Political Distortions and Infrastructure Networks in China: A Quantitative Spatial Equilibrium Analysis

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Outline

Motivation

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Appendix
China substantially expanded and modernized its national highway network starting in the 1990s

- Clearly specified policy: connect all cities with at least 500,000 people and all provincial capitals
- Resulted in network of approximately 35,000 km of high speed four-lane highways
- Estimated cost of US$ 120 billion until 2007 (Faber, 2014)

Broad question: How was the policy implemented?

- How were the paths chosen?
- Was the network designed optimally?
- If not: what can explain the distortions?
Targeted cities and underlying geography (slope)
China’s National Expressway Network
This Paper

- We focus on political determinants of infrastructure investments
- Our questions
  1. Can deviations between the *optimal* network and the *actual* network be explained by the birthplaces of high-ranking officials?
  2. If yes, what are the aggregate costs of the political distortion?
- Our approach
  - Approximate the income-maximizing transport network in a general equilibrium trade model (robustness with minimum spanning tree)
  - Combine transport network with CV data on Chinese politicians
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Literature overview (incomplete)

- China’s National Expressway Network
  - Faber (2014), Roberts et al. (2012)
- Transport network design in trade models
- Misallocation of infrastructure, ethnic favoritism, and birthplaces of politicians
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- Geography
  - Location of targeted cities (+500k, provincial capitals, birthplaces, counterfactuals)
  - Slope of the terrain
- Income
  - Income of each city proxied by luminosity within a 30km radius
- Politicians
  - CVs of Chinese politicians (China Vitae)
  - Matched birthplaces to counties in the census
  - Coded county as ‘birthplace’ if a politician who was born in that county and was in a political office during the planning phase
    - Politburo, provincial governor
    - Planning and implementation phase 1995-2001
    - Placebo after 2008
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Model

- Inter-regional trade model based on Eaton and Kortum (2002)
- Donaldson and Hornbeck (2016) derive ‘Market Access’ as a measure for the effect of transport infrastructure
- Gravity equation income equation

\[ Y_o = \sum_d X_{od} = \kappa T_o (q_o^{\alpha} w_o^{\gamma})^{-\theta} \sum_d [Y_d \tau_{od}^{-\theta} MA_d^{-1}] \]

Market Access of \( o \)

- Calibrate model using estimates from India (Alder, 2017)
Heuristic Network Design Algorithm

- Heuristic algorithm
  - Gastner (2005) and Gastner and Newman (2006) combined with general equilibrium model

1. Start from the fully connected network
2. Remove each link sequentially and compute net income
3. Remove links with lowest (most negative) net effect
4. Check if there are links that would be beneficial to add
5. Back to step 2 until no further improvements are possible to connect all cities

- Resulting network has similar structure as actual, but smaller
- Implies 0.75% higher aggregate net income annually
Network design algorithm
Approximation of Optimal Chinese Highway Network
Optimal and Actual Chinese Highway Network
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Reduced form estimation

- **Specification**

$$\Delta_{\text{opt-act distance}}_i = \alpha + \beta \text{ political access}_i + \gamma X_i \quad (1)$$

- Dependent variable: deviation between a county’s distance to the optimal and actual network
- Treatment indicator: high-ranking politicians from county $i$ in office between 1995 and 2001
- Placebo: politicians in office after 2008
- Controls: initial light density, area, distance to optimal network, province FE
## Effects of Birthplaces on Roads

**Preliminary results**

<table>
<thead>
<tr>
<th></th>
<th>(1) MSTdev</th>
<th>(2) MSTdev</th>
<th>(3) OPTdev</th>
<th>(4) OPTdev</th>
<th>(5) BCTdev</th>
<th>(6) BCTdev</th>
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<tbody>
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<td><strong>Pol POB</strong></td>
<td>0.451**</td>
<td>0.432**</td>
<td>0.504**</td>
<td>0.476*</td>
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<tr>
<td></td>
<td>(0.182)</td>
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<td>(0.224)</td>
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<td><strong>Placebo</strong></td>
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<td>(0.040)</td>
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<td><strong>Dist Optim</strong></td>
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<td>(0.048)</td>
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<td><strong>Dist Optim (NTHS budget)</strong></td>
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<td>(0.048)</td>
<td>(0.048)</td>
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<tr>
<td><strong>Observations</strong></td>
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<td>2175</td>
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<td>2175</td>
<td>2175</td>
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</tr>
<tr>
<td><strong>Adjusted $R^2$</strong></td>
<td>0.312</td>
<td>0.311</td>
<td>0.403</td>
<td>0.403</td>
<td>0.417</td>
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</table>

