ECON 5410 Paper Extension

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Overview

The authors (Krekel et al., 2017) provide a life-satisfaction approach to valuing the negative externalities associated with living near wind farms in Germany from 2000 to 2012. The authors use the German Socio-Economic Panel Study (SOEP) that asks respondents in Germany Likert-scale questions surrounding their life satisfaction. Additionally, geographical coordinates of wind turbines are used to to determine if there is causation between the proximity of wind turbine placement and the level of self-reported life satisfaction. The treatment group are citizens who live within 4,000 kilometers of a wind turbine. The authors find that there is a statistically significant negative relation between wind turbine placement and self-reported well-being for German residents living within 4,000 km of a wind turbine.

Pros of the Paper

One strong aspect of this research involves the authors comprehensiveness in trying to control for confounding factors. Specifically, the authors use microeconomic and macroeconomic controls, as well as weather data to ensure that the control and treatment group are similar in nearly all aspects other than wind turbine placement. The use of geographical coordinates is also beneficial to ensure proper connections between individuals and the nearest wind turbine, as opposed to postal codes used in prior studies. The authors also do a great job and creating a clear divide between the treatment and control group by introducing a "ban radius" in which they ignore sample units in which a wind turbine is built within 8000 km of the treatment radius (pg. 224). Lastly, the researchers utilize multiple robustness checks, including placebo tests, view shed analysis, and residential sorting, to ensure a proper causual connection can be made.

Cons of the Paper

The main shortcoming of this paper is examining further the factors influencing the causal link between living near a wind turbine and self-reported life-satisfaction. For example, this paper does not discuss how the residents chose the location of their house and whether this choice came before or after the construction of the wind turbines. Let t_0 be the period in which a consumer chooses which house to purchase. In period t_0, the consumer either knows the house is in the radius of a wind turbine or they know that the house is not in the radius of a wind turbine. If the former case, their utility from purchasing the home is certain and all relevent costs and benefits associated with purchasing a home near a wind turbine are certain. If, however, a wind turbine is not present at $t = 0$, the consumer must make a choice of the location of their house under uncertainty. Specifically, they are uncertain whether a wind turbine will be constructed in subsequent periods in the proximity of their chosen house.

Additionally, the micro and macro controls in the regression equation overlook behavioral factors such as political affiliation. For instance, political affiliation may contribute to resident's perceptions of the environment and how these perceptions influence the degree to which they are impacted by the wind turbines. Specifically, residents that support environmental legislation or environmental policies may be more likely to purchase homes near pre-existing wind turbines or near areas where wind-turbine construction may be more likely.

Paper Extension

Overview of Underlying Theory

This theory extension focuses on the choice that residents make when purchasing a home. Land where homes are less expensive is also land where wind turbine construction is more likely. Therefore, there is a trade-off between increasing wealth by purchasing a cheaper home and increasing noise from turbine externalities. This first extension assumes that wind turbines are already built and residents know with certainty where the turbines are located. A second extension is presented in which wind turbines have not been constructed yet and residents are uncertain whether wind turbines will be constructed in future periods, though they know which land is more likely to have a wind turbine built on it. Thus, the second scenario still examines the trade-off between wealth and noise, though a probabilistic nature is introduced.

Choice Under Certainty

An individual resident is deciding where to purchase a house on a plot of land. Suppose the land consists of a 6 by 6 grid of land, where each grid is 100 acres. The resident knows which grids contain wind turbines and which grids don't. Grid's that contain wind turbines have homes that are less expensive as compared to grids that don't contain wind turbines. Suppose that wind turbines cause negative externalities for residents located in the same grid as a wind turbine. Figure 1 below shows a visual model of the land in question.

