Measuring Ex Post Economic Effects: Lessons from Emerging Energy Industries

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- Views expressed are those of the author and may not be attributed to the Economic Research Service or the U.S. Department of Agriculture

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Background

- In farm-dependent states absence of economic opportunities drives rural outmigration (McGranahan et al., 2010)
- Economic effects from emerging energy industries may be substantial enough to alter development trajectories
- ERS researchers have been asked to review USDA commissioned studies measuring *ex ante* impacts of bio-refineries and wind power development
  - those reviewed have relied upon predictions of input-output models

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Methodological Questions

- How can *ex ante* estimates of emerging energy industries be verified with rigorous empirical analysis?
- Examples include:
  - Natural gas extraction
  - Wind power development
  - Corn-based ethanol facilities

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Potential Impacts: Wind Power Example

- Direct employment and income of those employed in the industry, particularly in the construction phase but also in the operations phase
- Demand for various goods and services produced or sold in the local economy from construction and operations expenditures
- Land lease payments made to local landowners on whose land wind turbines are located
- Owners of wind turbines that happen to reside in the local economy spend a portion of the profit from wind project operations locally
- Property taxes or payments in lieu of property taxes paid by wind energy operators to local governments

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Potential Impacts: Continued

- Spending by those employed in sector, other local residents, and governments from these additional sources of income may further induce local economic impacts
- Wind power development in one community may affect employment and income in neighboring communities, causing localized feedback effects
- Wind power development may affect overall demand for land and alternative uses of land; alternative investment opportunities; desire of people to live, visit or work in the area → accounting for net effects is important

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I-O Examples

- Natural gas extraction
  - Center for Business and Economic Research (2008)
    - 57 jobs per billion cubic feet (bcf)
  - Kelsey et al. (2009)
    - 62 jobs per bcf
- Wind power development
  - Lantz and Tegen (2009); Slattery et al. (2011)
    - 0.14 to 0.62 jobs per MW; $5,400 to $17,800 of income per MW
- Ethanol plant entrance
  - Swenson (2006)
    - 3.8 jobs per ethanol job
  - Low and Isserman (2009)
    - 2.9 to 5.6 jobs per ethanol job

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Empirical Approaches for Measuring Causal Effects

- Empirical approaches to estimating the causal effects seek to:
  - mimic experimental paradigm of a randomized experiment where assignment of treatment is random
  - nearly impossible in social sciences – quasi-experimental methods
- Matching of “treatment” and “control” counties
- Difference-in-Difference model
  - First difference is change in two time periods
  - Second difference is the difference between treatment and control
- Instrumental Variables
  - approach involves using one or more variables that affect where extraction or placement of wind turbines occur but that are otherwise unrelated to income or employment growth
- Approaches can be combined

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Empirical Examples: Natural Gas

- Extraction of unconventional natural gas (Weber, 2012)
  - Combines difference–in–difference model with instrumental variables (% of county covered with unconventional gas formation)
  - Counties in TX, CO, and WY
  - 30 jobs per bcf (considerably lower than I-O projections, ≈ 50%)

