The Local Environmental and Welfare Effects of Large Industrial Shutdowns

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Roadmap

Motivation

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The Impact of Large Industrial Shutdowns

The Amenity Effects of Industrial Closures

Conclusion

Structural Transformation in Germany

The New York Times

Germany Closes Its Last Black Coal Mine

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The Prosper-Haniel coal mine in Germany was closed with a ceremony last Friday. The black coal it produced helped fuel the country's industry. Christophe Gateau/DPA, via Agence France-Presse — Getty Images

By The Associated Press

Dec. 24, 2018

East Germany's old mines transformed into new lake district

Despite a €2.2bn regeneration programme, the Lusatian Lake District project, on land once occupied by the GDR's industrial heartland, remains relatively unknown to non-east Germans. So we took a tour ...

What a dive ... a floating house on Geierswalder lake, east Germany. Photograph: Alamy

"This was once one of the dirtiest areas in East Germany," says Sören, my tour guide from IBA Tours, as our bikes swoosh through the Lusatian Lake District. "When I was growing up here, before the Wall fell, we never hung our laundry outside, and we never wore white socks, because we knew they wouldn't be white after a few minutes. The coal dust was everywhere, all the time."

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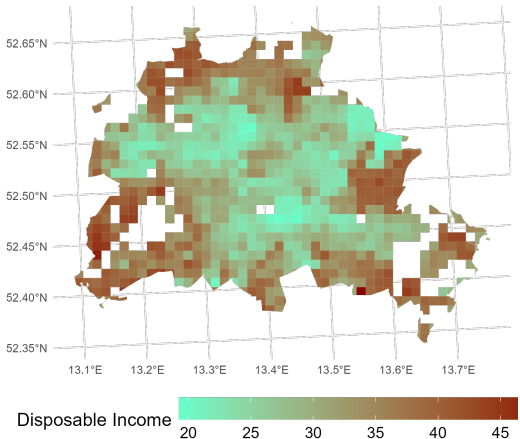
Data: EEA Industrial Reporting Database

- Combines previous reporting requirements from E-PRTR and IED
- Two reporting thresholds:
  - **pollutant** specific (e.g. 100t of nitrogen oxides per year)
  - **installation** specific (e.g. heat input $>=$ 50 MW for thermal power stations)
- Covers almost 100,000 facilities in the EU and partner countries since 2007 - 10,400 of which are located in Germany
- New release contains information on the operating status of reporting facilities
- CO2 emissions reported in 2021 account for 47% and 82% of total territorial and combined industry CO2 emissions respectively, reported NOx emissions cover 20% of national total ‣ Emission Breakdown

Data: Socio-Economic and Real Estate Information

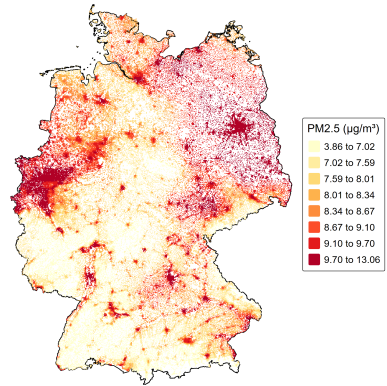
- Socio-Economic Data at 1km $\times$ 1km grid cell level from RWI-GEO-GRID for 2010-2021 (Breidenbach and Eilers, 2018)
- Real estate data on house/apartment sales and rents at the object level from *Immobilienscout24* (Schaffner and Thiel, 2024)
- $\Rightarrow$ Panel of $\approx$ 1.8 million grid cell - year observations



Mean Grid Cell Income Berlin 2021

Data: Air Pollution & Weather

- $PM_{2.5}$ monitor data from German Environment Agency (interpolated using chemical transport model) (Umweltbundesamt, 2022)
- ERA5 reanalysis data on precipitation, temperature and wind ($0.25° \times 0.25°$ resolution) (Hersbach et al., 2020)



Mean Ambient PM2.5 Concentration 2021

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Empirical Strategy

$$Y_{nt} = \sum_{s \neq -1} \theta_s \times Closure_n \times \mathbb{1}[t - \tau_n = s] +$$

$$\sum_{s \neq -1} \phi_s \times Downwind_n \times Closure_n \times \mathbb{1}[t - \tau_n = s] + C_{nt}\beta' + \alpha_n + \omega_t + \epsilon_{nt}$$

- Y_{nt}: Outcome of interest (PM2.5, housing prices, etc) in grid cell n
- $Closure_n$: indicator for facility closure affecting grid cell n
- C_{nt}: vector of weather controls
- τ_n year of **first** treatment for grid cell n

Model estimated using the two-stage estimator proposed in Gardner et al. (2024)