T $	T $	$$	$$	$$	$$
T $	T $	$$	$$	$$	T $
$$	$$	$$	$$	T $	T $
$$	$$	T $	T $	$$	$$
$$	$$	T $	T $	T $	$$
T $	T $	$$	$$	$$	$$

Figure 1: Land layout under certainty

A T in the top-left corner of each cell signifies that there is a wind turbine present in the 100 acre plot of land, and the absence of a T represents the absence of a wind turbine. A single dollar sign, $ denotes that homes available for sale are relatively cheaper on that 100 acre plot of land as compared to plots denoted with a double dollar sign, $$. Thus, an individual resident's utility function can be represented as:

$$U = u_1(Wealth, Noise) + u_2(Wealth, Noise),$$

where u_1 represents the individual's utility when they choose not to locate in a grid near a wind turbine and u_2 represents the individual's utility when they choose to locate in a grid near a wind turbine. Wealth is a function of the price of the house, p, and the distance of the house from a wind turbine, d:

$$Wealth = w(p(d)),$$

Noise contains all relevant costs associated with the negative externality of living near the wind turbine, and is a function of the distance from the wind turbine, d,

$$Noise = n(d).$$

Assume that under u_1, the individual faces minimal to no noise externality since they are not located near a wind turbine. Under both u_1 and u_2, $U'(Wealth) > 0$, $U''(Wealth) < 0$ and $U'(Noise) > 0, U''(Notise) < 0$. Each resident maximizes their utility by choosing the location of their house, d. Therefore, the optimization problem becomes:

$$\max_d U = u_1(Wealth, Noise) + u_2(Wealth, Noise) \tag{1}$$

$$s.t. Wealth = w(p(d)), Noise = n(d)$$

Or, equivalently, substituting the restrictions into the objective function (1) results in

$$\max_d U = u_1(w(p(d)), n(d)) + u_2(w(p(d)), n(d)) \tag{2}$$

The first-order condition becomes:

$$\frac{\partial U}{\partial d} = u_1'(w(p(d), n(d))w'(p(d))p'(d)n'(d) + u_2'(w(p(d), n(d))w'(p(d))p'(d)n'(d) = 0 \tag{3}$$

If it is assumed that noise is zero on plots of land without a wind turbine, then

$$\frac{\partial U}{\partial d} = u_1'(w(p(d))w'(p(d))p'(d) + u_2'(w(p(d), n(d))w'(p(d))p'(d)n'(d) = 0 \tag{4}$$

Solving for $n'(d)$ results in:

$$n'(d) = \frac{u_1'(w(p(d))}{u_2'(w(p(d), n(d))} \tag{5}$$

For an explicit solution, assume a quadratic functional form for utility:

$$U = (-\alpha_1 p d^2 + \beta_1 d) + (-\alpha_2 p d^2 + \beta_2 d)$$

where α_1, β_1, α_2, β_2 are scaling factors between 0 and 1, with an concave parabola shape. The first-order condition in this case becomes:

$$\frac{\partial U}{\partial d} = -2\alpha_1 p d + \beta_1 - 2\alpha_2 p d + \beta_2 = 0 \tag{6}$$

The optimal distance to locate from a wind turbine becomes:

$$d^* = \frac{\beta_1 + \beta_2}{2\alpha_1 p + 2\alpha_2 p} \tag{7}$$

Therefore, the optimal distance to purchase a house from a wind turbine is determined by the ratio of the magnitude of the noise externality from the wind turbine $(\beta_1 + \beta_2)$ and the price of both homes.

Choice Under Uncertainty

Now suppose an individual is deciding where to purchase a house on a plot of land. Suppose the land consists of a 6 by 6 grid of land, where each grid is 100 acres. The resident does not know which grids contain wind turbines and which grids don't. Figure 2 below

$\theta(T)\ \$$	$\theta(T)\ \$$	$\theta(T)\ \$\$$	$\theta(T)\ \$\$$	$\theta(T)\ \$\$$	$\theta(T)\ \$\$$
$\theta(T)\ \$$	$\theta(T)\ \$$	$\theta(T)\ \$\$$	$\theta(T)\ \$\$$	$\theta(T)\ \$\$$	$\theta(T)\ \$$
$\theta(T)\ \$\$$	$\theta(T)\ \$\$$	$\theta(T)\ \$\$$	$\theta(T)\ \$\$$	$\theta(T)\ \$$	$\theta(T)\ \$$
$\theta(T)\ \$\$$	$\theta(T)\ \$\$$	$\theta(T)\ \$$	$\theta(T)\ \$$	$\theta(T)\ \$\$$	$\theta(T)\ \$\$$
$\theta(T)\ \$\$$	$\theta(T)\ \$\$$	$\theta(T)\ \$$	$\theta(T)\ \$$	$\theta(T)\ \$$	$\theta(T)\ \$\$$
$\theta(T)\ \$$	$\theta(T)\ \$$	$\theta(T)\ \$\$$	$\theta(T)\ \$\$$	$\theta(T)\ \$\$$	$\theta(T)\ \$\$$

Figure 2: Land layout under uncertainty

In this case, $\theta(T)$ represents the probability of a wind turbine being constructed in a future period on that plot of land. The individual knows the price of houses on each plot of land, however.

