House Prices and the Visibility of a wind-farm

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Introduction

This paper has two objectives

1. To explain how it is theoretically and empirically possible to measure the cost to a community arising simply from changes in the landscape
2. To apply the findings of a research paper from the Spatial Economics Research Centre to the proposal for a Wind Farm adjacent to Helensburgh, a small town in the west of Scotland.

The Hedonic Price Model

The main econometric approach to evaluating the impact of things like attractive countryside, chemical works or having an electricity pylon in your front garden is using what is known as a Hedonic regression. Most (many) people are familiar with the idea of simple linear regression and its big brother multiple regression. For example the Local Authority Grant from central government is based on the hedonic regression of expenditure against factors like population, road length, number of children, number of people over 65, number over 80 and so on.

For house prices the standard equation is

$$HousePrice_i = \alpha+\beta_1X_{1i}+\beta_2X_{2i}+\beta_3X_{3i}+\beta_4X_{4i}+\beta_5X_{5i}+\beta_6X_{6i}+\gamma_1D_{1i}+\gamma_2D_{2i}+\varepsilon_i$$

Where X_{1i} might be the number of bedrooms in house number i,
X_{2i} the number of reception rooms
X_{3i} the area of garden
X_{4i} distance from the shops
And so on to up to 20 variables or more.

D_{ki} is a zero-one dummy variable indicating the presence or absence of something like a view of a wind-turbine. Again we might have a whole host of dummy variables covering things which can only take two values.

Obviously there are things like state of decoration or noisy neighbours that apply to some houses that are otherwise identical. These are captured by what is known as the "stochastic" term ε_i.

The parameter coefficients β_1, β_2, γ_1 etc, measure the effects of the associated parameters. For example β_1 would give the extra value one might expect from an extra bedroom, γ_1 the loss in value associated with seeing a windfarm. The "regression" is a procedure for estimating these values by choosing the set of coefficient values that minimises the sum of squares of the stochastic term.

For this to be accurate a huge number of assumptions have to be made. For example it may well be that the effects of the parameters should be a fixed percentage of the price rather than a simple penalty (specification error), that the stochastic term increases in size with house price (heteroskedasticity) and that the number of reception room and bedrooms move up together (multi-collinearity). Econometrics is largely about methods for dealing with all these problems so that least-squares regression is accurate or about developing methods for dealing with a stochastic term where the distribution is not zero mean, normally distributed.

When it comes to trying to identify the effect of windfarms there is collinearity between presence and rurality as well as all the other problems and, until the LSE paper, it has proved impossible to identify a significant effect of say £1000 in transactions with average values of £250,000. The stochastic noise was simply too great.

The LSE paper

An alternative approach is possible using time series. For example if you had the same house and the only thing that changed was a new view of a windfarm then any change in price could be attributed to the windfarm. Obviously things do change and a sample of 1 is not adequate to make statements about the average house. However what Gibbons (2014)[1] at the Spatial Economics Research Centre at the LSE did was to study numerous houses in different areas over time. The number of observations (1.7m) is obtained from data on 42,500 houses over 40 quarterly periods. This is known as Panel Data and brings with it an additional set of problems associated with different variances over time and over space, association of the stochastic terms over time (autocorrelation) and house price inflation

To implement this approach the following regression specification, on the sample of postcodes which had visible turbines within a given distance radius at the beginning of the study period (2000), or will have visible turbines within these radii or bands by the end of it (2011) was estimated

$$\log(HousePrice_{it}) = \beta X_{it} + \sum_k \gamma_k D_{kit-1} + f(i,t) + \varepsilon_{it}$$

D_{kit-1} is a 0,1 dummy for a distance band k and takes a value of 1 if at least 1 wind turbine is visible in postcode area i in the previous period (t-1).