▸ Estimation Sample

Effect of Plant Closures on PM2.5 Concentration

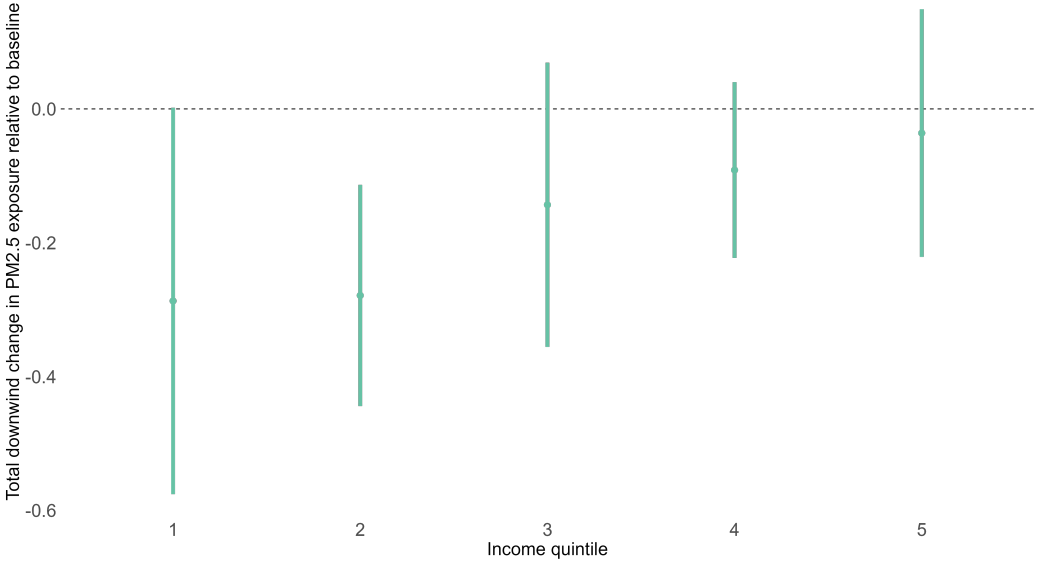
Effect of Plant Closures on PM2.5

▸ Event Study Results

Dependent Variable:	Mean Annual $PM_{2.5}$ Concentration		
Model:	(1)	(2)	(3)
Closure	-0.0535	-0.0426	0.0051
	(0.0580)	(0.0560)	(0.0624)
Closure × Downwind			-0.1732***
			(0.0671)
Weather Controls		✓	✓
Fixed-effects			
Year	✓	✓	✓
Grid Cell	✓	✓	✓
Observations	202,266	202,266	202,266
Within R^2	0.00069	0.00044	0.00225

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

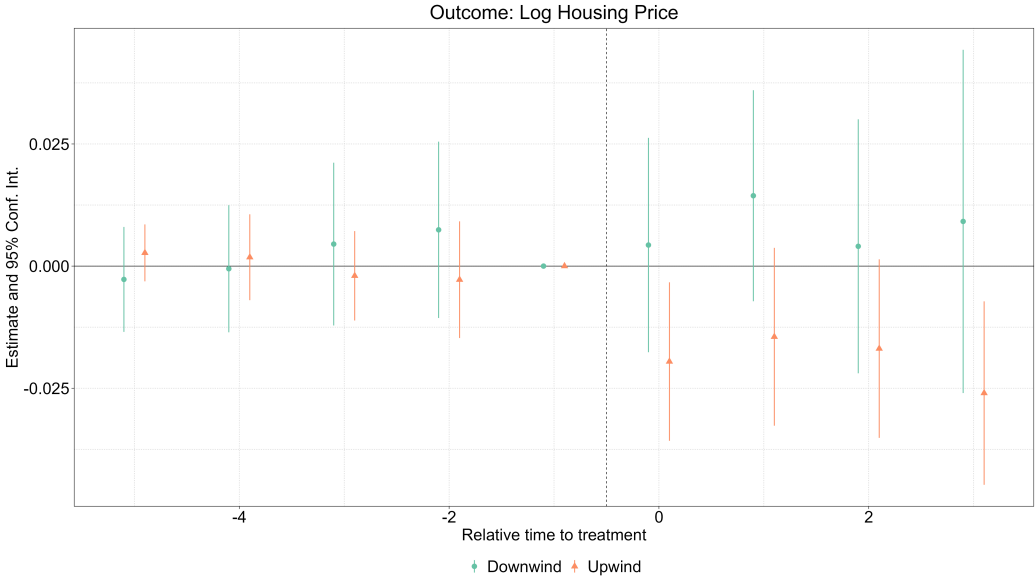
Treatment Effect Heterogeneity by Income Decile