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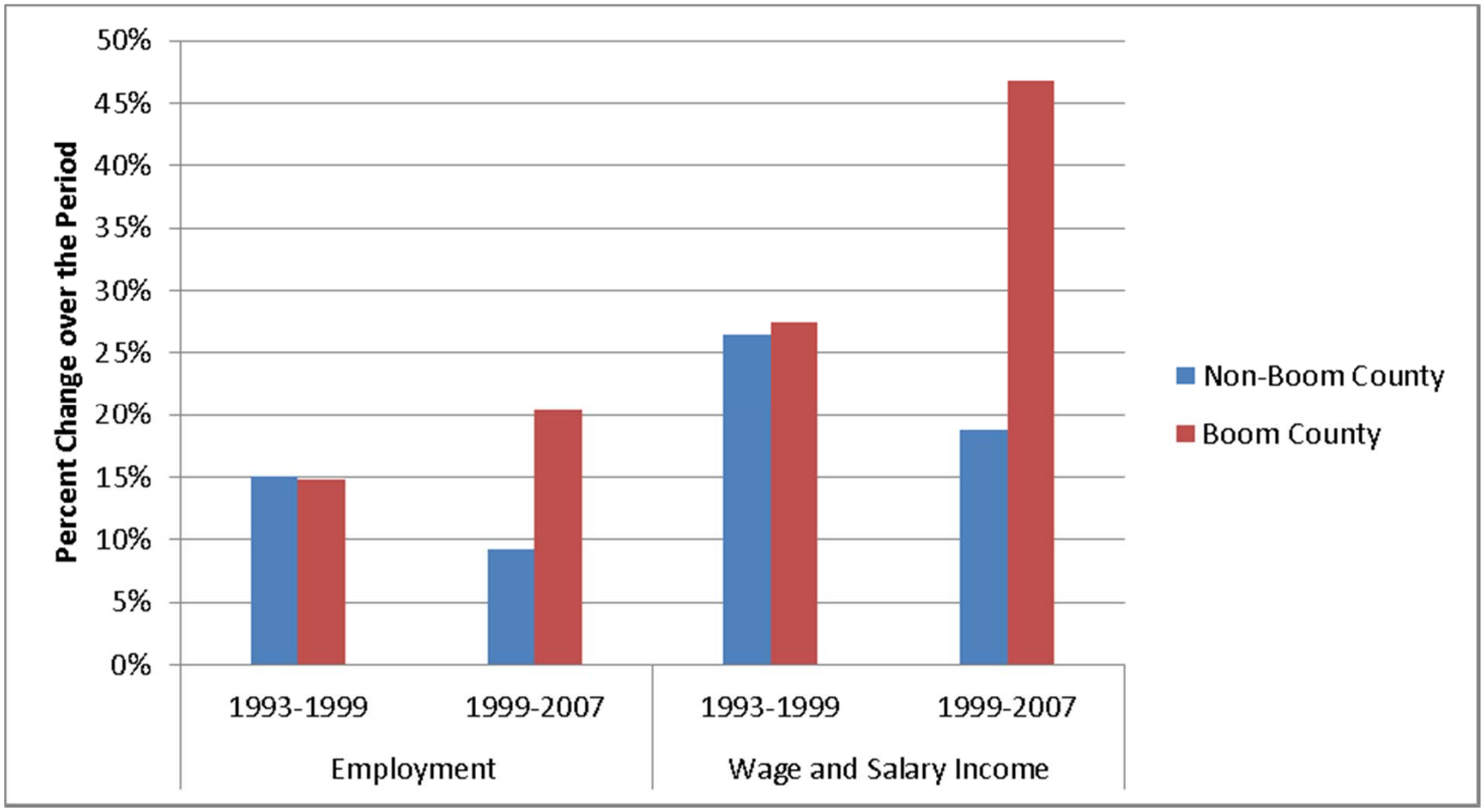
Growth before and after*



* Weber (2012) defined top 20 percent of counties with the largest increase as gas boom counties.

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Empirical Examples: Wind Power

- Effect of cumulative installed wind power capacity on changes in county per capita income and employment (Brown et al., 2012)
- Utilize wind resource potential as an instrumental variable
- 1000+ counties in 12 state region between 2000 and 2008
- 0.48 jobs per MW; $11,150 of personal income per MW (within range of I-O projections)