Crucially, this specification must allow for unobserved components which vary over time and space and which are correlated with the wind farm visibility indicator. This correlation with the geographical effects occurs because wind farms are not randomly assigned across space and postcodes close to wind farms and where turbines are visible may not be comparable to postcodes further away in terms of the other amenities that affect the housing process. The correlation with the time effects occurs because the number of wind farms is growing over time, so there is a spurious correlation between any general trends in prices over time and the indicator of wind farm visibility. These unobserved components are represented by the f(i,t) function and corrected for in the estimation process.

The key finding is that prices in postcodes where wind farms are close and visible are reduced quite substantially over the period in which a wind farm becomes operational. *The price impact is around*

[1] Gibbons S (2014) Gone with the Wind: Valuing the Visual Impacts of Wind turbines through House Prices SERC Discussion Paper 159, April 2014
http://www.spatialeconomics.ac.uk/textonly/SERC/publications/download/sercdp0159.pdf

6.5% within 1km, falling to 5.5-6% within 2km, 2.5-3% within 4km. Beyond 4km the effect falls below 1% and becomes statistically significant.

House Price Loss and the annual cost of windfarm visibility

The capital value of an asset, such as a house, reflects the flow of benefits one might expect in the future, discounted to allow for the risk we might not enjoy the asset. Thus if rents rise we would expect house prices to follow. Conversely if house prices fall we know that the annual value of the house has fallen.

If the flow of values is for ever and is discounted at r% then the annual cost of the windfarm is simply r% of the change in house price. Currently the government use 3% in real terms and there is assumed to be no inflation. With inflation the discount rate rises with the rate of inflation.

Helensburgh Wind Farm

To assess the cost to the community of Helensburgh we need to know

a) The number of households within 2km and 4km of the windfarm with a view of it
b) The average house price within these zones.

Unfortunately none of this data is available. However we do have

a) The number of people in each zone obtained by aggregating the population in each Census Output Area
b) The average household size by council ward
c) The average dwelling price by council ward

The two wards Helensburgh Central and Helensburgh South do not match the zones perfectly but give a good indication of the household size and house price. Table 1 shows the key data

	Ward Data			
	Popn	**Dwellings**	**Pop/dwelling**	**House Price**
Helensburgh and Lomond South	7420	3277	2.26	£183,748
Helensburgh Central	9446	4888	1.93	£165,255
TOTAL	**16866**	**8165**	**2.07**	**£172,677**

The number of people is obtained by GIS analysis. This involved identifying the Zone of Theoretical Visibility and the number of people living within Census Output Areas within this zone within 4km and 2km of the windfarm. Appendix 2 provides a screen shot of the analysis proceeding. The blue dots are the centres of the Output Areas selected because they are in Helensburgh South Ward, within 4km of the windfarm and can see it and the table shows the data associated with each (e.g the population or the number of children). Based on the pop/dwelling the number of dwellings is then estimated. The results are shown in Table 2

	Pop Affected			Estimated Dwellings	
	4km	**2km**	**2 to 4km**	**2-4km**	**<2km**
Helensburgh and Lomond South	3375	0	3375	1491	0
Helensburgh Central	9368	1308	8060	4171	677
TOTAL	12743	1308	11435	5661	677

From there we apply a 5.5% loss to house prices within 2km and a 2.5% loss to those in the 2-4km band and thence calculate the total cost to the Helensburgh community. This is shown in Table 3

	Loss/dwelling		Loss		Total
	2-4km	**<2km**	**2-4km**	**<2km**	
Helensburgh and Lomond South	£4,594	£10,106	£6,847,136	£0	**£6,847,136**
Helensburgh Central	£4,131	£9,089	£17,231,097	£6,151,886	**£23,382,983**
TOTAL			**£24,078,232**	**£6,151,886**	**£30,230,119**

Finally we obtain an annual loss to Helensburgh by taking 3% of the total; **£906,904**

