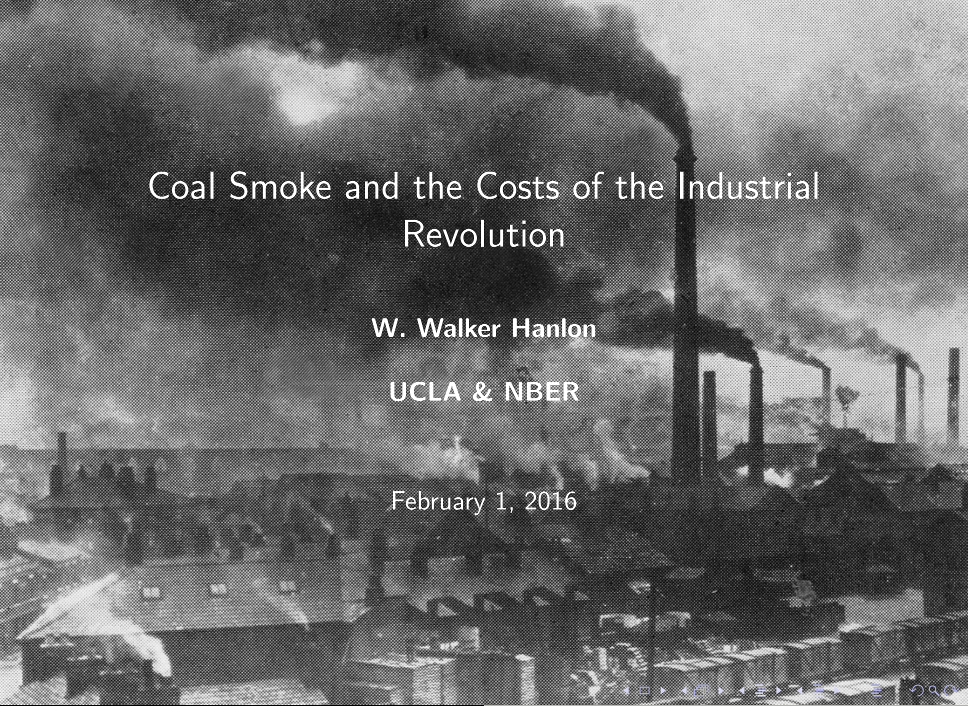

Coal Smoke and the Costs of the Industrial Revolution

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Industrialization and Pollution

Industrialization brings economic growth, but also comes with costs:

Industrial pollution

Goals of this paper:

1. Develop a methodology for measuring the costs of industrial pollution for local economic development over the long-term
2. Implement this approach in order to resolve a historical debate over the costs of the Industrial Revolution

The historical question

The big historical question:

How large were the negative externalities that accompanied the Industrial Revolution?

The historical question

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How large were the negative externalities that accompanied the Industrial Revolution?

Some more precise question:

1. How much did industrial pollution caused by burning coal reduce local economic growth in English cities from 1851-1911?
2. Can we say anything about the channels through which these effects occurred?

These are historical questions, but the same issues are faced by modern industrial cities

Three challenges to answering these questions

1. Need to separate out the positive and negative effects of growth in polluting industries
   - Industrial growth creates jobs, which increases local economic growth
   - But pollution can also reduce local economic growth
     1.1 Amenities – by making a location less desirable for workers, which raises the costs for firms
     1.2 Productivity – by affecting productivity, for example because workers fall sick
2. Direct measures of pollution levels are unavailable during this period
3. Do not have the detailed local wage and rent data needed by existing approaches (e.g., hedonic regressions)

Theory

Overview of the theory

A standard spatial equilibrium model in the Rosen-Roback tradition

- Many cities and many industries
- Goods and workers can more freely between locations

Standard model is modified in three important ways

- Industries are heterogeneous in their use of polluting inputs (coal)
- The level of industrial coal use in a city can affect consumer amenities and firm productivity
- Fixed local industry-specific factors distribute industries across space

The model delivers a new estimation approach that can be applied using only panel data on city-industry employment

