Environmental Inequality and Selective Migration: A Household-Level Panel Study on How Pollution Affects the Probability of Moving

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Environmental inequality

‘hundreds of studies conclude that, in general, ethnic minorities, indigenous persons, people of color, and low-income communities confront a higher burden of environmental exposure from air, water, and soil pollution’ (Mohai et al., 2009, p. 406)
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In Air Pollution

<table>
<thead>
<tr>
<th></th>
<th>0.00</th>
<th>0.00 to 11.09</th>
<th>11.09 to 17.98</th>
<th>17.98 to 18.99</th>
<th>over 18.99</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Foreigners</td>
<td></td>
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<tr>
<td>under 5.51</td>
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<td>5.51 to 6.88</td>
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<td>6.88 to 9.44</td>
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<td>9.44 to 13.10</td>
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<td></td>
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<tr>
<td>over 13.10</td>
<td></td>
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</tr>
</tbody>
</table>

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Gelsenkirchen Leverkusen
Low Environmental Inequality High Environmental Inequality
Facility location City centre
Research Question

Why are minorities in Germany disproportionately exposed to environmental pollution?

▶ Focus on selective out-migration
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Why are minorities in Germany disproportionately exposed to environmental pollution?

▶ Focus on selective out-migration

Why should we care?

▶ EU: air pollution caused 400,000 premature deaths in 2016 (European Environment Agency, 2019)
Theoretical mechanisms

Selective siting

$\Rightarrow$ Facilities are sited in minority / poor regions

(Banzhaf et al., 2019; Crowder and Downey, 2010)
Theoretical mechanisms

Selective siting
⇒ Facilities are sited in minority / poor regions

Selective migration
⇒ Natives / rich households move out of polluted areas
⇒ Minorities / poor households move into polluted areas
▶ Housing costs
▶ Housing discrimination
▶ Residential preferences
(Banzhaf et al., 2019; Crowder and Downey, 2010)
Theoretical mechanisms

Selective siting
⇒ Facilities are sited in minority / poor regions

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⇒ Natives / rich households move out of polluted areas
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▶ Housing costs
▶ Housing discrimination
▶ Residential preferences
(Banzhaf et al., 2019; Crowder and Downey, 2010)

Are households selectively ‘fleeing the nuisance’?
Previous results

On the aggregated level

▶ Very mixed results (e.g. Banzhaf et al., 2019)
Previous results

On the aggregated level
▶ Very mixed results (e.g. Banzhaf et al., 2019)

Individual level: in-migration
▶ Evidence for selective in-migration of minorities
  (Best and Rüttenauer, 2018; Crowder and Downey, 2010)
▶ Moderate income selectivity (Best and Rüttenauer, 2018)
Previous results

On the aggregated level

► Very mixed results (e.g. Banzhaf et al., 2019)

Individual level: in-migration

► Evidence for selective in-migration of minorities
  (Best and Rüttenauer, 2018; Crowder and Downey, 2010)
► Moderate income selectivity (Best and Rüttenauer, 2018)

Individual level: out-migration

► No selective out-migration based on race
  (Crowder and Downey, 2010)
► No test of income selectivity in out-migration
Out-migration: What do we expect?

Income

- Higher demand for / prices in clean areas
- Willingness to pay for environment increases with income (Liebe et al., 2010)

⇒ Selective out- and in-migration
Out-migration: What do we expect?

Income
- Higher demand for / prices in clean areas
- Willingness to pay for environment increases with income (Liebe et al., 2010)
⇒ Selective out- and in-migration

Minority status
- Housing costs
- Housing discrimination
- Residential preferences
Out-migration: What do we expect?

Income

- Higher demand for / prices in clean areas
- Willingness to pay for environment increases with income (Liebe et al., 2010)

⇒ Selective out- and in-migration

Minority status

- Housing costs
- Housing discrimination
- Residential preferences

⇒ Only plausible minority effect in out-migration runs through income
Data

German SOEP

- 13,247 observations and 3,792 households
- Unbalanced (min. 2 waves)
- Sample: min. 1 location change, min 1 stationary period

Variables

- Response: relocation (1 – 0)
- Main covariates I: impairment through air pollution (1 – 5)
- Main covariates II: immigrant (1st / 2nd gen), hh equivalence income
- Controls: year, age (5-year intervals), child(ren) in household, partner in household, distance to nearest city centre, housing conditions
Chamberlain’s Correlated Random Effects (CRE) probit

\[
P(y_{it} = 1|x_i) = \Phi(\psi + x_{it}\beta + \bar{x}_i\xi),
\]

using the decomposition of the individual-specific effects \(c_i = \psi + \bar{x}_i\xi + a_i\), where \(\Phi(\cdot)\) is a standard normal cumulative distribution function, \(\bar{x}_i\) are the individual-specific averages of \(x_{it}\) (Chamberlain, 1982; Mundlak, 1978; Wooldridge, 2010)

Advantage

- \(\beta\) are within estimates (like FE)
- allows to compute AMEs for \(\hat{\mu}_c \pm \hat{\sigma}_c\)
**Table**: Correlated random effects probit. Dependent variable: move-out.

