

# Expecting an Expressway

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Jeffrey Brinkman   Jeffrey Lin   Kyle Mangum

Federal Reserve Bank of Philadelphia<sup>a</sup>

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<sup>a</sup>The views expressed in this presentation are solely those of the authors and do not necessarily reflect the views of the Federal Reserve Bank of Philadelphia or the Federal Reserve System.

# Introduction

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# What determines urban spatial structure?

Do **self-fulfilling expectations** play a role?

- If moving is costly → households care about current & **future conditions**.
- With **externalities or spillovers**, future conditions depend on **others' choices**.
- If everyone expects that a neighborhood will be attractive in the future because other households will be there,  
→ it will attract households today, **proving such expectations correct**.

## Challenges

Identifying this **expectations** channel is challenging.

- Expectations are hard to measure.
- Expectations may be correlated with unobserved neighborhood factors, including realizations of expected future shocks.

## Our approach: Historical planned highway segments in US central cities

Certain construction, ...

- Broad support and few constraints ca. **1956**.
- Initial construction revealed **disamenities** from noise, pollution, barrier effects. Brinkman & Lin, 2022

... then certain cancellation.

- Federal and state reforms led to **cancellation** of some projects & dependent segments, esp. after **1973**. Expected future disamenities **never materialized**.
- In many cases, which segments were planned and cancelled depended on idiosyncratic factors.



## What we do: Evidence and theory

Evidence from 40+ US central cities that **expected highways caused neighborhood decline, and declines persisted even after plans were canceled.**

- Simple contrast, regression, matching, IV (early distant connections), runner-up.

Dynamic model where large—but temporary—shocks to expectations cause permanent neighborhood change.

- Two key ingredients: Forward-looking households & Agglomeration economies.
  - Potential multiplicity of steady states in neighborhood size.
  - **Self-fulfilling expectations:** Expected *future* decline in neighborhood QOL leads to neighborhood decline *today* by altering the number of steady states.
  - **Path dependence:** Nbhd decline persists, even when future shock is never realized.

## Contributions & implications

The spatial organization of the economy may feature multiple steady states.

- If strong spillovers, then many outcomes are possible, including path dependence & self-fulfilling expectations. Allen & Donaldson (2022), Bleakley & Lin (2012), Krugman (1991)
- We add to understanding when nature & history may not fully determine future spatial structure — i.e., when “anything” can happen!

Local development policy may be sensitive to expectations.

- Policy makers might leverage expectations to solve coordination problems. Owens, Rossi-Hansberg, & Sarte (2020), Hornbeck & Keniston (2017)
- Highway planning may affect spatial structure through expectations. Brinkman & Lin (2022), Duranton & Turner (2012), Baum-Snow (2007)

## **Case Study:** **The Crosstown Expressway**

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# Center City Philadelphia was to be encircled by expressways

1963 boundaries of Center City quite small  
Vine to Pine, River to river



 CENTER CITY DISTRICT

Framed by highways in the 1963 plan



 CENTER CITY DISTRICT

credit: Paul Levy, *Philadelphia Center City District*, 2017

- Some were built. Others—including the South Street or [Crosstown Expressway](#)—were not.

# The threat of construction changed behavior

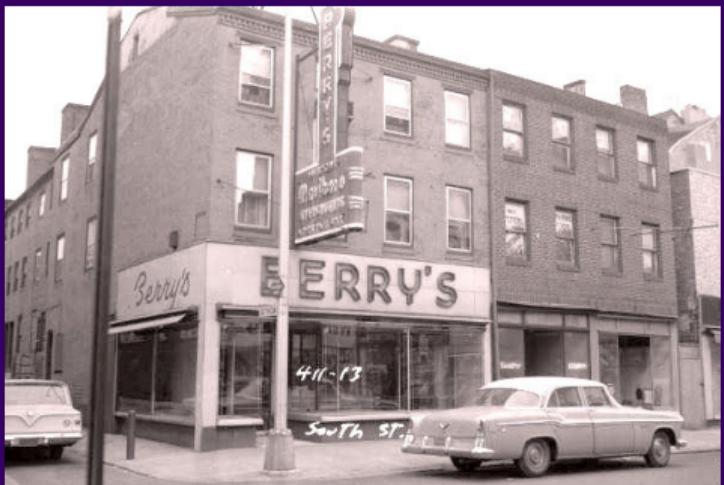
Threat of the highway helped depress South Street



L-9392-2 8-17-61

 CENTER CITY DISTRICT

& willingness of commercial owners to reinvest



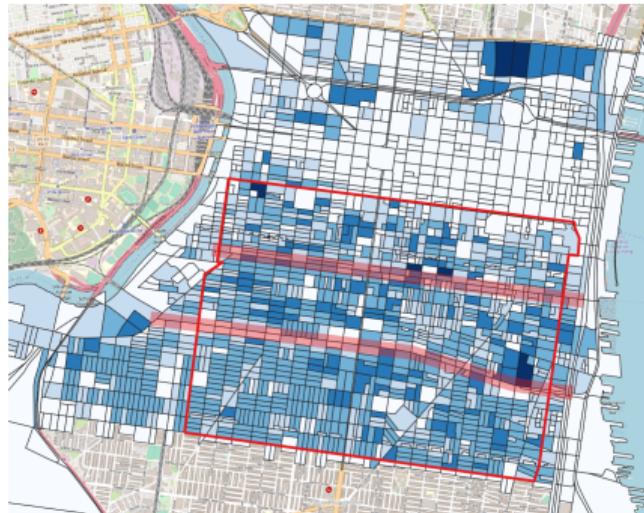
 CENTER CITY DISTRICT

credit: Paul Levy, *Philadelphia Center City District*, 2017



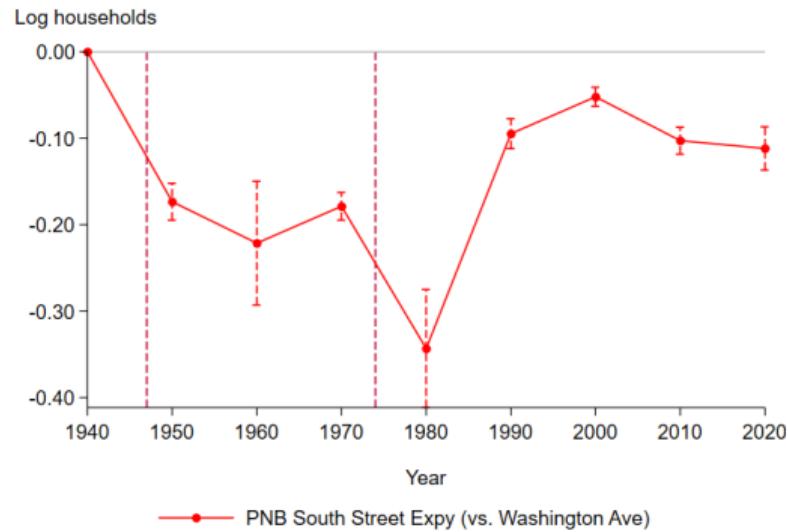
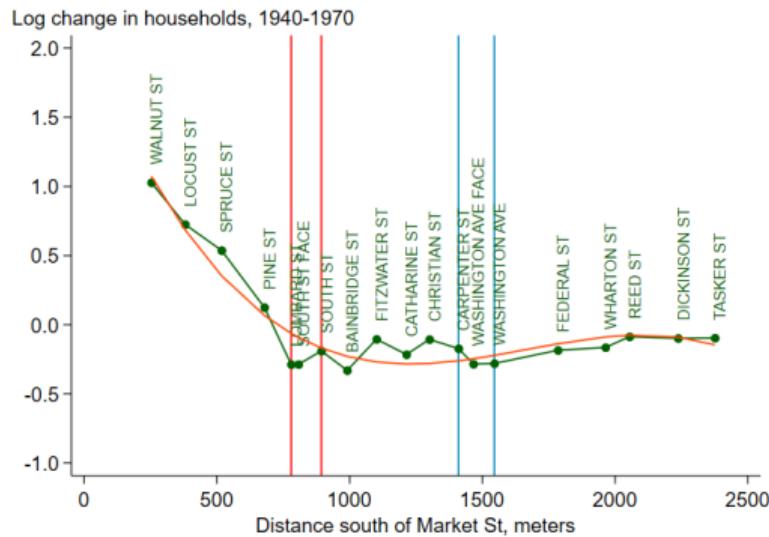
## Timeline and matched runner-up estimator

- 1910s: Early proposals for **South Street** alignment, **Washington Ave** runner-up alternative.
- 1947–1949: City approves and publicizes South Street alignment.
- 1964: First public hearing.
- 1973–1974: City, State abandon plans.



Sample area: Red box within Center City and South Philadelphia (Walnut to Tasker, 2nd to 24th)  
Map shows 1940 household population (blue) and South St, Washington Ave (red)

# Matched runner-up estimates



Estimated effect of **Planned but Not Built**:

- In 1970: -16.4%
- In 2020: -10.6%

## Cross-City Evidence

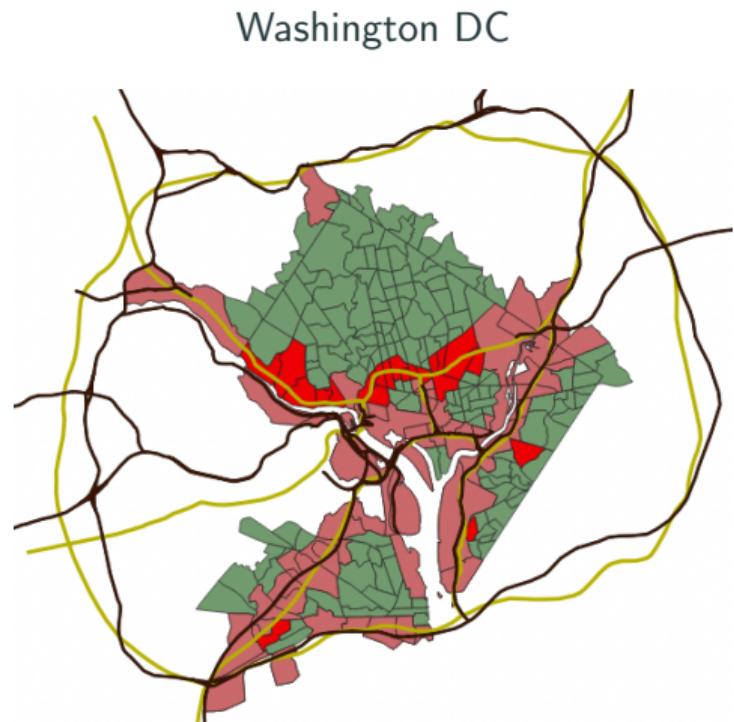
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## Data and sample selection

- Balanced panel of consistent-boundary census tracts, 1940–2017. Lee & Lin, 2018
  - Metro areas with digitized 1955 Yellow Book (YB) plans.
    - ▶ Neighborhoods that **expected** expressways.
  - National Highway Planning Network
    - ▶ Neighborhoods that **built** expressways.
  - Tracts with 5 miles of established city centers.
    - ▶ Consistent with net **negative** effects of highways. Brinkman & Lin, 2022
- 4,000+ tracts in 40+ metros that have YB *and* 1940 tract data.

