Disclosures

- No funding to disclose for this work
- I have no tobacco-related funding sources to disclose.
Motivation: Cigarette Smoking by Location

Source: Author’s calculations from National Longitudinal Survey of Youth, 1979. Smoking is daily smoking and rural is residence in a non-metro or non-metro adjacent county.
Motivation: Cigarette Smoking by Location

Source: Author’s calculations from National Health Interview Survey. Smoking is daily smoking and rural is anything outside of a MSA.
Motivation: Cigarette Smoking by Location

Source: Doogan et al. 2017

[Graph showing unadjusted cigarette smoking prevalence by year, with data points for rural and urban areas, showing a downward trend.]
Motivation: Historical Evidence

- Evidence from Haenszel et al., 1956
  - In 1956, 52% of urban men and 42% of rural men smoked cigarettes.

- Evidence from the American Lung Association:
  - In 2010, 24.7% of urban men and 30.6% of rural men smoked cigarettes.
Figure 1. Life expectancy at birth (years) by levels of urbanization, U.S., 2005–2009

Source: Singh et al. 2014
Goals of this Paper: Understand why smoking is increasingly a rural phenomenon.
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Possible Explanations:

1. Differential Tobacco Control Laws
Real State + Local Cigarette Taxes

Source: Author’s Calculations from NLSY 1979, Orzechowski and Walker (2017), and The American Nonsmokers Rights Foundation
Doogan et al. 2017:

“uniform federal policies may be important to expanding effective tobacco control and regulatory efforts into areas that lack the resources or political will to implement and enforce local policies that decrease initiation and increase cessation.”
Goals of this Paper: Understand why smoking is increasingly a rural phenomenon.

Possible Explanations:
1. Differential Tobacco Control Laws
2. Composition Changes
   a. Education
Education

Goals of this Paper: Understand *why* smoking is increasingly a rural phenomenon.

Possible Explanations:

1. Differential Tobacco Control Laws
2. Composition Differences
   a. Education
   b. Skill/Ability
Ways that Composition Matters

1. Innate, unobserved differences between urban and rural populations.
2. Selected internal migration over time.

Significant Urbanization:
Between 1950 and 2010, the share of the United States population living in an urban area increased from roughly 60% to 80% (Boustan et al. 2013).

Historically, urban areas were defined by high returns to skill.

Corr(Smoking, Education) < 0.

Composition differences/changes are difficult to capture using standard program evaluation methods.
1. Innate, unobserved differences between urban and rural populations.
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   - **Historically, urban areas were defined by high returns to skill.**
   - Corr(Smoking, Education)<0.

Composition differences/changes are difficult to capture using standard program evaluation methods.
This Paper

1. Estimate an empirical model of smoking, education, and location decisions
   - 30-years of longitudinal, geocoded data from the NLSY 1997.
   - Rich, local area tobacco control laws from the American Nonsmokers Rights Foundation.
   - Local area economic variables.

2. Simulate the model to isolate mechanisms.
By 2014, the smoking prevalence gap between urban and rural areas was 7.9 percentage points.
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1. Differential tobacco control laws explain only 9.6% of this gap.
   ▶ Divergence in smoking behavior occurred 10 years before divergence in cigarette taxes.
   ▶ Divergence in smoking behavior occurred 10-15 years before large-scale adoption of indoor smoking bans in urban area.
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   - Divergence in smoking behavior occurred 10 years before divergence in cigarette taxes.
   - Divergence in smoking behavior occurred 10-15 years before large-scale adoption of indoor smoking bans in urban area.

2. Instead, sorting on unobserved characteristics that predict smoking, education, and urban residence explain 70% of the gap.
Outline

Introduction

Background
Simple Model
Economics Literature

Data and Econometrics
Data
Smoking Regressions
Dynamic Empirical Model
Simulation

Conclusion
Simple Model to Exemplify Migration as a Mechanism

- The basic model is of young individuals in two locations, U and R, where the only input in firms’ production functions in both locations is labor.
- Workers are paid their marginal product, which is a function of a uni-dimensional measure of skill, $S$.
- Workers are differentiated by $S$ and their preference for cigarettes $Z$.
- Let $\rho$ denote the correlation between $S$ and $Z$.
- $S$ and $Z$ are drawn from a population distribution, independent of location.
Simple Model to Exemplify Migration as a Mechanism

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Simple Roy Model Predicts Divergent Trends:

- High skill individuals sort into urban areas; low skill individuals sort out of urban areas.
- Correlation between smoking and skill is negative.
- Urban/rural smoking gap is a long-term phenomenon.
Outline

Introduction

Background
  Simple Model
  Economics Literature

Data and Econometrics
  Data
  Smoking Regressions
  Dynamic Empirical Model
  Simulation

Conclusion
Skill-selected migration causes composition changes in local areas. Kwok & Leland (1982) and Miyagiwa (1991)

Anything correlated with skill could also see composition changes.