<table>
<thead>
<tr>
<th></th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Air pollution(t-1)</strong></td>
<td>0.051</td>
<td>-0.013</td>
<td>0.177***</td>
<td>0.125***</td>
<td>0.003</td>
</tr>
<tr>
<td></td>
<td>(0.038)</td>
<td>(0.039)</td>
<td>(0.024)</td>
<td>(0.024)</td>
<td>(0.041)</td>
</tr>
<tr>
<td><strong>Household income(t-1)</strong></td>
<td>-0.208***</td>
<td>-0.191***</td>
<td>0.080**</td>
<td>0.092***</td>
<td>-0.182***</td>
</tr>
<tr>
<td></td>
<td>(0.050)</td>
<td>(0.048)</td>
<td>(0.025)</td>
<td>(0.026)</td>
<td>(0.048)</td>
</tr>
<tr>
<td><strong>Income(t-1) \times pollution(t-1)</strong></td>
<td>0.080**</td>
<td>0.092***</td>
<td>0.087***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.025)</td>
<td>(0.026)</td>
<td>(0.026)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Minority (ref = German)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st generation \times pollution(t-1)</td>
<td>-0.123*</td>
<td>-0.107</td>
<td>-0.080</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.058)</td>
<td>(0.059)</td>
<td>(0.059)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2nd generation \times pollution(t-1)</td>
<td>0.050</td>
<td>0.074</td>
<td>0.067</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.099)</td>
<td>(0.097)</td>
<td>(0.096)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Basic controls</strong></td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td><strong>Additional controls</strong></td>
<td>no</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td><strong>AIC</strong></td>
<td>15343</td>
<td>14818</td>
<td>15364</td>
<td>14832</td>
<td>14821</td>
</tr>
<tr>
<td><strong>loglik</strong></td>
<td>-7630</td>
<td>-7348</td>
<td>-7639</td>
<td>-7353</td>
<td>-7344</td>
</tr>
<tr>
<td><strong>N households</strong></td>
<td>3789</td>
<td>3789</td>
<td>3789</td>
<td>3789</td>
<td>3789</td>
</tr>
<tr>
<td><strong>N</strong></td>
<td>13239</td>
<td>13239</td>
<td>13239</td>
<td>13239</td>
<td>13239</td>
</tr>
</tbody>
</table>

*** \(p < 0.001\), ** \(p < 0.01\), * \(p < 0.05\), twotailed test. Cluster robust standard errors in parentheses. SOEP waves: 1986, 1994, 1999, 2004, 2009, 2014, 2016. Basic controls: year, age (5-year interval dummies). Additional controls: child(ren) in hh, partner in hh, distance to city centre, flat condition. All covaraites are also included as household-specific mean (omitted in output).
Results income M1 (only basic controls)
Results income M2 (additional controls)

Av. marginal effect of pollution on moving probability

Household income (in t Euro)

M2 (full set of controls)
Results minorities

Average marginal effect of pollution

- Native German
- Minority 1st gen
- Minority 2nd gen

Basic controls (M3)  Additional controls (M4)  Plus income interaction (M5)
Results minorities

Average marginal effect of pollution

- Native German
- Minority 1st gen
- Minority 2nd gen

Basic controls (M3)
Additional controls (M4)
Plus income interaction (M5)
Results minorities × income

Av. marginal effect of pollution on moving probability

Household income (in t Euro)

- Native German
- Minority 1st gen
Discussion

Robustness

- Income effect: robust
- Minority effect: sensitive to model specification
Discussion

Robustness

- Income effect: robust
- Minority effect: sensitive to model specification

Effect size

- Relocation probability in 5 year interval: $\sim 40\%$
- Pollution effect on out-migration moderate
  - 4-5 %points
  - 1.6 %points change by income
  - 2.6 %points minority disadvantage
- Smaller effect size for full sample
- But: within-household effect
Conclusions

Selective Out-migration

▶ Income selectivity in escaping polluted areas
▶ (Minority disadvantages in out migration)
▶ Income explains over 20% of minority disadvantage
⇔ Contradicts findings on in-migration
   (Best and Rüttenauer, 2018)
Conclusions

Selective Out-migration
- Income selectivity in escaping polluted areas
- (Minority disadvantages in out migration)
- Income explains over 20% of minority disadvantage

\( \iff \) Contradicts findings on in-migration
(Best and Rüttenauer, 2018)

Implications
- Different mechanisms at different stages?
  1. Out-migration: income-selection
  2. In-migration: minority-selection
- Maybe explanation for mixed results on macro level
Thank you very much!


