Is There A Pollution-Poverty Trap for Seniors?

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Motivating Observations

Fine particulate air pollution ($PM_{2.5}$) is especially hazardous for seniors with respiratory illnesses

- Pope et al. (NEJM 2002), Schlenker and Walker (REStud 2016)

When seniors move, their moves tend to reduce exposure to $PM_{2.5}$

- Bishop, Ketcham, and Kuminoff (2018)

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When seniors move, their moves tend to reduce exposure to $PM_{2.5}$

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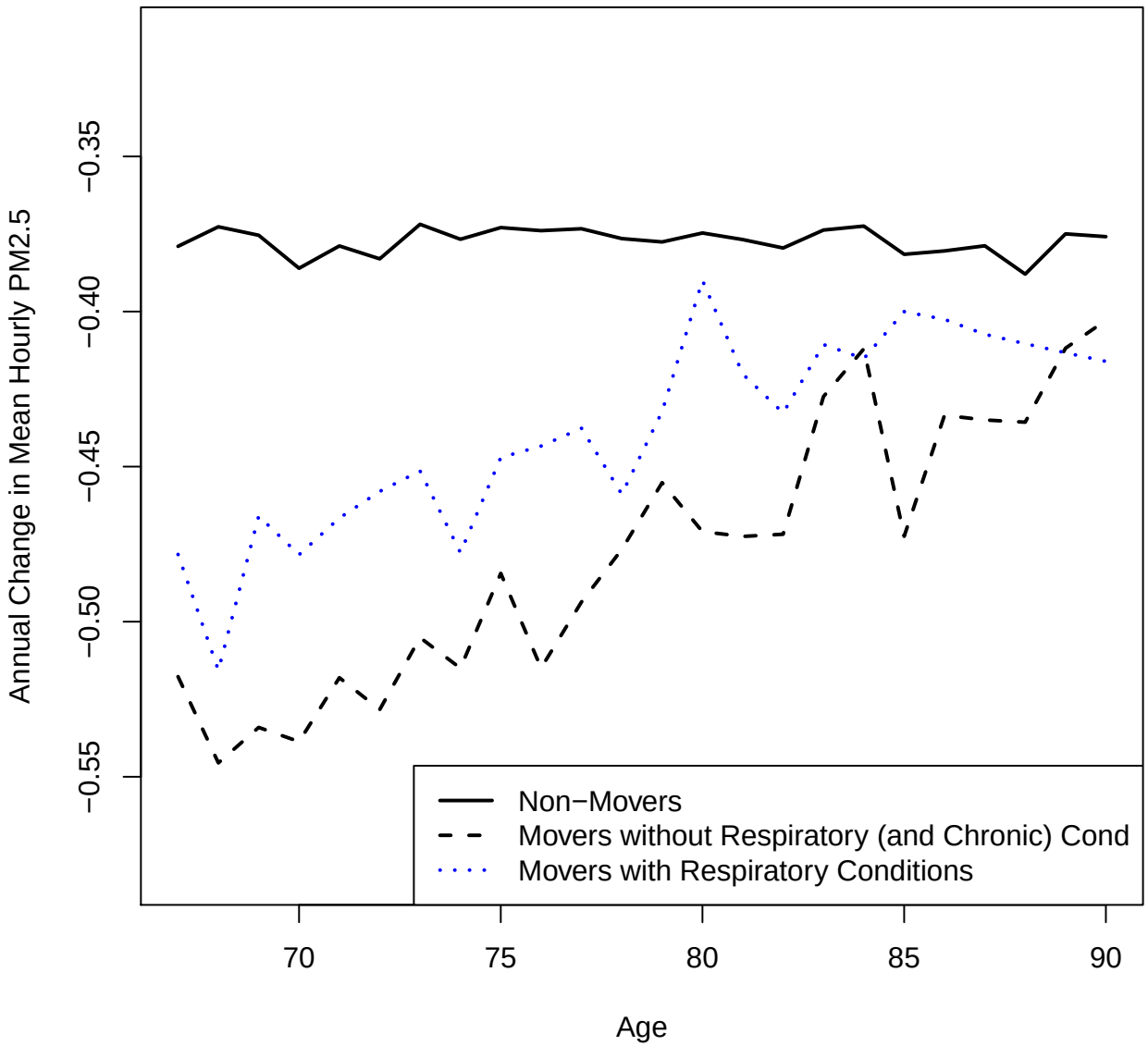
Puzzle: Movers with respiratory illnesses have *smaller* reductions in $PM_{2.5}$ than movers without respiratory illnesses

Annual Change in $PM_{2.5}$ by Age and Health, 2001-2013



Research Question

Can residential sorting patterns on health and income be explained by a **"pollution-poverty trap"**?

