Measuring the Returns to Highway Investments

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Economics of Transportation and Infrastructure in the 21st Century

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Overview of the Talk

• Discuss evidence on causal impacts of highways on the spatial structures of US cities 1960-2000
  • Population decentralization (by industry)
  • Job decentralization (by industry)

• Provide some interpretation of these estimated impacts
  • Decompose into various mechanisms for treatment effects of highways on urban population decentralization
  • Discuss components of welfare consequences

• Draw some general conclusions about the opportunities and challenges for cities associated with installing new highways

Based on the following paper:
Decentralization Patterns in Worker Residential Location
CDFs For 78 Large US Metro Areas (SMSAs), 1960 & 2000
CBD at Location 0, Edge of Primary Central City at Location 1
### Changes in Commuting Patterns, Large U.S. Metro Areas

<table>
<thead>
<tr>
<th></th>
<th>Millions (Fraction of Total)</th>
<th>Change</th>
<th>millions</th>
<th>(share)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1960</td>
<td>2000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Live in CC</td>
<td>16.5</td>
<td>12.0</td>
<td>-27%</td>
<td>-0.27</td>
</tr>
<tr>
<td>Work in CC</td>
<td>(0.43)</td>
<td>(0.16)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Live in CC</td>
<td>1.8</td>
<td>4.9</td>
<td>173%</td>
<td>0.02</td>
</tr>
<tr>
<td>Work in Ring</td>
<td>(0.05)</td>
<td>(0.07)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Live in CC</td>
<td>0.4</td>
<td>0.9</td>
<td>125%</td>
<td>0.00</td>
</tr>
<tr>
<td>Work Outside SMSA</td>
<td>(0.01)</td>
<td>(0.01)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Live in Ring</td>
<td>5.9</td>
<td>10.5</td>
<td>79%</td>
<td>-0.01</td>
</tr>
<tr>
<td>Work in CC</td>
<td>(0.15)</td>
<td>(0.14)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Live in Ring</td>
<td>10.8</td>
<td>32.4</td>
<td>200%</td>
<td>0.15</td>
</tr>
<tr>
<td>Work in Ring</td>
<td>(0.28)</td>
<td>(0.43)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Live in Ring</td>
<td>0.9</td>
<td>4.4</td>
<td>381%</td>
<td>0.04</td>
</tr>
<tr>
<td>Work Outside SMSA</td>
<td>(0.02)</td>
<td>(0.06)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Live Outside SMSA</td>
<td>1.0</td>
<td>3.0</td>
<td>206%</td>
<td>0.01</td>
</tr>
<tr>
<td>Work in CC</td>
<td>(0.03)</td>
<td>(0.04)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Live Outside SMSA</td>
<td>0.9</td>
<td>6.5</td>
<td>633%</td>
<td>0.06</td>
</tr>
<tr>
<td>Work in Ring</td>
<td>(0.02)</td>
<td>(0.09)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>38.1</td>
<td>74.6</td>
<td>96%</td>
<td></td>
</tr>
</tbody>
</table>
Empirical Model

• Goal is to estimate causal impacts of each highway on the allocation of industry-specific employment and working residents between central cities (CC) and suburbs, while holding the industry mix constant

• Estimate parameters $\rho_{1k}$ and $r_{1k}$ in the following regression equations:

$$
\Delta \ln( emp_{ki}^{CC} ) = \rho_{0k} + \rho_{1k} \Delta \text{hwy}_i + \rho_{2k} \Delta \ln( emp_{ki}^{SMSGA} ) + \sum_{j \neq k} \rho_{2j} \Delta \ln( emp_{ji}^{SMSGA} ) + X_i \Psi_k + \nu_{ik}
$$

$$
\Delta \ln( pop_{ki}^{CC} ) = r_{0k} + r_{1k} \Delta \text{hwy}_i + r_{2k} \Delta \ln( pop_{ki}^{SMSGA} ) + \sum_{j \neq k} r_{2j} \Delta \ln( pop_{ji}^{SMSGA} ) + X_i R_k + \nu_{ik}
$$

emp is # of jobs
pop is # of resident workers
in industry k and metro area i

• Need to find some pseudo-randomization in highway construction for identification

• Use planned radial highways from a 1947 map serving each metro area as an instrumental variable, which generates this pseudo-randomization
Metro Areas Used in the Analysis and the Interstate Highway System in 2000
The Projected System of Interstate Highways in 1947
## Implied Effects of Each Radial Highway on Decentralization by Industry