### Table: Summary Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Native German</th>
<th>1st gen. minority</th>
<th>2nd gen. minority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Move within two periods</td>
<td>0.378</td>
<td>0.393</td>
<td>0.411</td>
</tr>
<tr>
<td>Impairment air pollution</td>
<td>1.858</td>
<td>1.932</td>
<td>1.897</td>
</tr>
<tr>
<td>Household income (in t EUR)</td>
<td>1.59</td>
<td>1.220</td>
<td>1.685</td>
</tr>
<tr>
<td>Age</td>
<td>51.362</td>
<td>51.748</td>
<td>42.912</td>
</tr>
<tr>
<td>Child(ren) in household</td>
<td>0.447</td>
<td>0.634</td>
<td>0.485</td>
</tr>
<tr>
<td>Partner in household</td>
<td>0.685</td>
<td>0.797</td>
<td>0.696</td>
</tr>
<tr>
<td>Distance to city centre</td>
<td>3.099</td>
<td>3.013</td>
<td>2.730</td>
</tr>
<tr>
<td>Condition of flat/house</td>
<td>3.603</td>
<td>3.584</td>
<td>3.643</td>
</tr>
<tr>
<td>Owner of flat/house</td>
<td>0.342</td>
<td>0.231</td>
<td>0.264</td>
</tr>
<tr>
<td>N groups</td>
<td>3097</td>
<td>537</td>
<td>156</td>
</tr>
<tr>
<td>N</td>
<td>10910</td>
<td>1805</td>
<td>526</td>
</tr>
</tbody>
</table>
Fixed Effects Logit

\[ P(y_{it} = 1|x_{it}, c_i) = \Lambda(x_{it}\beta + c_i), \quad t = 1, \ldots, T, \]

where \( \Lambda(\cdot) \) is a logistic function, \( y_{it} \) the binary response, \( x_{it} \) a \( 1 \times K \) predictor vector, \( \beta \) a \( K \times 1 \) parameter vector, and \( c_i \) the unobserved individual effect (Wooldridge, 2010, pp.619)
Method

Fixed Effects Logit

\[ P(y_{it} = 1|x_{it}, c_i) = \Lambda(x_{it}\beta + c_i), \ t = 1, \ldots, T, \]  \hspace{1cm} (2)

where \( \Lambda(\cdot) \) is a logistic function, \( y_{it} \) the binary response, \( x_{it} \) a \( 1 \times K \) predictor vector, \( \beta \) a \( K \times 1 \) parameter vector, and \( c_i \) the unobserved individual effect (Wooldridge, 2010, pp.619)

Problems

- Coefficients of interactions in binary models not interpretable (e.g. Ai and Norton, 2003)
  \( \Rightarrow \) Use AMEs (Mize, 2019)
- But: no AMEs for FE logit possible
Table: Fixed-effects logit. Dependent variable: move-out.

