# Highway Investment, Freight Emission, and Export

You Zhou* Jeremy Sage*

*Freight Policy Transportation Institute
Washington State University

Transportation Research Forum, 2015

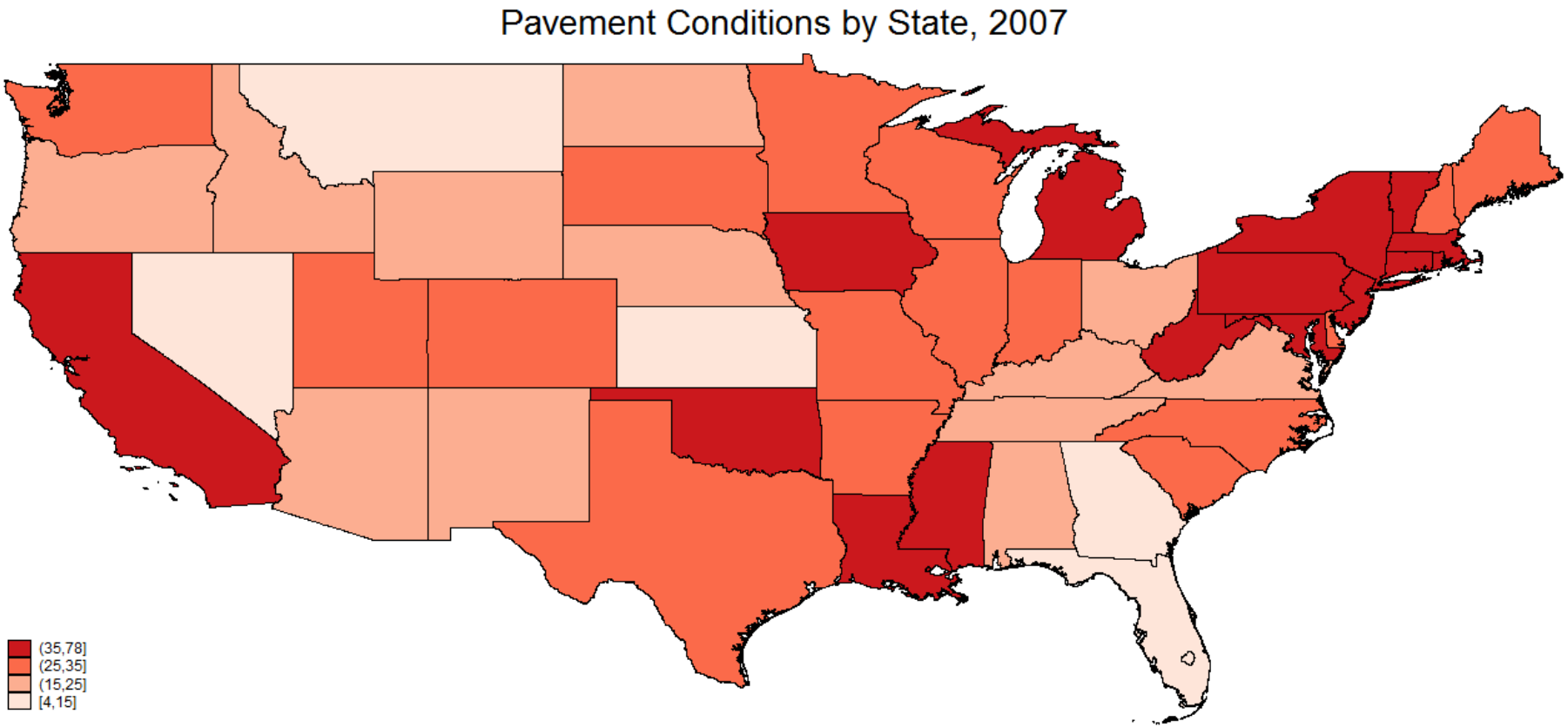
# Outline

- Motivation
- Research Question
- Related Literature
- Empirical Model
- Data
- Results

# Motivation

- Roads are essential for economic mobility
  - Interstate Highway System
  - Highway Investment
    - Increase reliability and efficiency
    - Attract business and raise the trade
- 32% of America's major roads are in poor or mediocre condition

# Pavement Condition



# Issues

- Freight emission
  - Main source for $CO_2$ and $NO_x$ emissions
  - Truck dominates the amount of freight emissions
  - Environment Protection Agency (EPA) sets the strict truck emission standards.
  - Federal level emission policy

# Research Question

- The impact of highway investment on freight emission, considering interactions among states.
  - Direct effect
  - Indirect effect:
    - Highway investment $\rightarrow$ export $\rightarrow$ emission

# Related Literature

- Transport Infrastructure and Trade:
  - Bougheas et al. (1999) and Limao & Venables (2001)
- Roads and export:
  - Duranton et al. (2014) and Albarran et al. (2013)
- Environment and trade:
  - Antweiler et al. (2001)
  - Cristea et al. (2013)
- Freight emission from trucks:
  - Kamakate and Schipper (2009)
- Environmental policy interaction among U.S. states:
  - Fredriksson and Millimet (2002)

