Urban Form and Air Pollution in US Urban Areas

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Air Pollution Impacts on Health

- Ozone
- PM$_{2.5}$
- PM$_{10}$
- Lead
- Nitrogen Dioxide (NO$_2$)
- Carbon Monoxide (CO)
- Sulfur Dioxide (SO$_2$)
- One or more pollutant

Millions of People

EPA, 2010
Urban Form Impacts on Air Quality

- Travel behavior
- Land cover
- Building design
- Distributions of land use
Purpose: Explore relationship between air pollution and urban form using empirical data

Research Questions: Is air pollution correlated to urban form? If so, at what magnitude?
Methods

• Stepwise linear regression

• Cross-section of 111 US urban areas
  • Year-1990
  • 38% of US population
  • 1% of US land area
Independent Variables

Urban Form: City Shape, Jobs-Housing Imbalance, Population Centrality, Population Density, Road Density (Bento et al., 2005)

Climate: Temperature, Dilution Rate

Transportation: Transit Supply, VMT

Other Urban Characteristics: Income, Size, Region

Dependent Variables

Air Pollution: Long-term population-weighted concentrations of ozone, fine particulate matter (PM$_{2.5}$), and a long-term air quality index (LAQI)
Urban Form Variables

City Shape

Jobs-Housing Imbalance

Population Centrality

Population Density

Road Density

Wichita, KS

Scranton, PA
Urban Form Variables

City Shape

Jobs-Housing Imbalance

Population Centrality

Population Density

Road Density

Salt Lake City, UT

Akron, OH
Urban Form Variables

City Shape

Jobs-Housing Imbalance

Population Centrality

Population Density

Road Density

Worcester, MA

Atlanta, GA
Urban Form Variables

City Shape

Jobs-Housing Imbalance

Population Centrality

Population Density

Road Density

Miami, FL
2,000 persons km$^2$

Melbourne, FL
500 persons km$^2$
Urban Form Variables

City Shape

Jobs-Housing Imbalance

Population Centrality

Population Density

Road Density

Las Vegas, NV

Huntsville, AL
## Regression Results: Statistical Significance

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<th>Urban Form</th>
<th>Ozone</th>
<th>PM$_{2.5}$</th>
<th>LAQI</th>
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**Positive association**

- $p < 0.01$
- $p < 0.05$
- $p < 0.10$
- $p > 0.10$

**Negative association**

- $p < 0.10$
- $p < 0.05$
- $p < 0.01$
Regression Results: Magnitude

Percent change in air pollution concentrations per interquartile range increase in independent variable

Urban Form | Transportation | Climate | Other
--- | --- | --- | ---
Population Centrality | Population Density | Transit Supply | Dilution Rate | Temperature | Region
Ozone | PM$_{2.5}$ | LAQI
-20% | -10% | 0% | 10% | 20% | 30%
Increasing population centrality across the interquartile range (for example, from Toledo to Albany levels) is associated with:

- decrease in ozone concentration by 2.9 ppb
- decrease in PM$_{2.5}$ concentration by 1.3 μg m$^{-3}$
Conclusions

• Air pollution correlates to urban form, after controlling for climate, transportation, income, size, and region

• Air pollution correlates to urban form with similar magnitude as climate

• Population density and population centrality are associated with air quality in opposing directions

• Need for greater understanding of the relationship between urban form and air pollution