Main analysis equation

$$\frac{L_{ict}}{L_{ict-1}} = \left(\frac{L_{it}}{L_{it-1}}\right)\left(\frac{L_{ct}}{L_{ct-1}}\right)^{\frac{(1-\gamma)(\beta_i-1)\lambda}{1-\alpha_i-\beta_i}}\left(\frac{CP_{ct}}{CP_{ct-1}}\right)^{\frac{-\psi(1-\beta_i)-\nu}{1-\alpha_i-\beta_i}} \left(\frac{P_t}{P_{t-1}}\right)^{\frac{(\beta_i-1)\gamma}{1-\alpha_i-\beta_i}}\left(\frac{v_t^*}{v_{t-1}^*}\right)^{\frac{(\beta_i-1)\gamma}{1-\alpha_i-\beta_i}}\Omega_{it}$$

Change in city employment can be express as a function of

1. National industry growth rate – reflects technological progress and demand shifts
2. City-size congestion force
3. Endogenous disamenity related to coal use
4. Other national-level factors

Important features of the estimation approach

Approach is similar to the widely-used instrument from Bartik (1991)

- But differs from previous studies in that it is micro-founded

Allows me to analyze the impact of pollution on long-run city growth using only panel data on city-industry employment

- These data are more easily obtained than local wage, rent and price data, in both historical and developing contexts
- Lends itself to application in other data-sparse environments

Empirical Setting

Empirical setting

Study the impact of industrial pollution English cities from 1851-1911

Why this setting?

- High pollution environment – similar levels of coal use to modern China
- Can look at long-run outcomes using rich panel data
- Observe effects in the absence of substantial government intervention or regulation
- Ongoing debate among economic historians over the pollution costs associated with the Industrial Revolution

Key features of this setting

Most of coal was burned by industry

- Industry accounted for 60-65% of coal consumption

Industrial coal use tended to be geographically concentrated

- Heavy industries tended to agglomeration geographically

Population mobility was fairly high

- From rural areas, as well as Ireland, Scotland and Wales

Regulation was absent or weak

- Including both pollution regulation and other constraints on city growth (e.g., no zoning laws)

Data and Measurement

Primary data sources

City-industry employment panel data from Census of Population Occupation reports

- Collapsed to 26 industries spanning essentially the entire private-sector economy
- For 31 largest British cities every decade from 1851-1911
- Obtained from a full census, not a sample

Coal use per worker by industry

- From 1907 Census of Production

Auxiliary data sets

- Mortality data for each decade 1851-1900
- Cross-section of local wage, rent and price data in 1905

Cities in the main dataset

Large variation in industry coal use intensity

Industry	Coal/worker	Workers in 1851
Earthenware, bricks, etc.	48.9	135,214
Metal and engine manufacturing	43.7	894,159
Food processing	12.0	220,860
Textile production	10.1	1,066,735
Apparel	1.6	243,968
Tobacco products	1.1	35,258

Measuring city coal use

Industrial coal use in city c is:

$$COAL_{ct} = \rho_t \sum_i (L_{ict} * \theta_i)$$

- θ_i is coal use per worker in industry i
- L_{ict} is employment in industry i, city c, year t
- ρ_t is a time-varying efficiency term

Key assumptions

- Relative coal use intensity of industries doesn't change too much over time
- Industry coal use intensity doesn't vary too much across locations

The paper offers several checks showing that these assumptions are reasonable

Analysis

Ingredients

Actual city-industry growth from $t-\tau$ to t:

$$\Delta\ln(L_{ict})$$

Predicted growth in city-industry employment:

$$\Delta\ln(PrEMP_{ict}) = \ln\left(L_{ict-\tau} * GR_{i-ct,t-\tau}\right) - \ln\left(L_{ict-\tau}\right)$$

Predicted change in overall city employment:

$$\Delta\ln(PrCityEMP_{ct}) = \ln\left(\sum_{j\neq i} L_{jct-\tau} * GR_{j-ct,t-\tau}\right) - \ln\left(\sum_{j\neq i} L_{jct-\tau}\right)$$

