Wind Turbines and Coastal Recreation Demand

Craig E. Landry, Tom Allen, Todd Cherry, and John Whitehead

Appalachian Energy Center

ECU Center for Sustainable Tourism

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

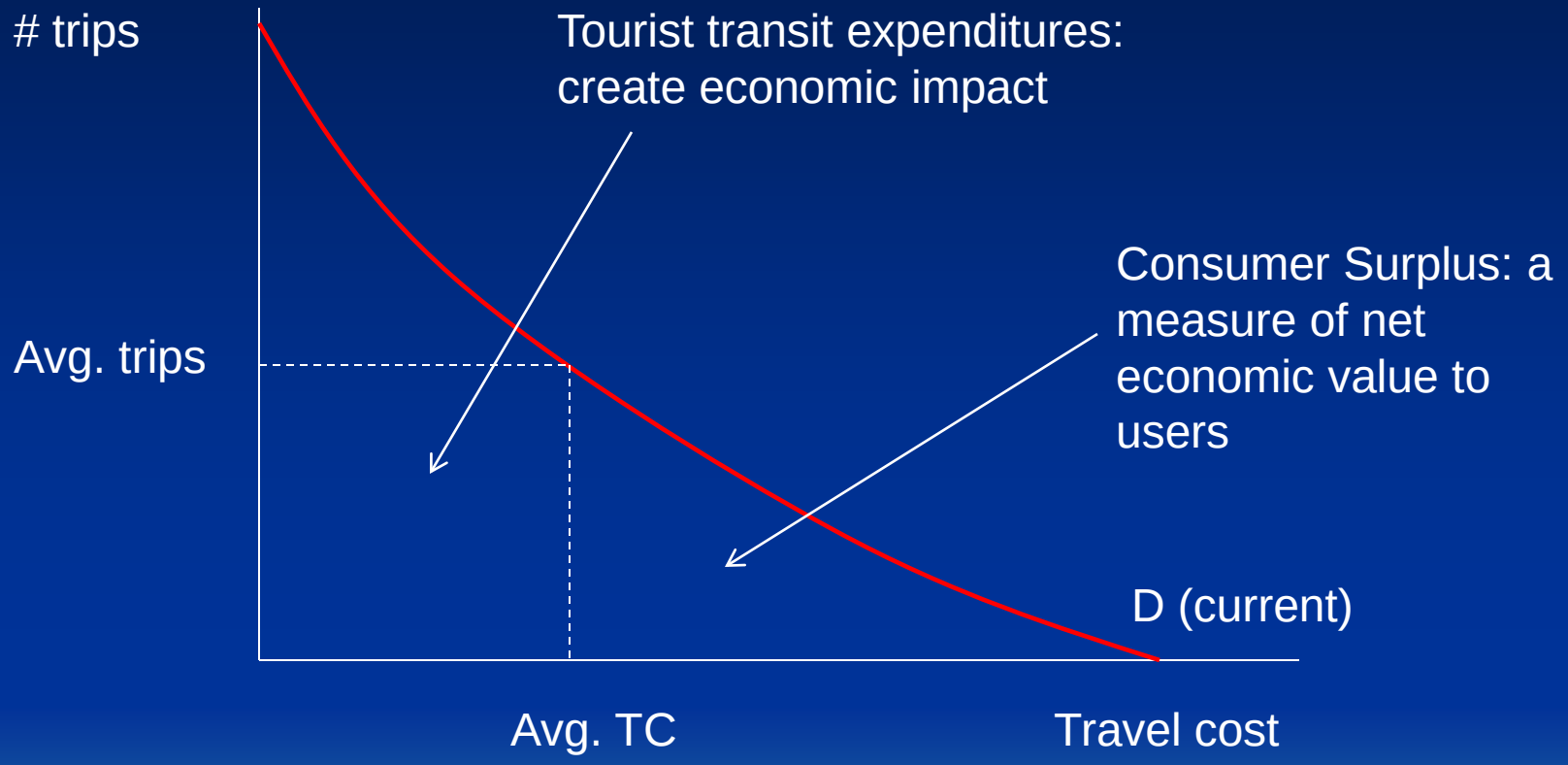
- What if wind turbines were present at the beach they planned to go to on their next visit?
  - 92% would visit the same beach
  - 4% would visit a different beach
  - 4% would not go to the beach

