Highway Investment, Freight Emission, and Export

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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

Pavement Conditions by State, 2007

Zhou and Sage (FPTI)
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
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:

\[
Export_{i,t} = \beta_1 \times Highway_{i,t-1} + \beta_2 \times X_{1i,t} + \mu_i + \mu_t + \varepsilon_{i,t}
\]

\[
Emission_{i,t} = \alpha_1 \times Export_{i,t} + \alpha_2 \times Highway_{i,t-1} + \alpha_3 \times X_{2i,t} + \tau_i + \tau_t + \nu_{i,t}
\]

- \( X_{1i,t} \) includes 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 investments.
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:

\[ \text{Highway}_{i,t-1} = \gamma * \sum_{j=1}^{n} W_{ij} * \text{Highway}_{j,t-1} + e_{i,t} \]

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:

\[
Emission_{i,t} = \rho \sum_{j=1}^{n} W_{ij} \times Emission_{j,t} + \alpha_1 \times Export_{i,t} \\
+ \alpha_2 \times Highway_{i,t-1} + \alpha_3 \times X_{2i,t} + \tau_i + \tau_t + \nu_{i,t}
\]

- 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\textsubscript{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
### Table 1: Summary of Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>St. Err.</th>
<th>Min</th>
<th>Max</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emission</td>
<td>7.35</td>
<td>7.12</td>
<td>0.67</td>
<td>50.64</td>
<td>EPA</td>
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<tr>
<td>Export</td>
<td>17.26</td>
<td>26.40</td>
<td>0.36</td>
<td>249.86</td>
<td>Census Bureau</td>
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<tr>
<td>Highway</td>
<td>2.25</td>
<td>2.30</td>
<td>0.23</td>
<td>16.44</td>
<td>Census Bureau</td>
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<tr>
<td>Price</td>
<td>14.78</td>
<td>6.28</td>
<td>5.88</td>
<td>29.08</td>
<td>EIA</td>
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<tr>
<td>Pop</td>
<td>0.19</td>
<td>0.25</td>
<td>0.004</td>
<td>1.20</td>
<td>Census Bureau</td>
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<tr>
<td>Scale</td>
<td>8.19</td>
<td>12.37</td>
<td>0.12</td>
<td>68.54</td>
<td>BEA</td>
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<tr>
<td>Income</td>
<td>32.17</td>
<td>7.56</td>
<td>17.38</td>
<td>57.55</td>
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<tr>
<td>Politics</td>
<td>0.51</td>
<td>0.15</td>
<td>0.15</td>
<td>0.90</td>
<td>BOS</td>
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Table 2: Results for First Equation

<table>
<thead>
<tr>
<th>Export</th>
<th>Fixed Effects</th>
<th>IV regression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highway</td>
<td>9.878***</td>
<td>16.276***</td>
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<tr>
<td>GDP</td>
<td>0.097**</td>
<td>-0.332***</td>
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<tr>
<td>Pop</td>
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<tr>
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<tr>
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<td>yes</td>
</tr>
<tr>
<td>Year</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Obs</td>
<td>816</td>
<td>816</td>
</tr>
</tbody>
</table>

Notes: * $p < 0.1$, ** $p < 0.05$ and *** $p < 0.01$

Fixed effects are hidden
### Table 3: Results for Second Equation

<table>
<thead>
<tr>
<th></th>
<th>Fixed Effects</th>
<th>IV regression</th>
<th>Spatial Model</th>
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</thead>
<tbody>
<tr>
<td>WEmission</td>
<td>-0.555***</td>
<td></td>
<td>-0.555***</td>
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<tr>
<td>Export</td>
<td>0.038***</td>
<td>0.083***</td>
<td>0.030***</td>
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<tr>
<td>Highway</td>
<td>0.930***</td>
<td>1.504***</td>
<td>0.916***</td>
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<tr>
<td>Price</td>
<td>0.154**</td>
<td>0.262*</td>
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<tr>
<td>Pop</td>
<td>52.800***</td>
<td>72.975***</td>
<td>55.271***</td>
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<tr>
<td>Scale</td>
<td>-0.076***</td>
<td>-0.157***</td>
<td>-0.083***</td>
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<tr>
<td>Income</td>
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<td>-0.065**</td>
<td>-0.046*</td>
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<tr>
<td>Politics</td>
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<tr>
<td>Year</td>
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</tr>
<tr>
<td>Obs</td>
<td>816</td>
<td>816</td>
<td>816</td>
</tr>
</tbody>
</table>

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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