Economic Impacts on U.S. Manufacturing of Regional Climate Agreements and Energy Price Changes

Wayne Gray (Clark U.), Joshua Linn (U. Maryland and RFF), and Richard Morgenstern (RFF)

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Any opinions and conclusions expressed here today are those of the authors and do not reflect those of the U.S. Census Bureau. All results using Census data have been reviewed to ensure that no confidential information is disclosed.

Overview

- Large decline in U.S. natural gas prices
  - Roughly 50% reduction in average NG prices, 2007-2012
  - Coincides with rebound in manufacturing employment post-2009
  - How much of increased employment comes from lower NG prices?
- Examine responses to energy price changes at the local level
  - Modeling past changes in county-industry employment
  - Based on past changes in electricity and fuels prices
  - Include other factors – input costs, proximity to product demand
  - Simulate impact of actual 2007-2012 natural gas price decline
- Preview of results:
  - Small increase in overall manufacturing employment
  - Smaller impacts than prior studies, due to controlling for other factors
  - Larger impacts on high-energy industries (but smaller than prior studies)
- Related work on climate change
  - U.S. regional climate programs – impacts of adding more states to RGGI

Existing Literature

- Melick (2014): 2-3% increase in U.S. manufacturing activity
- Kirat (2016): nearly 2% increase in U.S. manufacturing activity
- Hausman and Kellogg (2015):
  - Focus on gas-intensive industries (top decile)
  - Employment gains of 3.4% - 9.1%
  - Most gas-intensive industry (fertilizer mfg) gets 14% employment gain
- Considerable literature on industry agglomeration
  - Include controls for cost and availability of non-energy factors
  - Include controls for proximity to product demand
  - Include controls for international trade (imports and exports)

Data

- Plant-level data from U.S. Census Bureau restricted-access data

- Census of Manufactures
  - Every 5 years, 1972-2012
  - Total employment
  - Aggregate to about one million county - industry (NAICS-4) - year observations
  - Covers all manufacturing industries, entire U.S.

- Energy price sources
  - Plant-level electricity prices
  - State/county-level natural gas prices
  - Industry-level electricity and natural gas cost shares

- Other inputs = industry usage * county availability
  - Labor types: managers*college, skilled*HS, unskilled*non-HS
  - Resources: livestock, timber, farm products

