

# Expecting an Expressway

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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?

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

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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 & Externalities.
- **Forward-looking HHs → Self-fulfilling expectations:** Expected *future* decline in neighborhood QOL leads to neighborhood decline *today*.
- **Externalities → Path dependence:** Neighborhood 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 — when anything can happen!

## 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 — 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)

## Evidence

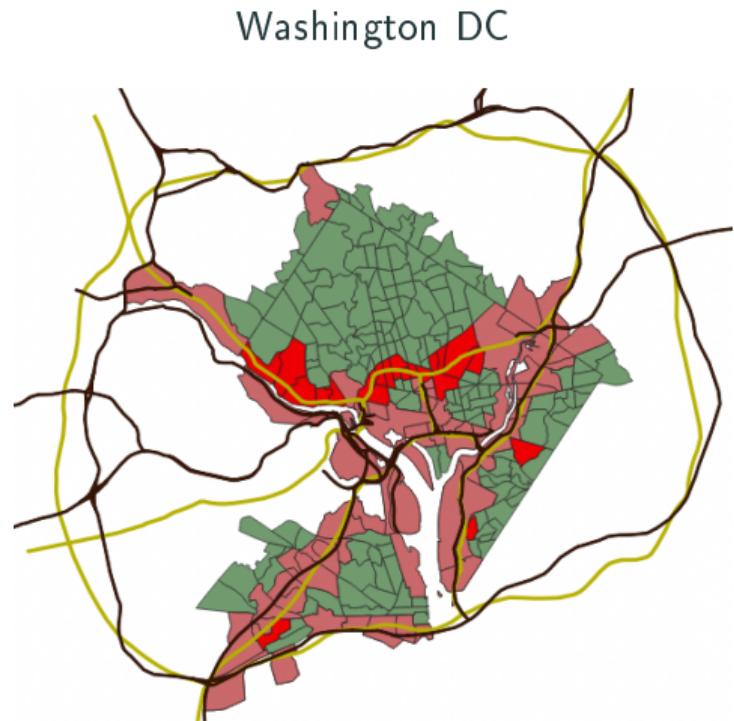
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## Data and sample selection

- Balanced panel of consistent-boundary census tracts, 1940–2010.
  - 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.

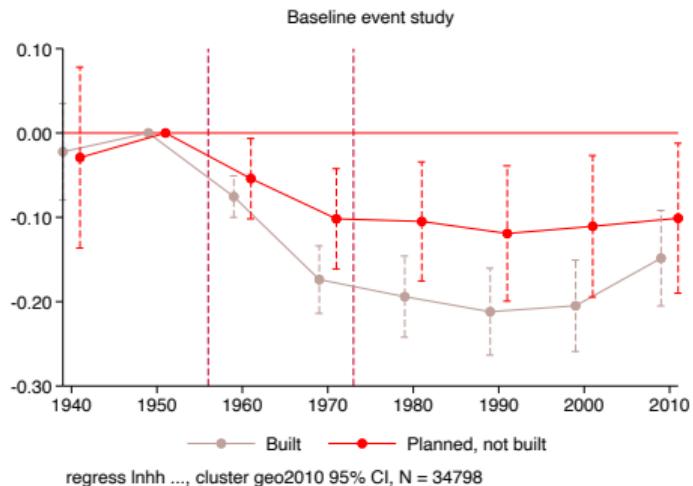
Use 4 strategies: Regression, matching on observables, IV, matched runner-up.

# Household population over time



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

# Event study estimates



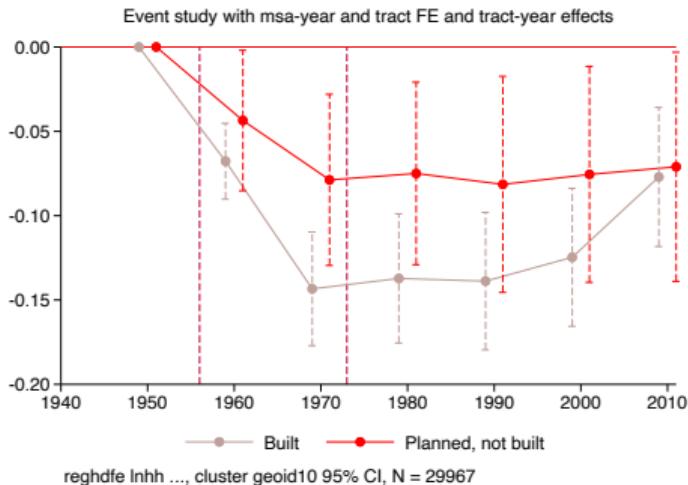
Differences in 1970:

SC	
PNB vs NP:	-9.7%
B vs NP:	-16.0%

Note:

- Pre-trends similar; [reversal of fortune](#).
- Decline persists after 1973, despite cancellations.