Effect of Plant Closures on Housing Prices

Effect of Plant Closures on Housing Prices

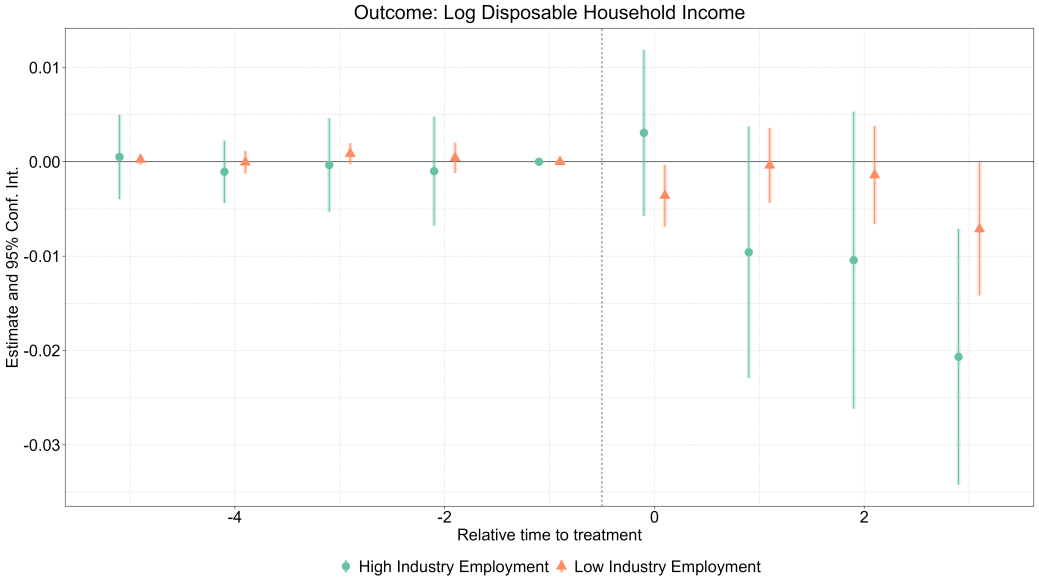
▸ Fraenkel et al (2024)



Effect of Plant Closures on Employment & Household Income

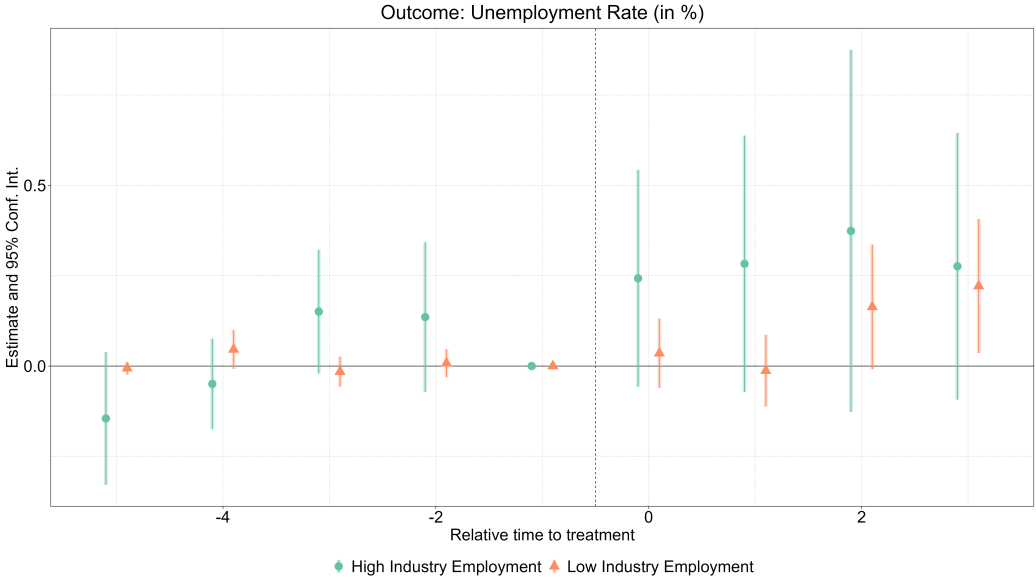
Effect of Plant Closures on Local Income

▸ Rud et al (2024)



Effect of Plant Closures on Local Employment

Population



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Model

Consider the most simple version of a Rosen-Roback framework as in Bartik et al. (2019) :

$$\max_{c,h} \; u_{ln} = A_n \cdot h^{\alpha} \cdot c^{1-\alpha} \cdot \theta_{ln}$$

$$s.t. \; h \cdot p_n + c = w_n.$$

Assume that:

- every worker inelastically supplies one unit of labor in the neighborhood they live in (i.e. no commuting to work in a different neighborhood)
- the taste shock θ_{ln} is drawn from a TII EV distribution