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



Recreation Demand Results

Random-effects Poisson regression — Number of obs = 787
Group variable: sub_id — Number of groups = 266
Random effects ε_i ~ Gamma — Wald chi2(10) = 48.59
Log likelihood = -2196.4487 — Prob > chi2 = 0.0000

t_trips	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
ptr	**-.0098842**	**.0018086**	**-5.47**	**0.000**	**-.0134291**	**-.0063394**
sub_ptr	**.010197**	**.0020911**	**4.88**	**0.000**	**.0060986**	**.0142954**
male	.0543585	.1989064	0.27	0.785	-.335491	.444208
age	**-.0106571**	**.005352**	**-1.99**	**0.046**	**-.0211469**	**-.0001673**
hschool	-.0178951	.2962082	-0.06	0.952	-.5984525	.5626623
some_coll	.2325259	.2796742	0.83	0.406	-.3156254	.7806772
college2	**.7638442**	**.3621505**	**2.11**	**0.035**	**.0540424**	**1.473646**
inc	-.0049906	.0033847	-1.47	0.140	-.0116245	.0016434
future	**.0451058**	**.0247075**	**1.83**	**0.068**	**-.00332**	**.0935315**
fut_wind	.0209284	.0248506	0.84	0.400	-.0277779	.0696348
_cons	**1.241217**	**.3744115**	**3.32**	**0.001**	**.5073837**	**1.97505**
lnalpha	**.3858138**	**.0858056**			**.2176378**	**.5539897**
alpha	**1.470811**	**1262038**			**1.243137**	**1.740182**

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

Recreation Demand Results

- ε_{op} = -2.19: *price elastic*
- ε_{cp} = 4.22: *responsive* to substitute price
- ε_{inc} = -.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

- Characteristics and possible levels are:
  - 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

No Trip (stay home)	Trip A	Trip B	Trip C
	People on the Beach: 40 - 200	**People on the Beach:** more than 200	**People on the Beach:** less than 40
	Distance from home: 120 miles	**Distance from home:** 90 miles	**Distance from home:** 60 miles
	Parking Fee: $0	**Parking Fee:** $4	**Parking Fee:** $8
	Ocean View: 1-mile wind farms 	**Ocean View:** 4-mile wind farms 	**Ocean View:** no wind farms 
	Sound View: 4-mile wind farms 	**Sound View:** no wind farms 	**Sound View:** 1-mile wind farms 

Choice Experiment Results

Mixed logit model — Number of obs = 2768

Wald chi2(10) = 325.64

Log likelihood = -760.2396 — 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	.0000403	.0000709	0.57	0.570	-.0000987	.0001792
park_fee	-.0019122	.0057844	-0.33	0.741	-.0132495	.0094251
oceanw1	-.4284264	.3975198	-1.08	0.281	-1.207551	.350698
oceanw4	1.494667	.709885	2.11	0.035	.1033183	2.886016
soundw1	.2391118	.6717933	0.36	0.722	-1.077579	1.555802
soundw4	-.0419696	.3534912	-0.12	0.905	-.7347996	.6508603

Choice Experiment Results

- **Compensating Variation** – required compensation to hold utility constant
  - $CV_{congestion}$ = \$0.05*, one additional person (not statistically significant)
  - $CV_{parking\_fee}$ = \$8, \$1 increase in parking fee
  - CV_{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 (nothern 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!

- Research supported by:
  - *Appalachian Energy Center*
  - *ECU Center for Sustainable Tourism*
    - Visualization support provided by *NC Renaissance Computing Initiative (RENCI)*
- Questions/Comments?