# Empirical Specification

- Consider a system of equations:

$$Export_{i,t} = \beta_1 * Highway_{i,t-1} + \beta_2 * X_{1i,t} + \mu_i + \mu_t + \varepsilon_{i,t}$$

$$\begin{aligned} Emission_{i,t} \quad = \quad & \alpha_1 * Export_{i,t} + \alpha_2 * Highway_{i,t-1} \\ & + \alpha_3 * X_{2i,t} + \tau_i + \tau_t + \nu_{i,t} \end{aligned}$$

- $X_{1i,t}$ incldues GDP per capita, population intensity, and political variable.
- $X_{2i,t}$ includes fuel prices, population intensity, scale effect, income level, and political variable.
- Allow one year lag for highway investemtnts.

# Instrument Variable

- Due to reversal causation in both equations, endogeneity problems could occur.
- Employ neighbor's highway investment as the instrument variable
- Construct IV reduced form equation:

$$Highway_{i,t-1} = \gamma * \sum_{j=1}^{n} W_{ij} * Highway_{j,t-1} + e_{i,t}$$

- Where $W_{ij}$ is spatial weighting matrix representing the spatial relationship between state $i$ and state $j$
- We use the inverse-distance as $W_{ij}$

# Spatial Model

- Add neighbor's emission variable in the second equation of system equations:

$$\begin{aligned} Emission_{i,t} &= \rho * \sum_{j=1}^{n} W_{ij} * Emission_{j,t} + \alpha_1 * Export_{i,t} \\ &\quad + \alpha_2 * Highway_{i,t-1} + \alpha_3 * X_{2i,t} + \tau_i + \tau_t + \nu_{i,t} \end{aligned}$$

- Inverse-distance as the spatial weighting matrix
- Parameter $\rho$ shows how neighbor's emission would affect own emission
- Two-step GMM to estimate the system

# Data

- Range from 1995 to 2011 in 48 contiguous states
- Use $CO_2$ to proxy emission
- All petroleum products average price in the transportation sector to proxy price
- Pop and income are represented by population intensity and per capita income
- Scale effect stands for GDP per land area
- Politics is percentage of democrats in state legislature

# Summary and Source

Table 1: Summary of Statistics

| Variable | Mean | Sta. Err. | Min | Max | Source |
|---|---|---|---|---|---|
| Emission | 7.35 | 7.12 | 0.67 | 50.64 | EPA |
| Export | 17.26 | 26.40 | 0.36 | 249.86 | Census Bureau |
| Highway | 2.25 | 2.30 | 0.23 | 16.44 | Census Bureau |
| Price | 14.78 | 6.28 | 5.88 | 29.08 | EIA |
| Pop | 0.19 | 0.25 | 0.004 | 1.20 | Census Bureau |
| Scale | 8.19 | 12.37 | 0.12 | 68.54 | BEA |
| Income | 32.17 | 7.56 | 17.38 | 57.55 | BEA |
| Politics | 0.51 | 0.15 | 0.15 | 0.90 | BOS |

# Results

Table 2: Results for First Equation

| Export | Fixed Effects | IV regression |
|---|---|---|
| Highway | 9.878*** | 16.276*** |
| GDP | 0.097** | -0.332*** |
| Pop | -44.201 | 3.359 |
| Politics | 2.518 | 0.407 |
| State | yes | yes |
| Year | yes | yes |
| Obs | 816 | 816 |

Notes:* $p < 0.1$, ** $p < 0.05$ and ***$p < 0.01$
Fixed effects are hidden

# Results

Table 3: Results for Second Equation

| Emission | Fixed Effects | IV regression | Spatial Model |
|---|---|---|---|
| WEmission | | | -0.555*** |
| Export | 0.038*** | 0.083*** | 0.030*** |
| Highway | 0.930*** | 1.504*** | 0.916*** |
| Price | 0.154** | 0.262* | 0.138 |
| Pop | 52.800*** | 72.975*** | 55.271*** |
| Scale | -0.076*** | -0.157*** | -0.083*** |
| Income | -0.031 | -0.065** | -0.046* |
| Politics | -0.511 | -0.739 | -0.651 |
| State | yes | yes | yes |
| Year | yes | yes | yes |
| Obs | 816 | 816 | 816 |

Notes:* $p < 0.1$, ** $p < 0.05$ and ***$p < 0.01$
Fixed effects are hidden

# Implications from Results

- A 1000-dollar increase in exports can positively increase emissions by 0.03 metric tons
- The direct and indirect effect of highway investment are positive and significant while investment in highway can reduce the congestion and bring efficiency
- Neighbor's highway infrastructure may absorb some transportation activities from own highways and lead to a negative effect on emission

# Further Steps

- Find different control variables for export equation
- Find diesel prices to proxy price variable
- Different measure for scale effect and political variable
- Robustness check:
  - different spatial weighting matrices
  - replace CO2 with NOx