Predicted change in city coal use:

$$\Delta\ln(PrCoal_{ct}) = \ln\left(\sum_{j\neq i} L_{jct-\tau} * GR_{j-ct,t-\tau} * \theta_j\right) - \ln\left(\sum_{j\neq i} L_{jct-\tau} * \theta_j\right)$$

Estimation approach

The baseline reduced-form regression specification is:

$$\Delta \ln(L_{ict}) = b_1 \Delta \ln(PrEMP_{i-ct}) + b_2 \Delta \ln(PrCityEMP_{ct}) + b_3 \Delta \ln(PrCoal_{ct}) + \mu_t + e_{ct}$$

Estimated using pooled cross sections with data from 1851-1911

- Allowing for serial correlation using Newey-West and spatial correlation following Conley

Baseline results with predicted employment growth term

	DV: Δ Log of city-industry employment					
	All industries			Manufacturing industries		
Difference:	One decade	Two decades	Three decades	One decade	Two decades	Three decades
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta Ln(PrEMP_{ict})$	0.931***	1.029***	1.068***	0.919***	1.029***	1.048***
	(0.0377)	(0.0302)	(0.0299)	(0.0597)	(0.0472)	(0.0452)
$\Delta Ln(PrCityEMP)$	-0.787*	-0.339	0.300	-0.933**	-0.444	-0.218
	(0.445)	(0.614)	(0.684)	(0.397)	(0.428)	(0.454)
$\Delta Ln(PredCoal)$	-0.389	-1.374**	-2.005***	-0.207	-1.244***	-1.593***
	(0.505)	(0.610)	(0.661)	(0.522)	(0.473)	(0.504)
Constant	0.276**	1.064***	1.559***	0.242	1.019***	1.461***
	(0.138)	(0.266)	(0.311)	(0.158)	(0.243)	(0.293)
Time effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,819	4,017	3,213	2,773	2,312	1,849
R-squared	0.211	0.313	0.381	0.198	0.286	0.343

Robustness checks

- Including industry-time effects
- Controlling for city features: weather, initial innovation level (patent data), initial city size and coal use
- Additional industry features: share of high to low skilled workers, average firm size, exports share, labor cost share
- Agglomeration forces: change in local employment in buyer or supplier industries, industries using demographically similar workers, or industries using occupationally similar workforces
- IV results using predicted change in coal use as an IV for the actual change in coal use intensity

Interpreting the results

All of these results suggest that increases in local industrial coal use had a strong effect on city-industry employment growth over two or three-decade periods

- Coefficient estimates range from -0.67 to -2, with most between -0.8 and -1.2

A one s.d. greater increase implies a reduction in city-industry growth of 12-25 percentage points!

- Average city-industry employment growth was 43.7 percent

These effects were stronger for industries with a higher labor cost shares

City-level regression results

DV: Δ Log of city employment in analysis industries						
	City employment in analysis ind.		Total city working pop.		Total city population	
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta\ln(PrWorkpop_{ct})$	1.072	0.554	0.829	0.163	0.354	-0.222
	(0.694)	(0.743)	(0.695)	(0.747)	(0.645)	(0.754)
$\Delta\ln(PrCoal_{ct})$	-1.668**	-1.880**	-1.501**	-1.551**	-0.992	-1.017
	(0.716)	(0.736)	(0.714)	(0.732)	(0.700)	(0.756)
Time effects	Yes	Yes	Yes	Yes	Yes	Yes
Other controls		Yes		Yes		Yes
Observations	155	155	155	155	155	155
R-squared	0.072	0.206	0.086	0.207	0.104	0.208

Implications for city growth and urbanization

What if it had been possible to reduce the growth in industrial coal use by 10% without affecting other fundamentals?

	Actual		Counterfactual	
Year	Population	Share of English population	Population	Share of English population
1851	5,147,432	0.30	5,147,432	0.30
1881	8,445,658	0.34	9,185,357	0.37
1911	11,626,649	0.34	13,072,470	0.38

What role did mortality play?