## Treatment and comparison groups

- B** “Built” – Highway intersects tract.
- PNB** “Planned, Not Built” – Highway *plan* intersects tract, but not built.
- NP** “Not Planned” – Neither **B** nor **PNB**.



Note: Only tracts within 5 miles of downtown are in analysis sample.

## Causal inference

Challenge: *Non-random* planning & construction of highways.

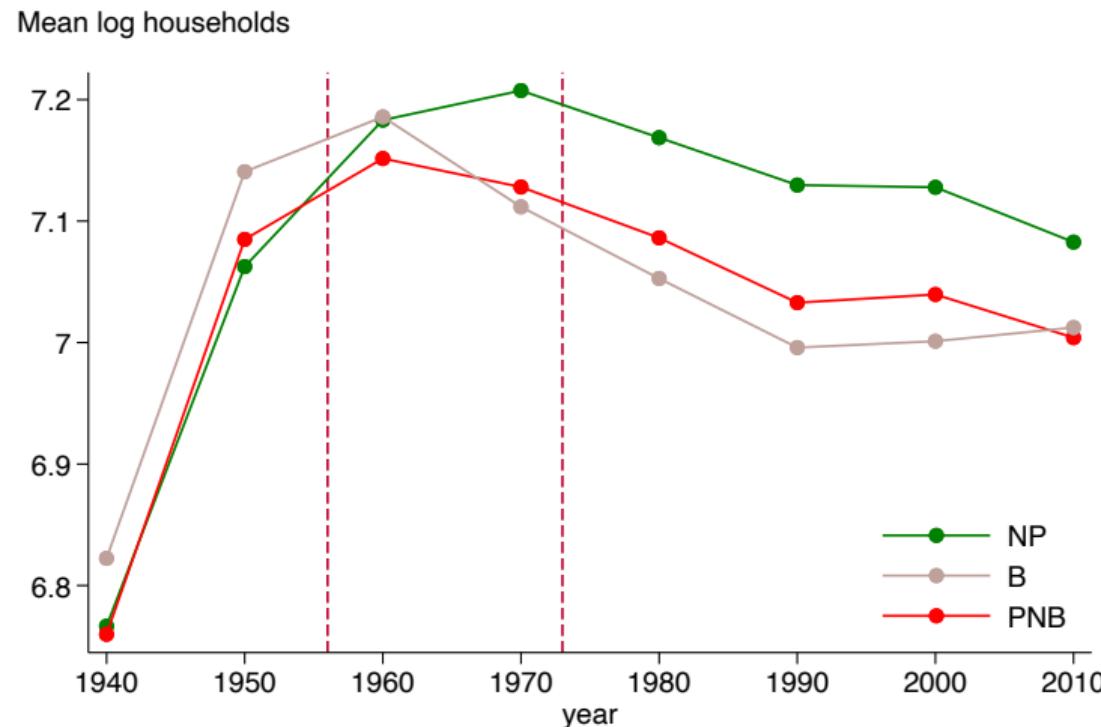
- Negative selection on growth factors into plan.
- Negative selection on growth factors into cancellation, conditioned on plan.

Narrative evidence suggests *positive selection*. Brinkman & Lin, 2022

- Highways planned in nbhds expected to grow most. ➔
- Cancellations typically in high-SES neighborhoods. ➔
- Pre-highway growth rates are similar (and  $> 0$ ); Reversal of fortune.

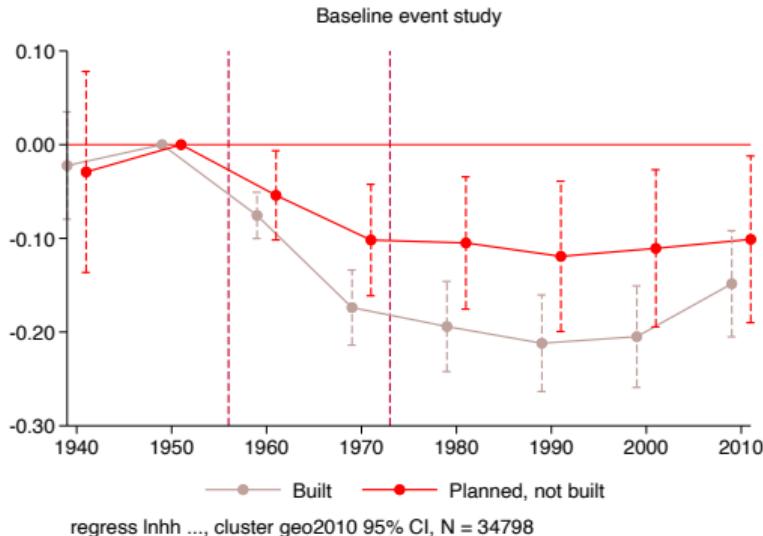
Designs: Simple contrast, regression, matching on observables, IV, matched runner-up.

# Household population over time



Number of tracts in 1950 = 4350, Number of metros = 41

# Event study estimates



Differences in 1980:

	PNB vs NP	B vs NP
Simple contrast	-10.0%	-17.6%
Regression adjustment	-7.2%	-12.8%
Matching	-7.4%	-13.3%
IV	-23.0%	-50.6%

- Pre-trends similar; **reversal of fortune**.
- Decline persists after 1973, despite cancellations.
- Regression adjustment with metro $\times$ year FE, tract FE, tract natural & historical factors $\times$ year effects.
- IV with “early distant completion.”

## Other outcomes, robustness, and extensions

### Other outcomes:

- Population: Quantitatively similar results.
- Housing units: Substantial disinvestment in **B** & **PNB** n'hoods. ➔
- Income, prices, and race: Large gross changes in total white and nonwhite populations; modest net effects on sorting. ➔ race ➔ income

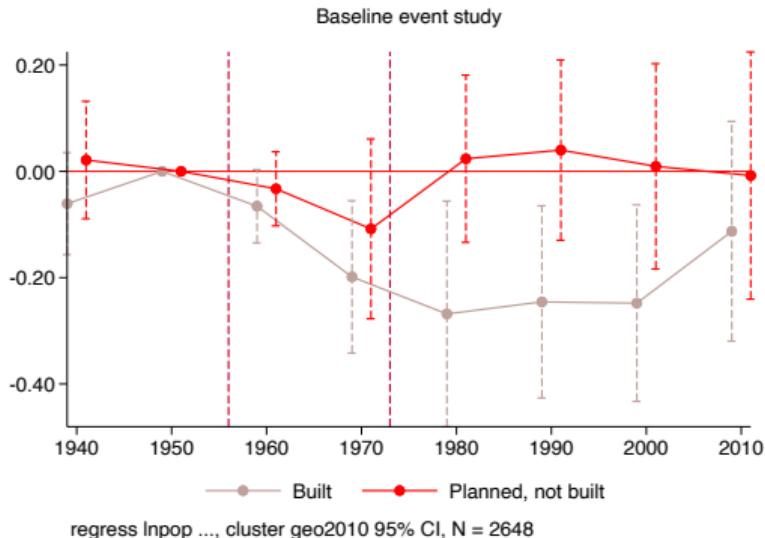
### Robustness:

- Sample selection: 25% densest tracts in each city;  $>14k$  pop/mi<sup>2</sup>;  $>4k$  HU/mi<sup>2</sup>.
- Spatial treatment: Log distance to **B** & **PNB** vs.  $1(\cdot)$ . ➔

### Extensions:

- Early cancellation has temporary effects (San Francisco, Baltimore).
- Matched runner-up design (Philadelphia's South Street Expy; Block scale).

# Early cancellation has temporary effects



San Francisco and Baltimore were exceptional in that they had local control powers to stop highway construction.

- SF had sole power to close roads; Board of Supervisors cancelled all highway construction in **1959**.
- Baltimore had sole authority to condemn properties.
- Differences in 1970 are similar, but **PNB** then returns to pre-highway levels.

## Summary of evidence

- Expected expressways caused significant **neighborhood decline**.
- Neighborhood decline **persisted**, even when construction was cancelled.
  - ▶ Except in cases where planned highways were **cancelled early**.

# Model

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## Model outline

Goal: Rationalize these results and quantify local agglomeration economies

Two key ingredients:

- Agglomeration economies
- Forward-looking households

Key results:

- Agglomeration economies → **multiple steady states** in neighborhood size.
- Expected *future* shock leads to nbhd decline *today* (**self-fulfilling expectations**).
- Decline persists, even when future shock is never realized (**path dependence**).

## Environment

- Households choose among  $J$  neighborhoods in each period, subject to a move cost.
- Value of nbhd  $j$  depends on exogenous amenities  $a_j$  and endogenous pop.  $n_j$ .
- Timing:
  - ▶ Initial allocation of population across neighborhoods.
  - ▶ Exogenous amenities determined  $a_t = f(a|a_{t-1}, \nu)$ .
  - ▶ Households choose location based on expected population  $\hat{n}_j$ .
  - ▶ Their choices determine realized population & next period's initial allocation.