Estimation and Simulation

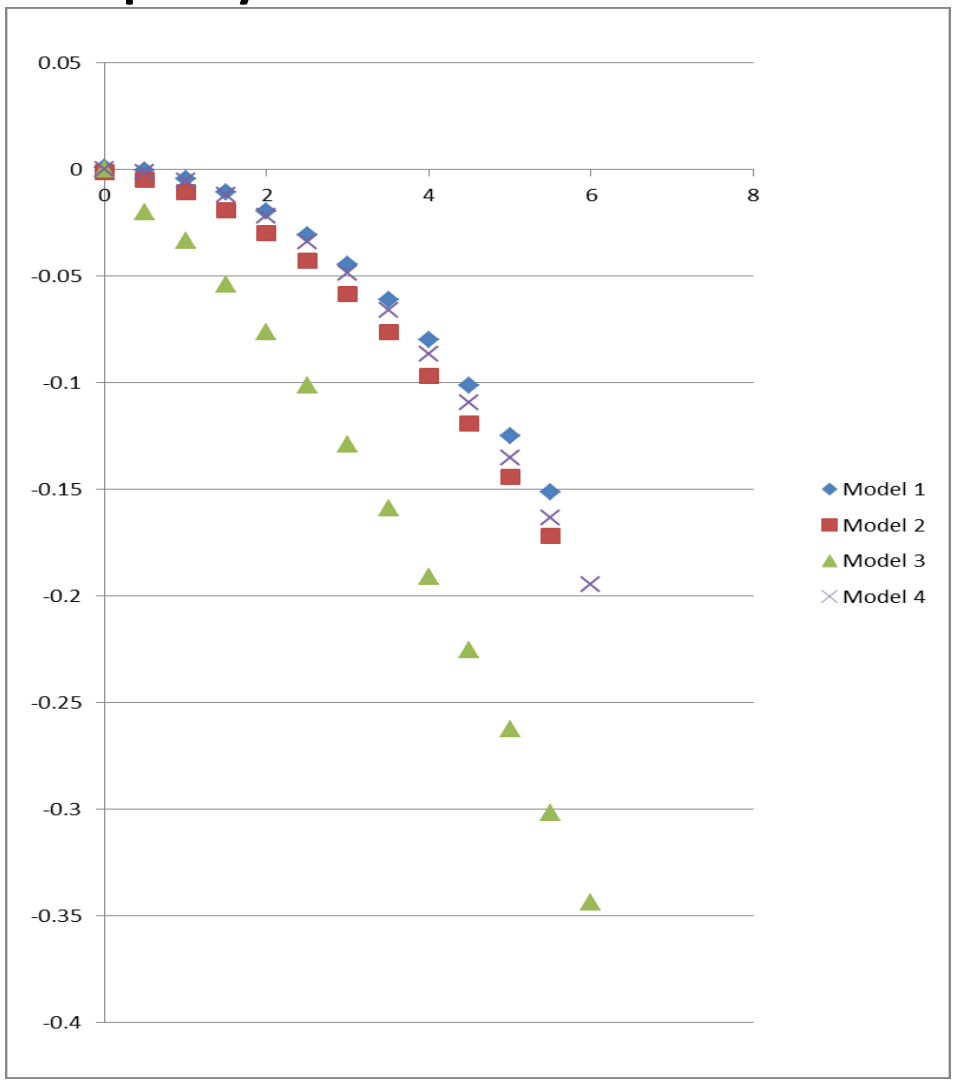
- Model estimated over full sample (1972-2012)
  - Explains 5-year changes in county-industry-year employment
  - Depends on 5-year changes in electricity, natural gas prices
    - Impact differs based on energy cost shares
    - Extra flexibility (spline) for natural gas price response
  - Test impact of including control variables (e.g. factor availability)
- Simulation
  - Done for each county-industry
  - Focus on actual 2007-2012 natural gas price declines
  - Includes predicted impact on electricity prices from cheaper NG
  - Calculate predicted 2007-2012 employment change
  - Compare to prediction with 0% NG (and electricity) price changes
  - Add up county-industry differences to national, state-level totals

Variation across Industries, 2007-2012

	All	Low natural gas intensity	Medium natural gas intensity	High natural gas intensity
Change in employment	–16.1%	–19.2%	–15.1%	–12.2%
Change in NG price	–50.7%	–50.7%	–50.6%	–50.7%
Elec cost share 1985	1.73%	0.99%	1.40%	3.17%
NG cost share 1985	1.11%	0.30%	0.68%	2.72%

Note: Low = NG cost share <0.5%, Medium = NG cost share 0.5%-1.0%, High = NG cost share >1.0%.

Employment Elasticities



Note: Natural gas cost shares from 0 to 6 percent; elasticities from +0.001 to -0.35.

Impacts of Lower NG Prices on Employment 2007-2012

	All industries	High natural gas intensity	Top decile NG intensity
Model 1 (flexible NG, with controls)	0.61%	1.78%	2.63%
Model 2 (less-flexible NG, with controls)	0.75%	1.95%	2.78%
Model 3 (flexible NG, without controls)	1.95%	3.34%	4.22%
Model 4 (less-flexible NG, without controls)	0.86%	2.22%	3.16%