Detailed mortality data are available for British cities during this period

Using these, I analyze the relationship between pollution and mortality using fixed effects regressions

I find that:

- Pollution is associated with increased mortality among the young and those over 35
- Among adults, these effects are concentrated in respiratory diseases
- However, these effects can explain just 4.4% of the impact of pollution on city population growth

Amenities, or productivity effects?

I provide tentative evidence on these channels, I use a cross-section of local wage, rent, and price data for 51 cities from 1905

From the model I have:

$$\underbrace{[\gamma \ln(P_t) + (1-\gamma)\ln(r_{ct})] - \ln(w_{ct})}_{\textbf{Quality of Life Measure}} = \ln(\delta_c) - \psi \ln(CP_{ct}) - v_t^*$$

Estimating this relationship allows me to obtain ψ, which determines the strength of the amenity channel

Use data for two types of common workers: skilled builders and skilled engineers

Estimates of the amenity channel parameter

	DV: QOL_c for Skilled Builder			DV: QOL_c for Skilled Engineer		
	(1)	(2)	(3)	(4)	(5)	(6)
$Ln(COAL_c)$	-0.0172*	-0.0504**	-0.0458*	-0.0294***	-0.0452**	-0.0219
	(0.00946)	(0.0203)	(0.0240)	(0.0108)	(0.0174)	(0.0266)
$Ln(POP_c)$		0.0421**	0.0334		0.0185	-0.00326
		(0.0208)	(0.0245)		(0.0187)	(0.0273)
Controls			Yes			Yes
Observations	51	51	51	47	47	47
R-squared	0.053	0.133	0.206	0.139	0.153	0.206

These results suggest that workers were compensated for living in more polluted cities with higher real wages

- But these effects are not large
- For reasonable production function parameter values, they imply that the productivity effects were always larger than the amenity effects

Was reducing industrial coal use possible?

To answer this question, I draw on the extremely detailed study of coal use in Britain undertaken in the 1871 Coal Commission Report

- Report was commissioned by Parliament in response to fears that Britain was running out of coal
- Undertaken by experts divided into committees focused on different topics
- Committee B was tasked with looking at whether coal was being wasted by inefficient use

Conclusions of the coal committee report

"Without traveling beyond known principles, it was thought that a considerable savings of fuel could be effected."

Three major areas of waste:

1. Inefficient stoking
2. Failure to insulate boilers in order to reduce heat loss
3. Use of inefficient furnaces that didn't reuse hot air

At least the first two of these could have substantially reduced coal consumption at a modest cost

Why, then, weren't these improvements implemented?

1. Coal was cheap

   "in places where coal is cheap and abundant, it is used with but little regard for economy, and that indeed in some localities men actually boast of the quantity of coal which they have contrived to burn."

2. Pollution regulations were weak and ineffective

3. The harmful effects of coal pollution were largely external to firms

Conclusions and implications

What do we learn from this study?

- The long-run consequences of industrial pollution for local economic development can be large
- However, these effects are not obvious from casual observation because they are bound up with employment gains in polluting industries
- This study provides a framework for separating these effect
- An important feature of this approach is that it can be applied in relatively data sparse environments, such as developing countries

Checking the coal use measure

Show that relative industry coal use intensity is fairly stable over time

- Comparing industry coal use in 1907 to the next available Census of Production in 1924
- Link

Show that my measure does a reasonable job reproducing county-level coal use in 1871

- Using data from the 1871 Coal Committee Report
- Link

Overview of the theory

Spatial-equilibrium framework:

- Many cities c with economies composed of many industries i
- Workers choose the city that maximizes their utility
- Free trade in goods and labor mobility
- Industry growth driven in part by national demand or technology factors

Production

Each industry i is composed of many perfectly competitive firms f

Firms produce output using:

- Labor L_{fict}
- Polluting input C_{fict}
- City-industry resources R_{fict}

$$y_{fict} = a_{ict} L_{fict}^{\alpha_i} C_{fict}^{\beta_i} R_{fict}^{1-\alpha_i-\beta_i}$$