## Value of a location depends on others' choices

Choice-specific values, conditioned on beginning in nbhd  $j$ :

$$\text{stay: } v_j(a_{j,t}, n_{j,t-1}) = \underbrace{u(a_{j,t}, n_{j,t})}_{\text{flow util}} + \beta \underbrace{V(a_{j,t}, n_{j,t})}_{\text{continuation value}}$$

$$\text{move: } v_0 = u_0 + \underbrace{c_0}_{\text{move cost}} + \beta V_0$$

## How a location depends on others' choices

Utility can contain terms for **negative** and **positive** effects of neighborhood population

$$u(a_{j,t}, n_{j,t}) = a_{j,t} + \underbrace{u^-(n_{j,t})}_{\text{congestion}} + \underbrace{u^+(n_{j,t})}_{\text{agglomeration}}$$

We want do inference on **the shape of  $u$** .

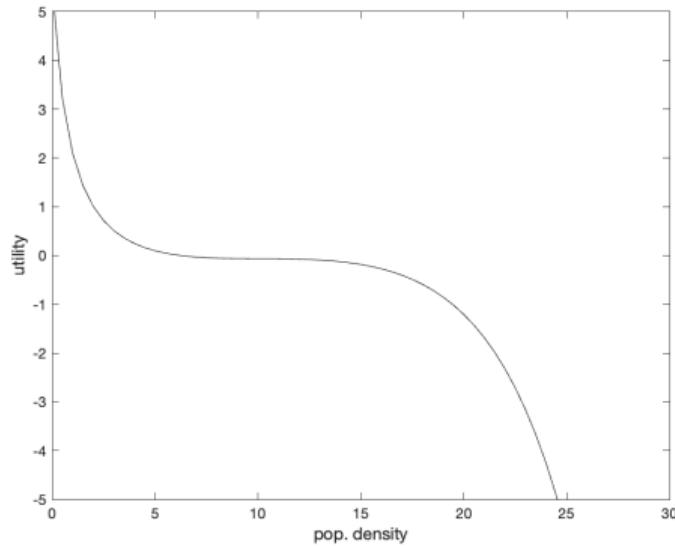
- Monotone congestion is when  $u_n() < 0$  (for all  $n$ ).
- Net agglomeration is when  $u_n() > 0$  (over some  $n$ ).

e.g.,

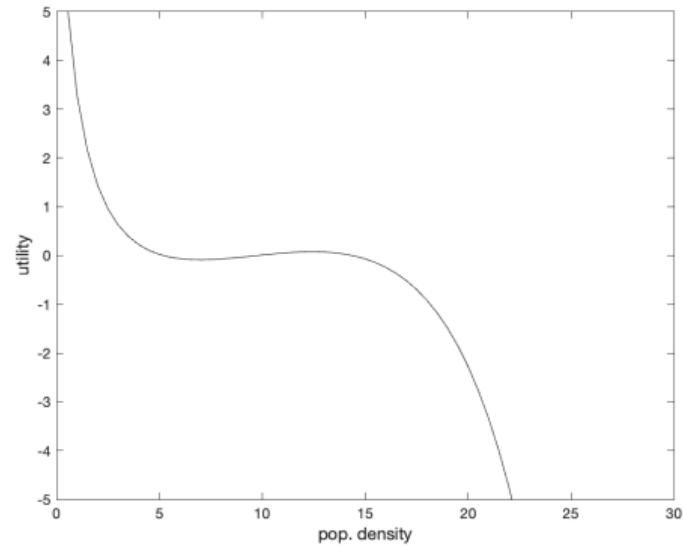
$$u(a_{j,t}, n_{j,t}) = a_{j,t} - \underbrace{\frac{A_1}{1+n_j}}_{\text{shared resource}} + \underbrace{A_2 n_j}_{\text{IRS consumption}} - \underbrace{A_3 \exp(n_j)}_{\text{rent}}$$

## Shape of utility: 2 cases

Complete Congestion



Some Agglomeration



## Definition of equilibrium population

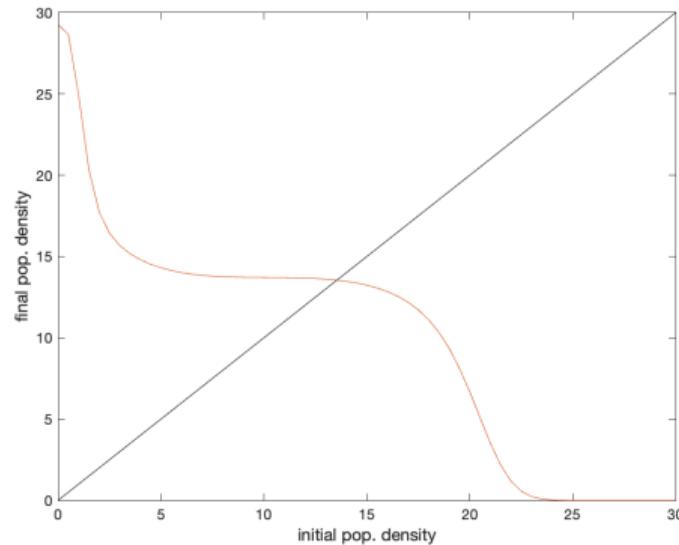
- Let choice probability from  $i$  to  $j$  be  $\sigma_{j,i}(v_{j|i}(\hat{n}_j))$ .
  - ▶ Standard extreme value shocks (logit demand).
- Equilibrium is **fixed point** in population, i.e., expected = realized population.

$$n_1^{*t} = \sigma_{1,0}(n_1^{*t}) n_0^{t-1} + \sigma_{1,1}(n_1^{*t}) n_1^{t-1}$$

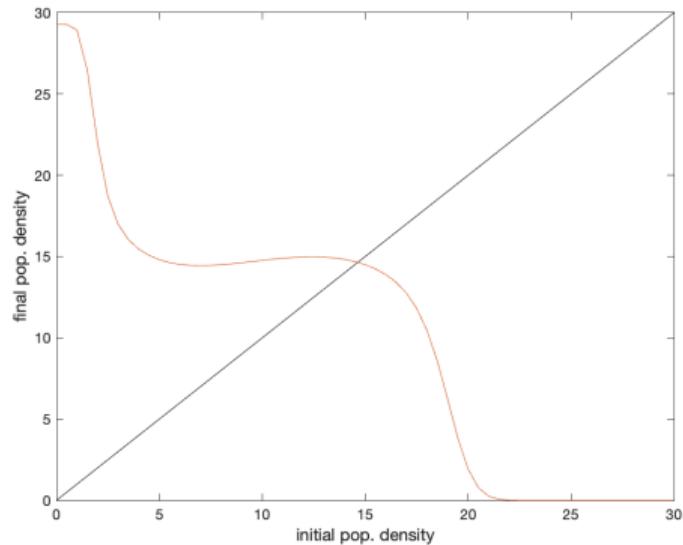
- ▶ **History matters:** Initial population allocations affect the equilibrium allocation.
- ▶ There may be multiple equilibria and/or multiple steady states, depending on the shape of  $v_{j|i}(\hat{p}_j)$ .