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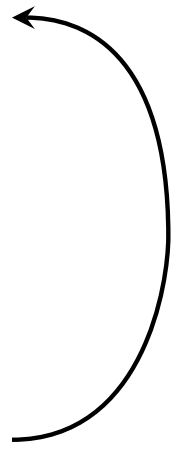
1. Lower income people sort into more polluted places
2. Pollution negatively affects health
3. Negative health shocks increase medical expenditures and thus lower disposable income



Related Literature

Equilibrium Residential Sorting

- Kuminoff, Smith, and Timmins (JEL 2013)

Poverty Trap

- Durlauf (JEconGrowth 1996), Durlauf and Seshadri (2018)

Pollution-Poverty Trap

- Isen, Rossin-Slater, and Walker (JPE 2017)

Environmental Justice

- Banzhaf 2012, Depro, Timmins, and O'Neil (JAERE 2015)

Outline

1. Multi-Period Residential Sorting Model
2. Numerical Illustration
3. Data
4. Empirical Evidence on Key Mechanisms
5. Next Steps

Multi-Period Residential Sorting Model: Setup

Retired individuals $i \in \{1, ..., I\}$ live for 3 periods

Individuals are myopic

Individuals are heterogenenous in health ε_i and income y_i

Each period, choose a neighborhood $j \in \{1, ..., J\}$

Neighborhoods differ in quality (amenities, pollution, noise, etc)

Each neighborhood has a housing supply curve with positive slope

Multi-Period Residential Sorting Model: Utility

Assume CES utility function

$$U(c_i, q_j, \varepsilon_i) = (\alpha c_i^{\sigma} + (1-\alpha) v(q_j, \varepsilon_i)^{\sigma})^{\frac{1}{\sigma}}$$

Utility increases in consumption (c) and neighborhood quality (q)

Utility decreases as health worsens

- $\varepsilon = 0$ perfect health
- $\varepsilon \uparrow$ increasing illness

Assumption:
Marginal utility of quality is weakly increasing in health

$$v_{q\varepsilon} <= 0$$

Multi-Period Residential Sorting Model: Budget

Spend income on c, housing (p), and medical services (m)

$$c_i + p(q_j) + m(\varepsilon_i) = y_i$$

Assumption:
Illness increases medical expenditures

$$\frac{dm}{d\varepsilon} > 0$$

Multi-Period Residential Sorting Model

Health production function:

$$\varepsilon_{i,t+1} = f(q_{j,t}, \varepsilon_{i,t}) + \eta_{i,t+1} \ , \quad \text{where}$$

of

- $\varepsilon_{i,t}$: stock of health
- $q_{j,t}$: neighborhood quality
- $\eta_{i,t+1}$: idiosyncratic health shock

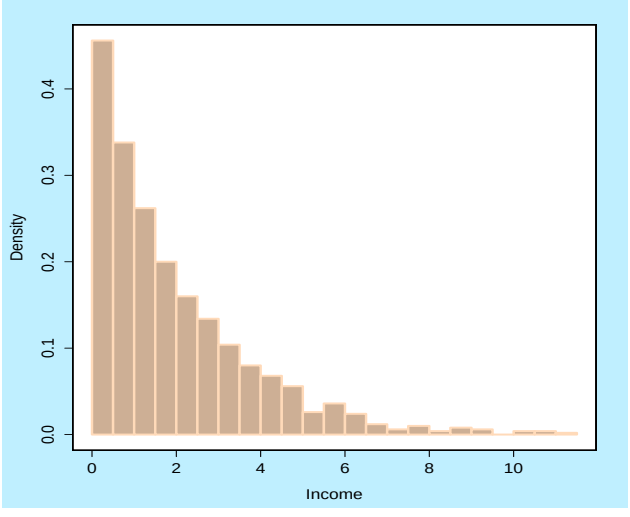
Future health is weakly decreasing in current pollution