<table>
<thead>
<tr>
<th></th>
<th>M1</th>
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<th>M3</th>
<th>M4</th>
<th>M5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air pollution&lt;sub&gt;t-1&lt;/sub&gt;</td>
<td>0.039</td>
<td>−0.042</td>
<td>0.220***</td>
<td>0.154***</td>
<td>−0.022</td>
</tr>
<tr>
<td></td>
<td>(0.053)</td>
<td>(0.055)</td>
<td>(0.031)</td>
<td>(0.033)</td>
<td>(0.059)</td>
</tr>
<tr>
<td>Household income&lt;sub&gt;t-1&lt;/sub&gt;</td>
<td>−0.229**</td>
<td>−0.211**</td>
<td></td>
<td>−0.200**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.071)</td>
<td>(0.072)</td>
<td></td>
<td>(0.072)</td>
<td></td>
</tr>
<tr>
<td>Income&lt;sub&gt;t-1&lt;/sub&gt; × pollution&lt;sub&gt;t-1&lt;/sub&gt;</td>
<td>0.118***</td>
<td>0.135***</td>
<td></td>
<td>0.129***</td>
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</tr>
<tr>
<td></td>
<td>(0.034)</td>
<td>(0.035)</td>
<td></td>
<td>(0.036)</td>
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</tr>
<tr>
<td>Minority (ref = German)</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>1st generation × pollution&lt;sub&gt;t-1&lt;/sub&gt;</td>
<td></td>
<td></td>
<td>−0.164*</td>
<td>−0.134</td>
<td>−0.095</td>
</tr>
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<td></td>
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<td></td>
<td>(0.076)</td>
<td>(0.078)</td>
<td>(0.079)</td>
</tr>
<tr>
<td>2nd generation × pollution&lt;sub&gt;t-1&lt;/sub&gt;</td>
<td></td>
<td></td>
<td>0.055</td>
<td>0.074</td>
<td>0.073</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>(0.138)</td>
<td>(0.141)</td>
<td>(0.140)</td>
</tr>
</tbody>
</table>

Basic controls: year, age (5-year interval dummies). Additional controls: child(ren) in hh, partner in hh, distance to city centre, flat condition.

*** p < 0.001, ** p < 0.01, * p < 0.05, twotailed test. Cluster robust standard errors in parentheses.
### Table: Fixed-effects linear probability model. Dependent variable: move-out.

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<th>M3</th>
<th>M4</th>
<th>M5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Air pollution_{t−1}</strong></td>
<td>0.023***</td>
<td>0.012</td>
<td>0.039***</td>
<td>0.029***</td>
<td>0.014*</td>
</tr>
<tr>
<td></td>
<td>(0.007)</td>
<td>(0.007)</td>
<td>(0.004)</td>
<td>(0.004)</td>
<td>(0.007)</td>
</tr>
<tr>
<td><strong>Household income_{t−1}</strong></td>
<td>−0.027***</td>
<td>−0.025***</td>
<td></td>
<td>−0.024***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.007)</td>
<td>(0.007)</td>
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<td>(0.007)</td>
<td></td>
</tr>
<tr>
<td><strong>Income_{t−1} × pollution_{t−1}</strong></td>
<td>0.009**</td>
<td>0.011**</td>
<td></td>
<td></td>
<td>0.011**</td>
</tr>
<tr>
<td></td>
<td>(0.004)</td>
<td>(0.004)</td>
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<td>(0.004)</td>
</tr>
<tr>
<td><strong>Minority (ref = German)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st generation × pollution_{t−1}</td>
<td></td>
<td></td>
<td>−0.020</td>
<td>−0.017</td>
<td>−0.013</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.013)</td>
<td>(0.013)</td>
<td>(0.013)</td>
</tr>
<tr>
<td>2nd generation × pollution_{t−1}</td>
<td></td>
<td></td>
<td>0.008</td>
<td>0.006</td>
<td>0.005</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.020)</td>
<td>(0.019)</td>
<td>(0.019)</td>
</tr>
</tbody>
</table>

|                           | yes    | yes    | yes    | yes    | yes    |
| Basic controls            | no     |        |        |        |        |
| Additional controls       |        | yes    |        |        | yes    |
| **AIC**                   | 11099  | 10166  | 11114  | 10179  | 10167  |
| loglik                    | -5527  | -5050  | -5534  | -5057  | -5049  |
| N households              | 8867   | 8867   | 8867   | 8867   | 8867   |
| N                         | 28408  | 28408  | 28408  | 28408  | 28408  |

Subsample vs. full sample

Cases in FE Logit

- N = 13,241
- Only cases with a least 1 stationary and 1 relocation period
- All other cases: no within information
- Average treatment effect on treated (ATT)
Subsample vs. full sample

Cases in FE Logit
- $N = 13,241$
- Only cases with at least 1 stationary and 1 relocation period
- All other cases: no within information
- Average treatment effect on treated (ATT)

CRE Probit
- So far: same sample
- But also possible for only stationary / moving households
- $N = 28,408 (8,867)$
Subsample vs. full sample

AMEs M2: Subsample

AMEs M2: Full sample

References  Descriptives  Method  Robustness  Sample

21 / 14
Subsample vs. full sample

AMEs M2: Subsample

AMEs M2: Full sample

Average marginal effect of pollution

Basic controls (M3)  Additional controls (M4)  Plus income interaction (M5)

Native German

Minority 1st gen

Minority 2nd gen

References  Descriptives  Method  Robustness  Sample