Young (2013) shows that differential skill prices are not needed to generate skill composition shifts if workers select on unobserved individual characteristics that are correlated with education.
Urban workers (in the 1990s) earned 33% higher wages than non-urban workers. Why?

1. Is the urban wage premium selection into cities of more able workers?
2. Is the urban wage premium a wage growth effect or a wage level effect?
   - Wage level effect: migrants to cities immediately enjoy an increase in wages; those leaving cities see immediate decline.
   - Wage growth effect: wages grow faster in cities, and those leaving cities do not see a drop.
   - Evidence says the growth effect is real: longer term migrants enjoy a larger wage premium.

Does this translate to smoking? How may urban areas may cause less smoking:

1. Tobacco Control Laws
2. Information externalities
3. Space
4. Social norms
Outline

Introduction

Background
  Simple Model
  Economics Literature

Data and Econometrics
  Data
  Smoking Regressions
  Dynamic Empirical Model
  Simulation

Conclusion
Data from:

1. **National Longitudinal Survey of Youth, 1979 Cohort (NLSY)**
   - Longitudinal information on a single cohort is important for the study of cross-sectional, long-run disparities because a panel allows me to hold the sample of study fixed.

2. **United States Department of Agriculture Economic Research Service**

3. **Carneiro et al. 2012**

4. **American Nonsmokers’ Rights Foundation**

5. **Orzechowski and Walker**
1. NLSY 1979 Cohort

**National Longitudinal Survey of Youth, 1979 Cohort (NLSY)**

- Panel of young men and women between 15 and 22 years of age in 1979.
- Annual surveys from 1979 to 1994, then every two years.
- Geocoded sample includes county of residence and county at age 14.
- Rich information on sociodemographic, economic, and environmental characteristics.
  - Focus on extensive margin of current smoking.
# Sample Construction

<table>
<thead>
<tr>
<th>Unique Individuals</th>
<th>Person/Years</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>12,484</td>
<td>71,026</td>
<td>Baseline Sample</td>
</tr>
<tr>
<td>10,534</td>
<td>58,371</td>
<td>- those with non-missing smoking waves.</td>
</tr>
<tr>
<td>9,163</td>
<td>51,375</td>
<td>- those with non-missing smoking or education.</td>
</tr>
<tr>
<td>5,260</td>
<td>42,080</td>
<td>- those not leaving through attrition.</td>
</tr>
<tr>
<td>4,626</td>
<td>37,008</td>
<td>- those without missing geocodes</td>
</tr>
</tbody>
</table>
There is no consensus on how to define rural. Usual variables include:

- County population
- Commuting flows
- Proximity to major urban centers.

Unit of analysis is almost always a county.
United States Office of Management and Budget (OMB):

- **Metropolitan County** a dense urban area of 50,000 residents or more and which has outlying counties that are economically dependent.

- **Non-metropolitan County** all other counties and are the traditional definition of rural counties in most economic and public health research.
2013 Rural-Urban Continuum Codes, AKA Beale Codes

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Counties in metro areas of 1 million population or more</td>
</tr>
<tr>
<td>2</td>
<td>Counties in metro areas of 250,000 to 1 million population</td>
</tr>
<tr>
<td>3</td>
<td>Counties in metro areas of 50,000-250,000 population</td>
</tr>
<tr>
<td>4</td>
<td>Urban population of 20,000-49,999, adjacent to a metro area</td>
</tr>
<tr>
<td>5</td>
<td>Urban population of 20,000-49,999, not adjacent to a metro area</td>
</tr>
<tr>
<td>6</td>
<td>Urban population of 2,500 to 19,999, adjacent to a metro area</td>
</tr>
<tr>
<td>7</td>
<td>Urban population of 2,500 to 19,999, not adjacent to a metro area</td>
</tr>
<tr>
<td>8</td>
<td>Completely rural or less than 2,500 urban population, adjacent to a metro area</td>
</tr>
<tr>
<td>9</td>
<td>Completely rural or less than 2,500 urban population, not adjacent to a metro area</td>
</tr>
</tbody>
</table>

Provides more granular definition with metro/nonmetro.
Two Problems . . .