In this case, an individual resident's utility function can be represented as:

$$U = \theta u_1(Wealth, Noise) + (1-\theta)u_2(Wealth, Noise),$$

where θ represents the probability that at least one wind turbine is present in a given grid. Wealth is again denoted by $Wealth = w(p(d))$ and noise is denoted by $Noise = n(d)$. The optimization problem therefore becomes:

$$\max_d U = \theta u_1(w(p(d)), n(d)) + (1-\theta)u_2(w(p(d)), n(d)) \tag{8}$$

The first-order condition is:

$$\frac{\partial U}{\partial d} = \theta u_1'(w(p(d), n(d))w'(p(d))p'(d)n'(d) + (1-\theta)u_2'(w(p(d), n(d))w'(p(d))p'(d)n'(d) = 0 \tag{9}$$

Again assume the following quadratic form for utility:

$$U = \theta(-\alpha_1 pd^2 + \beta_1 d) + (1-\theta)(-\alpha_2 pd^2 + \beta_2 d) \tag{10}$$

The first-order condition becomes:

$$-2\theta\alpha_1 pd + \theta\beta_1 - 2(1-\theta)\alpha_2 pd + (1-\theta)\beta_2 = 0 \tag{11}$$

The optimal distance to locate from a wind turbine in this case becomes:

$$d^* = \frac{\theta\beta_1 + (1-\theta)\beta_2}{2\theta\alpha_1 p + 2(1-\theta)\alpha_2 p} \tag{12}$$

One natural question that arises is whether, under this uncertain case, residents can use the current price of houses on a given plot of land as an indicator of where they should choose to locate. Solving (9) for the optimal price results in:

$$p^* = \frac{\theta\beta_1 + \beta_2(1-\theta)}{2\theta\alpha_1 d + 2\alpha_2 d(1-\theta)}$$

If the probability of a wind turbine being constructed increases, the optimal change in price is:

$$\frac{dp^*}{d\theta} = \frac{(\beta_1 - \beta_2)(2\theta\alpha_1 d + 2\alpha_2 d - 2\alpha_2 d\theta) - (\theta\beta_1 + \beta_2(1-\theta))(2\alpha_1 d - 2\alpha_2 d)}{(2\theta\alpha_1 d + 2\alpha_2 d - 2\alpha_2 d\theta)^2} > 0 \tag{13}$$

Equation (11) indicates that as the probability of a wind turbine being present increases, a resident should spend more money on a house at the optimum. Therefore, if a resident has reason to believe that the probability of a wind turbine being present on a given plot of land is higher, they should choose to purchase a house in a grid with more expensive homes.

Discussion and Concluding Remarks

The purpose of this extension offers an explanation as to how the homeowners in the authors' paper chose to purchase a house, and whether this choice involved certainty as to where a wind turbine is located. If consumers know where wind turbines are located, they will choose to purchase a home depending on the magnitude of the noise from the wind turbines, $\beta_1 + \beta_2$, and the prices of homes on the land. If the noise effect, $\beta_1 + \beta_2$, is larger than the wealth effect, $2\alpha_1 p + 2\alpha_2 p$, the consumer will choose to purchase a house further away from wind turbine installations and vice versa. If uncertainty is introduced into the model, the consumer again compares the probability-weighted wealth effect and noise effect when choosing where to locate their home. If the consumer has a reason to believe a wind turbine will be constructed on a given plot of land in a future period, their optimal price-level for homes is more expensive, indicating they should purchase houses on a more expensive plot of land.

References

Krekel, C., & Zerrahn, A. (2017). Does the presence of wind turbines have negative externalities for people in their surroundings? Evidence from well-being data. Journal of Environmental Economics and Management, 82, 221-238.