Conclusions and Caveats

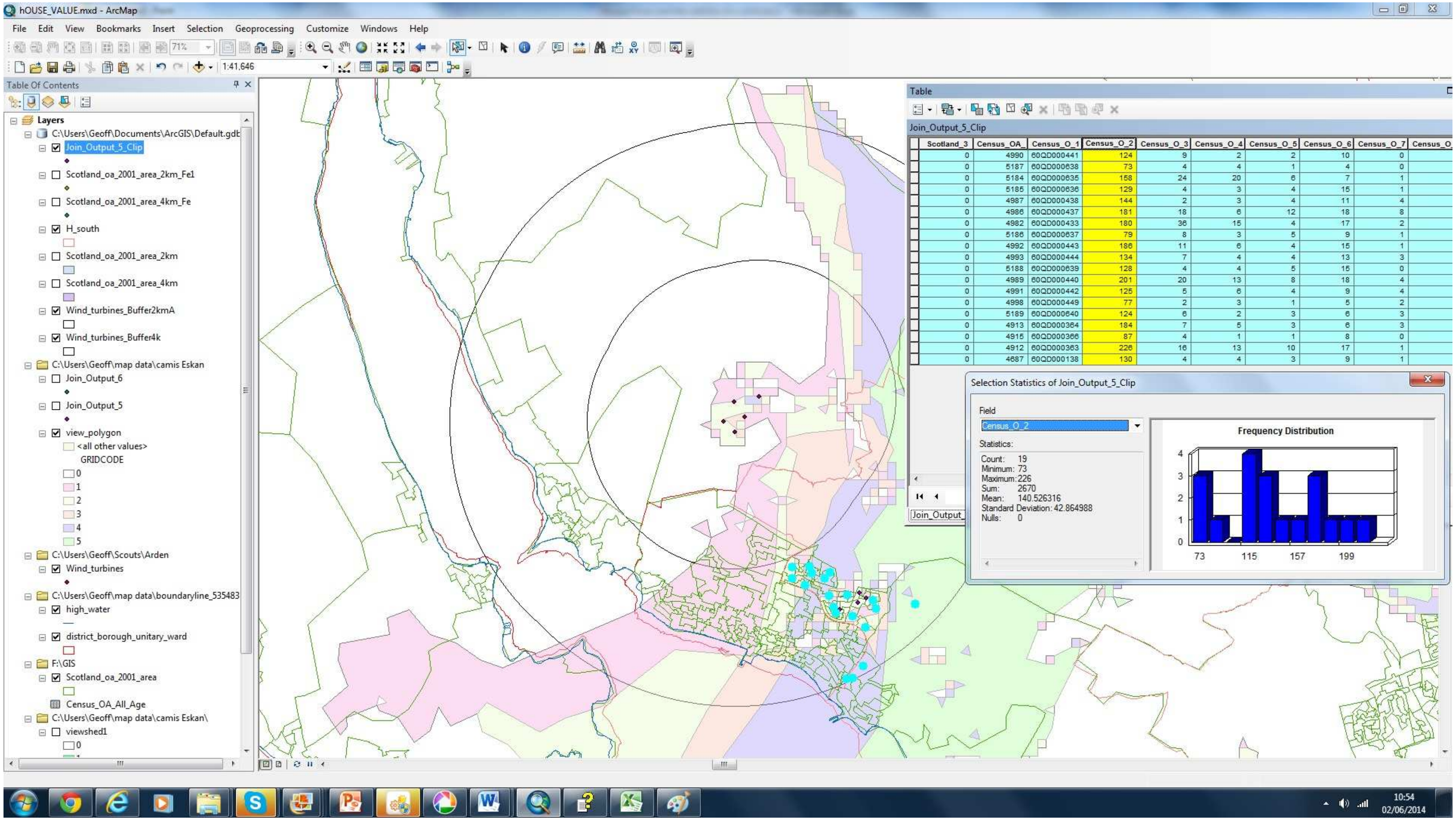
It may be argued that the estimates generated by Gibbons are just that and should not be relied upon. In common with all regression work the parameter coefficients have a calculated standard error and we can calculate the range of likely values. Technically 95% of actual estimates will lie within 2 standard errors of the best (central) estimate. Appendix 1 presents the estimated results and suggest that 95% of the actual estimates for the 2km effect lie between 3.6% and 7.4% and for the 4km effect the range is 1.57% to 3.77%. Thus we can be very confident that the minimum capital loss to the community will exceed £19m giving a minimum annual cost of £574,000.

