The geography of environmental regulation: Welfare and distributional impacts of the CAA

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Indiana

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Colorado

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Florida State

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Cornell

SEERE 2022

Environmental regulation improves amenities

South Boston, MA in 1973 and 2012

Environmental regulation raises costs

Clean Air Act compliance will be costly, official says

By MAGGIE SIEGER
The Daily News

ENVIRONMENT

Galveston County must reduce toxic emissions by at least 15 percent no later than Nov. 1, 1996, or face losing massive amounts of federal dollars, said Texas Water Commissioner Pam Reed.

Reed met Tuesday with the Island Rotary Club to discuss the Clean Air Act amendments, federal laws that require cities to clean up air and water quality or lose federal funding. The amendments, passed in 1990, apply to a variety of small businesses never before subjected to regulation, Reed said.

The Texas Water Commission will assume the responsibilities of the Texas Air Control Board Sept. 1, becoming the Texas Natural Resource Conservation Commission. The three-member water commission board will oversee the new commission.

Texas must have a plan on how it will reach federally mandated clean air standards by Nov. 1, 1994, Reed said.

The Houston-Galveston area, composed of eight counties, is the only area in the state classified as severely out of compliance. The classification allows the region until 2007 to reach some federal standards. El Paso, Dallas-Fort Worth and Beaumont are the only other Texas regions classified as out of compliance.

The cost of reaching compliance will be extremely high, Reed said. She had no spe-

See AIR, 11-A

Business

• Stock market continues slide .... Page D-2
• There's a workshop on state taxes ...... Page D-2
• Gazette classified ads................. Pages D-6, 7, 8

D

The Indiana, PA Gazette Sunday, April 25, 1993

Penelec pegs $210 million to help clear air

$135.5 million at Conemaugh Station

Spending for environmental improvements at generating stations owned or operated by Penelec — including scrubbers at Conemaugh Station — is expected to top $210 million this year, or double what was spent last year and 10 times what was spent in 1987.

The increases are due primarily to improvements needed to comply with the Clean Air Act amendments of 1990, the company said.

The company plans to spend $39.3 million at stations it owns, with the remaining $171 million coming from utilities which own all or parts of other stations operated by Penelec.

"More than half of the budgeted outlay will be spent on installation of a flue gas desulfurization system — known as scrubbers — at the Conemaugh Station in Indiana, according to A.A. Slowik, director of generation technical services at Penelec.

"A total of $135.5 million is budgeted this year for that $314-million project," he said.

Penelec operates the Conemaugh Station for a group of nine utility owners.

The scrubbers are expected to remove approximately 95 percent of the sulfur dioxide emitted from exhaust gases at the two units of the 1,700-megawatt generating station.

Installation of scrubbers at Unit 1 will cost $112.8 million this year. That project is expected to be completed by late 1994. Approximately $22.8 million will be spent on scrubber work at Unit 2 and that project should be completed by late 1995, Slowik said.

"Although the scrubbers are a big-ticket project, they aren't the only work we have to do to comply with the Clean Air Act amendments," Slowik said. "This year, we will also be studying the possibility of installing scrubbers at another station and will be spending more than $35 million to install special low-NOx burners at boilers in a number of stations."

Work related to the Clean Air Act amendments include:

♦ A project to determine the feasibility of installing scrubbers at Homer City Station Unit 3, which is a $2.8-million study.

♦ Installation of low-NOx burners to reduce nitrogen oxide emissions at Conemaugh Station, $15.3 million; Homer City Station, $1.5 million; Seward Station, $3.3 million; Shawville Station in Clearfield County, $15.9 million; Keystone Station in Armstrong County, $1.1 million; and Warren Station in Warren County, $252,000.

Those outlays will be supplemented by money to be spent in 1994 and 1995 to complete most of those projects, it was noted.

Low-NOx burners are expected to reduce emissions at the respective generating units by approximately 50 percent.

Other projects at Homer City include:

♦ A study regarding installation of large filters that will remove 99.9 percent of the fly ash from the flue gas leaving the plant's stacks, $2.3 million.

♦ Coal-refuse site development, $1.9 million.

A project at Keystone Station in Armstrong County:

♦ Fly-ash disposal site development and expansion, $2.1 million.

A project at Conemaugh:

♦ Upgrades to a wastewater-treatment facility will be made to accommodate increased waste water produced by the station's scrubbers, $1.6 million. Again, Slowik added that spending more money on those ongoing projects is anticipated in the future.

What did the NAAQS do to welfare and employment?

What has been the welfare impact of the National Ambient Air Quality Standards (NAAQS)?

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What is the incidence of costs and benefits across space and sectors?

What role did physical and economic geography play in the aggregate and distributional effects?

→ Migration, trade, pollution transport, GE effects

NAAQS in spatial general equilibrium

1. We develop an integrated spatial assessment model
   - Eaton and Kortum (2002) Ricardian model
     - → Inter-county and inter-industry reallocation
   - Muller and Mendelsohn (2009) AP3
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2. We structurally estimate impacts on emissions and productivity
3. We simulate the spatial equilibrium effects of nonattainment designations in 1997
   - First geographic/equilibrium analysis of the CAA: use novel trade cost data (Jaworski and Kitchens, 2021)

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  - Lots of heterogeneity: -2% to +0.5% effects

Why do we need an equilibrium model?

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Economic geography: reduced form evidence shows firms and workers reallocate across space and sectors in response to nonattainment (Henderson, 1996; Becker and Henderson, 2000; Walker, 2013)

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Physical geography: emissions cross county borders and alters amenities in other locations

- Reallocation of emissions affects amenities and sorting everywhere: we need an equilibrium model

Roadmap

Step 1: Institutional background

- What are the NAAQS and how do they work?

Step 2: Estimation

- Estimate impacts on implicit marginal cost of emissions
- Estimate impacts on firm fundamental productivity

Step 3: Quantitative model

- EK model linked to AP3

Step 4: Results

- What if nonattainment counties in 1997 never went into nonattainment?