<table>
<thead>
<tr>
<th>Industry</th>
<th>Employment</th>
<th>Working Residents</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>-0.06*</td>
<td>-0.16**</td>
<td>0.10**</td>
</tr>
<tr>
<td></td>
<td>(0.04)</td>
<td>(0.07)</td>
<td>(0.04)</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>-0.08</td>
<td>-0.15***</td>
<td>0.07</td>
</tr>
<tr>
<td></td>
<td>(0.05)</td>
<td>(0.05)</td>
<td>(0.06)</td>
</tr>
<tr>
<td>Services</td>
<td>-0.07**</td>
<td>-0.15***</td>
<td>0.08**</td>
</tr>
<tr>
<td></td>
<td>(0.03)</td>
<td>(0.05)</td>
<td>(0.03)</td>
</tr>
<tr>
<td>Retail and Wholesale Trade</td>
<td>-0.14**</td>
<td>-0.19***</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>(0.05)</td>
<td>(0.05)</td>
<td>(0.04)</td>
</tr>
<tr>
<td>TCPU</td>
<td>-0.07*</td>
<td>-0.13***</td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td>(0.04)</td>
<td>(0.05)</td>
<td>(0.05)</td>
</tr>
<tr>
<td>Construction</td>
<td>-0.08**</td>
<td>-0.21***</td>
<td>0.14***</td>
</tr>
<tr>
<td></td>
<td>(0.04)</td>
<td>(0.06)</td>
<td>(0.05)</td>
</tr>
<tr>
<td>Public Administration</td>
<td>0.01</td>
<td>-0.13***</td>
<td>0.14**</td>
</tr>
<tr>
<td></td>
<td>(0.03)</td>
<td>(0.05)</td>
<td>(0.06)</td>
</tr>
<tr>
<td>FIRE</td>
<td>-0.04</td>
<td>-0.12***</td>
<td>0.07</td>
</tr>
<tr>
<td></td>
<td>(0.05)</td>
<td>(0.05)</td>
<td>(0.05)</td>
</tr>
</tbody>
</table>
Using The Estimated Treatment Effects

• Specify a simple model for quantification

• Focus mainly on the observation that each radial highway decentralized about 6% of employment and 16% of working residents from cities to suburbs
  
  • But recognize that smaller impacts reflect stronger agglomeration forces which incentivize firms to stay centralized

• The main idea is that because they reduce commuting costs, highways increase the amount of space available for urban uses in a metro area (within a given commute time from the center)
Outline of the Model

• Setting

  • “Closed city” with central city and suburban regions
  • Traded goods produced with land, labor and capital, subject to agglomeration economies and location-specific productivity
  • Housing produced with land, labor and capital
  • Consumers spend income net of commute cost on housing and consumption and care about local amenities
    • Commuting exists from the suburbs to the city and within each region

• Equilibrium

  • Land and labor market clearing in each region
  • Consumer and firm indifference across regions
Mechanisms through Which Highways Caused Urban Residential Decentralization (Total Impact: 16%)

• Holding firm locations constant

  • Commuting and housing costs fall, leading to greater real incomes, boosting housing demand (9%-17% of total) holding the land share in housing and goods production constant

  • The decline in the price of space leads to more intensive use of land in housing and goods production, crowding out residential density
    • Housing component (21%-43% of total)
    • Central city firms also demand more space, crowding out space used for residential housing (14%-27% of total)

  • Additional income effect from wage increases further boosts demand for housing but also increases cost of housing production (negligible % of total)

• Additional impacts of changes in firm relocation decisions to suburbs (negative 10%-15% of total)
Welfare Consequences

• Income net of commuting costs (probably positive)
  • Decline in the price of space lead to more space per worker (+)
  • More dispersed employment throughout the metro area (?)
  • Commute time (+)
  • Based on calibrations, these forces add up to 1.1 to 2.4 percent increase per additional highway of initial income net of commuting costs

• Housing cost impacts
  • Decline in the price of space (+)
  • Increase in wages in the construction sector (-)
  • Based on calibrations, results in declines of 0.6 to 1.3 percent of initial housing cost

• Capital losses in central city land value of 4.3 to 8.5 percent
Summary of Welfare

• Renter Welfare
  • Calibrations indicate 1.2% to 2.6% increase in real income per radial highway

• Homeowner Welfare
  • Calibrations indicate 1.0% to 2.2% increase in real income per radial highway (incorporating capital losses)

• Typical construction cost per mile is about $100 million or about $1 billion per radial highway in a medium sized city
  • The majority of radial highways that were built thus easily pass a cost-benefit test based on this analysis
Caveats to Welfare Analysis

• Trade (impacts on the consumption price index)

• Changes in local amenities
  • Neighborhoods near highways may experience reductions in their amenity values (Brinkman & Lin, 2019)

• Environmental costs

• Incidence
  • Wage impacts may be greater for higher income residents
  • Income segregation may increase
Conclusions

• Highways caused a movement of jobs, people and commutes from cities to suburbs

  • Estimated job decentralization in response to highways is smaller than estimated population decentralization responses in absolute and percentage terms

• Through the lens of a simple model, we can conclude from these estimated impacts that US urban highways promoted welfare gains that exceeded their construction costs

  • Most of these welfare gains came because the highways opened up additional space for urban uses
Thank You