Wind Turbines and Coastal Recreation Demand

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Electric Power Generation

• Increasing price levels and volatility
• Climate Change & National Security
• Wind energy as an alternative
  – Large upfront costs, but low operation costs
  – Cost stability
  – No carbon residuals, but other environmental impacts
Impact on Visual Amenities

- Places with high wind energy potential (mountaintops and coastal waters) are also associated with scenic vistas
  - Local concerns
  - Recreation and tourism
  - Property values
Impact of Diminution of View Amenities on Coastal Recreation

- Beach visitation data collected for 16 northern CAMA counties in the OBX region (telephone)

- **Class 1: Coastal** – Carteret, Hyde, Dare, Currituck

- **Class 2: Adjacent** – Beaufort, Bertie, Camden, Chowan, Craven, Gates, Hertford, Pamlico, Pasquotank, Perquimans, Tyrell, Washington
Data

• Telephone Survey
  – Opinions on wind energy & climate change
  – Recreation Demand Data:
    • Past beach trips (RP)
    • Planned future beach trips (SP)
    • Future beach trips w/ offshore wind turbines (SP)
  – Estimate recreation demand model to measure lost consumer surplus

• Internet Survey
  – Beach site choice data (SP) with windmill visualizations
Telephone Data

• Incentive = $20 Food Lion gift card
• 361 telephone responses: 31% resp. rate
• Possible evidence of selection bias
• Inverse probability weights to adjust for under-representation of young males and those lower income and education levels.
  – Still a possibility of selection based on unobserved factors
Telephone Data

- What if wind turbines were present at the beach they planned to go to on their next visit?
  - 92% would visit the same beach
  - 4% would visit a different beach
  - 4% would not go to the beach
Recreation Demand Model

• Household production of beach trips using:
  – Automobile (gasoline, wear-and-tear costs)
  – Time (*opportunity cost*)

• Quasi-panel data:
  – 18.6 NC beach trips in the previous year
  – 19.9 NC beach trips planned for next year
  – 18.7 NC beach trips w/ wind farms

• Count data regression (Random effects Poisson) - # trips = non-negative integer

# trips = f(tc, sub_tc, income, demographics, conditions)
Recreation Demand Model

- # trips
- Avg. trips
- Avg. TC
- Travel cost

Tourist transit expenditures: create economic impact

Consumer Surplus: a measure of net economic value to users

D (current)
Recreation Demand Results

- **Random-effects Poisson** regression
- Group variable: sub_id
- Random effects $\varepsilon_i \sim$ Gamma
- Log likelihood = -2196.4487

|                         | Coef.  | Std. Err. | z      | P>|z|   | [95% Conf. Interval] |
|-------------------------|--------|-----------|--------|-------|---------------------|
| t_trips | ptr | -0.0098842 | 0.0018086 | -5.47 | 0.000 | -0.0134291, -0.0063394 |
|                | sub_ptr | 0.010197 | 0.0020911 | 4.88 | 0.000 | 0.0060986, 0.0142954 |
|                | male | 0.0543585 | 0.1989064 | 0.27 | 0.785 | -0.335491, 0.444208 |
|                | age | -0.0106571 | 0.005352 | -1.99 | 0.046 | -0.0211469, -0.001673 |
|                | hschool | -0.0178951 | 0.2962082 | -0.06 | 0.952 | -0.5984525, 0.5626623 |
|                | some_coll | 0.2325259 | 0.2796742 | 0.83 | 0.406 | -0.3156254, 0.7806772 |
|                | college2 | 0.7638442 | 0.3621505 | 2.11 | 0.035 | 0.0540424, 1.473646 |
|                | inc | -0.0049906 | 0.0033847 | -1.47 | 0.140 | -0.0116245, 0.0016434 |
|                | future | 0.0451058 | 0.0247075 | 1.83 | 0.068 | -0.00332, 0.0935315 |
|                | fut_wind | 0.0209284 | 0.0248506 | 0.84 | 0.400 | -0.0277779, 0.0696348 |
|                | _cons | 1.241217 | 0.3744115 | 3.32 | 0.001 | 0.5073837, 1.97505 |

lnalpha | 0.3858138 | 0.0858056 | 0.3010778 | 0.761 | 0.2176378, 0.5539897 |

alpha | 1.470811 | 1.262038 | 1.243137 | 1.740182 |

Likelihood-ratio test of alpha=0: chibar2(01) = 1.7e+04 Prob>=chibar2 = 0.000
Recreation Demand Results

- $\epsilon_{op} = -2.19$: price elastic
- $\epsilon_{cp} = 4.22$: responsive to substitute price
- $\epsilon_{inc} = -0.395$: beach visitation is *inferior* good

Consumer surplus:
- Current: $2120 per year
- Projected: $2218 per year
- w/ turbines: $2164 per year

Annual loss = $53 per year (~2%)
Trip Choices with Visualization

• Internet survey – 118 respondents
  – Imagine you are deciding on a destination for your first OBX single-day beach trip of the year.
  – In what follows we have laid out a set of alternatives for this decision.
  – Each alternative is described by characteristics of the available beaches.
  – The characteristics have a number of levels.
Trip Choice with Visualization