What are the NAAQS?

Pollutant [links to historical tables of NAAQS reviews]		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide (CO)		primary	8 hours	9 ppm	Not to be exceeded more than once per year
			1 hour	35 ppm	
Lead (Pb)		primary and secondary	Rolling 3 month average	0.15 µg/m^3 (1)	Not to be exceeded
Nitrogen Dioxide (NO_2)		primary	1 hour	100 ppb	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		primary and secondary	1 year	53 ppb (2)	Annual Mean
Ozone (O_3)		primary and secondary	8 hours	0.070 ppm (3)	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years
Particle Pollution (PM)	$PM_{2.5}$	primary	1 year	12.0 µg/m^3	annual mean, averaged over 3 years
		secondary	1 year	15.0 µg/m^3	annual mean, averaged over 3 years
		primary and secondary	24 hours	35 µg/m^3	98th percentile, averaged over 3 years
	PM_{10}	primary and secondary	24 hours	150 µg/m^3	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide (SO_2)		primary	1 hour	75 ppb (4)	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		secondary	3 hours	0.5 ppm	Not to be exceeded more than once per year

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Counties violating the standard are designated as in nonattainment

Enforcement of nonattainment

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- Adoption of lowest achievable emissions rate for new or modified sources
- Adoption of reasonably available control technology for existing sources
- Pollution offsets for new sources (i.e. local tradable permits)
- Potential federal sanctions, fines, or loss of federal funding if SIP isn't followed or developed

Firm impacts of nonattainment

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- Higher abatement expenditures and operating costs (Becker and Henderson, 2001; Becker, 2005)
- Lower productivity, capital, and output (Greenstone, 2002; Greenstone, List and Syverson, 2012)
- Fewer plant openings and increased plant and worker exit (Henderson, 1996; Becker and Henderson, 2000; Walker, 2013)

Increases costs in polluting industries

Who Pays for the Clean Air Act?

By Susan Lee

This time around, Washington couldn't be prouder. Twenty years ago, when the major provisions of the Clean Air Act were passed, the word "cost" was hardly mentioned. Now, with the bill in a House-Senate conference, the debate over amendments to the act is filled with figures purporting to capture the cost of the tiniest provision.

The trouble is, it's all hot air. Nobody has any idea what it will cost — worse, there has been a conspiracy of silence on who will pay the bill.

There are plenty of estimates of the total cost. Unfortunately, the range is large; respectable guesses run from $22 billion to more than $100 billion a year, and almost nobody is willing to declare any number definitive.

As laughably flabby as the cost estimates are, at least they define the territory. Getting a grasp on the dollar number for the benefits is like charting Planet Debbie — virtually impossible. The problem is that the benefits from cleaner air are broad. They include everything from fewer deaths from lung cancer to more relief from sinus headaches.

Thus, estimating the money saved has to take into account profound speculation — like the value of a life (perhaps $2 million to $5 million), savings in medical costs and days lost due to respiratory diseases. It should include, too, less profound categories such as less frequent house painting and reduced damage to national monuments. Toting this up is a mug's game; unsurprisingly, there are no reliable estimates of the benefits.

Why, then, do we seem so eager to pass legislation that could be as expensive as $100 billion a year without knowing whether the benefits will justify the cost? Simply put, the discussion has not focused on who, ultimately, will pay; instead, there is an implicit promise that the Clean Air Act will be a free lunch.

Ask who will pay the bill, and the answer is that business will have to ante up. Granted, the added cost will be felt first by the tens of thousands of businesses that must comply with

new regulations on acid rain, toxic emissions and urban smog.

Utilities will have to cut back on cheaper high-sulfur coal and use more expensive low-sulfur coal or install scrubbers to reduce sulfur dioxide emissions. Auto companies will have to limit tailpipe emissions of hydrocarbons and nitrogen oxide, and small businesses like bakeries, gas stations and restaurants will have to control their use of alcohol- and petroleum-based products that contribute to smog. Chemical and steel companies — and dry cleaners, auto body shops and pest control companies — will have to buy new equipment to control airborne toxic substances.

But in the final analysis, business doesn't pay. We pay. Business will pass the increased cost along. Either consumers will pay in the form of higher prices for products or services, or workers will pay in the form of lower wages, or shareholders will pay in the form of lower dividends or stock prices.

That means we all will pay more for electricity, gasoline, cars, bread and paint. Workers in affected industries, like steel and mining, will absorb the cost by receiving lower pay hikes or benefits. People who own stock in utility or oil companies will find their dividends are lower or their stocks are worth less. And owners of mom-and-pop dry cleaners will take out less profit.

There is an indirect cost to all of us, too, because the economy won't grow as fast as it could otherwise. After all, money spent for pollution control cannot be spent to make widgets. Likewise, it cannot be spent for new equipment to produce widgets more efficiently.

Finally, the added cost to business will diminish the attractiveness of doing business here, and companies will relocate to other countries, taking production and jobs with them.

Perhaps the blank-check aspect of the Clean Air Act cannot be avoided. The law will mandate what experts agree are sensible goals, and incorporate efficient ways of achieving those goals; the cost will follow. But Congress, the Administration and environmentalists should come clean and point out who will ultimately cough up the money. Twenty-two billion dollars to $100 billion would buy a lot of research on breast cancer, Alzheimer's and heart disease. That's a significant trade-off — one that ought to be considered since the direct cost could be $90 to $450 a person a year. □

Susan Lee is writing a book on the origins of economic crises.