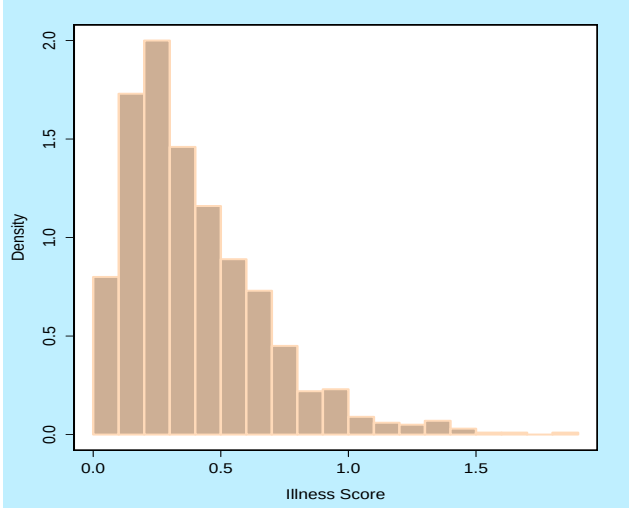
$$\frac{df}{dq} < 0$$

Numerical Illustration

Period 1:

- 3 neighborhoods differ in quality: $q_1 < q_2 < q_3$
- Health and income are drawn $i.i.d.$
- Given p_j, q_j, y_i, $\varepsilon_{i,1}$, individuals pick optimal neighborhood

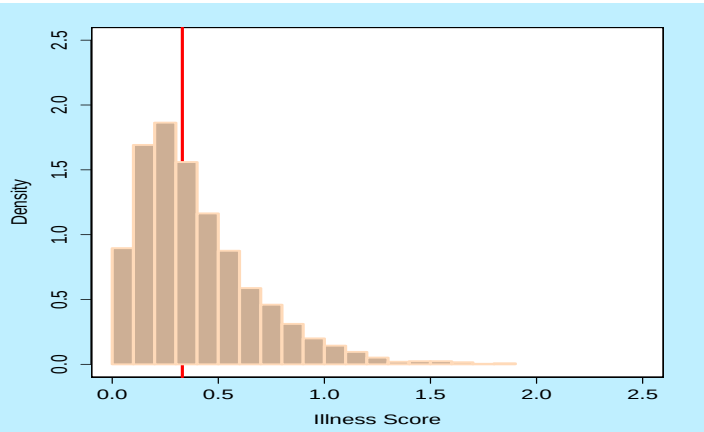




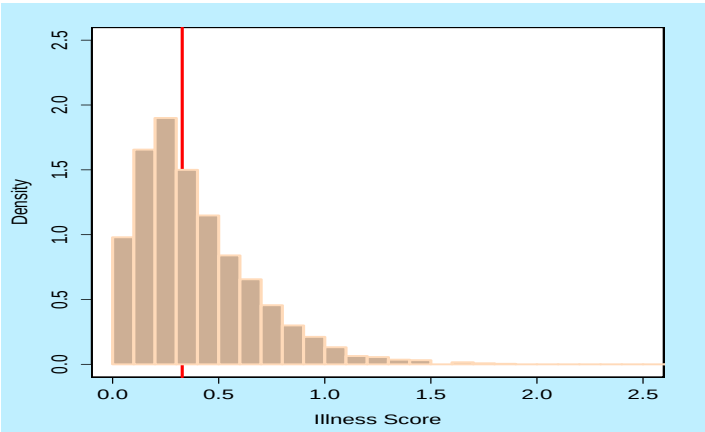
Period 2:

- $\varepsilon_{i,2}$ is drawn depending on $q_{j,i}$, $\varepsilon_{i,1}$, and $\eta_{i,2}$

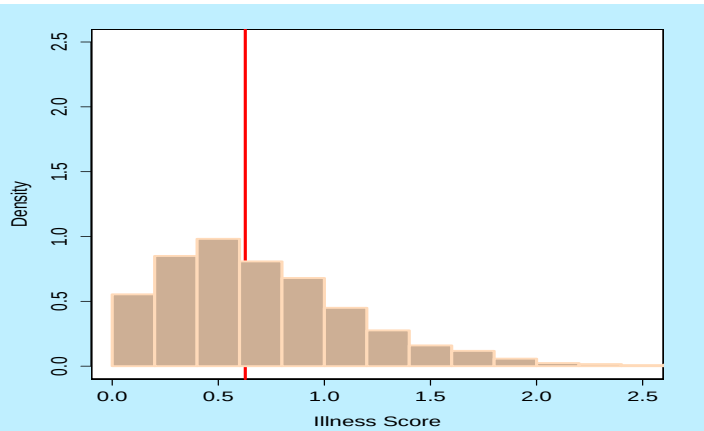
Numerical Illustration: Evolution of Health