# Equilibrium

Complete Congestion

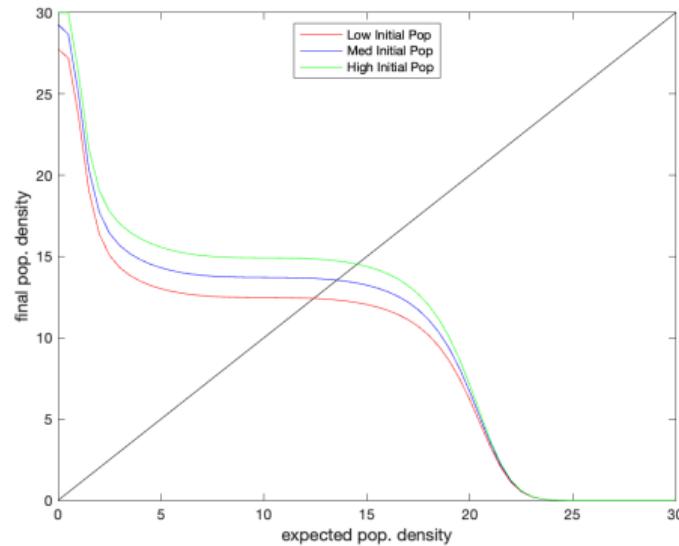


Some Agglomeration

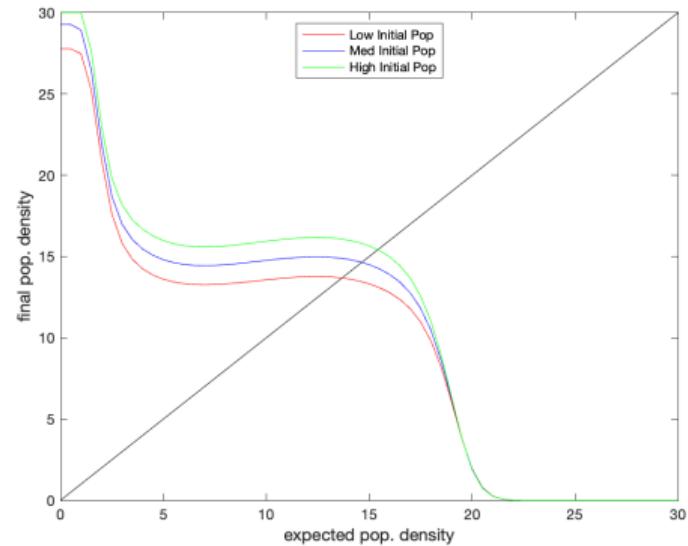


# Equilibrium depends on history

Complete Congestion

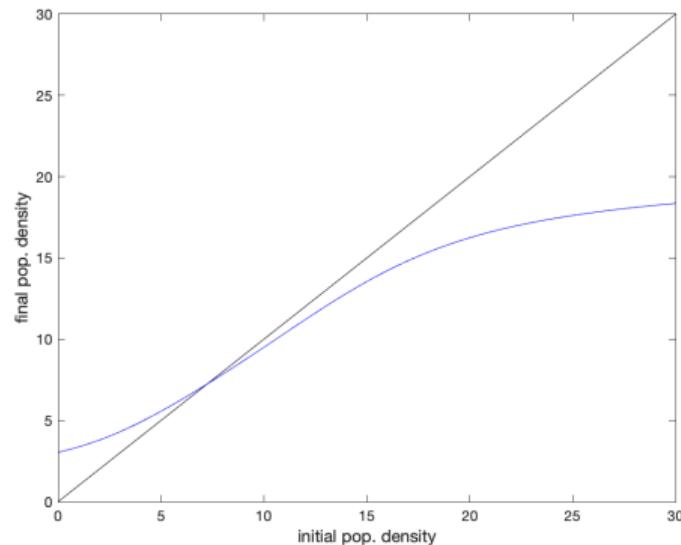


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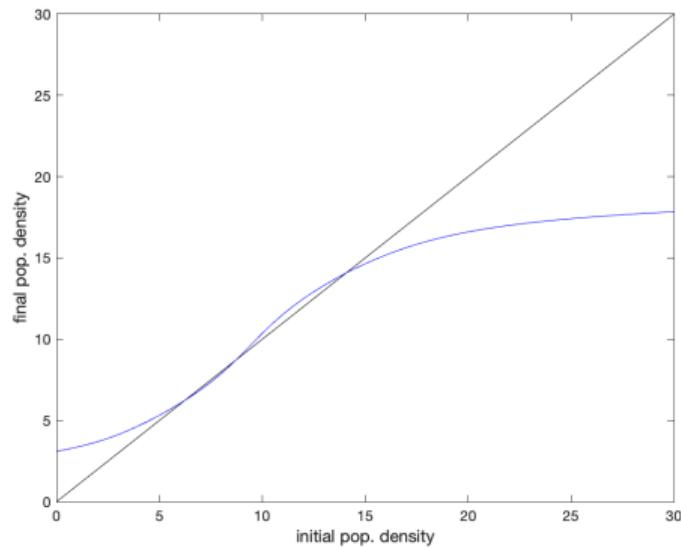


# History-dependent equilibrium determines population transitions

Complete Congestion



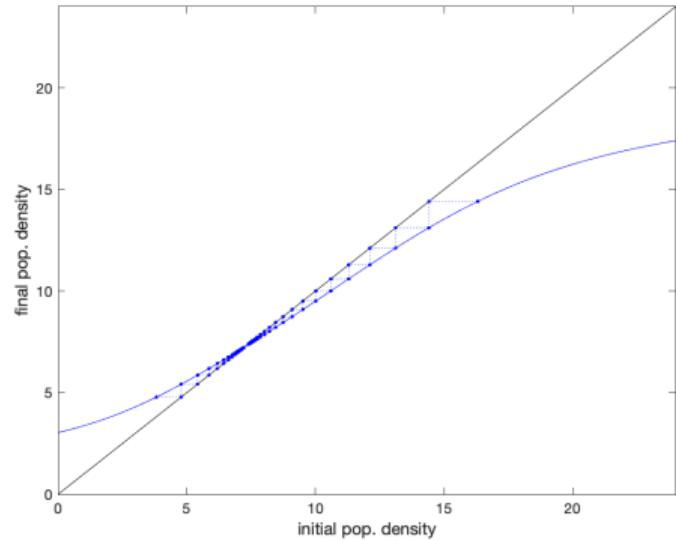
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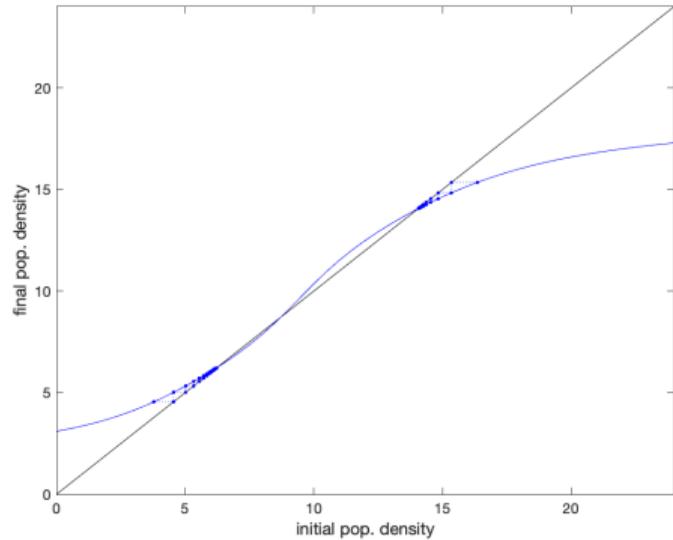
- Agglomeration can yield multiple equilibria or (in this case) **multiple steady states**.

# Population dynamics: Toward steady-state(s)

Complete Congestion



Some Agglomeration

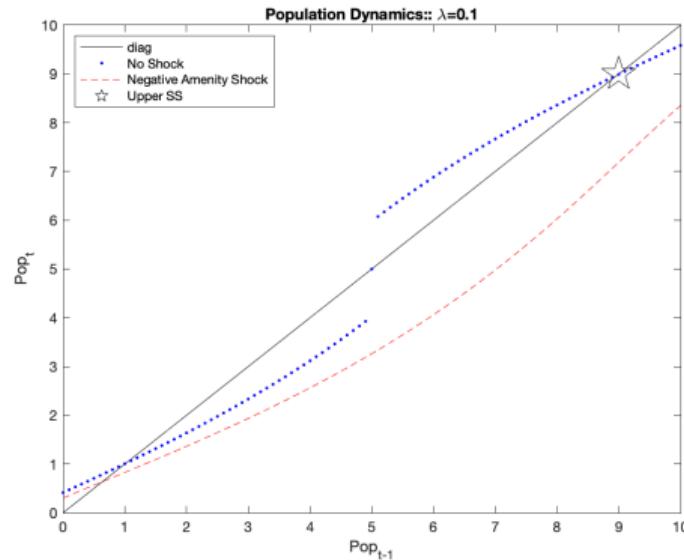


## Bad news shock

Start from a high steady-state population.

- At date  $t$ , it is announced in  $s$  periods, nbhd 1 amenity will decline.
  - ▶ Changes **expectations** but negative amenity shock is not realized yet.
  - ▶ Forward-looking agents begin to act (via expectations of future population).
- In some cases, the shock is unexpectedly **cancelled** at  $t + s' < t + s$ .
  - ▶ But if  $s' > 0$ , households have already begun acting on the news.

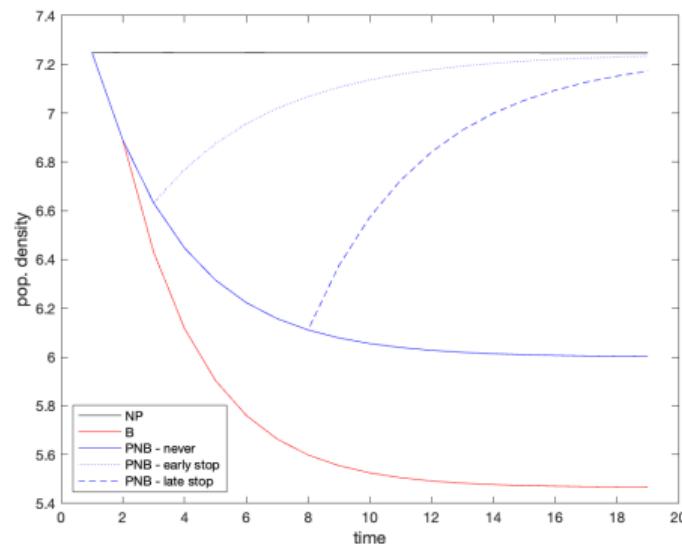
# Future bad news leads to neighborhood decline today



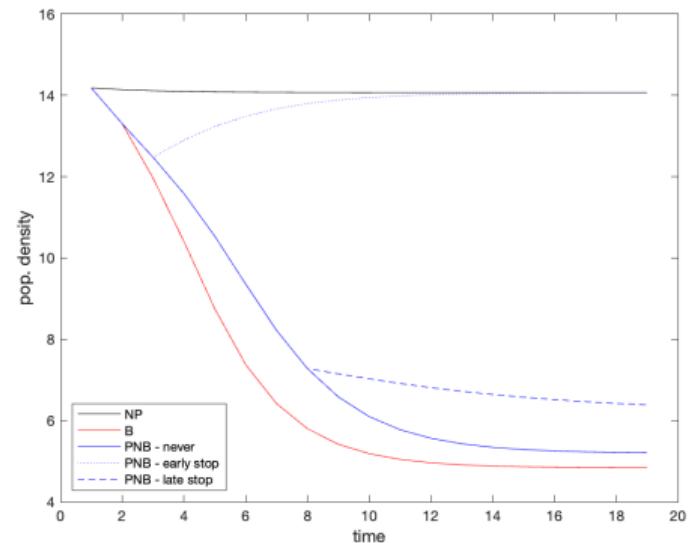
- “Bad news shock,” eliminates steady state ★, leaving only one steady state.
- **Self-fulfilling expectations:** Nbhd declines immediately, transitioning to remaining (low) s/s.
- **Path dependence:** Nbhd doesn’t recover, even after cancellation.

# Population dynamics after PNB/B shock

Complete Congestion



Some Agglomeration



Nb. Effect size ordering: **PNB < B**.

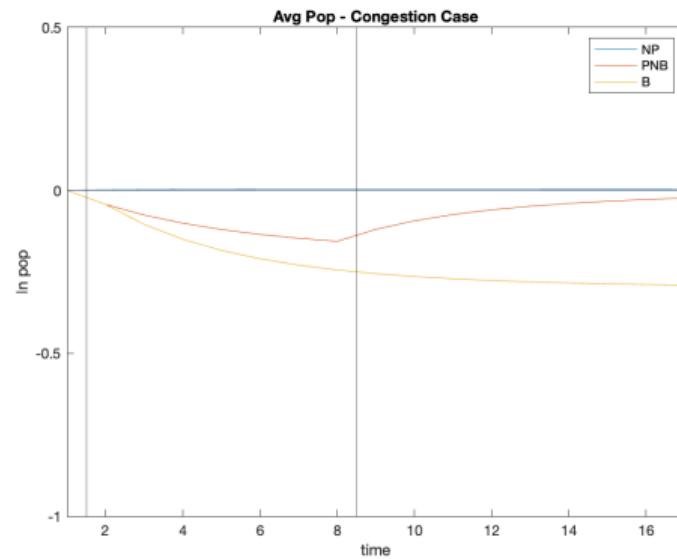
## Estimation

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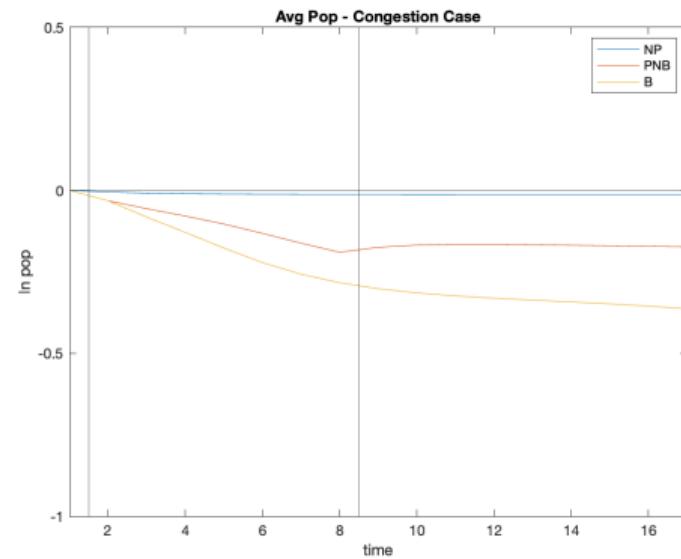
# Estimation: distinguishing utility functions

We can simulate data from different utility functions and run the same regression:

Complete Congestion



Some Agglomeration



Divergence in treatment effect dynamics—PNB in particular—identifies utility function.