E.P.A. ADVOCATING HIGHER STANDARDS TO CLEAN THE AIR

INDUSTRY WARNS OF COSTS

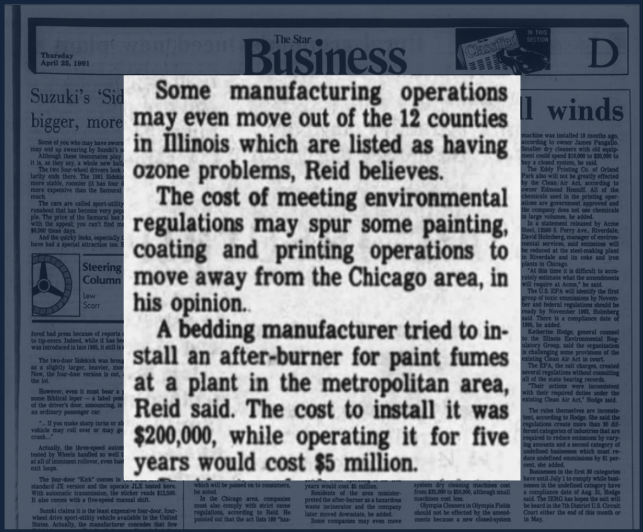
In Areas Struggling to Reduce Pollution, New U.S. Goals Could Be Hard to Meet

By JOHN H. CUSHMAN Jr.

WASHINGTON, Nov. 24 — The Environmental Protection Agency is recommending tighter national standards for emissions of the chemicals and particles that form smog and soot, some of the most pervasive and unhealthy forms of air pollution.

The new definition of how clean the air must be to protect the public's health is sure to be one of the biggest environmental fights of the coming year, raging from the Oval Office to Capitol Hill and drawing in Federal judges and governors.

Polluting industries shut down or move



Thursday
April 25, 1991

The Star
Business

D

Suzuki's 'Sid
bigger, more

Steering
Column

Some manufacturing operations may even move out of the 12 counties in Illinois which are listed as having ozone problems, Reid believes.

The cost of meeting environmental regulations may spur some painting, coating and printing operations to move away from the Chicago area, in his opinion.

A bedding manufacturer tried to install an after-burner for paint fumes at a plant in the metropolitan area, Reid said. The cost to install it was $200,000, while operating it for five years would cost $5 million.

l winds

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These impacts are capitalized into housing values and rents (Chay and Greenstone, 2005; Grainger, 2012; Bento et al., 2015)

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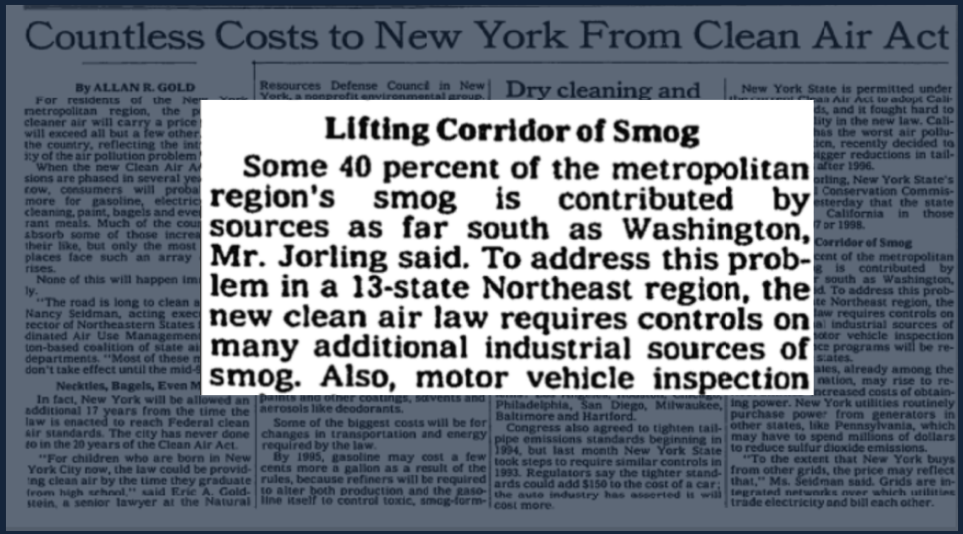
These impacts are capitalized into housing values and rents (Chay and Greenstone, 2005; Grainger, 2012; Bento et al., 2015)

Benefits persist in subsequent (not exposed!) generations (Colmer and Voorheis, 2020)

Reduces emissions locally and elsewhere



Countless Costs to New York From Clean Air Act

By ALLAN R. GOLD

For residents of the Ne
metropolitan region, the p
cleaner air will carry a price t
will exceed all but a few other
the country, reflecting the int
ity of the air pollution problem

When the new Clean Air A
sions are phased in several ye
row, consumers will proba
more for gasoline, electric
cleaning, paint, bagels and eve
rant meals. Much of the cou
absorb some of those increa
their like, but only the most
places face such an array
rises.

None of this will happen im
ly.

"The road is long to clean a
Nancy Seidman, acting exec
rector of Northeastern States
dinated Air Use Managemen
ton-based coalition of state ai
departments. "Most of these m
don't take effect until the mid-

Necktles, Bagels, Even M

In fact, New York will be allowed an additional 17 years from the time the law is enacted to reach Federal clean air standards. The city has never done so in the 20 years of the Clean Air Act.

"For children who are born in New York City now, the law could be providing clean air by the time they graduate from high school," said Eric A. Goldstein, a senior lawyer at the Natural Resources Defense Council in New York, a nonprofit environmental group

Dry cleaning and

Paints and other coatings, solvents and aerosols like deodorants.

Some of the biggest costs will be for changes in transportation and energy required by the law.

By 1995, gasoline may cost a few cents more a gallon as a result of the rules, because refiners will be required to alter both production and the gasoline itself to control toxic, smog-form-

Philadelphia, San Diego, Milwaukee, Baltimore and Hartford.

Congress also agreed to tighten tailpipe emissions standards beginning in 1994, but last month New York State took steps to require similar controls in 1993. Regulators say the tighter standards could add $150 to the cost of a car; the auto industry has asserted it will cost more.

New York State is permitted under
as Air Act to adopt Cali
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has the worst air pollu
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Corridor of Smog

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ates, already among the
nation, may rise to re-
ncreased costs of obtain-
ing power. New York utilities routinely purchase power from generators in other states, like Pennsylvania, which may have to spend millions of dollars to reduce sulfur dioxide emissions.