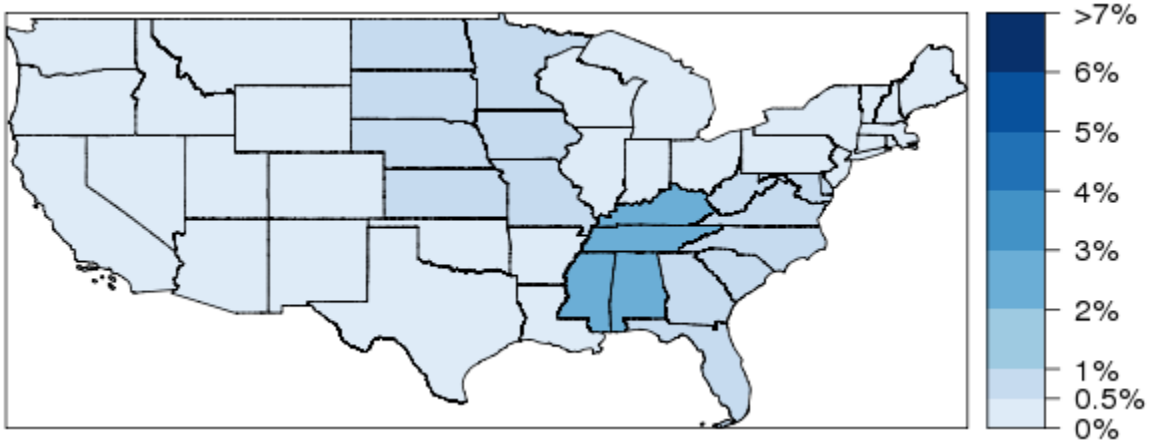
Variation across Regions, 2007-2012

	New England	Middle Atlantic	East North Central	West North Central	South Atlantic
Change in employment	–17.8%	–19.4%	–13.7%	–10.2%	–21.1%
Change in NG price	–31.2%	–16.4%	–44.6%	–56.7%	–54.3%
Elec cost share 1985	1.69%	1.71%	1.72%	1.72%	1.76%
NG cost share 1985	1.11%	1.15%	1.12%	1.07%	1.12%

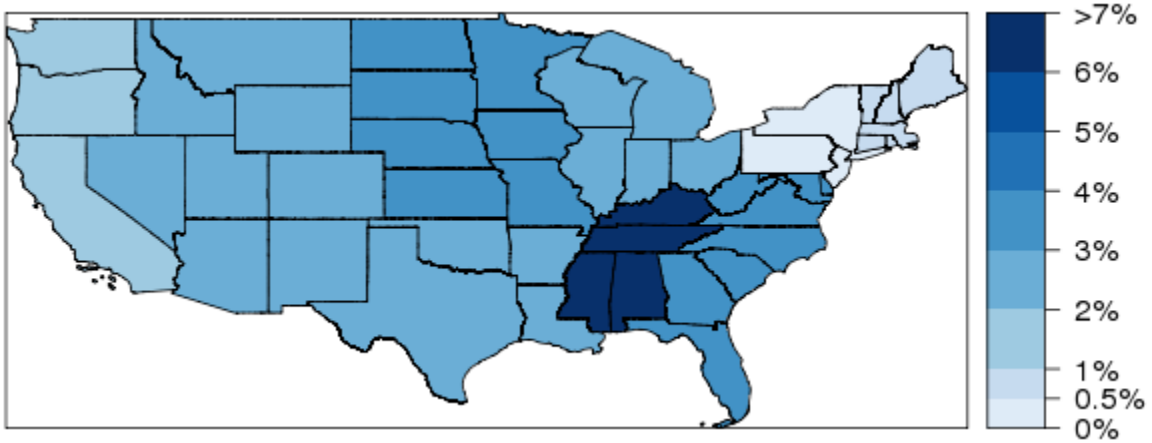
	East South Central	West South Central	Mountain	Pacific
Change in employment	–21.5%	–11.6%	–13.2%	–18.3%
Change in NG price	–71.2%	–67.6%	–41.0%	–37.8%
Elec cost share 1985	1.78%	1.74%	1.72%	1.69%
NG cost share 1985	1.06%	1.12%	1.09%	1.13%

Estimated Employment Impacts

All Manufacturing Industries



Top Decile Energy-Using Industries



Conclusions- Natural Gas Prices

- Lower natural gas prices increased manufacturing employment
  - Relatively small impact (0.6%) relative to 2007-2012 decline (16.1%)
  - Bigger impact on high NG intensity industries (1.8%)
  - Explains sizable part of cross-industry employment growth differences
  - Smaller employment gains than prior literature suggested
  - Due (at least in part) to controlling for other factors
- Substantial regional variation in employment effects
  - Smaller gains in New England, Pacific
  - Larger gains in East South Central, West North Central
  - Primarily driven by regional differences in natural gas price changes