## Estimation procedure

1. Calibrate outside the model
  - ▶ Move costs, discount rates, and distribution of idiosyncratic draws.
  - ▶ Size of outside option relative to neighborhood.
2. Estimate via indirect inference
  - ▶ Distribution of shocks to neighborhoods.
  - ▶ Utility function  $u(n_j, \lambda)$ .

► Non-parameteric ID argument

## Conclusion

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## Summary and next steps

Expected expressways led to neighborhood decline that persisted even after cancellation.

- A big shock over nearly two decades; Little uncertainty; Surprise cancellation.

A model with externalities and forward-looking households can rationalize this result.

- Shocks to expectations can change equilibrium configurations → transition to a new steady state.

On the agenda:

- Quantifying externalities in the structural model.

## Appendix

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## Historical evidence on planned route selection

Routes were favored that:

- Penetrated downtown or circumvented cities via beltway.
- Used undeveloped land.
- Linked to other modes such as rail stations and ports.
- Followed forecasted demand.
- Followed topography and physical features such as rivers.
- Were compatible with existing land use.
- National defense.

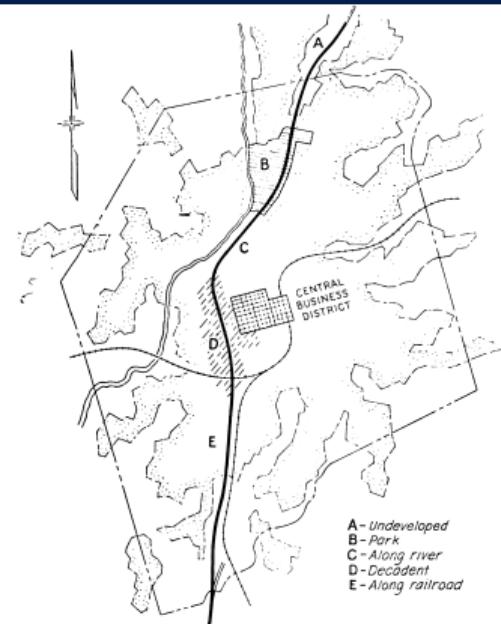
"Criteria for Selection of Interstate System Routes," testimony of CPR C.D. Curtiss, 4/15/1955.

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# 1957 AAHSO Red Book

"The improvement of radial highways in the past stimulated land development along them and often left *wedges of relatively unused land* between these ribbons of development. These undeveloped land areas may offer locations for new radials."

→ Planned routes likely to be *positively selected* on nbhd growth factors.



LOCATION OPPORTUNITIES FOR ARTERIAL HIGHWAYS  
AS RELATED TO LAND USE AND PHYSICAL CONTROLS

Figure B-6

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## Historical evidence on canceled route selection

- vs. neighborhoods with built highways, nbhds with **unbuilt** YB plans:
  - ▶ More educational attainment in 1950.
  - ▶ Lower black share in 1950.
  - ▶ Higher population density in 1950.
  - ▶ Far from coastlines or rivers.

Brinkman & Lin, 2022

→? Conditioned on plan, canceled routes might have been *negatively selected* on neighborhood growth factors.

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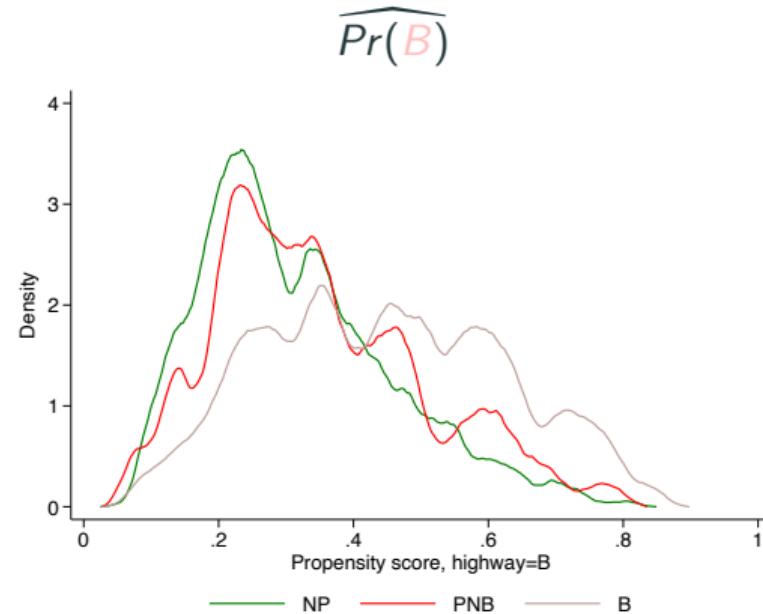
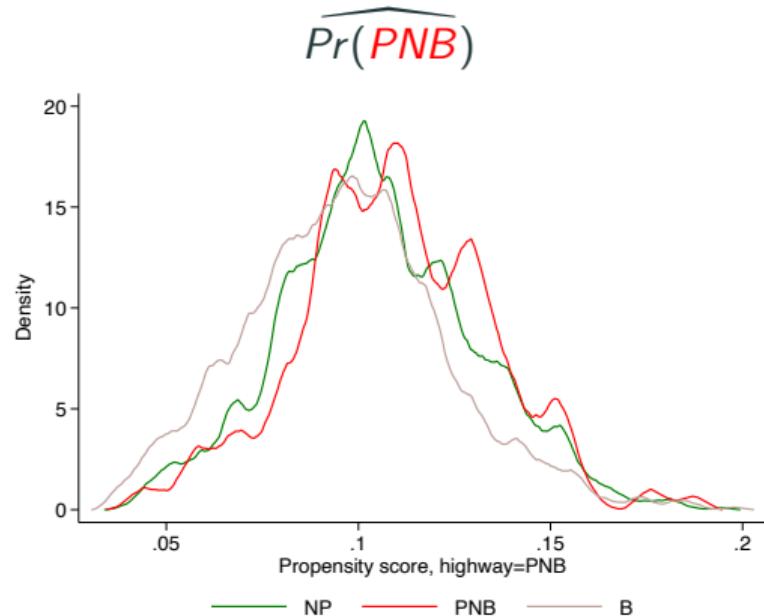
## Matching estimator

Inverse probability weighted regression adjustment Wooldridge, 2007; Cattaneo, 2010

- Estimator of multi-level treatment effects that combines matching and regression.
  - (1) Estimate probability of treatment  $h$  conditioned on  $W$ .
  - (2) Estimate treatment-level mean outcomes (conditioned on  $X$ ) with inverse probability weights.
    - ▶  $\widehat{ATE}$  is contrast between predicted treatment-level means.
- Doubly-robust, if treatment model OR outcome model are correctly specified, then estimator is consistent.
  - ▶ IPWs magnify controls that look like treated ( $W$ ) and vice versa.
  - ▶ RA accounts for differences in  $X$  across treated and control.

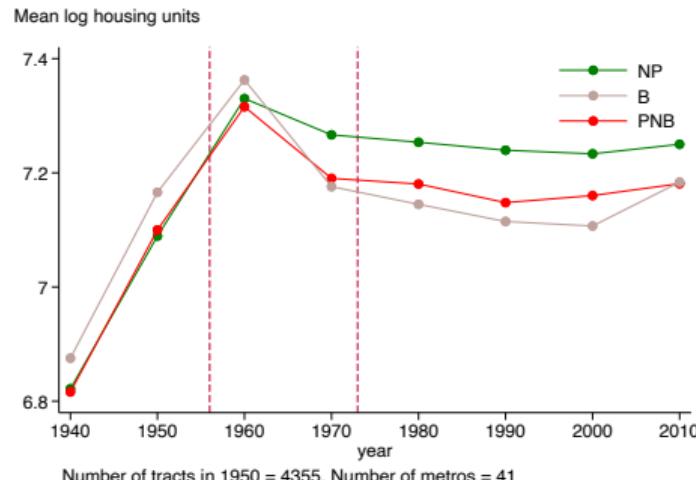
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# Overlap



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# Housing units



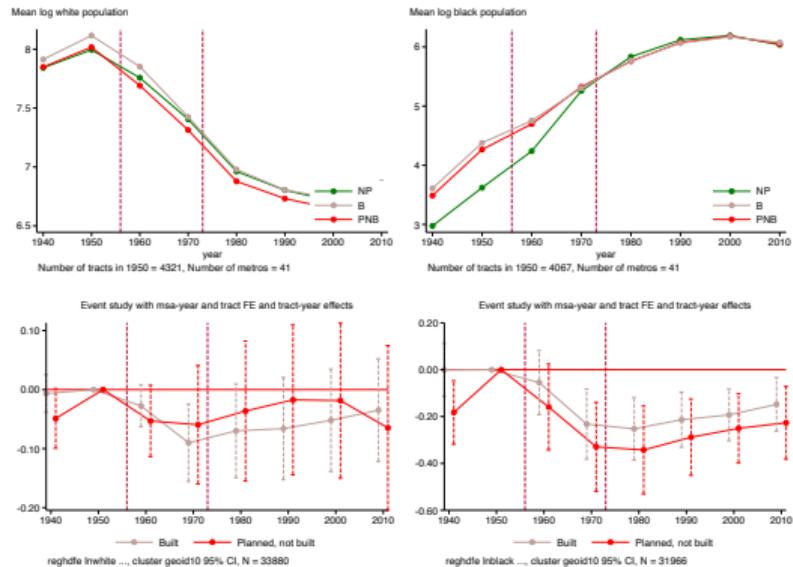
Evidence of substantial housing disinvestment.