- **People on the Beach** – # people per mile
- **Distance from Home** – one-way miles travelled
- **Parking Fees** – amount paid to park your car
- **Ocean View** – a clear view of the ocean; wind farm 1 mile out; wind farm 4 miles out
- **Sound View** – a clear view of the sound; wind farm 1 mile out; wind farm 4 miles out
Visualization of Beach Conditions

• No wind turbines

• Ocean

• Sound
Visualization of Beach Conditions

- Wind turbines 1 mile away

- Ocean

- Sound
Visualization of Beach Conditions

- Wind turbines 4 miles away
- Ocean
- Sound
Random Utility Model

- Assume individual chooses trip that yields the highest satisfaction, where satisfaction depends upon attributes of the trip and unobservable factors.
- Choice set: 3 trips options & no-trip
- Model probability of making selection over series of six choice sets.
- Mixed logit model - parameters are estimated by *Simulated Maximum Likelihood*
Example: Choice Set

<table>
<thead>
<tr>
<th>No Trip (stay home)</th>
<th>Trip A</th>
<th>Trip B</th>
<th>Trip C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>People on the Beach:</strong></td>
<td>40 - 200</td>
<td>more than 200</td>
<td>less than 40</td>
</tr>
<tr>
<td><strong>Distance from home:</strong></td>
<td>120 miles</td>
<td>90 miles</td>
<td>60 miles</td>
</tr>
<tr>
<td><strong>Parking Fee:</strong></td>
<td>$0</td>
<td>$4</td>
<td>$8</td>
</tr>
<tr>
<td><strong>Ocean View:</strong></td>
<td>1-mile wind farms</td>
<td>4-mile wind farms</td>
<td>no wind farms</td>
</tr>
<tr>
<td><strong>Sound View:</strong></td>
<td>4-mile wind farms</td>
<td>no wind farms</td>
<td>1-mile wind farms</td>
</tr>
</tbody>
</table>
### Choice Experiment Results

- **Mixed logit model**
- Wald chi2(10) = 325.64
- Log likelihood = -760.2396
- Number of obs = 2768
- Prob > chi2 = 0.0000

| y    | Coef.  | Robust Std. Err. | z    | P>|z| | [95% Conf. Interval] |
|------|--------|------------------|------|-----|----------------------|
| Mean |        |                  |      |     |                      |
| no_trip | -2.008872 | .941546         | -2.13 | 0.033 | -3.854268   - .1634753 |
| alt_A   | .5314615  | .2431104        | 2.19  | 0.029 | .0549739    1.007949   |
| alt_B   | .8878032  | .2845311        | 3.12  | 0.002 | .3301324    1.445474   |
| tc      | -.0115428 | .0042834        | -2.69 | 0.007 | -.0199381   -.0031476  |
| congestion | .0006707  | .0015837        | 0.42  | 0.672 | -.0024332   .0037747   |
| park_fee | -.0932135 | .0304854        | -3.06 | 0.002 | -.1529638   -.0334633  |
| oceanw1 | -.7144252 | .2685468        | -2.66 | 0.008 | -1.240767   -.1880831  |
| oceanw4 | .4506703  | .6296497        | 0.72  | 0.474 | -.7834204   1.684761   |
| soundw1 | .0352767  | .3891418        | 0.09  | 0.928 | -.7274273   .7979807   |
| soundw4 | .4263244  | .4071793        | 1.05  | 0.295 | -.3717324   1.224381   |
## Choice Experiment Results

|                | Coef.  | Robust Std. Err. | z     | P>|z| | [95% Conf. Interval] |
|----------------|--------|------------------|-------|-----|----------------------|
| SD             |        |                  |       |     |                      |
| congestion     | 0.0000403 | 0.0000709  | 0.57  | 0.570 | -0.0000987  | 0.0001792 |
| park_fee       | -0.0019122 | 0.0057844  | -0.33 | 0.741 | -0.0132495 | 0.0094251 |
| oceanw1        | -0.4284264 | 0.3975198  | -1.08 | 0.281 | -1.207551   | 0.350698  |
| oceanw4        | 1.494667   | 0.709885   | 2.11  | 0.035 | 0.1033183   | 2.886016  |
| soundw1        | 0.2391118  | 0.6717933  | 0.36  | 0.722 | -1.077579   | 1.555802  |
| soundw4        | -0.0419696 | 0.3534912  | -0.12 | 0.905 | -0.7347996 | 0.6508603 |
|                |        |                  |       |     |                      |
Choice Experiment Results

• **Compensating Variation** – required compensation to hold utility constant
  - $CV_{\text{congestion}} = 0.05^*$, one additional person (not statistically significant)
  - $CV_{\text{parking_fee}} = 8$, $1$ increase in parking fee
  - $CV_{\text{ocean1}} = 62$, avoid wind farms $1$ mile offshore
  - Other wind effects not statistically significant
Conclusions

• Estimates of contingent behavior in presence of wind energy projects in the coastal zone
  – How would annual demand change with widespread wind farms?
  – How do wind energy projects affect site choice?

• Focus on coastal residents (northern CAMA counties)
Conclusions

- **Aggregate recreation demand** – annual loss of about $53 in consumer surplus (about 2%)

- **Site choice model:**
  - Parking fees decrease utility & site choice probabilities
  - Offshore wind farms (1 mile) drive visitors away (lower probability)
    - WTP $62 per trip to avoid offshore wind farms
  - Other wind farms have no impact on site choice
Thanks!

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• Questions/Comments?