miles.

[15]We also attempted an instrumental variables approach to this problem using two instruments - the wind potential of each parcel and the elevation of each parcel. The first was strongly correlated with the location of turbines, but also correlated with property values - parcels that are exposed to higher winds are less desirable. The second instrument was not correlated with property values in our sample, but was not a strong predictor of the location of turbines. For these reasons, we abandoned this approach.

[16]Spatial autocorrelation, when applied at the property level in a repeat sales analysis, is similar to serial correlation in that the error term in one transaction is likely to be correlated with the error term in a transaction of the same property at a different date.

[17]The covariate results presented here are from the first regression (that with just the ln(inverse distance)), but are representative of results from the other regressions. Detailed results are available from the authors.

[18]These two variables are negatively correlated in our sample. The correlation coefficient is -0.2854.

[19]Percentage effects throughout are calculated following Halvorsen and Palmquist (1980) who showed that the appropriate interpretation of dummy variable coefficients when using a semi-log specification is $g = e^c - 1$ where c is the estimated coefficient.

[20]Estates are defined according to NYSORPS as "A residential property of not less than 5 acres with a luxurious residence and auxiliary buildings."

[21]Note that the full set of other covariates are included in these regressions. Results are

broadly consistent with those already presented, so they are not reported here.

[22]The distribution of local vs. non-local buyers differs somewhat between counties. Buyers in Lewis County are less likely to be local with about 32% of Lewis County sales being non-local as opposed to 21% in Clinton/Franklin Counties.

[23]We also tested log-linear inverse distance and log-linear distance specifications and the results were consistent with those reported here. There was no evidence that these alternative specifications provided a better fit to the data.