- Housing units = occupied + vacant;  
i.e., “habitable.”

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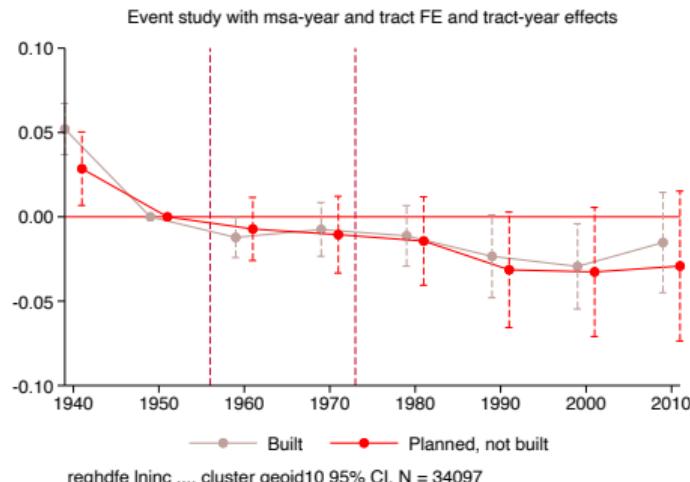
# Race

- Large net population changes.
- Relative decline in both white and black pop in both **B** & **PNB** n'hoods.
- Net effect is modest and insignificant decline in nonwhite share.



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# Income

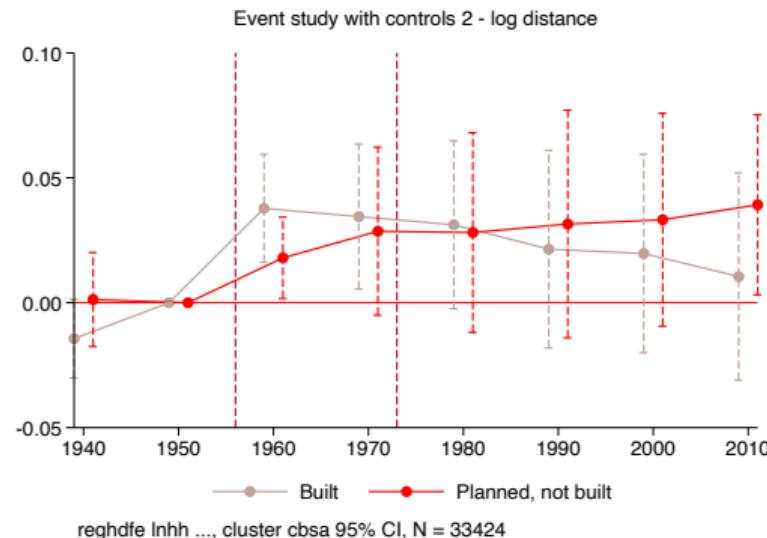


Modest and insignificant decline in income.

- Theory is ambiguous w/ multiple dimensions of heterogeneity.

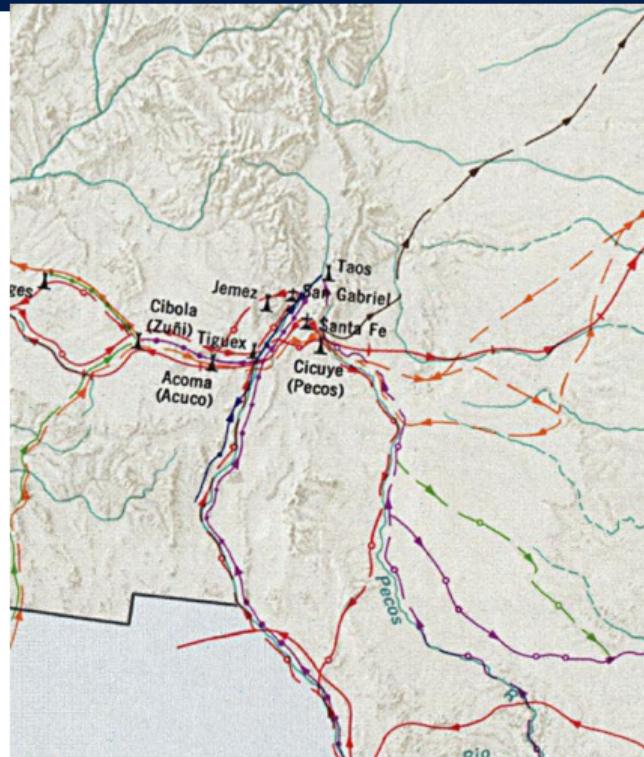
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# Log distance treatment



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# Historical routes



Pre-1675 explorer routes near Santa Fe, NM

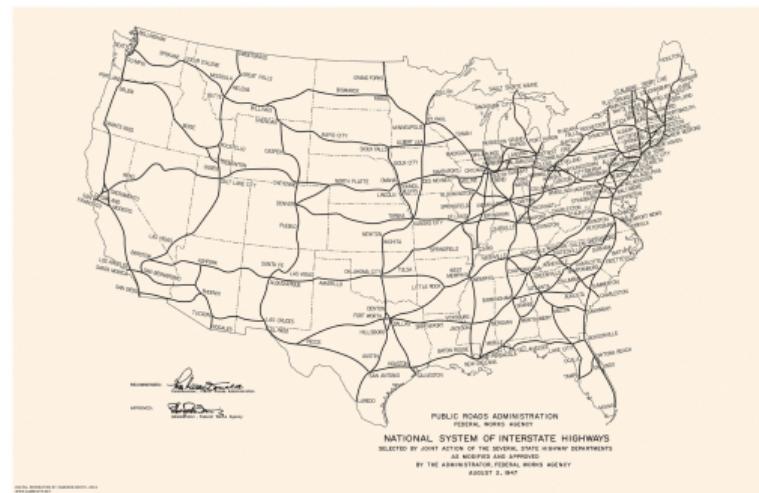
Least-cost routes based on obsolete topography + history dependence. Duranton & Turner, 2012

- Pre-1898 rail routes.
- 16th-19th c. explorer routes.

# Planned intercity routes

Planners connected distant cities for reasons of interregional trade and national defense unrelated to contemporary neighborhood factors. Baum-Snow, 2007

- 1947 intercity plan.
- Variant of 1947 intercity plan.



1947 intercity plan

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## IV estimator

2-step IV estimator for binary endogenous treatments. Wooldridge, 2010; Xu, 2021

- Step 1. Estimate a binary response model (MNL) by maximum likelihood.
- Step 2. Use predicted values  $\hat{B}, \hat{PNB}$  as excluded instruments in 2SLS.

Virtues:

- Usual 2SLS inference is asymptotically valid. Wooldridge, 2010
- Optimal feasible instrument if Step 1 correctly specified; Consistent even if incorrect. Wooldridge, 2010
- Nonlinear form improves efficiency and addresses weak instruments. Xu, 2021

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## Early cancellation

San Francisco and Baltimore were exceptional in that they had (and used) local control powers to stop highway construction early on.

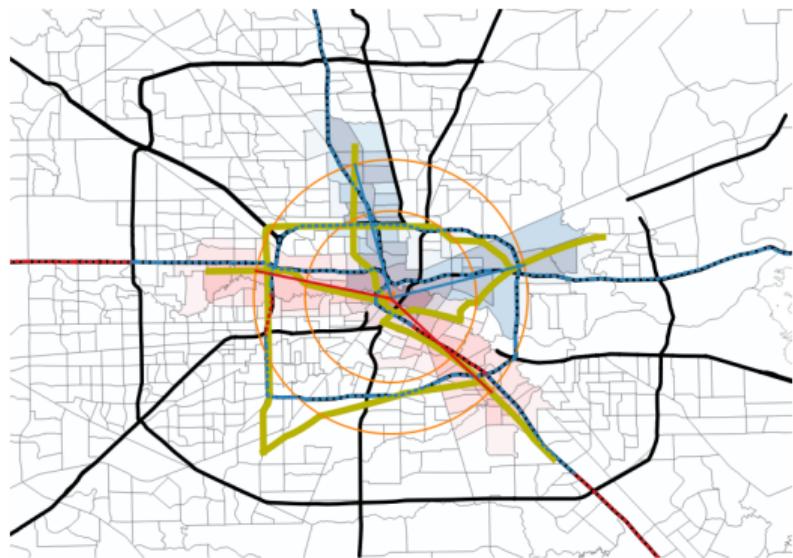
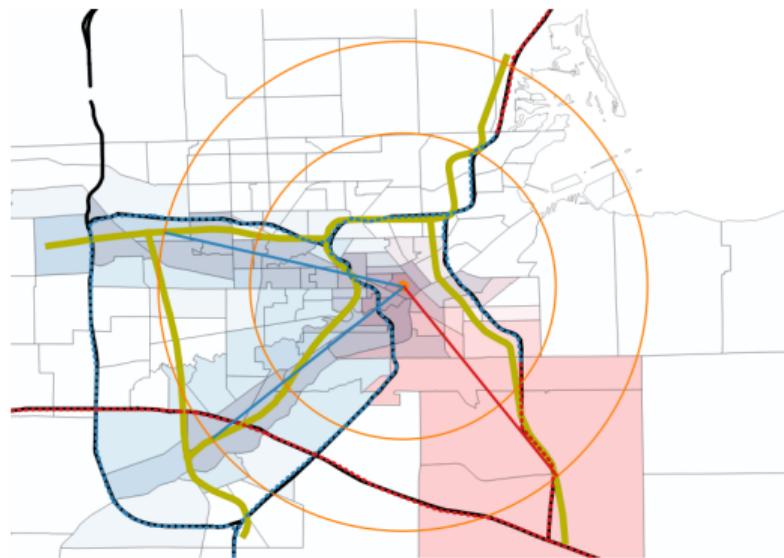
### San Francisco