Model

Indirect utility of living in neighborhood n is given by

$$U_{ln} = \frac{A_n w_n}{h_n^{\alpha}} \theta_{ln}$$

Hence, the probability that a worker chooses neighborhood n over any neighborhood r is given by

$$P\Big(\frac{A_n w_n}{h_n^{\alpha}} \theta_{nl} \geq \frac{A_r w_r}{h_r^{\alpha}} \theta_{rl} \Big) \qquad \forall\, r \neq n.$$

Model

Using the assumption that $\theta_{ln} \sim F(\theta_n) = exp(-\theta^{-\phi})$, the share of workers living in neighborhood n can be expressed as

$$s_n = \frac{\left(\frac{A_n w_n}{h_n^{\alpha}}\right)^{\phi}}{\sum_{r=1}^{N} \left(\frac{A_r w_r}{h_r^{\alpha}}\right)^{\phi}}.$$

Let $R_n = L \cdot s_n$ the population in neighborhood n

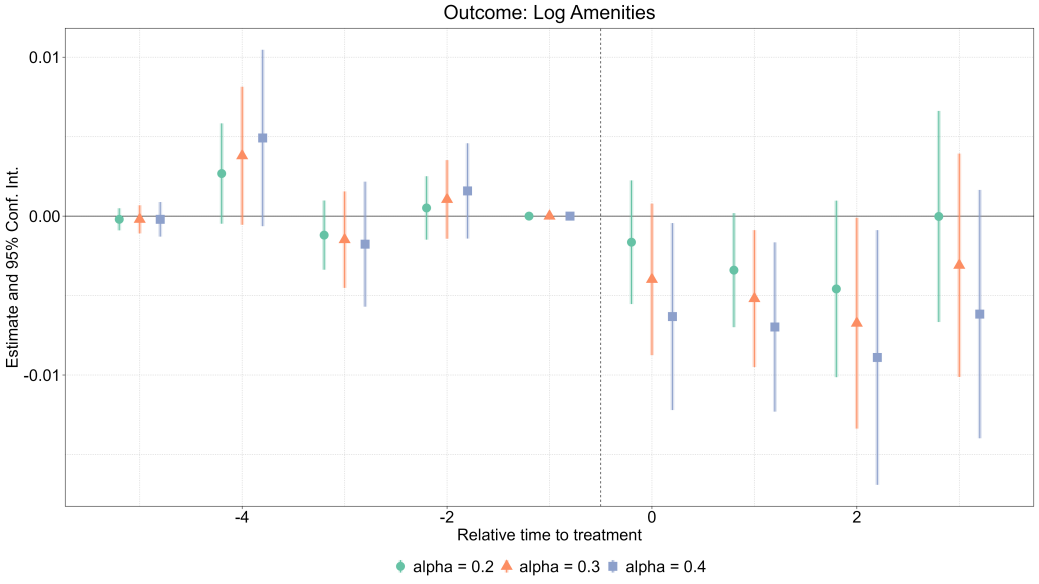
Model

Rearranging the previous expression for s_n gives an expression of amenities in neighborhood n as a function of observables and the parameters ϕ and α

$$ln(A_n) = \frac{1}{\phi} ln(R_n) + \alpha\, ln(h_n) - ln(w_n) - \frac{1}{\phi} ln(L) + \frac{1}{\phi} ln\Big(\sum_{r=1}^{N} \frac{A_r w_r}{h_r^{\alpha}} \Big)^{\phi}$$

- ϕ = 4.56 based on a recent estimate for Germany by Krebs and Pflüger (2023)
- $\alpha \in (0.2; 0.4)$ based on Monte et al. (2018); Quentel (2023)

Effect of Plant Closures on log Amenities



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Conclusion

- Industrial Shutdowns lead to improved local air quality in downwind neighborhoods and reduce exposure gap locally
- Significant drop in housing prices in both, upwind and downwind neighborhoods
- Industrial shutdowns induce significant detrimental effects on local labor markets in certain areas

Thank you for your attention!