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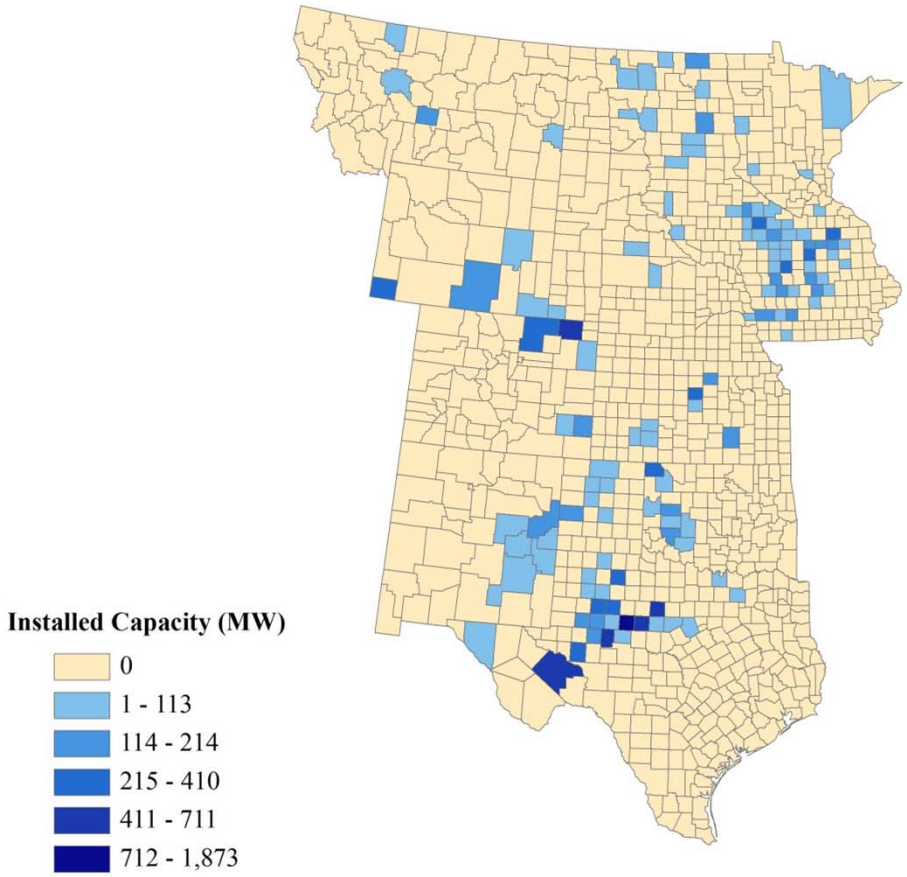
Installed Wind Power Capacity (MW) 2000 to 2008



Source: Brown et al. (2012)

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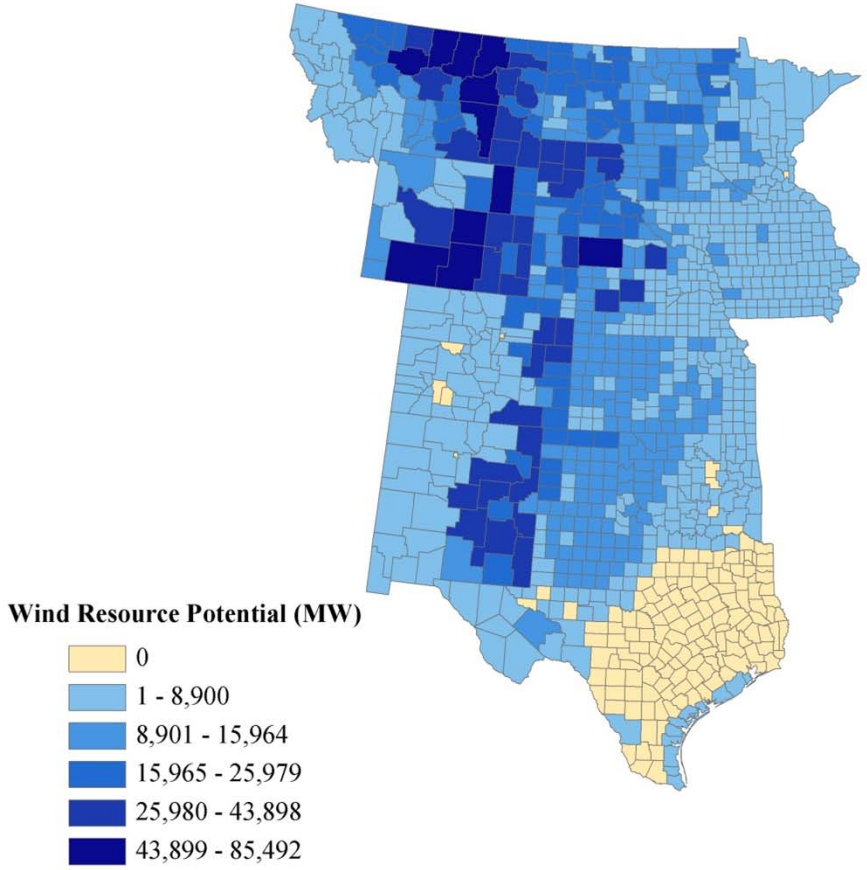
Wind Resource Potential (Power class 3 – 7)