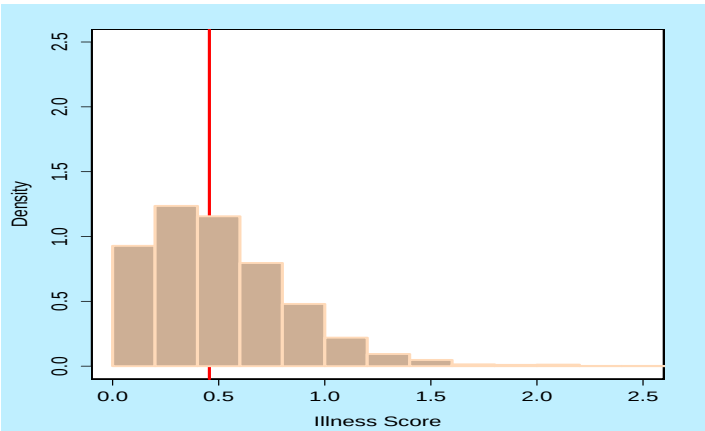
(a) Period 1: Low Income 25%



(c) Period 1: High Income 25%



(b) Period 2: Low Income 25%



(d) Period 2: High Income 25%

Does empirical evidence support or reject the pollution-poverty trap hypothesis?

Pollution Poverty Trap: Key Mechanisms

1. Housing is cheaper in more polluted neighborhoods
2. Income is negatively correlated with $PM_{2.5}$ exposure
3. Pollution causes health shocks
4. Health shocks increase medical expenditures and migration

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Higher pollution decreases property values

- Chay and Greenstone (JPE 2005), Currie et al (AER 2015)

Individuals have a positive willingness to pay to avoid air pollution

- Smith and Huang (JPE 1995)

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Long term exposure to air pollution increases mortality

- Di et al (NEJM 2017), Dockery et al (NEJM 1993)

Increases in air pollution increase hospitalization rates

- Dockery and Pope (ARPH 1994), Brunekreef and Holgate (*Lancet* 2002)

Even moderate amounts of air pollution lead to acute exacerbation

- Bernstein et al (JACI 2004), Li (*ClinImm* 2003)

Pollution Poverty Trap: Key Mechanisms

It remains to show:

1. Housing is cheaper in more polluted neighborhoods
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Data: CMS Administrative Panel + Medicare Current Beneficiary Survey (MCBS)

Source: Center for Medicare and Medicaid Services (CMS)

- Annual location and health records
- 7 million individuals of advanced age
  - 10 percent random sample of all 65+
- MCBS Add-on: Personal demographics for 46,000 individuals (interviewed 2005-2011)

Data: CMS Administrative Panel + Medicare Current Beneficiary Survey (MCBS)

For each year and individual

- know precise residential location (ZIP+4 code)
- presence or absence of over 50 specified health conditions