- a_{ict} is city-industry productivity
- α_i and β_i are industry-specific parameters

Local city-industry resources are fixed at $\bar{R}_{ic}$

- As in Kovak (2013), Kline & Moretti (2013), Hanlon & Miscio (2014)

Firm optimization

$$\max_{L_{fict}, C_{fict}, R_{fict}} p_{it} a_{ict} L_{fict}^{\alpha_i} C_{fict}^{\beta_i} R_{fict}^{1-\alpha_i-\beta_i} - w_{ct} L_{fict} - \phi_t C_{fict} - \chi_{ict} R_{fict} \, .$$

Using the first order conditions from this problem, I obtain:

$$\frac{C_{fict}}{L_{fict}} = \left(\frac{\beta_i}{\alpha_i}\right) \frac{w_{ct}}{\phi_t}$$

The empirical portion of this paper exploits the variation in industry coal use intensity represented by β_i/α_i

Labor demand

Summing across firms, industry labor demand is:

$$L_{ict} = \alpha_i^{\frac{1-\beta_i}{1-\alpha_i-\beta_i}} \left(a_{ict} p_{it}\right)^{\frac{1}{1-\alpha_i-\beta_i}} \left(\beta_i/\phi_t\right)^{\frac{\beta_i}{1-\alpha_i-\beta_i}} w_{ct}^{-\frac{1-\beta_i}{1-\alpha_i-\beta_i}} \bar{R}_{ic}$$

Note that, in equilibrium, the sum of firm resource use must equal total city-industry resources, which are fixed at $\bar{R}_{ic}$.

Housing supply

Housing supply is modeled in a simple reduced-form way:

$$\ln(r_{ct}) = \lambda \ln(L_{ct}) + \eta_c$$

- r_{ct} is the price of housing
- λ is the housing supply elasticity
- L_{ct} is city employed population
- η_c is a city housing cost shifter

Workers

Worker's utility depends on consumption of goods and housing and the city amenity level
Indirect utility function:

$$V_{ct} = \gamma \ln\left(\frac{w_{ct}}{P_t}\right) + (1-\gamma)\ln\left(\frac{w_{ct}}{r_{ct}}\right) + \ln(A_{ct})$$

- A_{ct} is the city amenity
- P_t is an index over goods prices
- γ determines expenditures shares on housing vs. goods

Workers face an outside option utility level v_t*, so labor supply depends on:

$$w_{ct} = P_t^{\gamma}\, L_{ct}^{(1-\gamma)\lambda}\, \eta_c^{1-\gamma}\, A_{ct}^{-1}\, v_t^*$$

Note: The model is also populated by capitalists who receive resource and housing rents. For simplicity, they live outside of cities.

Incorporating the effects of pollution

Amenity side:

$$A_{ct} = \delta_c \, CP_{ct}^{-\psi}$$

- CP_{ct} is coal pollution in the city

Productivity side:

$$a_{ict} = a_{it} \, CP_{ct}^{-\nu}$$

The ψ and ν parameters determine the impact of coal use on amenities and productivity, respectively

City-industry employment growth

$$\frac{L_{ict}}{L_{ict-1}} = \left(\frac{a_{it}p_{it}}{a_{it-1}p_{it-1}}\right)^{\frac{1}{1-\alpha_i-\beta_i}} \left(\frac{\phi_t}{\phi_{t-1}}\right)^{\frac{-\beta_i}{1-\alpha_i-\beta_i}} \left(\frac{P_t}{P_{t-1}}\right)^{\frac{-(1-\beta_i)\gamma}{1-\alpha_i-\beta_i}} \left(\frac{v_t^*}{v_{t-1}^*}\right)^{\frac{-(1-\beta_i)}{1-\alpha_i-\beta_i}}$$
$$\left(\frac{L_{ct}}{L_{ct-1}}\right)^{\frac{-(1-\gamma)(1-\beta_i)\lambda}{1-\alpha_i-\beta_i}} \left(\frac{CP_{ct}}{CP_{ct-1}}\right)^{\frac{-\psi(1-\beta_i)-\nu}{1-\alpha_i-\beta_i}}$$