- Paper available online – RFF Report – January 2018

U.S. Regional Climate Programs

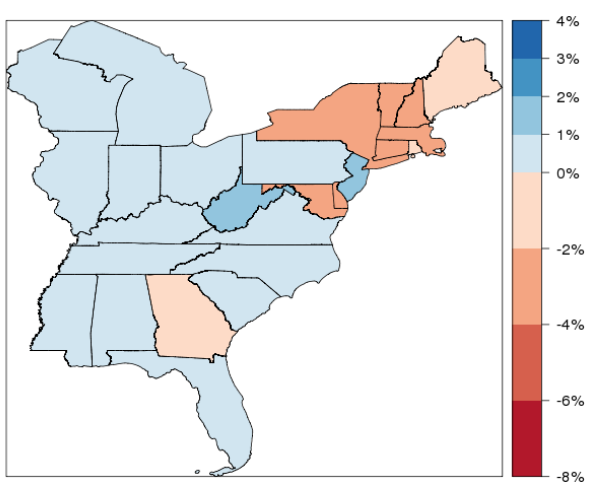
- Regional Greenhouse Gas Initiative (RGGI)
  - Initial agreement in 2005; seven Northeastern states
  - Currently 9 states – New England and NY, DE, MD
  - Cap-and-trade program for greenhouse gases, starting in 2009
  - Covers fossil fuel-fired electric power generators
- Impact of RGGI (compared to "No-RGGI" alternative)
  - Difference between $0 carbon price and $10 carbon price
  - Higher electricity and fuels prices in RGGI states
  - Expect some reductions in economic activity in RGGI states
  - Expect some leakage of economic activity to neighboring states
- Suppose neighboring states join RGGI (NJ, PA)
  - Impacts on RGGI states, newly joining states
  - Spillovers to other neighboring states

Model and Data

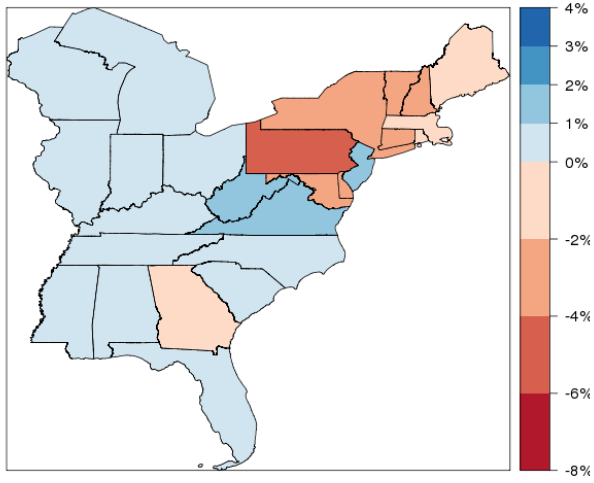
- Plant-level Census data, 1982-2011
  - All manufacturing industries
  - Energy prices and cost shares
  - Input-output table – who buys what inputs
- Focus on competitors and energy prices
  - Average for same 6-digit industry in states within 500 miles
  - Own vs. competitors, electricity and fuels prices
  - Direct and indirect energy costs (indirect=materials purchased)
  - Control for labor costs and product demand growth
- Estimated for 8 industry groups, based on energy intensity
  - Allows for different sensitivity to energy prices across groups
- Simulate impact of higher energy prices in RGGI states
  - Aggregate plant-level impacts to state-level totals
  - All industries and energy-intensive industries (top 25%)