"To the extent that New York buys from other grids, the price may reflect that," Ms. Seidman said. Grids are integrated networks over which utilities trade electricity and bill each other.

Lifting Corridor of Smog

Some 40 percent of the metropolitan region's smog is contributed by sources as far south as Washington, Mr. Jorling said. To address this problem in a 13-state Northeast region, the new clean air law requires controls on many additional industrial sources of smog. Also, motor vehicle inspection

Model: Firm production

$$q_i^k = \left[\prod_{p=1}^{P} \left(e_i^{kp}\right)^{\xi^{kp}}\right] \left[z_i^k \left(K_i^k\right)^{1-\gamma} \left(L_i^k\right)^{\gamma}\right]^{1-\sum_{p=1}^{P} \xi^{kp}}$$

Perfectly competitive firms produce different varieties ω using a CRS Cobb-Douglas technology combining:

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ξ^{kp} is the emissions elasticity: calibrated from Shapiro and Walker (2018)

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ξ^{kp} is the emissions elasticity: calibrated from Shapiro and Walker (2018)

γ is the aggregate labor share from FRED

Model: Emissions

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Inverting CD factor shares gives us equilibrium emissions intensity:

$$\frac{e_i^{kp}}{q_i^k} = \frac{\xi^{kp} P_i^k}{\eta_i^{kp}}$$

The effect on the MC of emissions

We let $\eta_i^{kp} = \bar{\eta}_i^{kp} \exp\left(\beta_\eta^p N_i\right)$ where $N_i \in \{0, 1\}$ is an indicator for being in nonattainment

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Equilibrium emissions are given by:

$$\underbrace{\log\left(e_i^{kp}\right)}_{\text{emissions}} = \underbrace{-\beta_\eta^p N_i}_{\text{nonattainment}} + \underbrace{\log\left(w_i^k L_i^k\right)}_{\text{wage bill}} + \underbrace{\log\left(\frac{\xi^{kp}}{\gamma\left(1 - \sum_{q=1}^{P} \xi^{kq}\right)}\right)}_{\text{emissions share / labor share}} - \underbrace{\log\left(\bar{\eta}_i^{kp}\right)}_{\text{emissions price}}$$

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Emissions decline in: non-attainment, price of other regulations

Emissions increase in: production, share of emissions in production

1990 CAAAs quasi-experiment

We estimate β_{η}^{p} exploiting variation induced by the 1990s CAAAs (Grainger, 2012; Walker, 2013; Bento et al., 2015)

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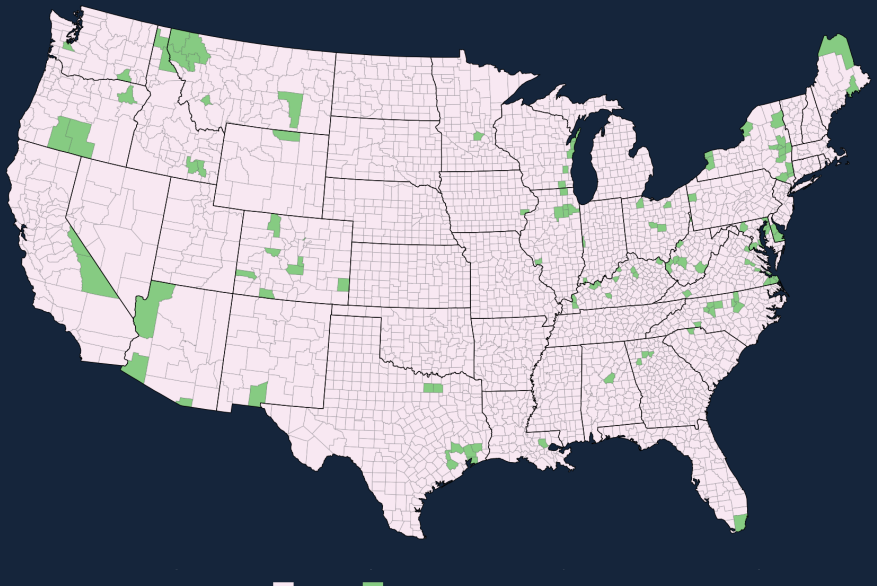
This lead to the largest increase in nonattainment since the 1970s

Newly in nonattainment



Difference-in-differences

Compare manufacturing emissions in (new) nonattainment vs attainment counties, before vs after post-1990 CAAAs nonattainment designations

$$\log\left(e_{i,t}^{p}\right) = -\beta_{\eta}^{p} N_{i,t} + \log\left(w_{i,t} L_{i,t}\right) + \psi_{i} + \nu_{p,t} + \varepsilon_{i,t}^{p}$$

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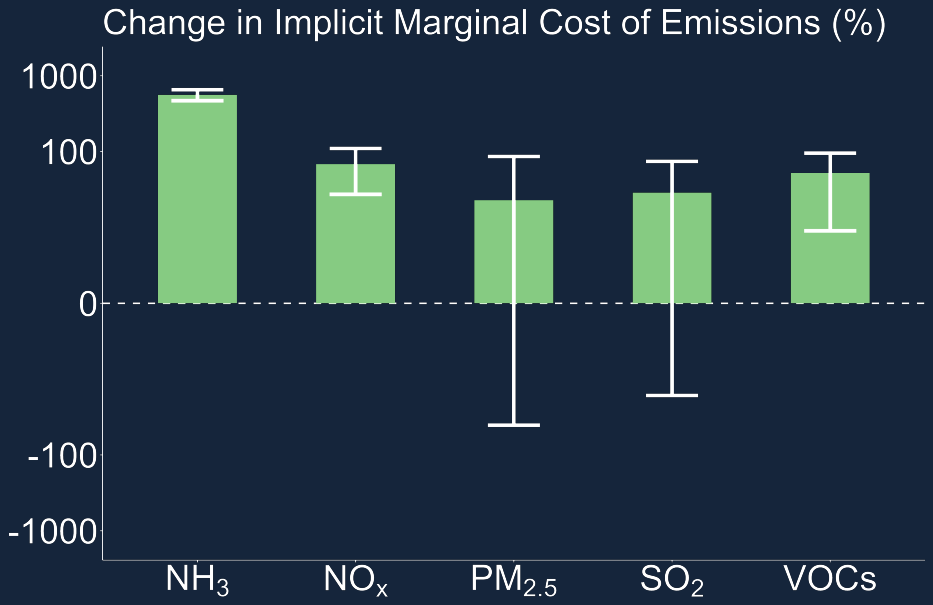
Estimate the model using NEI data in 1990, 1996-2001 (no event studies)