Note that the $a_{it}p_{it}$ terms are unobserved here

- Can estimate this equation while including industry-time fixed effects
- Or, I can use national industry growth rates to substitute out these terms

Results with industry-year effects

	DV: Δ Log of city-industry employment					
	All industries			Manufacturing industries		
Difference:	One decade (7)	Two decades (8)	Three decades (9)	One decade (10)	Two decades (11)	Three decades (12)
$\Delta Ln(PrCityEMP)$	-0.556	0.152	1.016	-0.700	0.268	0.987
	(0.521)	(0.705)	(0.787)	(0.539)	(0.570)	(0.687)
$\Delta Ln(PredCoal)$	-0.584	-1.822**	-2.676***	-0.485	-2.095***	-3.021***
	(0.614)	(0.721)	(0.788)	(0.733)	(0.666)	(0.806)
Constant	0.557***	1.585***	2.393***	0.341	1.736***	2.621***
	(0.163)	(0.312)	(0.372)	(0.227)	(0.343)	(0.470)
Ind.-time effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,819	4,017	3,213	2,773	2,312	1,849
R-squared	0.288	0.391	0.463	0.265	0.362	0.427

Identification concerns (1)

Is there something different about cities that experience a substantial growth in industrial coal use?

- Control for city innovation using patents filed by inventors in the city in the 1850s
- Control for weather conditions – rainfall and air frost days
- Control for the initial level of coal use and initial city size at the beginning of each period
- Dropping London, the main outlier, does not change the results

Results with city-level controls

In another check, I show that the lagged change in industrial coal use in a city also has no effect on city-industry employment growth

Results with lagged change in coal use

Identification concerns (2)

Are there other industry characteristics that are correlated with coal use and also affect employment growth?

Using the same approach I used for city coal use, I construct measures for city-level changes in:

- Share of salaried to wage workers
- Average firm size
- Share of output exported
- Ratio of labor costs to total revenue

Including these controls does not affect the main results

▸ Results with controls for other industry characteristics

Identification concerns (3)

Is coal use just reflecting changing agglomeration forces, such as the presence of more buyer or supplier industries?

I construct measures for:

- Change in local employment in buyer industries (using IO matrix)
- Change in local employment in supplier industries (using IO matrix)
- Change in local employment in industries using demographically-similar workforces
- Change in local employment in industries with similar occupational structures

Controlling for these does not change the results

Results with controls for inter-industry connections

Instrumental variables

It is also possible to use the predicted change in coal use as an instrument for the actual change in the local coal use intensity based on actual city-industry growth rates

This IV approach delivers similar results

IV results

City-level regressions

$$\Delta \ln(L_{ct}) = a_0 + a_1 \Delta \ln(PrWorkpop_{ct}) + a_2 \Delta \ln(PrCoal_{ct}) + \xi_t + e_{ct}$$

Where $PrWorkpop_{ct}$ and $PrCoal_{ct}$ are constructed as before, but summing across all city industries

Conclusions of the coal committee report

"Without traveling beyond known principles, it was thought that a considerable savings of fuel could be effected."

Three major areas of waste:

1. Inefficient stoking
2. Failure to insulate boilers in order to reduce heat loss
   - "...we feel called upon to notice the enormous wast of heat, and consequently wasteful consumption of fuel, in a very large majority of the steam boilers used in this country...their being left to the influence of every change in the atmospheric conditions, quite exposed to winds, rains, and snows, when a slight covering of non-conducting substance would, by protecting them, improve their steam-producing power, and save a considerable quantity of coal."