RGGI – Employment – All Industries

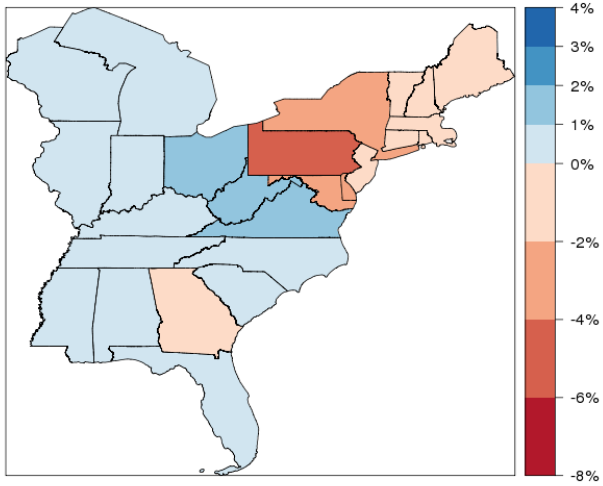
RGGI



RGGI + PA



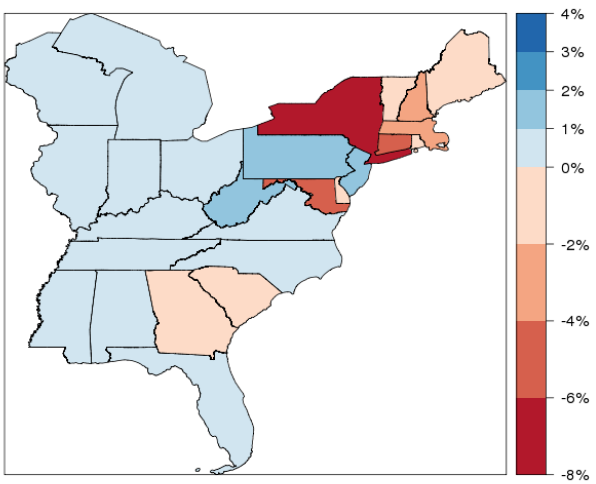
RGGI + PA + NJ



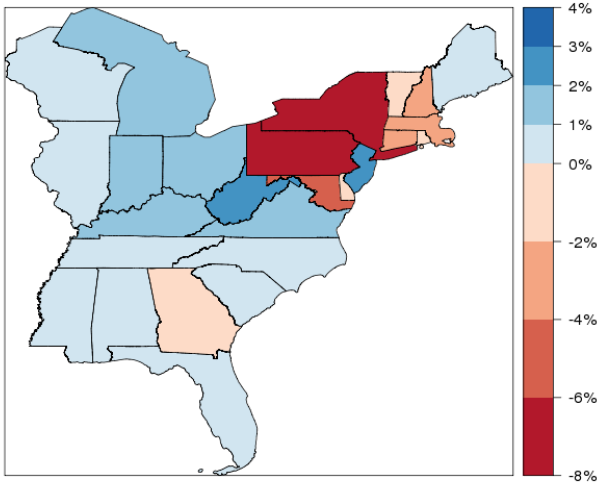
Impacts range from +4% to -6%

RGGI – Employment – Energy-Intensive Industries

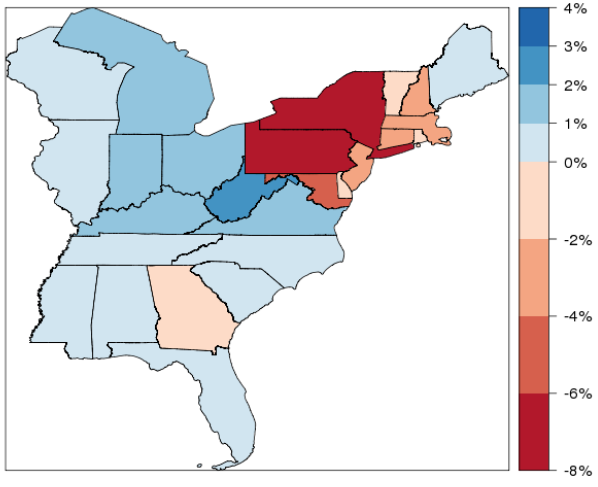
RGGI



RGGI + PA



RGGI + PA + NJ



Impacts range from +4% to -8%

Conclusions- RGGI

- Responsiveness typically increases with energy intensity
- Economic activity decreases with own energy prices
- Economic activity increases with energy prices of competitors
- Indirect energy cost impacts are weaker than direct costs

- Mostly expected results from simulations
  - More energy-intensive industries have bigger impacts
  - Economic activity increases in neighboring states
  - States joining RGGI shift from positive to negative
  - Bigger impacts on RGGI states near non-RGGI states
  - High-energy industry employment losses up to 6%

Expanding This Research

- Applications of this model in other settings
  - Carbon leakage under A.B. 32 in California
  - Clean Power Plan, possible future carbon prices
- Ex-Post analysis comparing predictions to results
  - Actual responses in California, RGGI
  - Takes time for data to become available
  - Policy "experiments" would be helpful (random assignment?)
- Modeling expectations and policy uncertainty
- Regulation of toxics and other non-CO_2 pollution

Climate Policy and Clean Innovation

- Usually focus on Product innovation
  - R&D subsidies => Invent new clean technology
- Don't forget Process innovation
  - "Way of doing business"
  - Carbon price => incentives to change behavior
  - Higher gasoline prices =>
    - Drive hybrid car
    - Drive more efficiently
    - Drive less
- Can use output/energy to measure overall process innovation
- Reducing carbon footprint can be costly
  - Concerns about leakage are real
  - TANSTAAFL

Comments and suggestions welcome.