Large increases in MC of $PM_{2.5}$ precursors



Model continued: Productivity

$$q_i^k = \left[\prod_{p=1}^{P} \left(e_i^{kp}\right)^{\xi^{kp}}\right] \left[z_i^k \left(K_i^k\right)^{1-\gamma} \left(L_i^k\right)^{\gamma}\right]^{1-\sum_{p=1}^{P} \xi^{kp}}$$

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We let $T_i^k = \bar{T}_i^k \exp\left(\beta_T^k N_i\right)$, where $\bar{T}_i^k$ captures other sources of productivity

$\beta_{\mathbf{T}}^{\mathbf{k}} = 0$ for the non-polluting sector

The effect on productivity

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Industry income increases in: base productivity

Triple difference

Compare manufacturing vs nonmanufacturing income, in attainment vs nonattainment counties, before vs after post-1990 CAAAs nonattainment designations (Walker, 2013)

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Identifying assumption: trend differences across manufacturing / nonmanufacturing in nonattainment counties would have followed trend differences in attainment counties in the absence of nonattainment

Nonattainment reduces productivity

$\beta_T^k - \theta^k \sum_{p=1}^{P} \eta^{kp} \beta_\eta^p$	-0.074**	-0.059**	-0.099**	-0.091**
	(0.031)	(0.026)	(0.049)	(0.036)
Observations	72,279	72,279	72,279	72,279
Ind-County / Ind-Year FEs	Yes	Yes	Yes	Yes
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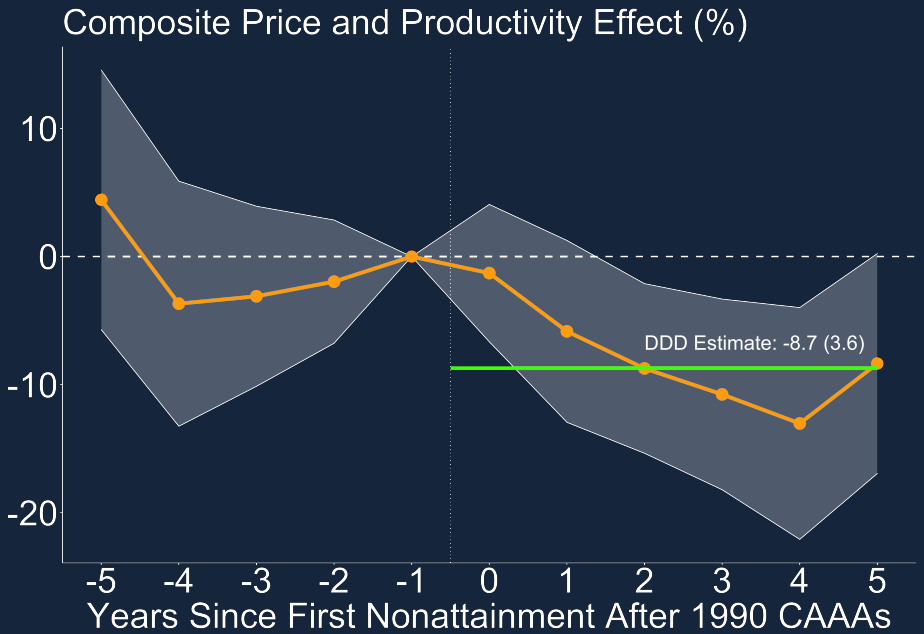
Preferred estimate gives $\hat{\beta}_T^k = -0.05$ with nonparametric p-value of 0.096

The effect on productivity



Model: Household objective

$$U_j^m = \max_{i \in N, k \in K} B_i \, \delta_{ji}^{mk} \prod_{l=1}^{K} \left(C_i^l\right)^{\alpha^l}$$

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Model: Amenities

B_i captures all location specific amenities, including ambient particulate matter y_i

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y_i is a function Y_i of emissions of pollutants $p = 1, \ldots, P$ from all locations

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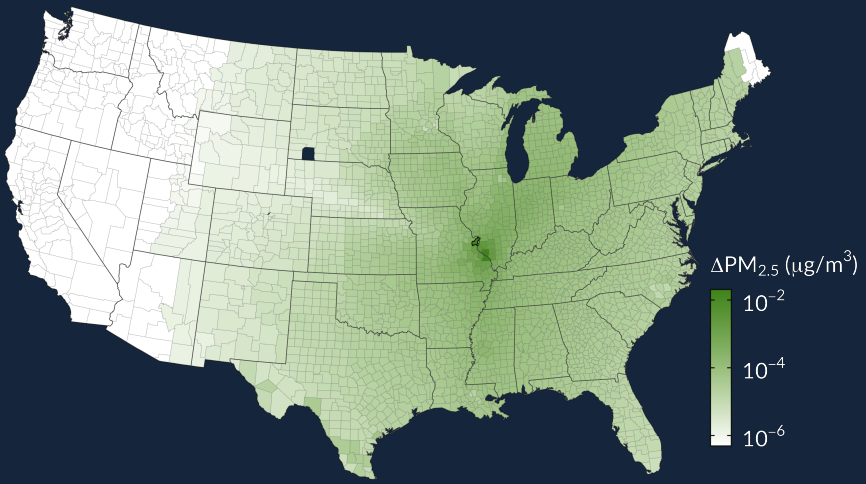
Y_i is the atmospheric transport model from AP3