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Roadmap

Appendix

Pollution Exposure Across Income Deciles

References I

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Appendix

Pollution Exposure Across Income Deciles

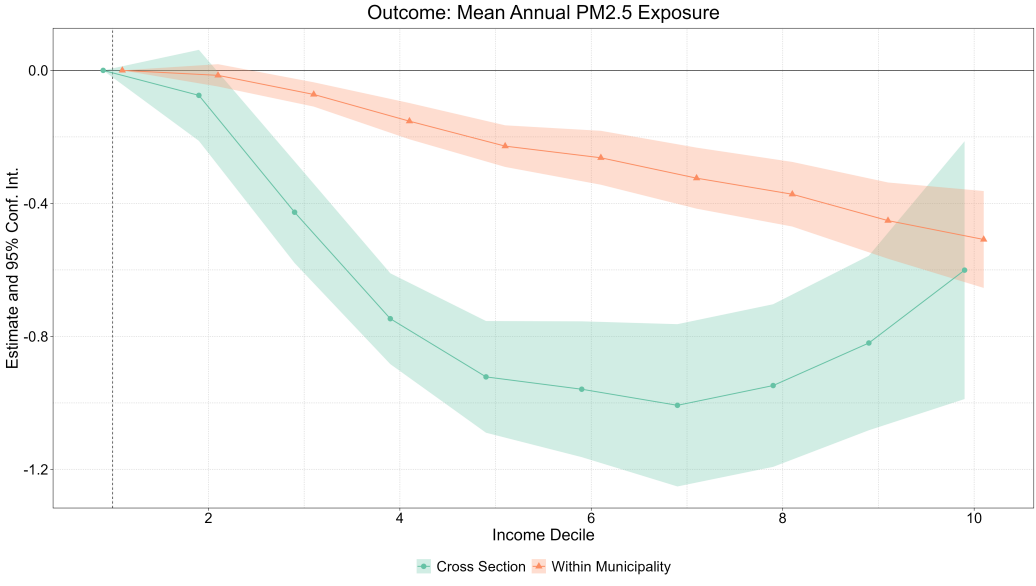
Pollution Exposure Across Income Deciles

$$PM_{2.5,nt} = \omega_t + \sum_{k=2}^{10} \theta_k \mathbb{1}(D_{nt} = k) + C_{nt}\beta' + \delta X_{nt} + \epsilon_{nt} \quad (1)$$

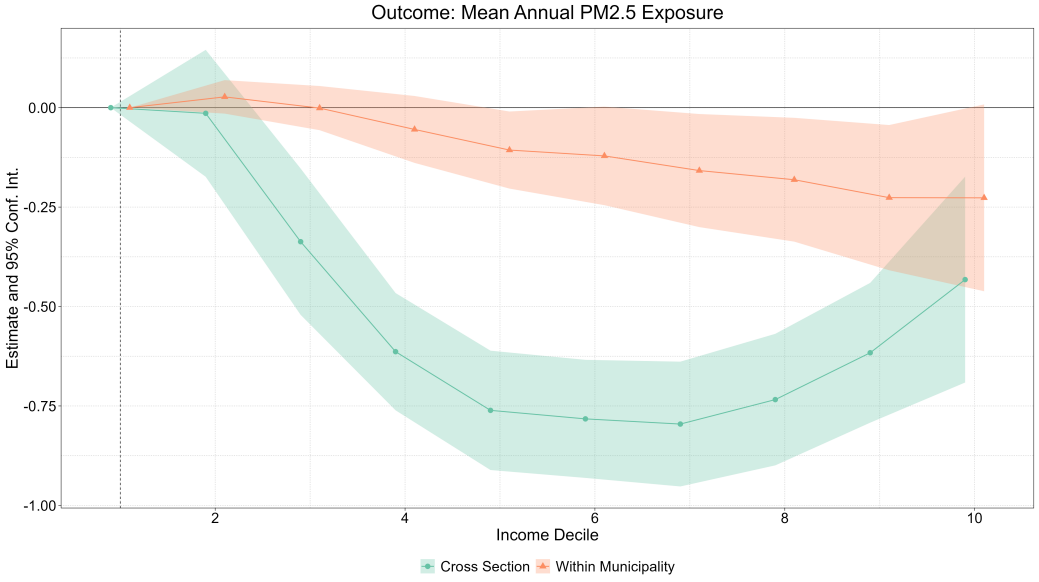
- $PM_{2.5,nt}$: Mean annual PM2.5 concentration in grid cell n in year t
- D_{nt}: Decile of mean annual disposable household income
- C_{nt}: Average Temperature & Precipitation
- X_{nt}: Share of foreign-born residents

Pollution Exposure across Income Deciles

▸ Raw Distribution



Pollution Exposure across Income Deciles (w Ethnicity Controls)