Data: Precision of ZIP+4 Codes

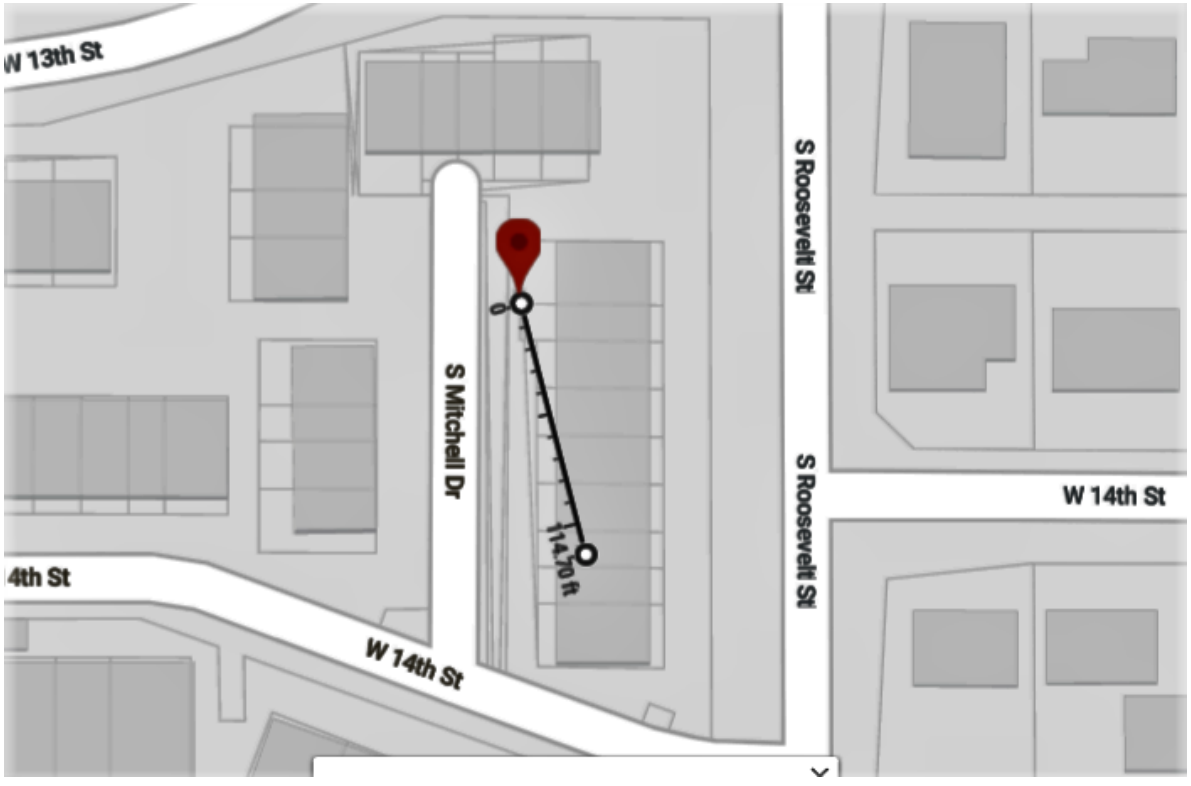

Figure: Distance between ZIP+4 Centroid and House

Data: EPA Air Quality Monitors

EPA monitors most common and dangerous pollutants

- Particulate matter, ozone, etc
- 3,000 monitoring stations in over 1,000 counties

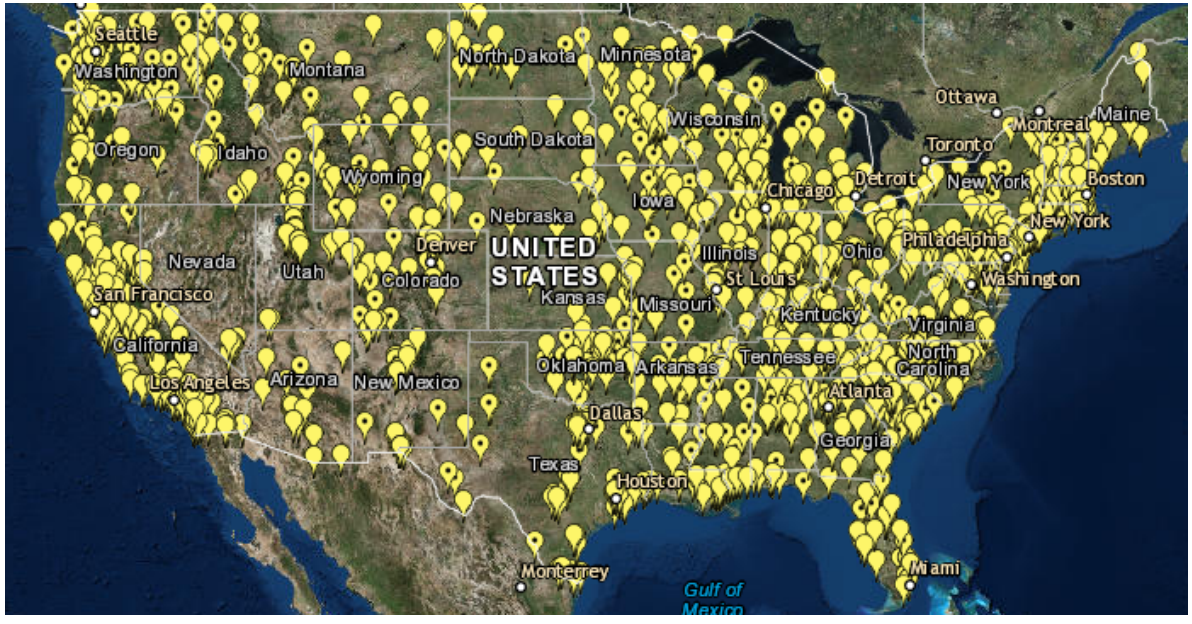

Figure: Map of Air Quality Monitors. Source: EPA

Pollution Poverty Trap: Key Mechanisms

1. Housing is cheaper in more polluted neighborhoods
2. Lower-income seniors live in more polluted neighborhoods
3. Pollution causes health shocks
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Step 2: Income is Negatively Correlated with $PM_{2.5}$

