Mutual Causation in Highway Construction and Economic Development

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Causal Effects of Transportation Investment

- Difficult to isolate, jointly determined
- Microdata
  - No longitudinal element (Census, ACS)
  - Firm-level data often proprietary
- Aggregate data
  - Publicly available (FHWA, BEA)
  - More temporal detail
  - Lacks sufficient spatial detail for policy sensitivity
Approaches

- **Granger Causality**
  - Temporal relationships (e.g. highways, employment)
  - State/province level
  - Sectoral disaggregation
- **County growth / regional adjustment models**
  - Carlino/Mills (1987)
  - Population, employment density
  - Equilibrium represents firm / household optimization
- **Agglomeration**
  - Transportation networks allow greater density, more productivity
Present Study

- Builds on previous approaches
- More spatial detail (county-level)
- Highway networks
  - Not assumed to be fixed
  - Disaggregated (local road vs. highway)
- Growth mechanism
  - Highways, local roads allow greater agglomeration
  - Agglomerations induce more roads
- Mature network
Minnesota Population

Source: U.S. Census Bureau
Census 2010 Summary File 1
population by census tract
Job-Worker Balance (1970)

Legend
Job-Worker ratio (1970)
- 0.580 - 0.685
- 0.686 - 0.790
- 0.791 - 0.895
- 0.896 - 1.000
- 1.001 - 1.105
- 1.106 - 1.210
- 1.211 - 1.315
- 1.316 - 1.420
- 1.421 - 1.525
- 1.526 - 1.630

0 35 70 140 Miles
Job-Worker Balance (1990)
Job-Worker Balance (2000)
Job-Worker Balance (2010)
Network Deployment

![Network Deployment Diagram](image)
Approaching Saturation?
Growth in Employment and Road Networks (Minnesota)
Framework
Empirical Specification

\[ y_{ct} = \alpha_0 + \theta_i y_{c(t-5)} + \sum_{i=1}^{3} \beta_i x_{ic(t-5)} + \sum_{i=4}^{6} \beta_i \Delta x_{ic(t-5,t)} + \sum_{i=7}^{10} \beta_i \Delta S_{i(t-5,t)} + \varepsilon_{ct} \]

(Initial conditions) (Local changes) (Statewide trends)
Data

- 20-year panel (1988-2007) – county level
- Employment
  - Private, non-farm employment by county
- Population
  - Decennial counts, intercensal estimates
- Road Networks
  - Local Roads
    - City, county, township, special use
  - Highways
    - All federal and state highways
    - Measures road miles
      - Lane-miles not available prior to 2002
- All data normalized into densities
Model Estimation

- Four equations
- Estimation: OLS with S.E. corrected for
  - Correlation across panels
  - First-order serial correlation (Prais-Winsten)
Tests for Granger Causality

- Model specification includes 3 variations of each independent variable
  - Lagged level, 5-year change (local), statewide trend
- Joint significance of each set of variables examined via an F-test

\[ H_0: \beta_1 = \beta_4 = \beta_7 = 0 \]

Test statistic is distributed \( \approx F(3,1214) \)
Results of Significance Tests

<table>
<thead>
<tr>
<th>Causality</th>
<th>F statistic</th>
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<tbody>
<tr>
<td>Local Roads — Employment</td>
<td><strong>4.53</strong></td>
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<td>Highways — Employment</td>
<td><strong>7.01</strong></td>
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<td>Local Roads — Population</td>
<td><strong>62.53</strong></td>
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<td>Highways — Population</td>
<td><strong>10.47</strong></td>
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<tr>
<td>Employment — Local Roads</td>
<td><em>3.22</em>*</td>
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<tr>
<td>Population — Local Roads</td>
<td><strong>34.33</strong></td>
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<tr>
<td>Employment — Highways</td>
<td>1.97</td>
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<tr>
<td>Population — Highways</td>
<td><strong>13.09</strong></td>
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</tbody>
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Note:
* = statistically significant at $p < 0.05$ level of significance
** = statistically significant at $p < 0.01$ level of significance
## Significance of Individual Variables
\((\Delta x_i)\)

| Equation  | Variable      | Expected Sign | Actual Sign | Significant?
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<td>Local Roads</td>
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Observations

- Employment density \textit{negatively} correlated with growth in highway density
- Population density not significantly correlated with changes in \textit{either} road density variable
- Highway density significantly correlated with employment (-) and population (+) density changes
Conclusions

- Granger causality between variables
  - Exists for all but one pair of variables
    - Employment density \rightarrow Highway density
  - Effects of recent changes small
    - Effect of maturity?

- Limitations
  - Measurement of road networks
    - Road miles vs. lane-miles
    - Others: accessibility
The ‘Streetlight Effect’

“I’m searching for my keys”