Model: 1000 tons of NO_x in St Louis



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Local ambient pollution is mapped into dollar damages d_i using the AP3 dose-response functions:

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Pollution transport + dose-response gives us marginal damages:

$$md_{ij} := \frac{\partial d_i}{\partial e_j} = \frac{\partial D(y_i)}{\partial y_i} \frac{\partial y_i}{\partial e_j}$$

Model: Amenities

The welfare cost for workers in market (i, k) in consumption equivalent terms is multiplicative (tractability):

$$B_i = \underbrace{\bar{B}_i}_{\substack{\text{non-pollution} \\ \text{amenities}}} \prod_{j=1}^{N} \underbrace{\left(1 - md_{ij}/C_i^k\right)^{e_j}}_{\substack{\text{consumption-} \\ \text{equivalent} \\ \text{damages}}}$$

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Marginal damages in consumption-equivalent terms

Multiplicative expression ensures non-negative amenities

Model: Labor reallocation

Moving from (j, m) to (i, k) incurs a utility cost $\delta_{ji}^{mk} \in (0, 1]$ where

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The share of households migrating from (j, m) to (i, k) is:

$$\pi_{ji}^{mk} = \frac{\frac{w_i^k}{P_i} B_i \bar{\delta}_{ji}^{mk}}{\sum_{n=1}^{N} \sum_{l=1}^{K} \frac{w_n^l}{P_n} B_n \bar{\delta}_{jn}^{ml}}$$

To the quantitative results

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To the quantitative results

Higher price of emissions → substitution toward labor →

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Higher price of emissions → substitution toward labor → manufacturing workers better off from higher nominal wages

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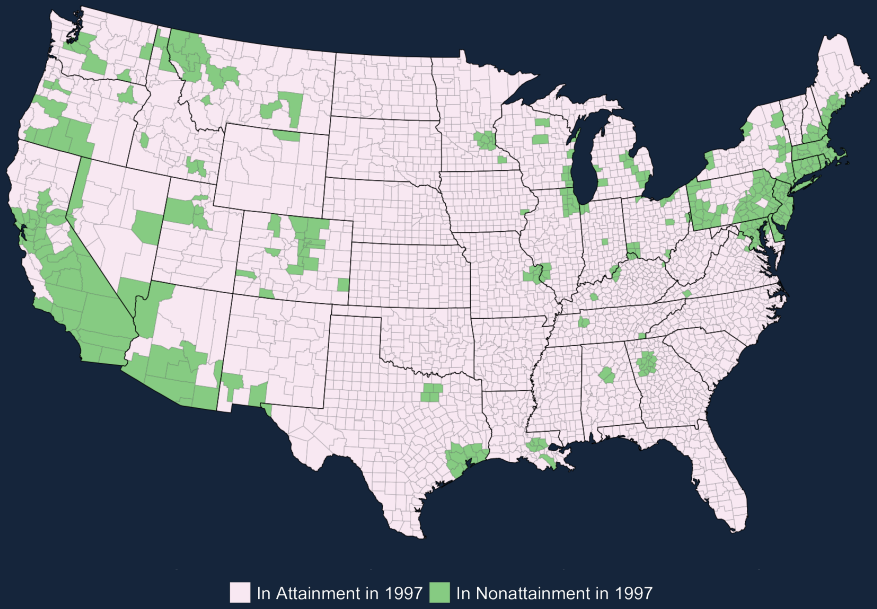
Spatial equilibrium model will let us quantify these effects

The 1997 nonattainment shock



Aggregate welfare improvements are substantial

	Total		Amenity		Consumption	
	%	Billion $	%	Billion $	%	Billion $
Aggregate	*0.49*	*19.3*	*0.52*	*20.6*	*-0.03*	*-1.2*
Manufacturing Sector	0.38	2.1	0.53	2.9	-0.17	-0.9
Nonmanufacturing Sector	0.51	17.1	0.52	17.6	-0.01	-0.3
Attainment Counties	0.21	3.9	0.17	3.2	0.03	0.6
Nonattainment Counties	0.76	15.4	0.86	17.4	-0.09	-1.8

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	Total		Amenity		Consumption	
	%	Billion $	%	Billion $	%	Billion $
Aggregate	*0.49*	*19.3*	*0.52*	*20.6*	*-0.03*	*-1.2*
Manufacturing Sector	0.38	2.1	0.53	2.9	-0.17	-0.9
Nonmanufacturing Sector	0.51	17.1	0.52	17.6	-0.01	-0.3
Attainment Counties	0.21	3.9	0.17	3.2	0.03	0.6
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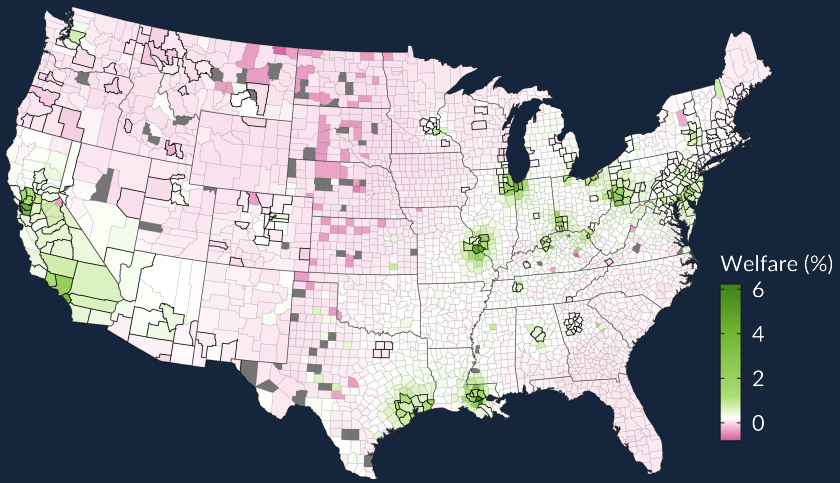
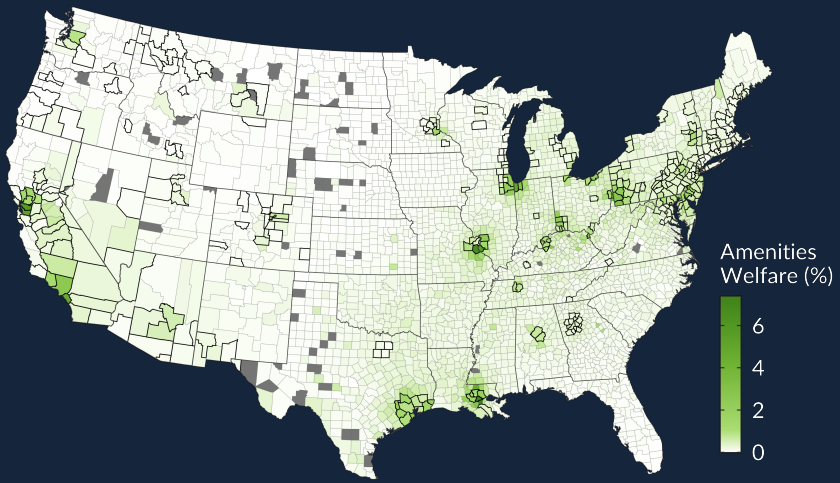
Significant spatial heterogeneity