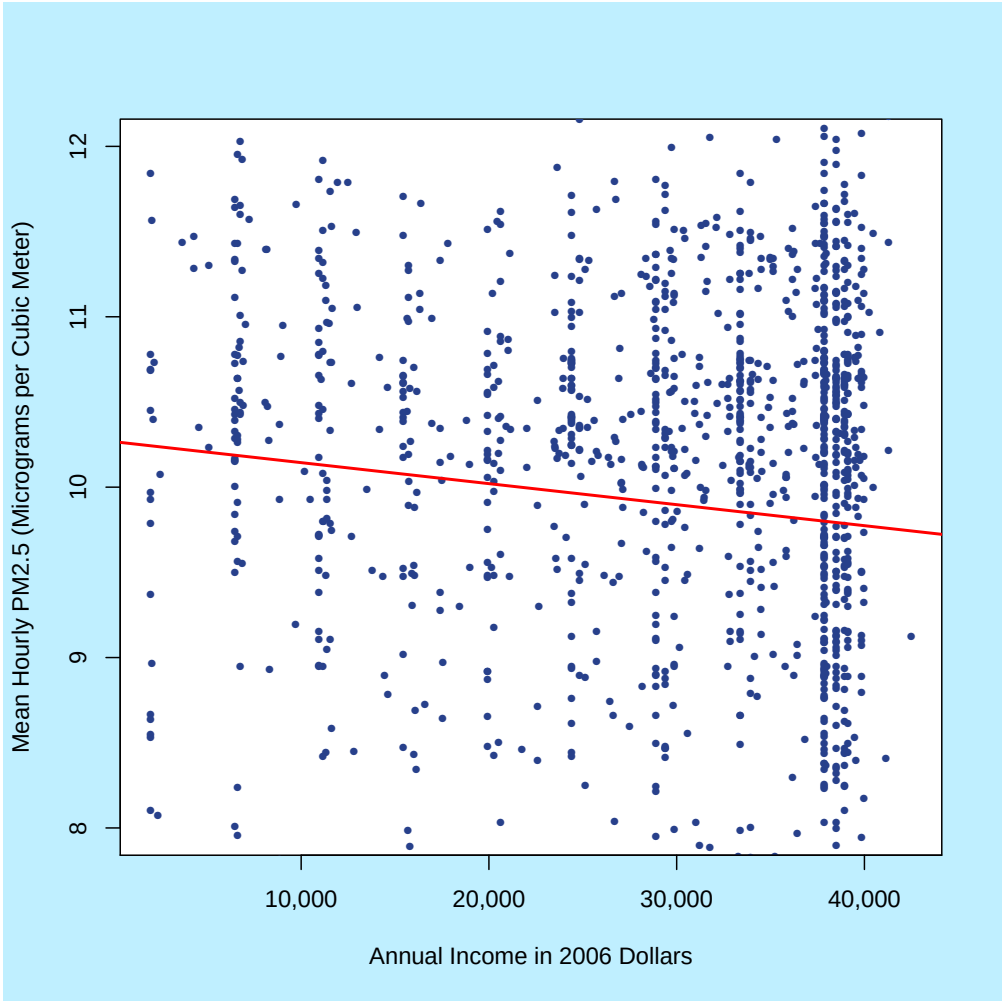

Figure: Exposure to $PM_{2.5}$ Across Income Groups in 2011

Step 4: Health Shocks Increase Medical Expenditures

First Difference Estimation:

Effect of change in health status on change in medical expenditures

$$\Delta exp_{it} = \beta \cdot \Delta diag_{i,t} + \epsilon_{i,t}$$

Dependent variable:
Total annual out-of-pocket costs in Medicare Part A&B

Part 4: Health Shocks Increase Medical Expenditures

	All		Non-movers	
Lung cancer	2916	(20)	2954	(20)
Stroke	1392	(10)	1373	(10)
Acute myocardial infarction	1367	(16)	1368	(16)
Atrial fibrillation	1329	(10)	1327	(10)
Chronic kidney disease	1233	(7)	1217	(7)
COPD	936	(9)	928	(9)
Ischemic heart disease	754	(8)	750	(8)
PVD	598	(9)	619	(9)
Intercept	-288	(2)	-269	(2)
Adj R^2	0.13		0.13	
N	3.7m		3.5m	

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Median household income in the sample is around 25,000 USD

Part 4: Health Shocks Increase Propensity to Move

Linear probability estimation:

Effect of new diagnosis in $t-1$ on probability of moving in t

$$move_{it} = \beta \cdot \Delta diag_{i,t-1} + \gamma \cdot z_i + \epsilon_{i,t}$$

Covariates z_i:

- 6 race dummies
- 27 age dummies (plus age by gender)
- 3,092 county dummies

Part 4: Health Shocks Increase Propensity to Move

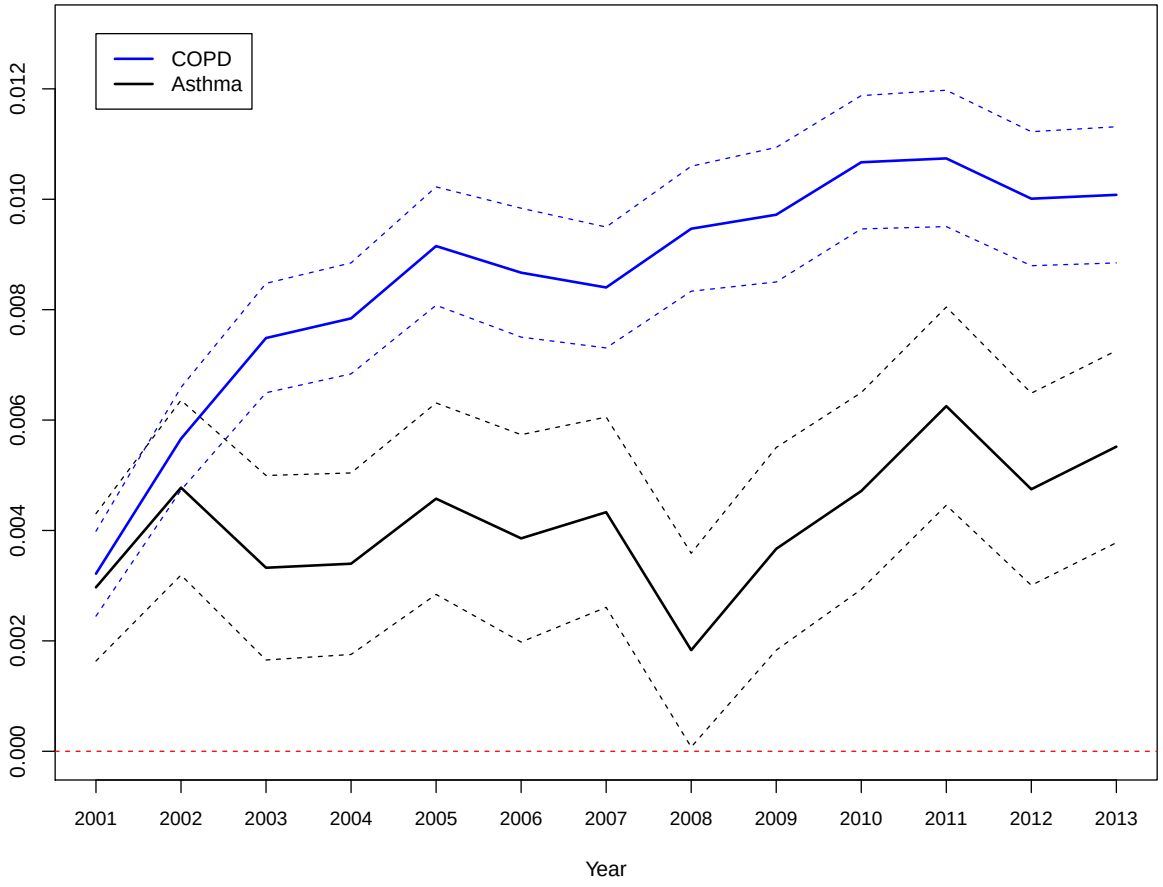
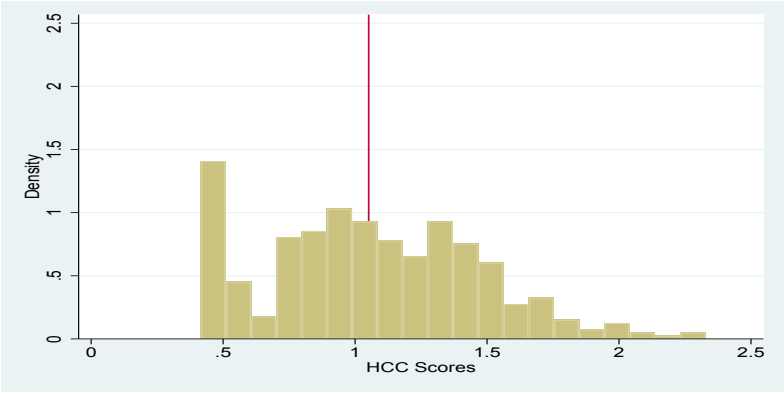
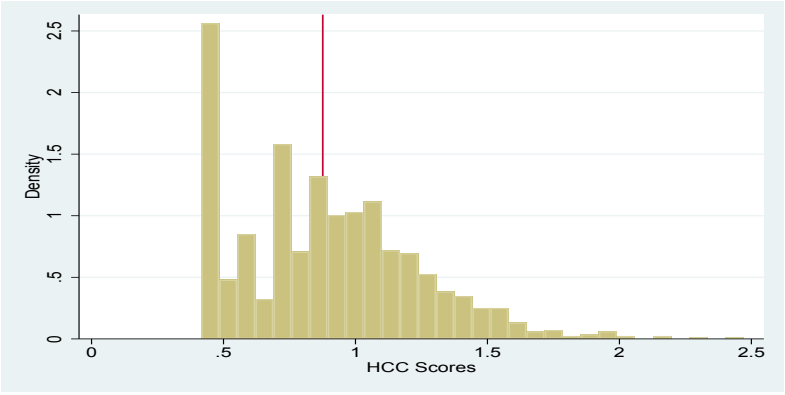