Results with city-level controls

	DV: Δ Log of city-industry employment				
	(1)	(2)	(3)	(4)	(5)
$\Delta Ln(PrEMP_{ict})$	1.022***	1.020***	1.028***	1.019***	1.034***
	(0.0298)	(0.0305)	(0.0304)	(0.0299)	(0.0299)
$\Delta Ln(PrCityEMP)$	-0.459	-0.512	-0.385	-1.188**	-1.170**
	(0.562)	(0.581)	(0.583)	(0.513)	(0.520)
$\Delta Ln(PredCoal)$	-1.742***	-1.745***	-1.503**	-1.298**	-1.315**
	(0.661)	(0.662)	(0.631)	(0.560)	(0.565)
City Air-frost Days	-0.00281*	-0.00282*	-0.00299*	-0.00267*	-0.00269*
	(0.00152)	(0.00152)	(0.00155)	(0.00149)	(0.00149)
City Rainfall	-0.0950	-0.102	-0.0999	-0.181*	-0.185*
	(0.101)	(0.105)	(0.0971)	(0.104)	(0.109)
Ln(City Patenting)		0.00312	0.00161	0.0221*	0.0224*
		(0.00895)	(0.00834)	(0.0118)	(0.0121)
Ln(Initial city pop.)				-0.154***	-0.151***
				(0.0282)	(0.0322)
Ln(Initial coal use)				0.115***	0.113***
				(0.0285)	(0.0288)
Border Chg. Flag			0.118***		
			(0.0281)		
Constant	1.539***	1.549***	1.345***	1.658***	1.642***
	(0.378)	(0.385)	(0.374)	(0.348)	(0.359)
Time effects	Yes	Yes	Yes	Yes	Yes
Dropping London					Yes
Observations	4,017	4,017	4,017	4,017	3,887
R-squared	0.318	0.318	0.329	0.333	0.329

Return

Results with lagged change in predicted city coal use

	DV: Δ Log of city-industry employment			
	All industries		Manufacturing only	
	(1)	(2)	(3)	(4)
$\Delta Ln(PrEMP_{ict})$	1.015***	1.019***	1.010***	1.010***
	(0.0394)	(0.0393)	(0.0550)	(0.0548)
$\Delta Ln(PrCityEMP)$	-1.586**	-0.363	-2.018***	-1.333***
	(0.645)	(0.845)	(0.368)	(0.477)
$\Delta Ln(PredCoal)$		-2.414**		-1.328
		(0.978)		(0.880)
Lagged $\Delta Ln(PredCoal)$	-0.0494	0.619	0.414	0.651
	(0.395)	(0.454)	(0.356)	(0.452)
Constant	0.491***	0.396**	0.248	0.287
	(0.173)	(0.179)	(0.189)	(0.188)
Time effects	Yes	Yes	Yes	Yes
Observations	2,405	2,405	1,382	1,382
R-squared	0.291	0.302	0.314	0.316

Return

Results controlling for other industry characteristics

These controls available for manufacturing industries only

	DV: Δ Log of city-industry employment				
	(1)	(2)	(3)	(4)	(5)
$\Delta Ln(L_{i-ct})$	1.024***	1.030***	1.029***	1.022***	1.026***
	(0.0477)	(0.0470)	(0.0471)	(0.0475)	(0.0486)
$\Delta Ln(PrCityEMP)$	-0.456	-0.341	-0.432	-0.248	-0.133
	(0.424)	(0.485)	(0.449)	(0.416)	(0.588)
$\Delta Ln(PredCoal)$	-1.387***	-1.355***	-1.270**	-1.524***	-1.447***
	(0.483)	(0.501)	(0.527)	(0.466)	(0.515)
$\Delta Ln(SalariedWkr.Shr.)$	-0.624				0.254
	(0.972)				(1.463)
$\Delta Ln(Avg.FirmSize)$		0.204			0.413
		(0.403)			(0.609)
$\Delta Ln(ExportsShr.)$			0.0711		-0.811
			(0.877)		(1.212)
$\Delta Ln(LaborCostShr.)$				8.163*	9.555**
				(4.328)	(4.654)
Constant	1.127***	1.073***	1.033***	1.161***	1.089***
	(0.270)	(0.252)	(0.269)	(0.241)	(0.268)
Time effects	Yes	Yes	Yes	Yes	Yes
Observations	2,312	2,312	2,312	2,312	2,312
R-squared	0.286	0.286	0.286	0.287	0.288