- CA State law gave power to close roads to local government
- SF Board of Supervisors had veto power over freeway system
  - Board of Supervisors cancelled further highway construction in 1959

### Baltimore

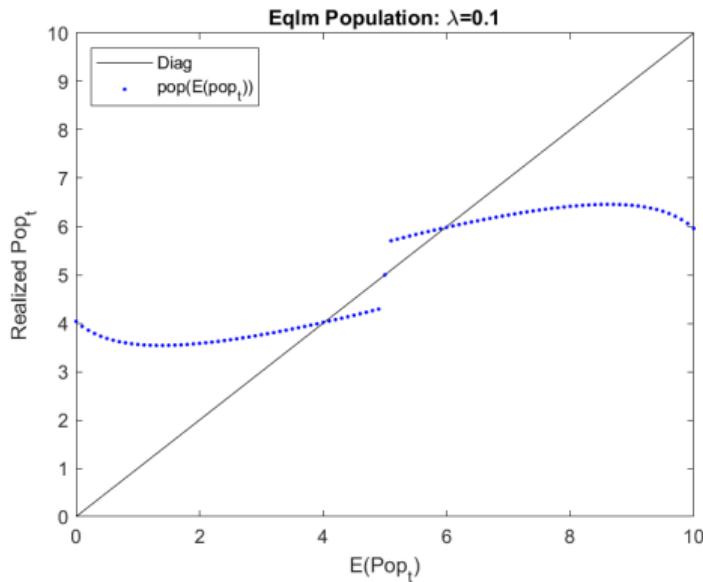
- Two unique provisions in city's home-rule charter
- City council had sole authority to condemn properties
  - City's planning commission could reject state highway plans

## Early distant completions - Toledo and Houston examples



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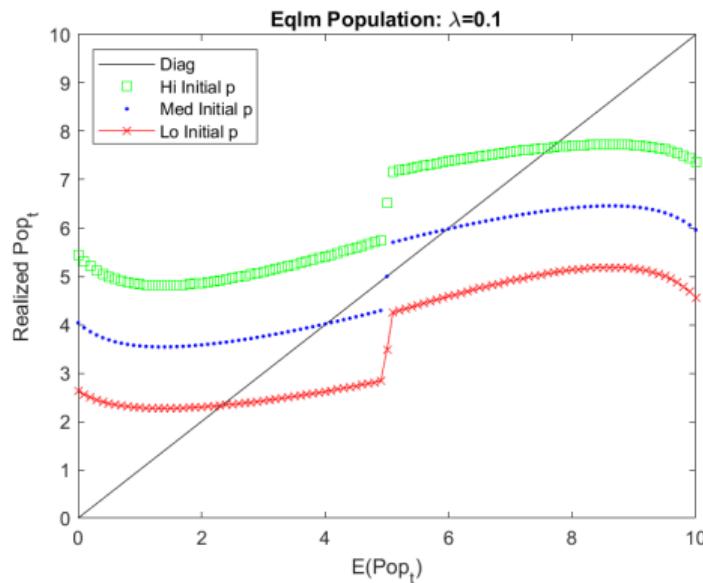
# Equilibrium population



- Net agglomeration case:  
Upward-sloping utility (over some range).
- Equilibrium: realized = expected pop.
- There may be multiple equilibria.

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# Equilibrium configurations depend on initial population allocations

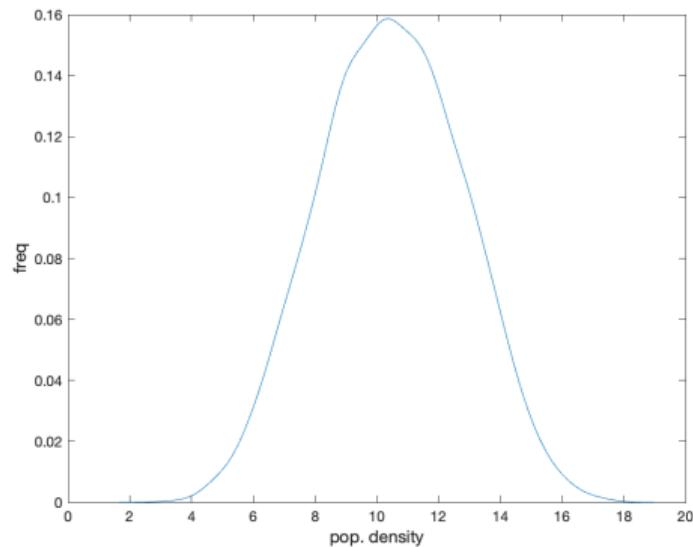


- Some initial conditions reach multiple equilibria; some have only one.

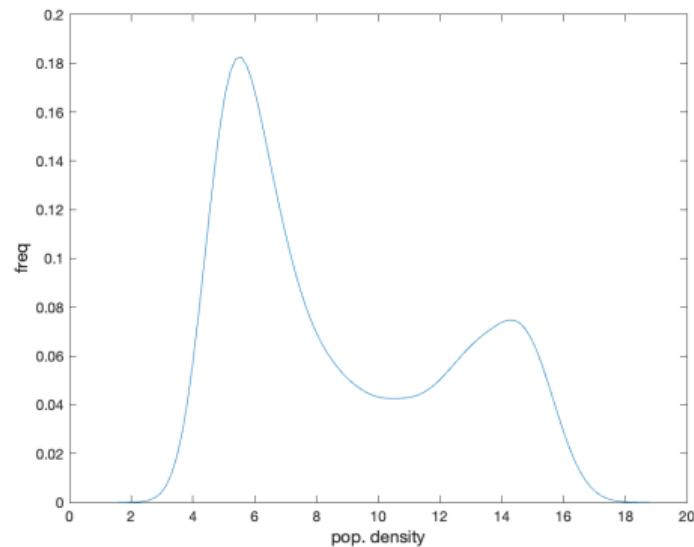
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# Ergodic distribution of neighborhood size

Complete Congestion



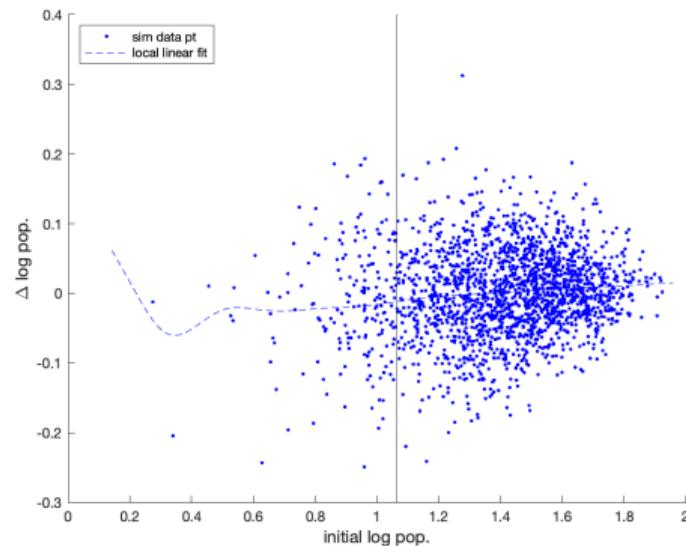
Some Agglomeration



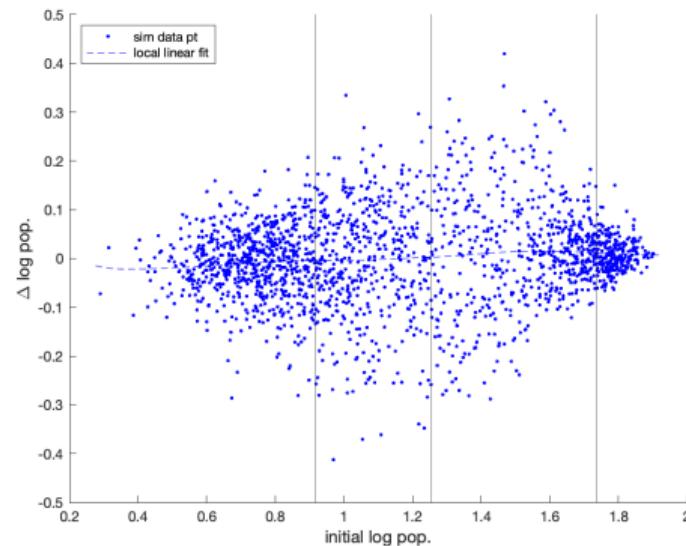
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# Ergodic distribution of neighborhood population change (mean)