Effect of Plant Closures on PM2.5

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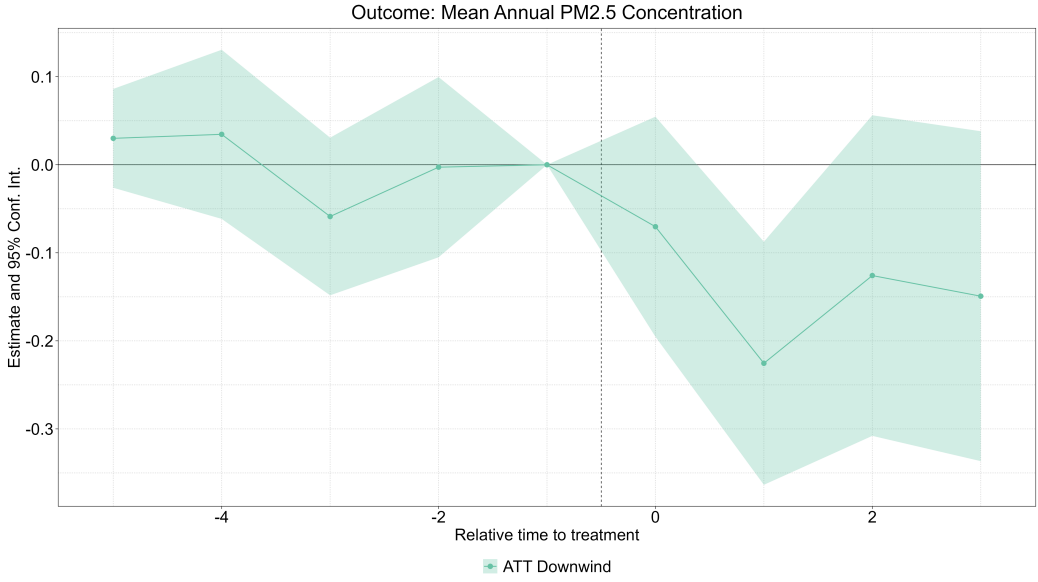

Within Municipality Variation - Berlin

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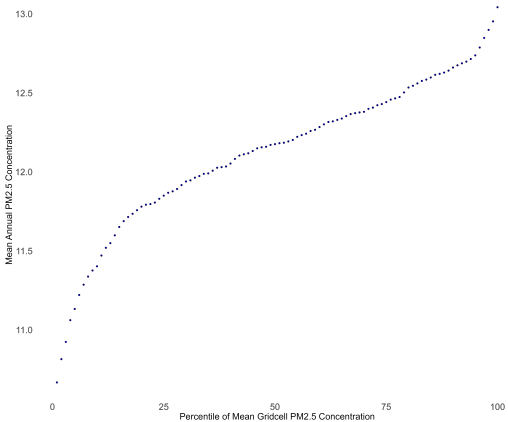
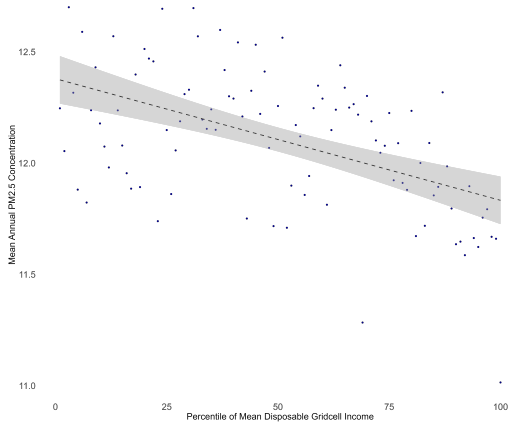


(a) PM2.5 Percentile



(b) Household Income Percentile

Summary Statistics

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Variable	Mean	SD	P25	Median	P75
			Full Sample		
PM2.5	10.71	2.401	9	10.5	12.18
Disp HH Income (1000)	26.28	4.591	23.19	25.84	28.85
Unemployment Rate	4.759	3.293	2.48	3.97	6.19
Foreign Share	5.327	6.102	0.87	3.68	7.63
Population	543.9	1184	52	143	474
Industrial Employment (%)	17.87	6.676	12.88	17.15	21.93
Precipitation (mm)	0.09835	0.02289	0.08424	0.09552	0.1087
Temperature (°C)	9.798	1.032	9.186	9.897	10.51
N			1793951		
			Estimation Sample (Grid Cell)		
PM2.5	11.6	2.584	9.723	11.35	13.22
Disp HH Income (1000)	27.01	4.853	23.61	26.59	29.93
Unemployment Rate	5.511	3.769	2.77	4.69	7.42
Foreign Share	7.23	7.319	1.88	5.31	10.26
Population	1154	1941	91	328	1340
Industrial Employment (%)	17.72	6.597	12.63	16.94	21.41
Precipitation (mm)	0.09763	0.01917	0.08561	0.09654	0.1083
Temperature	9.978	1.034	9.337	10.07	10.72
N			202294		
			Estimation Sample (Property)		
Price ()	381153	401251	195000	282400	425900
Living Space (m^2)	181.2	100.9	124	150	201
Plot Area (m^2)	645.2	548.2	317	519	780
No Rooms	6.313	3.258	4	5	7
Construction Year	1973	45.79	1953	1980	2011
N			978726		