1. Little consensus on classification/grouping using Beale Codes
2. Beale Codes are only updated every 10 years, and they are generally not comparable over time.

This lack of uniformity makes comparisons of “rural” disparities across behaviors and outcomes difficult.
1. Define rural based on “remoteness”, following Winkler (2016)
   - **Metro**: Beale Codes 1, 2, and 3
   - **Adjacent**: Non-metro counties adjacent to a metro county. Beale Codes 4, 6, and 8.
   - **Remote**: Non-metro counties not adjacent to a metro county. Beale Codes 5, 7, and 9.

2. Focus on the 2013 Beale Code:
   - Updates in 2003 and 2013 are not compatible with 1983 and 1993.
   - Time varying definitions complicate empirical modeling.
   - No measurement error in years with largest smoking gap.
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   - No measurement error in years with largest smoking gap.

3. For this paper:
   - **Urban** = Metro + Adjacent
   - **Rural** = Remote
Smoking Prevalence

Proportion Smoking

Year

Urban
Rural

State and Local Cigarette Taxes

![Graph showing the increase in cigarette taxes from 1984 to 2016 for urban and rural areas. The graph indicates a steady increase in taxes over time, with urban areas generally having higher taxes than rural areas.]
Outline

Introduction

Background
Simple Model
Economics Literature

Data and Econometrics
Data
Smoking Regressions
Dynamic Empirical Model
Simulation

Conclusion
Smoking Regression

Preliminary Attempt to Explain Disparity:

\[
\text{Smoke}_{it} = \alpha_0 + \sum_{t=2}^{8} \alpha_{1t} 1[\text{Wave} = t] + \sum_{t=1}^{8} \alpha_{2t} 1[\text{Wave} = t]1[\text{Rural}_{it} = 1] + \chi_{it}\beta + \epsilon_{it}
\]  

(1)

- Smoking is binary based on DS-7, which asks about daily smoking.
Plot Coefficients without Controls

Source: Author’s Calculations from NLSY 1979
## Smoking Regression Results

### Mean of Urban Smoking in 1984 = 0.395

<table>
<thead>
<tr>
<th>Year</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \alpha_{2,1984} )</td>
<td>0.013</td>
<td>-0.014</td>
<td>-0.019</td>
<td>-0.034</td>
<td>-0.034</td>
</tr>
<tr>
<td></td>
<td>(0.031)</td>
<td>(0.031)</td>
<td>(0.032)</td>
<td>(0.031)</td>
<td>(0.031)</td>
<td>(0.031)</td>
</tr>
<tr>
<td></td>
<td>( \alpha_{2,1992} )</td>
<td>0.075**</td>
<td>0.075**</td>
<td>0.070**</td>
<td>0.045</td>
<td>0.045</td>
</tr>
<tr>
<td></td>
<td>(0.032)</td>
<td>(0.032)</td>
<td>(0.033)</td>
<td>(0.032)</td>
<td>(0.032)</td>
<td>(0.029)</td>
</tr>
<tr>
<td></td>
<td>( \alpha_{2,1994} )</td>
<td>0.097***</td>
<td>0.098***</td>
<td>0.091***</td>
<td>0.069**</td>
<td>0.069**</td>
</tr>
<tr>
<td></td>
<td>(0.031)</td>
<td>(0.031)</td>
<td>(0.031)</td>
<td>(0.031)</td>
<td>(0.031)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \alpha_{2,1998} )</td>
<td>0.065**</td>
<td>0.065**</td>
<td>0.058**</td>
<td>0.038</td>
<td>0.039</td>
</tr>
<tr>
<td></td>
<td>(0.029)</td>
<td>(0.029)</td>
<td>(0.029)</td>
<td>(0.028)</td>
<td>(0.028)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \alpha_{2,2008} )</td>
<td>0.067**</td>
<td>0.067**</td>
<td>0.060**</td>
<td>0.039</td>
<td>0.039</td>
</tr>
<tr>
<td></td>
<td>(0.029)</td>
<td>(0.029)</td>
<td>(0.029)</td>
<td>(0.028)</td>
<td>(0.028)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \alpha_{2,2010} )</td>
<td>0.075***</td>
<td>0.074***</td>
<td>0.068**</td>
<td>0.046*</td>
<td>0.047*</td>
</tr>
<tr>
<td></td>
<td>(0.028)</td>
<td>(0.028)</td>
<td>(0.028)</td>
<td>(0.027)</td>
<td>(0.027)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \alpha_{2,2012} )</td>
<td>0.090***</td>
<td>0.089***</td>
<td>0.083***</td>
<td>0.065**</td>
<td>0.067**</td>
</tr>
<tr>
<td></td>
<td>(0.028)</td>
<td>(0.028)</td>
<td>(0.028)</td>
<td>(0.027)</td>
<td>(0.027)</td>
<td></td>
</tr>
</tbody>
</table>