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Dependent variable is the difference between each county’s distance to the optimal and actual network. All regressions control for initial light density, county area, and province fixed effects. Standard errors are clustered at the province level.
Quantifying the distortions

- Reduced form regressions suggest that birthplaces are more likely to be close to the actual network relative to the optimal network.
- Optimal network implies 0.75% higher aggregate net income.
  - But only part of the deviation explained by birthplaces.
- What are the aggregate costs of the distortion caused by birthplaces?
  - We use the general equilibrium model to compare aggregate welfare of counterfactual transport networks (work in progress).
Quantifying the distortions

We compare welfare from two networks

1. Optimal network connecting targeted cities + birthplaces that are predicted to be connected
   ⇒ + counterfactual cities may be connected if worthwhile

2. Optimal network connecting targeted cities
   ⇒ + birthplaces and counterfactual cities may be connected if worthwhile
Actual vs optimal network and birthplaces

red = optimal, black = actual, green=predicted birthplace-connections
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- Compare the actual and (approximately) optimal highway network in China using a general equilibrium framework
  ⇒ Implementing policy of connecting “intermediate sized cities”
- Actual and optimal networks have similar structure
  ⇒ but precise connections and paths differ
- Difference between actual and optimal network can partly be explained by the birthplace of politicians
  ⇒ Only when in office during planning and implementation phase
- Ongoing work to compute the aggregate welfare costs due to the distortion
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A Model of Income and Market Access I

- Inter-regional trade model based on Eaton and Kortum (2002)
- Donaldson and Hornbeck (2016) derive ‘Market Access’ as a measure for the effect of transport infrastructure

Setup
  - Geography
    - Many trading locations
    - Iceberg trade costs
  - Technology
    - Cobb-Douglas production with capital (mobile), labor (fixed), and land (fixed)
    - Probabilistic productivity of each district in each variety (comparative advantage)
  - Preferences
    - CES utility over a continuum of differentiated goods
Gravity: Eaton and Kortum (2002) show that trade from location \( o \) to location \( d \) is

\[
X_{od} = \frac{T_o (q_o^\alpha w_o^{\gamma})^{-\theta}}{\text{Origin's productivity and factor costs}} \times Y_d \times \tau_{od}^{-\theta} \times \kappa_1 MA_d^{-1} \times \text{Destination's income} \times \text{Bilateral trade costs} \times \text{Destination's market access}
\]

Summing the gravity equation over destinations \( d \) yields total expenditure (income) of origin \( o \):

\[
Y_o = \sum_d X_{od} = \kappa_1 T_o (q_o^\alpha w_o^{\gamma})^{-\theta} \sum_d \left[ Y_d \tau_{od}^{-\theta} MA_d^{-1} \right] \times \text{Market Access of } o
\]
Substituting for factor prices and solving for real income yields

\[
\ln (Y'_o) = \frac{1}{1 + \theta \alpha + \theta \gamma} \ln (\kappa_2) \\
\quad \text{Constant over locations}
\]

\[
- \frac{\theta \alpha}{1 + \theta (\alpha + \gamma)} \ln \left( \frac{\alpha}{L_o} \right) - \frac{\theta \gamma}{1 + \theta (\alpha + \gamma)} \ln \left( \frac{\gamma}{H_o} \right) \\
\quad \text{Constant over time}
\]

\[
+ \frac{1}{1 + \theta (\alpha + \gamma)} \ln (T_o) + \frac{1 + \theta (1 + \alpha + \gamma)}{(1 + \theta (\alpha + \gamma))^\theta} \ln (MA_o) \\
\quad \text{Productivity} \quad \text{Market access}
\]
# Effects of Birthplaces on Roads

**Linear probability model**

<table>
<thead>
<tr>
<th></th>
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<th>(3) BCTdev_hi</th>
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<tbody>
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<td>Placebo</td>
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<td></td>
<td>(0.077)</td>
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<td>(0.100)</td>
</tr>
<tr>
<td>Observations</td>
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<td>2175</td>
<td>2175</td>
</tr>
<tr>
<td>Adjusted (R^2)</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Standard errors in parentheses

* \( p < 0.10 \), ** \( p < 0.05 \), *** \( p < 0.01 \)