Gains concentrated in major cities, labor and trade frictions matter



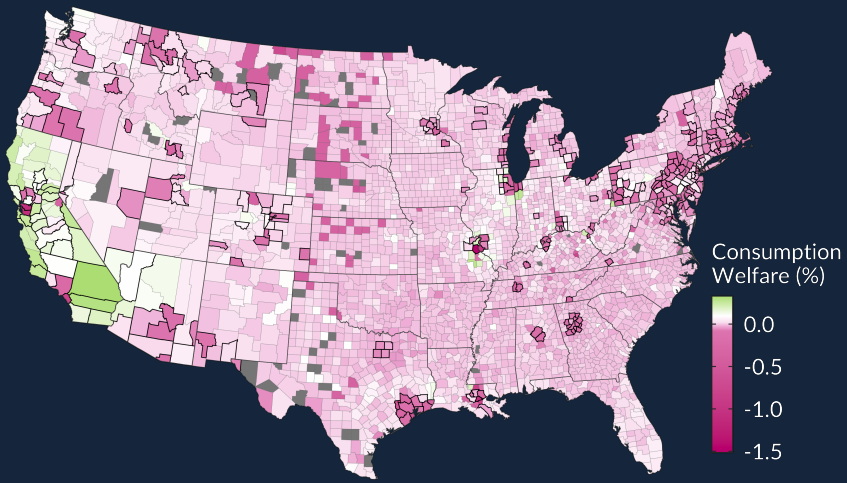
Amenities improve everywhere

Nonattainment emissions decline by up to 85% + *negative* leakage



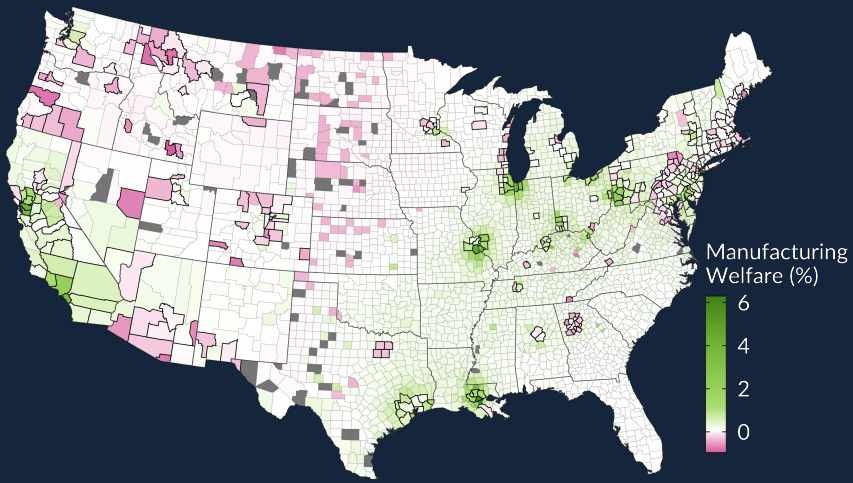
Losses are due to declining consumption

Higher prices and lower wages



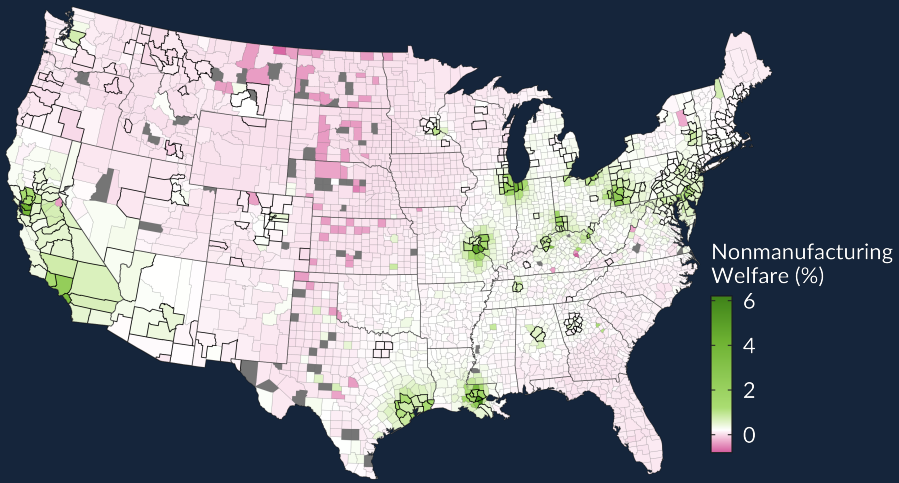
Nonattainment harms manufacturing

But nonattainment is welfare-enhancing for manufacturing in high emission areas



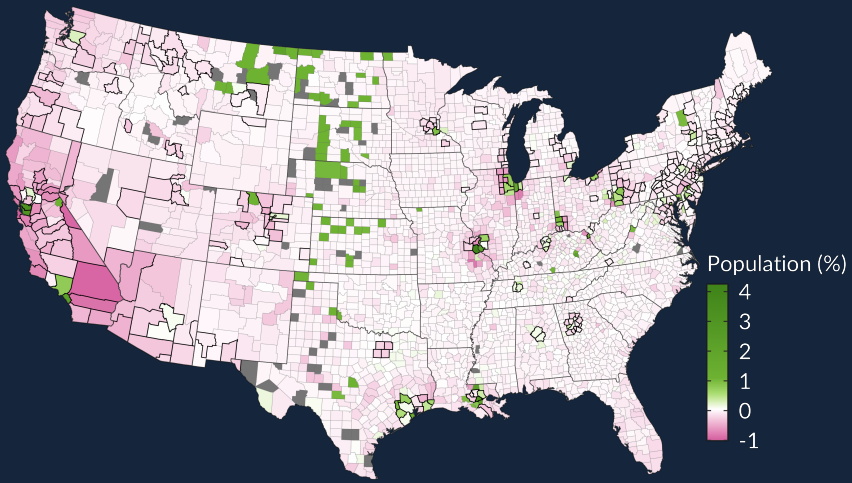
Nonattainment benefits nonmanufacturing

Real wage effect in nonattainment counties is much smaller for nonmanufacturing



