Air Pollution, Energy Inequality and Health Effects: Evidence from China

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Motivation

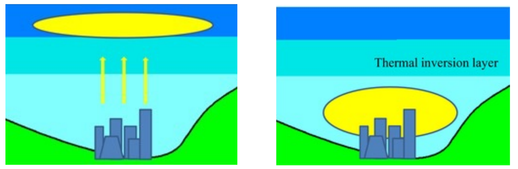
- Developing countries experience economic growth, while accompanied by **air pollution**.
  - Both **medical and economic studies** confirm the **negative impact of air pollution on health**.
- Although the causal relationship between air pollution and residents' health is now clear, the underlying **mechanisms** of its effect remain largely **uncertain**.
  - **Increasing energy consumption** is a common adaptive behavior to combat air pollution.
  - However, only a few studies have discussed the causal relationship between **air pollution, household electricity consumption and health** especially **developing countries**.
- There is a **severe inequality in energy consumption.**
  - The poorest 40% of world's population accounts for only about 10% of total final energy consumption
  - **We study the role of energy consumption and its inequality in the impact of air pollution on health.**

Method and Data

- Two-stage least-squares (2SLS) model

$$PM2.5_{c,t} = \alpha_0 + \alpha_1 Inversion_{c,t} + Controls + \partial_c + \gamma_d + \theta_{p,t} + \varepsilon_{c,t}$$

$$Health_{i,t} = \delta_0 + \delta_1 \widehat{PM2.5}_{c,t} + Controls + \partial_c + \gamma_d + \theta_{p,t} + \varepsilon_{c,t}$$

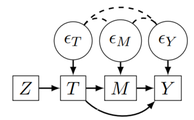


- The Mediation Model with IV

Model Equations

$$T = f_T(Z, \epsilon_T)$$
$$M = f_M(T, \epsilon_M)$$
$$Y = f_Y(T, M, \epsilon_Y)$$
$$Z \perp\!\!\!\perp (\epsilon_T, \epsilon_M, \epsilon_Y)$$

DAG



Effect of T on M: $\beta_M^T + \beta_M^J \cdot \beta_J^T$

Effect of M on Y: $\beta_Y^M + \beta_Y^K \cdot \beta_K^M$

Direct Effect of T on Y: $\beta_Y^T + \beta_Y^J \cdot \beta_J^T + \beta_Y^K \cdot \beta_K^T$

Indirect Effect of T on Y: $(\beta_Y^M + \beta_Y^K \cdot \beta_K^M) \cdot (\beta_Y^T + \beta_Y^J \cdot \beta_J^T + \beta_Y^K \cdot \beta_K^T)$

- Main data
  - China Labor-force Dynamic Survey (CLDS); China National Environmental Monitoring

Results

Table 1: Effect of Pm2.5 on energy usage

	(1)	(2)	(3)	(4)
1st-stage estimation (Panel A)	*Dep. Var.: Pm2.5*			
Inversion	0.005***	0.002***	0.004***	**0.004*** **
	(0.000)	(0.000)	(0.000)	**(0.000)**
Observations	38,374	38,374	38,374	38,374
2nd-stage estimation (Panel B)	*Dep. Var.*: Energy usage			
Pm2.5	0.010***	0.031***	0.039***	**0.091** **
	(0.001)	(0.002)	(0.004)	**(0.040)**
Observations	19,545	19,545	19,545	19,542
KP F-statistics	353.7	1068	366	355.5
Month-Day *FE*	No	Yes	Yes	Yes
City *FE*	No	Yes	Yes	Yes
Province by Year *FE*	No	Yes	Yes	Yes
Weather Controls	No	No	Yes	Yes
Individual Controls	No	No	No	Yes

Table 2: Effect of Pm2.5 on health condition

	(1)	(2)	(3)	(4)
1st-stage estimation (Panel A)	*Dep. Var.: Pm2.5*			
Inversion	0.005***	0.002***	0.004***	**0.004*** **
	(0.000)	(0.000)	(0.000)	**(0.000)**
Observations	38,374	38,374	38,374	38,374
2nd-stage estimation (Panel B)	*Dep. Var.*: Health condition (1,5)			
Pm2.5	-0.008***	0.044*	0.039**	**0.034** **
	(0.001)	(0.024)	(0.018)	**(0.017)**
Observations	38,947	38,947	38,947	38,374
KP F-statistics	1403	1159	2117	2117
Month-Day *FE*	No	Yes	Yes	Yes
City *FE*	No	Yes	Yes	Yes
Province by Year *FE*	No	Yes	Yes	Yes
Weather Controls	No	No	Yes	Yes
Individual Controls	No	No	No	Yes