Figure: Impact of New Diagnoses of Asthma and COPD on Propensity to Move. Coefficient Estimates and 95 Percent CI.

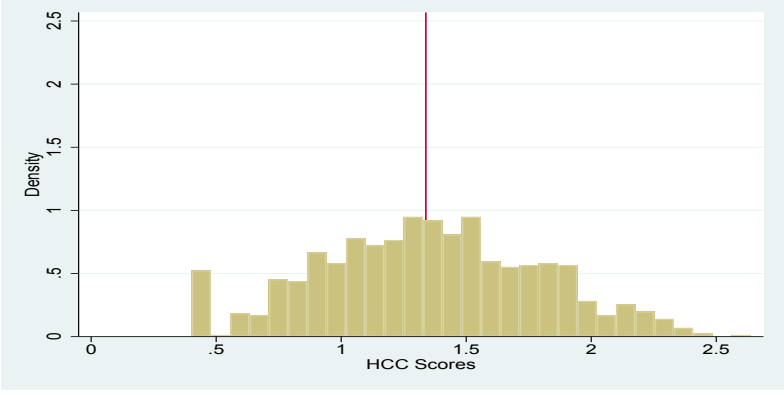
Distribution of HCC Scores in 2011



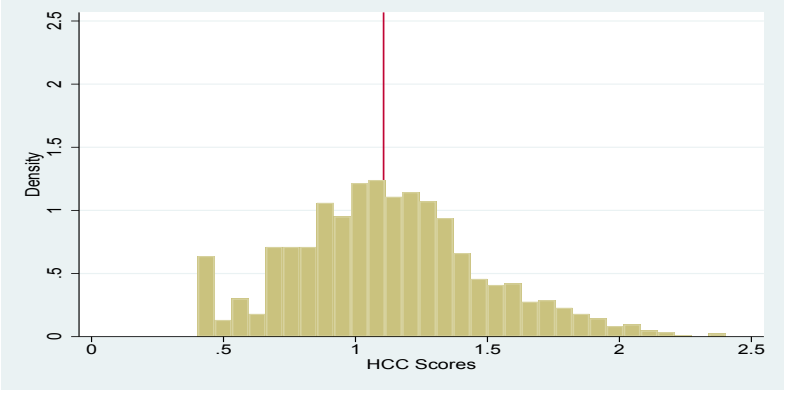
(a) Low Income, Age 65 to 74



(c) High Income, Age 65 to 74



(b) Low Income, Age 75 to 84



(d) High Income, Age 75 to 84

Summary

1. Housing is cheaper in more polluted neighborhoods ✓
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Next Steps

- Structural estimation of model parameters
- Policy counterfactuals
  - Effects of reducing air pollution

Thank you for your attention!

Backup: Model Simulation with 3 Communities

- $n = 10,000$ individuals
- Assume initial distribution $y \sim \Gamma(1, 0.5)$, $\varepsilon \sim \Gamma(2, 5)$
- Utility function

$$U = 0.4 \cdot \log(c) + \frac{0.6}{1 + \varepsilon} \cdot \log(q)$$

- Budget restriction

$$y = c + h + 0.2 \cdot \varepsilon$$

- Health translation function

$$\varepsilon_{t+1} = \beta(q) \cdot \varepsilon + \eta, \quad \eta \sim N(0.1, 0.2)$$

Backup: Model Simulation with 3 Communities

- Quality $q = (1, 4, 8)$
- Prices $h = (0.2, 0.7, 1.6)$
- Health translation $\beta = (0.2, 0.7, 1.6)$