### Controls

- None
- Age
- Gender
- Race
- Education
- AFQT
- TCP

### Ind. FE

- No
- Yes

---

Johns Hopkins University, Cities and Smoking, 2/4/2021
Suggestive Evidence of Composition Changes

![Graph showing proportion of smoking by year for urban and rural areas from 1984 to 2016. The graph indicates a decrease in the proportion of smoking over time, with a slightly steeper decline in urban areas compared to rural areas.](image-url)
Suggestive Evidence of Composition Changes

![Graph showing the proportion urban over the years from 1984 to 2016 for urban and rural areas. The graph indicates a steady increase in urban proportion from 1984 to 1996, followed by a stagnation period from 1996 to 2000, and then a slight decrease from 2000 to 2016.]
Does moving to a new area cause a change in smoking behavior?

- Estimate event study regressions around different types of migration.
- Omit the NLSY wave just prior to migration.

\[
\text{Smoke}_{it} = \sum_{t=2}^{8} \alpha_{0t} 1[\text{Wave} = t] + \phi_1 1[\text{Moved in wave } t+5] + \ldots + \phi_5 1[\text{Moved in wave } t+1] + \\
+ \phi_6 1[\text{Moved in wave } t] + \phi_7 1[\text{Moved in wave } t-1] + \phi_8 1[\text{Moved 2 or waves prior to } t] + x_{it}\beta + \mu_i + \epsilon_{it}
\]

(2)
Event Study: State Migration

![Graph showing coefficient and 95% CI over time periods.]

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Johns Hopkins University, Cities and Smoking, 2/4/2021
Event Study: County Migration
Event Study: Rural to Urban Migration
Outline

Introduction

Background
   Simple Model
   Economics Literature

Data and Econometrics
   Data
   Smoking Regressions
   Dynamic Empirical Model
   Simulation

Conclusion
Overview

- Estimate a system of equations that captures:
  - Dynamics of Smoking
  - Education
  - Location Decisions

- Simulate the model under counterfactuals that isolate mechanisms (e.g., equalize tobacco control policies across space)
Timeline

Local Tobacco Variables
Age=14
Year∈[1971-1979]
$\mu_i = f(\text{Location})$

Local Edu. Variables
Age=17
Year∈[1974-1982]

Initial Conditions:
Location
Smoking
Education

Year=1984

Smoking
Year=1992

Year=2014

Johns Hopkins University, Cities and Smoking, 2/4/2021
Initial Condition: Age 14

- All individuals are in school
- No individuals smoke

Yet location is endogenous. I allow residence at age 14 to affect a permanent and discrete unobserved factor $\mu_i$ (Keane and Wolpin (1997)):

$$\tau_j = P(\mu = \mu_j) = \frac{\exp(\psi_{0j} + \psi_{1j}1[Rural_{age=14} = 1])}{\sum_{k=1}^{3} \exp(\psi_{0k} + \psi_{1k}1[Rural_{age=14} = 1])}$$

(3)

Estimation:
- Estimate a step function: $\mu_i$ takes 3 points: $(\mu_1, \ldots, \mu_3)$.
- Subject to normalizations, I estimate how $\mu$ affects each subsequent behavior or outcome as well as the associated probabilities of each type.
1984: Initial Conditions

Model the smoking behavior, location choice, and education outcomes as of 1984:

\[ \ln \left[ \frac{p(e_i = e)}{p(e_i = 0)} \right] = f^E(X_i, 1984, M_i, age=17) + \mu^e_i \]  
\[ (4) \]

\[ \ln \left[ \frac{p(m'_t=1)}{p(m'_t=0)} \right] = f^{m'}(X_i, 1984, e_i) + \mu^{m'}_i \]  
\[ (5) \]

\[ \ln \left[ \frac{p(s_i = 1)}{p(s_i = 0)} \right] = f^S(X_i, 1984, e_i, P_{age=14}) + \mu^s_i \]  
\[ (6) \]

- \( e \in \{1, 2, 3, 4\} \)
- \( M \) includes county level education supply factors.
- \( m' \in \{Urban, Rural\} \)
- \( P_{age=14} \) tobacco control laws in a person’s county at age 14.
Dynamic Equations: Location then Smoking