PM2.5 Concentration across Income Percentiles 2010

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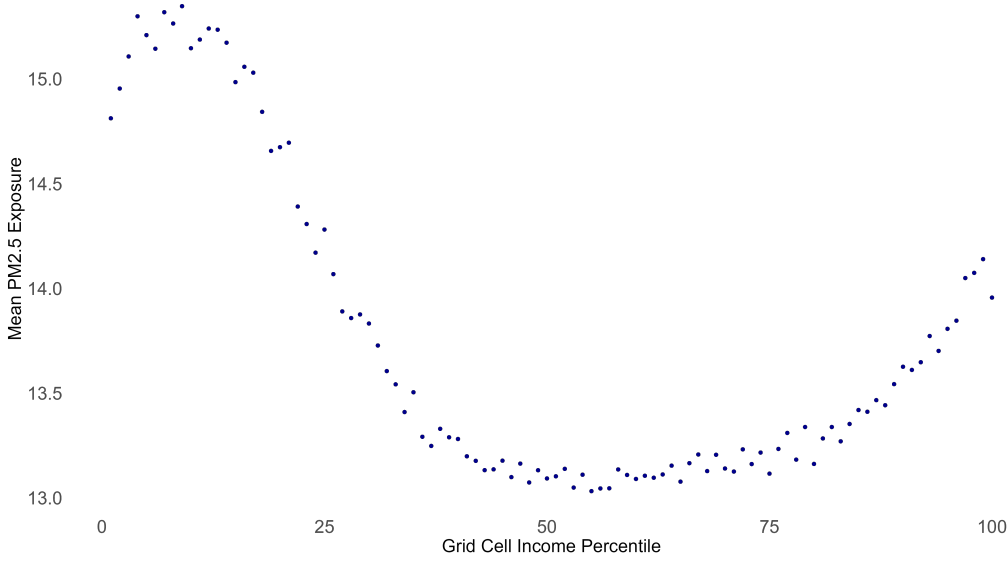

Housing Price Effects Coal Unit Retirements US

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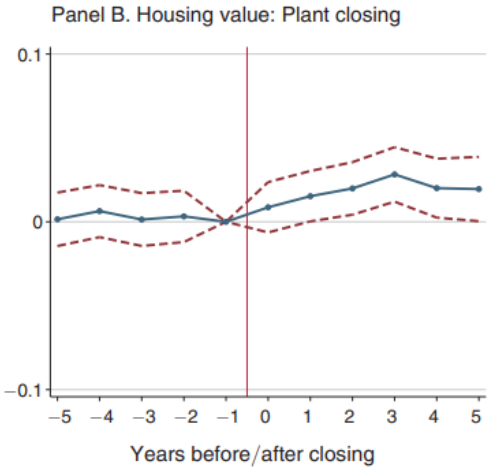
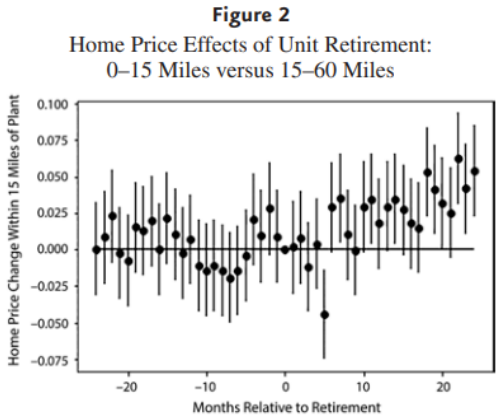


(a) Currie et al. (2015)



(b) Fraenkel et al. (2024)

Earnings Loss Coal Mines UK

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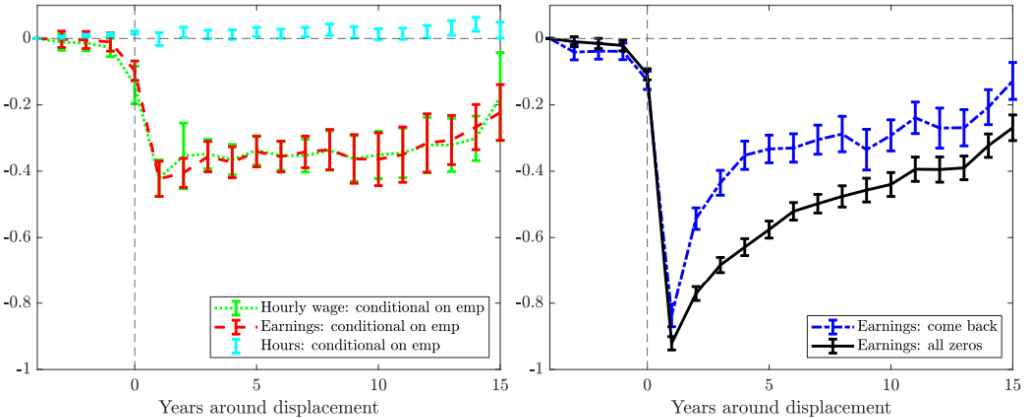