Return

Results controlling for inter-industry connections

These controls available for only a subset of industries

	DV: Δ Log of city-industry employment			
	(1)	(2)	(3)	(4)
$\Delta Ln(PrEMP_{ict})$	0.968***	0.969***	1.017***	0.971***
	(0.0490)	(0.0490)	(0.0490)	(0.0491)
$\Delta Ln(PrCityEMP)$	-0.400	-0.404	0.233	0.0278
	(0.437)	(0.439)	(0.448)	(0.550)
$\Delta Ln(PredCoal)$	-1.205***	-1.182**	-0.783*	-1.144**
	(0.464)	(0.467)	(0.459)	(0.466)
$\Delta Ln(IOin)$	0.0676			
	(0.0663)			
$\Delta Ln(IOout)$		0.00277		
		(0.0557)		
$\Delta Ln(DEM)$			-0.960***	
			(0.173)	
$\Delta Ln(OCC)$				-0.478
				(0.337)
Constant	0.970***	0.972***	0.842***	0.967***
	(0.241)	(0.244)	(0.236)	(0.241)
Time effects	Yes	Yes	Yes	Yes
Observations	2,004	2,004	2,004	2,004
R-squared	0.238	0.237	0.253	0.238

Return

Results allowing for heterogeneous effects

These results available only for manufacturing industries

	DV: Δ Log of city-industry employment			
	(1)	(2)	(3)	(4)
$\Delta Ln(PrEMP_{ict})$	1.011***	1.001***	0.948***	0.955***
	(0.0470)	(0.0478)	(0.0469)	(0.0497)
$\Delta Ln(PrCityEMP)$	-0.550	-1.609***	-0.585	-1.559***
	(0.465)	(0.499)	(0.473)	(0.507)
$\Delta Ln(PrCityEMP)$*Labor Shr.	0.611	0.570	0.669	0.577
	(1.262)	(1.268)	(1.271)	(1.279)
$\Delta Ln(PredCoal)$	-1.079**	-0.722	-1.391***	-1.058**
	(0.491)	(0.467)	(0.531)	(0.506)
$\Delta Ln(PredCoal)$*Labor Shr.	-0.968*	-0.989*	-1.158**	-1.134**
	(0.513)	(0.516)	(0.515)	(0.520)
Industry Labor Cost Shr.	0.361	0.380	0.433	0.444
	(0.350)	(0.353)	(0.352)	(0.355)
$\Delta Ln(PrCityEMP)$*Coal Use			0.0120	0.0129*
			(0.00739)	(0.00737)
$\Delta Ln(PredCoal)$*Coal Use			0.00450*	0.00363
			(0.00265)	(0.00267)
Industry Coal Per Worker			-0.00717***	-0.00647***
			(0.00227)	(0.00227)
Time effects	Yes	Yes	Yes	Yes
City-level controls		Yes		Yes
Observations	2,312	2,312	2,312	2,312
R-squared	0.288	0.305	0.295	0.310

Return

Instrumental variables regression results

Focusing on manufacturing industries only

- Instrument is weaker for all industries because national industry growth rates are not as good a predictor of city-industry growth outside of manufacturing industries

	DV: Δ Log of city-industry employment			
	(1)	(2)	(3)	(4)
$\Delta \ln(CoalPW_{ct})$	-0.913**	-0.653	-1.526**	-1.182*
	(0.448)	(0.397)	(0.733)	(0.680)
$\Delta Ln(PrEMP_{ict})$	1.025***	1.013***		
	(0.0568)	(0.0568)		
$\Delta Ln(PredCityEMP)$	-1.728***	-2.529***	-1.888***	-2.795***
	(0.300)	(0.493)	(0.343)	(0.562)
Time effects	Yes	Yes		
Ind-time effects			Yes	Yes
Other controls		Yes		Yes
First-stage F-stat	20.50	25.99	10.67	10.73
Observations	2,312	2,312	2,312	2,312

Return