Dynamic Location Equation: \( m \in \{\text{Urban, Rural}\} \)

\[
\ln \left[ \frac{p(m_{it} = 1)}{p(m_{it} = 0)} \right] = f^M(X_{it}, E_i, m_{it-1}, S_{it-1}, L_{it-1}) + \mu_i^m
\]  

(7)

Dynamic Smoking Equation: \( s \in \{0, 1\} \)

\[
\ln \left[ \frac{p(s_{it} = 1)}{p(s_{it} = 0)} \right] = f^S(S_{it-1}, X_{it}, E_i, m_{it}, P_{it}) + \mu_i^s
\]  

(8)

The error structure for the smoking equation:

\[ \mu_i^s + \epsilon_{it}^s \]
The error structure for the smoking equation:

$$\mu_i^s + \epsilon_{it}^s$$

Assume that $\epsilon_{it}^s$ follows an extreme value type 1 distribution →

$$P(s_{it} = 1) = \frac{\exp(\text{observable heterogeneity} + \mu_i^s)}{1 + \exp(\text{observable heterogeneity} + \mu_i^s)}$$
Individual $i$’s contribution to the likelihood function is:

$$L_i(\Delta) = \sum_{k=1}^{3} \tau_k \left\{ \prod_{e=0}^{3} P(e_i = e | \mu_k)^{1[e_i = e]} \prod_{m' = 0}^{2} P(m_{i'} = m | \mu_k)^{1[m_{i'} = m]} \prod_{s = 0}^{1} P(s' = s | \mu_k)^{1[s_{i'} = s]} \times \prod_{t=2}^{8} \prod_{m=0}^{2} P(m_{it} = m | \mu_k)^{1[m_{it} = m]} \prod_{s = 0}^{1} P(s_{it} = s | \mu_k)^{1[s_{it} = s]} \right\}$$

(9)
Outline

Introduction

Background
  Simple Model
  Economics Literature

Data and Econometrics
  Data
  Smoking Regressions
  Dynamic Empirical Model
  Simulation

Conclusion
To simulate the model I:

1. Expand each person’s observation by 50 → 231,300 person/draw observations
2. Endow each with random draws from all error terms. $\mu$ draws are based on the actual location at age 14.
3. Simulate Behavior *while updating state vector.*
4. Collapse results by person, draw, and time.
Model Fit: Urban Smoking

![Graph showing the proportion of smoking over years from 1984 to 2016. The graph compares sample data (solid line) and simulated data (dashed line). The proportion of smoking decreases over time.]
Model Fit: Rural Smoking
Distribution of Unobserved Heterogeneity over Time in Rural Counties

Proportion

1984
1. 0.588692
   2. 0.233268
   3. 0.178041

1992
1. 0.578815
   2. 0.234692
   3. 0.186493

2014
1. 0.540988
   2. 0.254687
   3. 0.204325

Legend:
1  2  3
Overview

1. Baseline Simulation to Establish the Model Adjusted Smoking Gap
2. Equalized Type Distribution
3. No Migration
4. Equalized Type Distribution + No Migration
Simulation: Baseline

Simulated Smoking Gap in 2014: 7.9 percentage points.
Simulation: Urban Taxes

![Graph showing the proportion of smoking over years for urban and rural areas.](image-url)
Simulation: Equalized Type Distribution

![Graph showing proportion of smoking over years for urban and rural areas. The graph indicates a decrease in the proportion of smoking over time, with urban areas showing a steeper decline compared to rural areas.](image)
Simulation: No Migration

Proportion Smoking

Year


0.5 0.4 0.3 0.2 0.1

No Migration: Urban
No Migration: Rural
Simulation: Equalized Types + No Migration

![Graph showing the proportion of smokers over years for urban and rural areas. The graph illustrates a decreasing trend in smoking rates from 1984 to 2016. The urban line starts at approximately 0.3 in 1984 and decreases to about 0.15 in 2016. The rural line starts at approximately 0.4 in 1984 and decreases to about 0.2 in 2016.](image)
I simulate a dynamic empirical model of smoking, education, and location to understand the smoking gap between urban and rural individuals. I find:

- Differential Tobacco Control Policies explain only 9.6%.
- Selection on unobserved heterogeneity and migration are much more important.
- Little evidence that migration causes changes in smoking behavior.
Thanks!

- Comments to michaeldarden@jhu.edu
- medarden.com