Overall the best estimate of the loss of capital values because of the visibility of the wind farm is over £30m and the community as a whole would need an income of over £900,000 per year as compensation. In the past the number affected within 4km have normally been measured in tens. This proposal is unique in terms of both the number of dwellings closely affected (over 6,000) and the visibility from a National Park, from nationally promoted long distance paths and from a large urban conglomeration (InverClyde). It is difficult to imagine a worse location.

Appendix 1: Estimated Model Results

Radius	<1km	<1km	<2km	<2km	<2km	<4km	<4km	<4km	<8km	<8km	<8km	<14km	<14km	<14km
Control Vars	No	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Visible-Operational	-0.0632***	-0.0666**	-0.0628***	-0.0554***	-0.0556***	-0.0300***	-0.0267***	-0.0239***	-0.0144***	-0.0046	-0.0033	-0.0048*	-0.0018	-0.0026
SE	-0.0171	-0.0221	-0.0095	-0.0095	-0.0095	-0.0057	-0.0055	-0.0054	-0.0032	-0.0029	-0.0029	-0.0019	-0.0018	-0.0017
Non-visible-Operational	-	-	-	-	-0.0638	-	-	-0.0026	-	-	0.0161***	-	-	-0.0027
SE	-	-	-	-	-0.0644	-	-	-0.0125	-	-	-0.0041	-	-	-0.002
Obs	8,052	8,052	36,298	36,298	37,998	125,619	125,619	150,907	417,108	417,107	621,395	984,294	984,292	1,710,293
R-squared	0.8141	0.8459	0.8284	0.858	0.8603	0.8377	0.8626	0.864	0.8487	0.8719	0.8734	0.8461	0.8706	0.8715

Source: Gibbons(2014)



Scotland_3	Census_OA_	Census_O_1	Census_O_2	Census_O_3	Census_O_4	Census_O_5	Census_O_6	Census_O_7
0	4990	60QD000441	124	9	2	2	10	0
0	5187	60QD000638	73	4	4	1	4	0
0	5184	60QD000635	158	24	20	6	7	1
0	5185	60QD000636	129	4	3	4	15	1
0	4987	60QD000438	144	2	3	4	11	4
0	4986	60QD000437	181	18	6	12	18	8
0	4982	60QD000433	180	36	15	4	17	2
0	5186	60QD000637	79	8	3	5	9	1
0	4992	60QD000443	186	11	6	4	15	1
0	4993	60QD000444	134	7	4	4	13	3
0	5188	60QD000639	128	4	4	5	15	0
0	4989	60QD000440	201	20	13	8	18	4
0	4991	60QD000442	125	5	6	4	9	4
0	4998	60QD000449	77	2	3	1	5	2
0	5189	60QD000640	124	6	2	3	6	3
0	4913	60QD000364	184	7	5	3	6	3
0	4915	60QD000366	87	4	1	1	8	0
0	4912	60QD000363	226	16	13	10	17	1
0	4687	60QD000138	130	4	4	3	9	1

Appendix 2: Screenshot of GIS Analysis Routines

Appendix 3 Note on Data Sources

The ZTV analysis is based upon the Open Source OS 1:50,000 Landform series (now Terrain50) in DTM format. This provides the height at each 10m*10m square. It. The Analysis itself uses the Viewshed routine.

The Output Area Boundaries are part of the Boundaries collection of vector maps developed by Edinburgh University and available, *inter alia*, at the EDINA website (www.edina.ac.uk). These are linked to the 2001 Census Output Area data available from the UKDataService (http://census.ukdataservice.ac.uk) using Arc-Map procedures. Data on house prices in Helensburgh was obtained from the Scottish Neighbourhood Statistics website (http://www.sns.gov.uk).