Complete Congestion

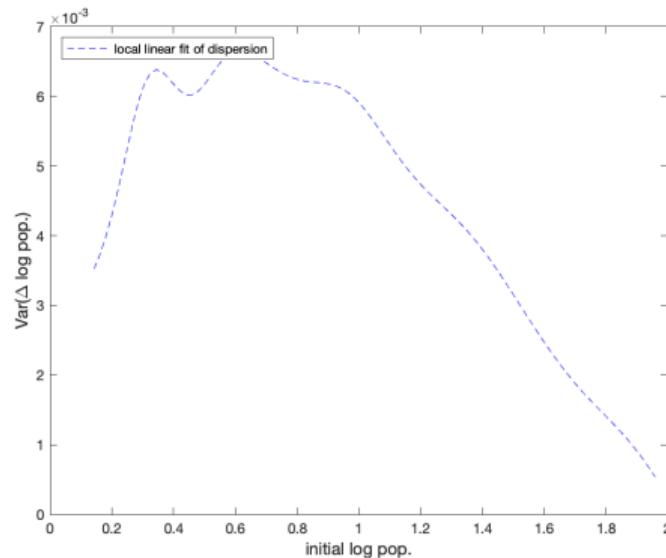


Some Agglomeration

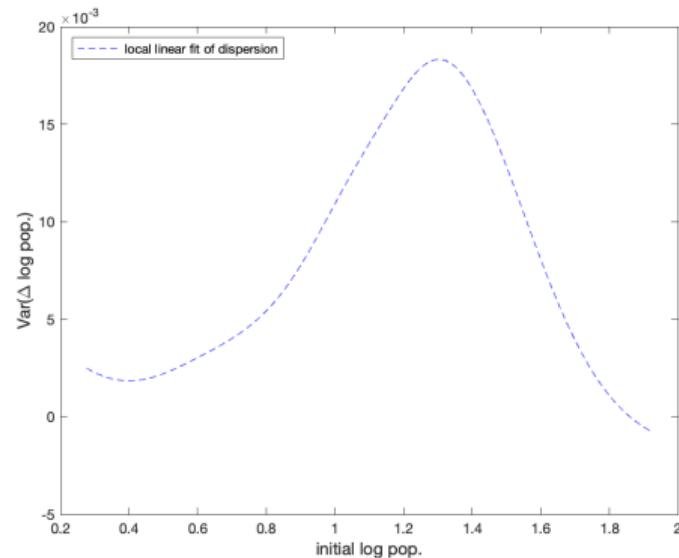


# Ergodic distribution of neighborhood population change (variance)

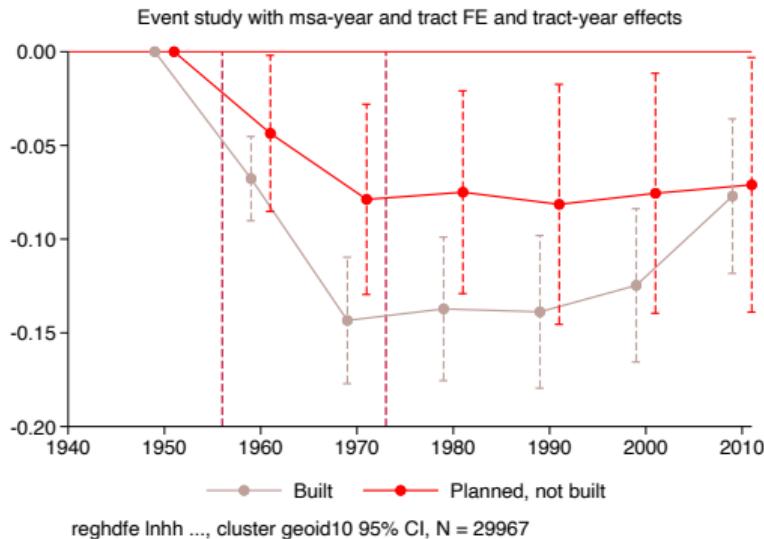
Complete Congestion



Some Agglomeration



# Event study estimates with FE, natural & historical controls



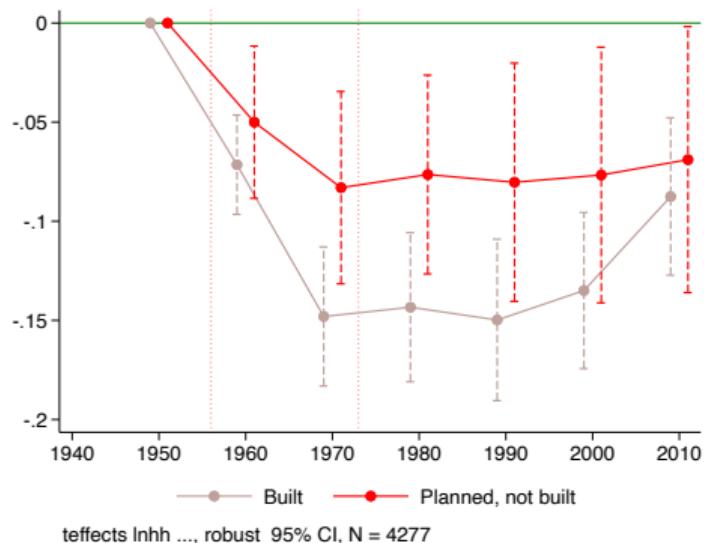
Differences in 1980:

	PNB vs NP	B vs NP
Simple contrast	-10.0%	-17.6%
Regression adjustment	-7.2%	-12.8%

Controls:

- Metro×Year FE
- Tract FE
- Tract natural & historical factors×Year effects  
(e.g., Year×flexible dummies for quantiles of proximity to river, to city center, slope, land area, 1940/1950 demographics)

# Matching estimates



Differences in 1980:

	PNB vs NP	B vs NP
Simple contrast	-10.0%	-17.6%
Regression adjustment	-7.2%	-12.8%
Matching	-7.4%	-13.3%

Treatment factors: ➔ IPWRA ➔ overlap

- Tract natural factors (e.g., proximity to river, to city center, slope, land area) & pre-determined historical factors (1940/1950 demographics).

## IV estimator

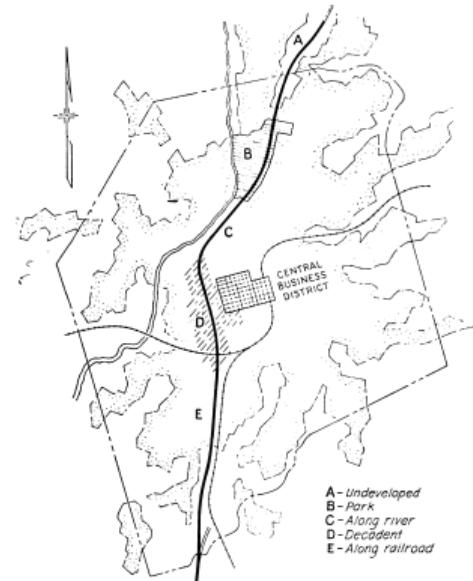
Remaining concern is that conditional ignorability of planning & cancellation is too strong an assumption.

- We need 2 instruments for 2 endogenous vars (B, PNB) or 2 endogenous margins:
  1. Selection into plan, and
  2. Selection into cancellation (conditioned on plan).
- We propose and use 2 types of IVs:
  - ▶ Historical rail and explorer routes [<sup>1</sup>]. ➔ Duranton & Turner, 2012
  - ▶ 1947 **Inter**-city plan routes [<sup>1</sup>]. ➔ Baum-Snow, 2007
  - ▶ Early and delayed distant connections [<sup>2</sup>] — These are new.

# Early distant completions

Early, rural highway construction affected cancellation.

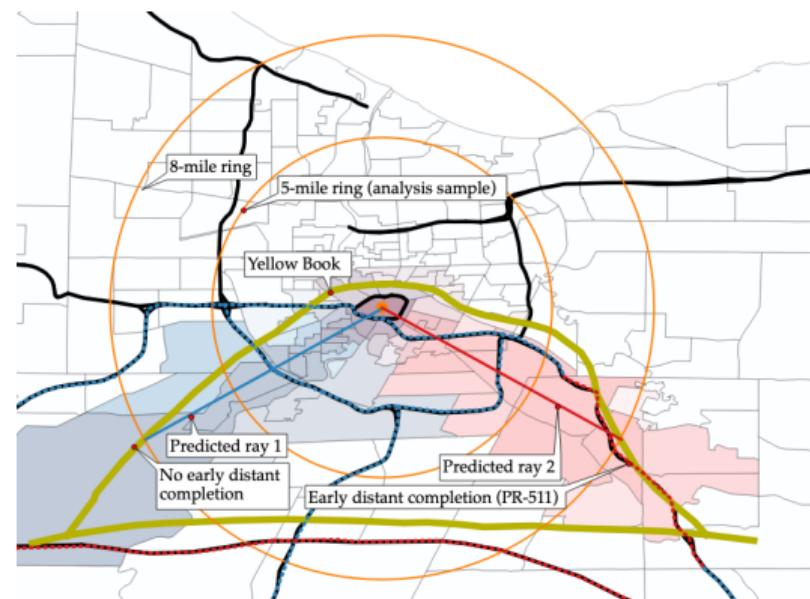
- Pre-1956 State routes were rural; no opposition.
- Which projects were started first often idiosyncratic; unrelated to central neighborhood factors. Johnson, 1965
- Design standards called for rays converging to CBD. →
- **Early distant completion** of rural rays (A) **reduced** likelihood that central rays (C) would be cancelled.
- On the other hand, **delayed distant completion** of rural rays **increased** likelihood of central-ray cancellation.



LOCATION OPPORTUNITIES FOR ARTERIAL HIGHWAYS  
AS RELATED TO LAND USE AND PHYSICAL CONTROLS  
Figure B-6

## Early distant completions — Example

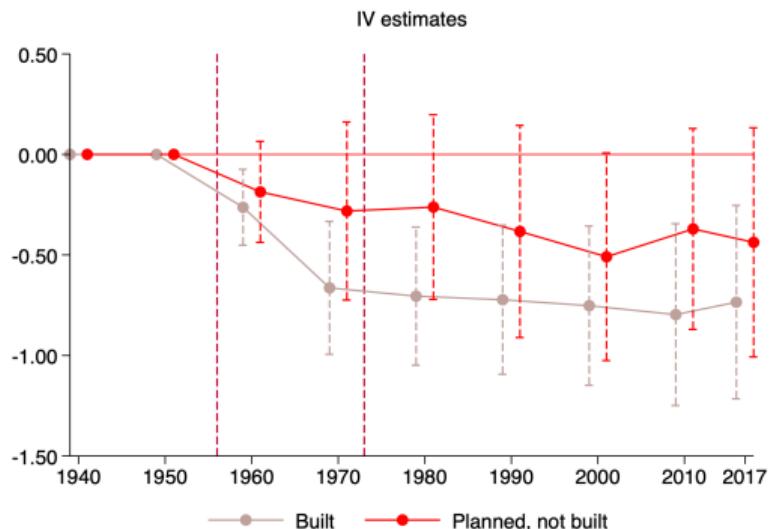
- 8-mi ring defines 2 predicted rays.
- Rural portion of ray 2 completed 1955, predicts **B** | Plan.
- Rural portion of ray 1 *not* completed by 1956, predicts **PNB** | Plan.
- **19 cities** have both early & delayed distant completions.



Rochester example

► Toledo and Houston

# IV estimates



Differences in 1970:

	PNB vs NP	B vs NP
Simple contrast	-10.0%	-17.6%
Regression adjustment	-7.2%	-12.8%
Matching	-7.4%	-13.3%
IV	-23.0%	-50.6%

- 2-step IV estimator. ➡ Wooldridge, 2010
- Instrumentation is strong. ( $F^B = 99$ ,  $F^{PNB} = 46$ )
- Larger IV estimates consistent with narrative, statistical evidence that highways planned & cancelled in neighborhoods expected to grow.