Source: Brown et al. (2012)

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Wind Power Development

County Personal Income		County Employment	
$11,150 per MW		**0.48 jobs per MW**	
Estimated Personal Income from Wind		**Estimated Jobs from Wind**	
Percentile	Personal Income	Percentile	Employment
25th	159,998	25th	7.0
50th	762,648	50th	33.8
75th	1,689,216	75th	74.2
Percentile	% of base income in 2000	Percentile	% of base employment in 2000
25th	0.03%	25th	0.1%
50th	0.2%	50th	0.4%
75th	0.9%	75th	1.4%

Source: Brown et al. (2012) estimated the impacts from cumulative installations of wind power from 2000 to 2008 at the county level for a 12 state region.

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Empirical Examples: Ethanol Plants

- Corn-based ethanol plants (Wojan et al., 2012)
- Using difference-in-difference approach combined with matching "treatment" and "control" counties
  - First difference was two years prior and one year after plant entry (QCEW)
- 46 plants identified as starting operation between 2000 and 2006 in the study area
- 4.6 jobs per ethanol job (within range of I-O projections)

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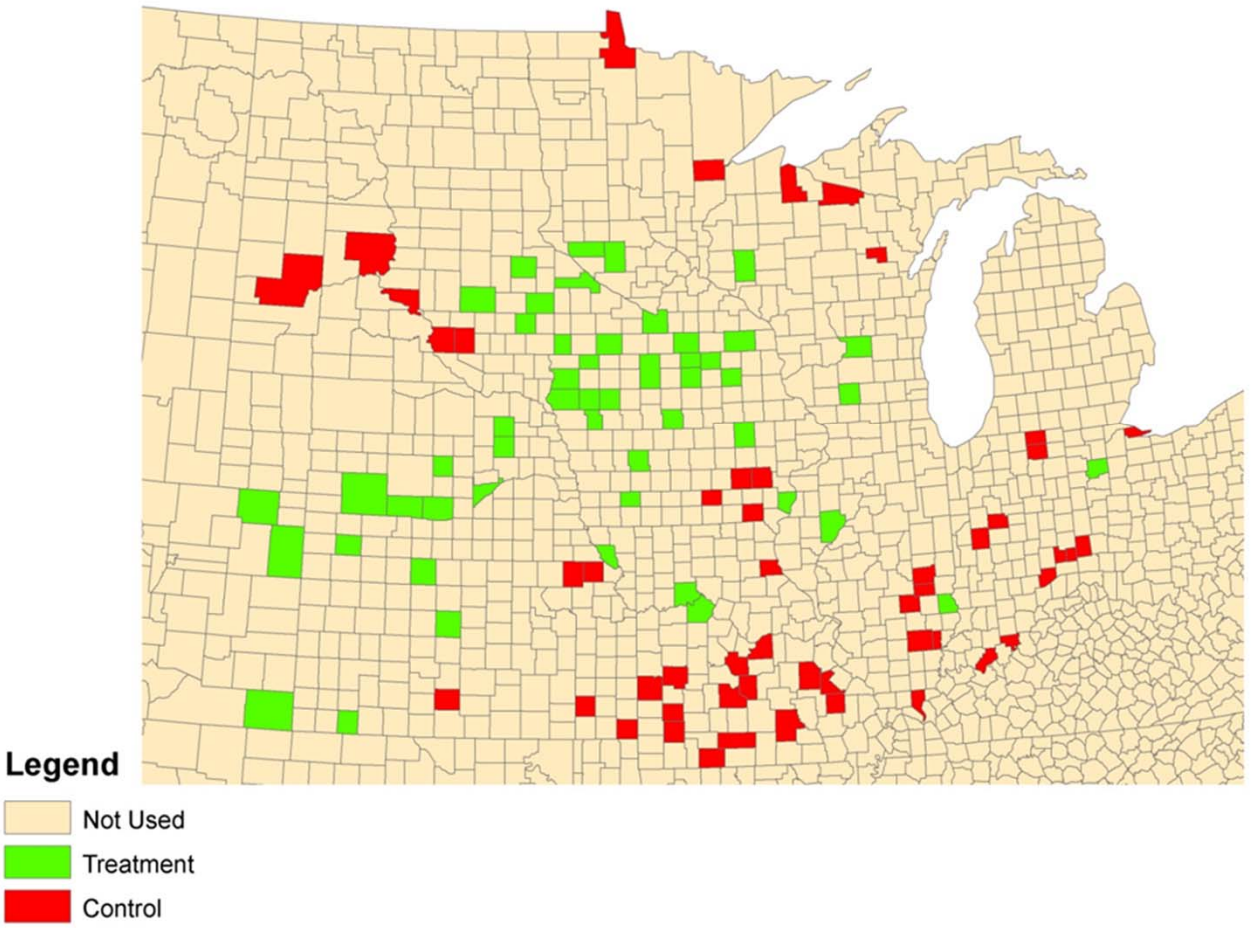
Matched Sample in Ethanol Study



Source: Wojan et al. (2012)

Employment Effects from a New Ethanol Plant

County Employment	
4.6 jobs per ethanol job	
Percentile	Total Predicted Employment
25th	95.2
50th	147.8
75th	173.6
Percentile	% of base total employment
25th	0.8%
50th	1.9%
75th	5.6%

Source: Wojan et al. (2012)

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Estimated Increases in Employment

Percentile of Counties	Natural Gas	Wind	Ethanol
25th	3.4%	0.1%	0.8%
50th	9.9%	0.4%	1.9%
75th	27.6%	1.4%	5.6%
Average increase in annual production ($ millions)	757	31	180

Notes: For natural gas, only gas boom counties are considered; for wind, counties with some installation in wind capacity from 2000 to 2008 are considered; and for ethanol, counties where an ethanol plant was constructed from 2000 to 2006 are considered.

Wind – cost basis ($97 per MWh) using average amount of installed capacity (123 MW) and assuming 30% utilization.

Ethanol – assuming 60 MGY plant $3 per gallon.

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Conclusions

- Empirical estimates of effects were within the range of projections from wind and ethanol I-O studies
- One limitation of empirical methods is that they often require multiple years of data on many counties to yield precise and credible estimates
- I-O methods, on the other hand, can estimate the effects of a proposed activity long before an empirical study would be possible
- Empirical methods can be used to verify I-O projections
- I-O and empirical methods are compliments, not substitutes

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Future Research

- Questions about gross versus net effects, especially when conducting analysis on a state, national or global scale, largely remain understudied
- Distribution of costs and benefits warrants further study as well
- Other applications are possible - e.g. agricultural commodity boom

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