Labor reallocates across space

People leave nonattainment counties



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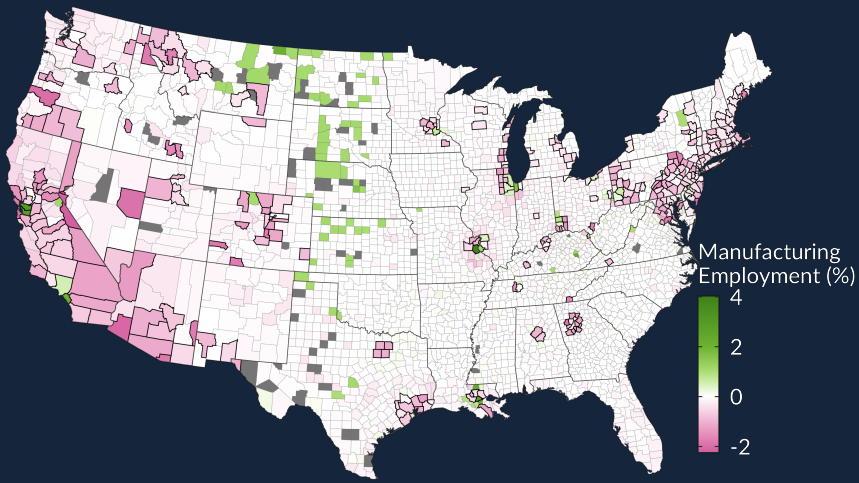
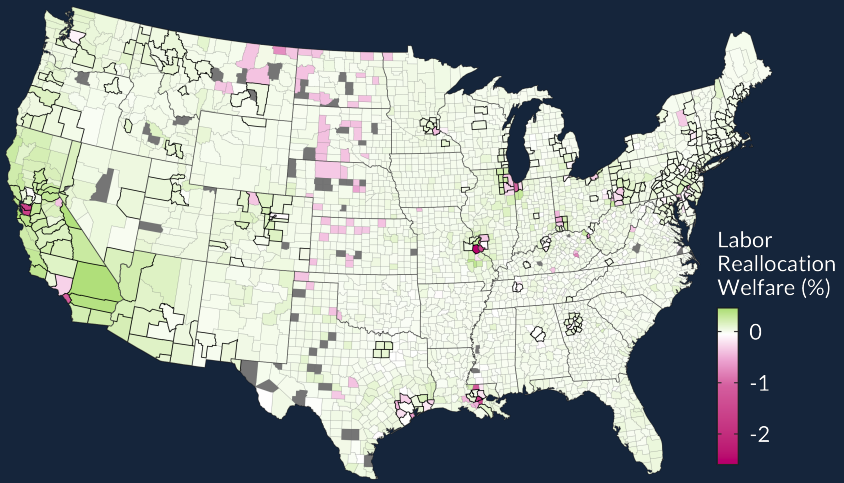


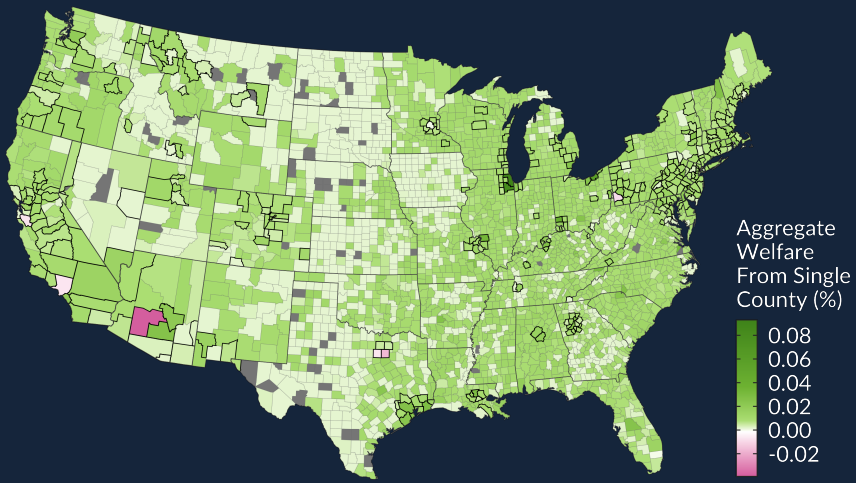
Heterogeneous benefits of reallocation

Good for people moving, bad for incumbents where they go



Who should be in nonattainment?

Stricter regulations are welfare-enhancing almost everywhere



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Missing pieces: IO propagation of productivity effects, non-$PM_{2.5}$ pollutants