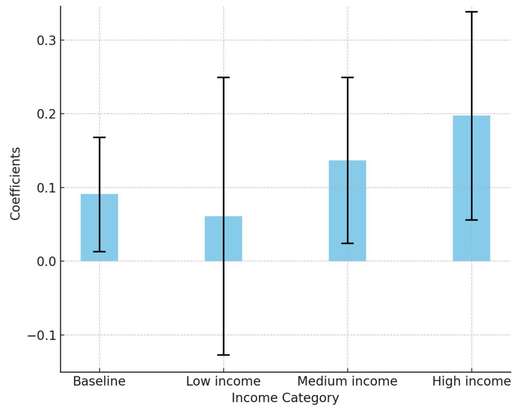


Figure 1: Heterogeneous by income of energy usage

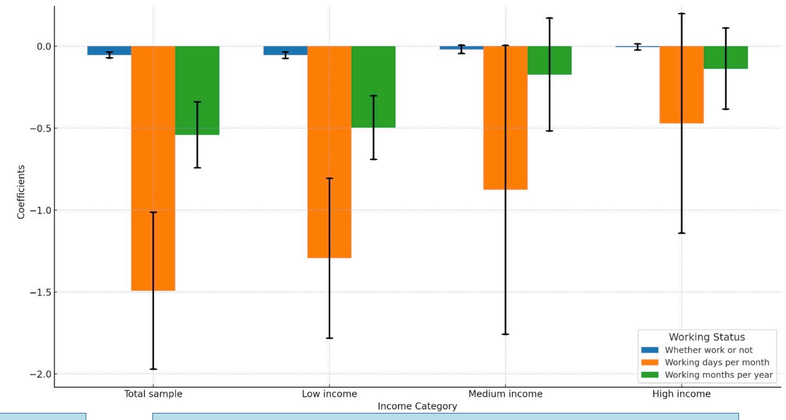


Figure 2: Heterogeneous by income of work status

Table 3: Heterogeneous effect by working types

	(1)	(2)	(3)	(4)
Panel A	Mental working	Physical working	Mental working	Physical working
Dep. Var.	Working days per month		Working months per year	
Pm2.5	-0.020	**-1.489*** **	0.112	**-0.397** **
	(0.839)	**(0.486)**	(0.351)	**(0.184)**
Observations	4,934	15,554	4,931	15,498
KP F-statistics	66.73	182.7	66.36	182.6
Panel B	Indoor working	Outdoor working	Indoor working	Outdoor working
Dep. Var.	Working days per month		Working months per year	
Pm2.5	-0.367	**-1.734*** **	0.227	**-0.521*** **
	(0.409)	**(0.515)**	(0.171)	**(0.188)**
Observations	11,320	13,270	11,288	13,230
KP F-statistics	527.6	166	530.1	165.1

Table 4: Mediation effect of energy usage on health condition

Dep. Var.	(1) Energy usage	(2) Health condition	(3) Health condition	(4) Energy usage	(5) Health condition	(6) Health condition	(7) Energy usage	(8) Health condition	(9) Health condition
Energy usage			-2.606			1.044			-0.158
			(2.958)			(0.831)			(0.289)
Pm2.5	-0.016	0.091**	0.054	0.051*	0.068**	0.008	0.149***	-0.019	-0.002
	(0.033)	(0.036)	(0.051)	(0.029)	(0.032)	(0.013)	(0.040)	(0.037)	(0.011)
Income Ranking	Low	Low	Low	Medium	Medium	Medium	High	High	High
Observations	13,249	13,678	13,245	11,917	12,251	11,917	11,053	11,384	11,051
Mediation Effect			**55.33%**			**43.91%**			**31.42%**

Conclusions

- While overall air pollution has significantly reduced individuals' health and increased their electricity consumption, subsample regression results reveal income level heterogeneity.
  - **High-income**: increase electricity consumption without significant changes in health levels. **Low-income**: do not increase their electricity consumption and health levels decrease because of **budget limitations**
- **Inequality in energy consumption** is a significant **channel** through which air pollution impacts health: the **explanatory power** of electricity consumption **diminishes with rising income levels of individuals**.