(a) Wages and earnings conditional on employment

(b) Earnings including zeros

Source: Rud et al. (2024)

Effect of Plant Closures on Population

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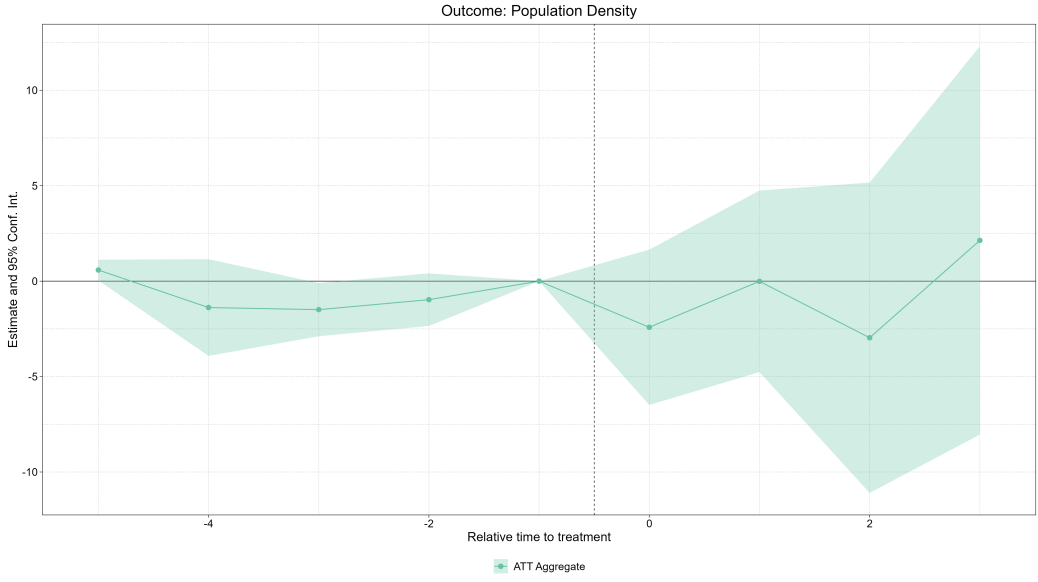

Composition of CO2 Emissions

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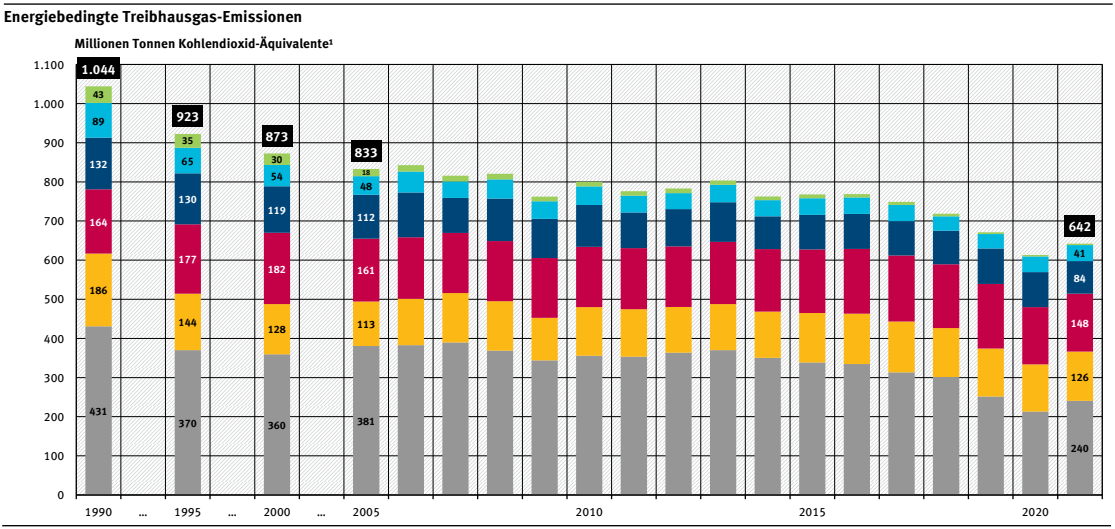

¹ in Kohlendioxid-Äquivalenten, berücksichtigt sind Kohlendioxid (CO_2), Methan (CH_4) und Lachgas (N_2O)
² einschließlich Militär und Landwirtschaft (energiebedingt)
³ enthält nur Emissionen aus Industriefeuerungen, keine Prozessemissionen
⁴ durch Gewinnung, Umwandlung und Verteilung von Brennstoffen

Quelle: Umweltbundesamt, Nationale Trendtabellen für die deutsche Berichterstattung atmosphärischer Emissionen 1990-2021 (Treibhausgase), Stand 04/2022