# Event study estimates with FE, natural & historical controls



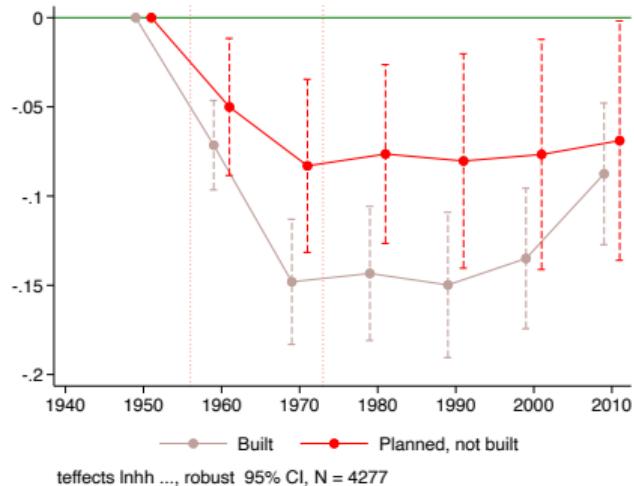
Differences in 1970:

	RA	SC
PNB vs NP:	-7.6%	-9.7%
B vs NP:	-13.6%	-16.0%

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 1970:

	IPWRA	RA	SC
PNB vs NP:	-8.0%	-7.6%	-9.7%
B vs NP:	-13.8%	-13.6%	-16.0%

Treatment factors: ▶ IPWRA ▶ overlap

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

## IV estimator

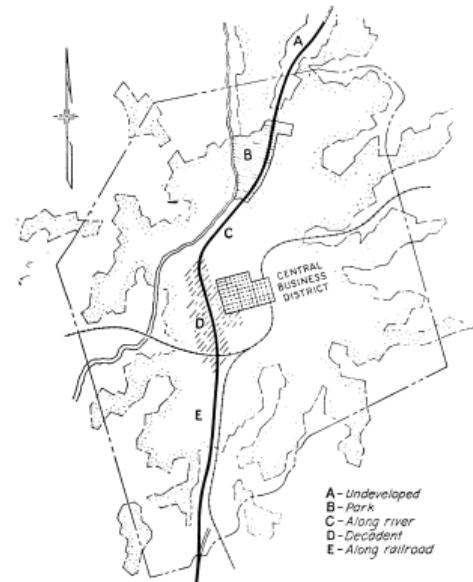
Remaining concern is that conditional ignorability of planning, cancellation is too strong an assumption.

- We need 2 instruments for 2 endogenous 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 [1].  Duranton & Turner, 2012
  - ▶ 1947 Inter-city plan routes [1].  Baum-Snow, 2007
  - ▶ Early and delayed distant connections [2] — **These are new**.

# Early distant completions

Early, rural highway construction affected cancellation.

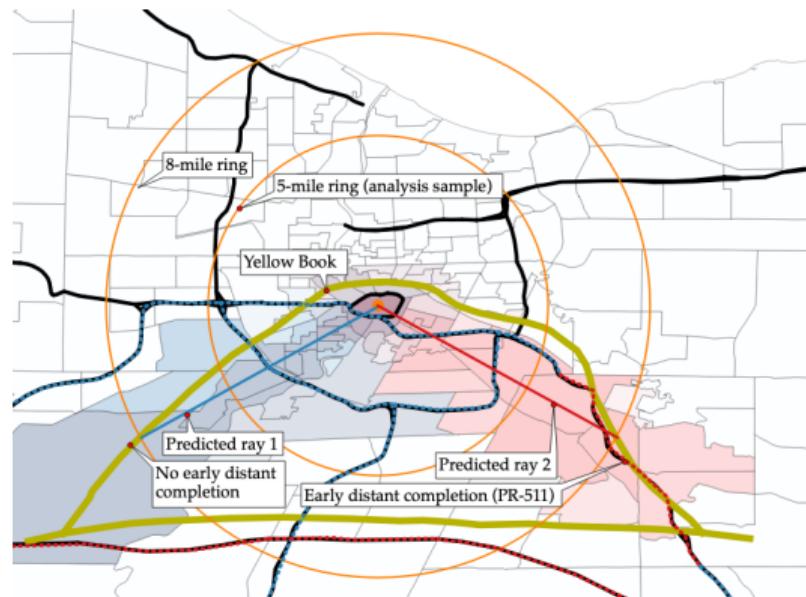
- Pre-1956 State routes were rural; no opposition.
- Which projects were started first often idiosyncratic; unrelated to central neighborhood factors. Johnson, 1965
- Design standards called for rays converging to CBD. →
- **Early distant completion** of rural rays (A) **reduced** likelihood that central 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

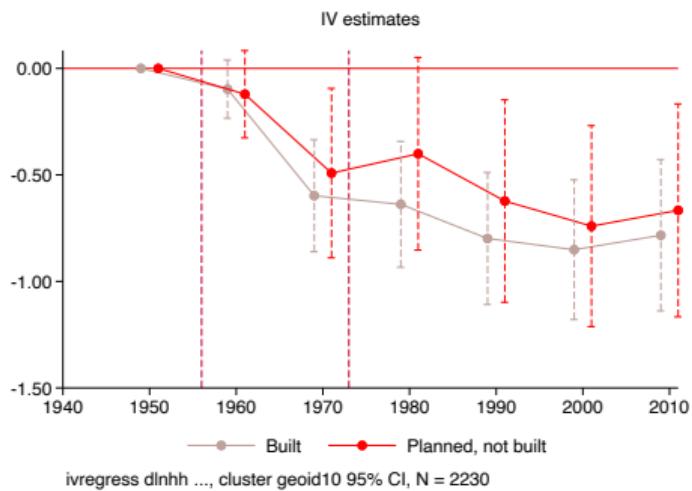
- 8-mi ring defines 2 predicted rays.
- Rural portion of ray 2 completed 1955, predicts **B** | Plan.
- Rural portion of ray 1 *not* completed by 1956, predicts **PNB** | Plan.
- **19 cities** have both early & delayed distant completions.



Rochester example

► Toledo and Houston

# IV estimates



Differences in 1970:

	IV	IPWRA	RA	SC
PNB vs NP:	-38.8%	-8.0%	-7.6%	-9.7%
B vs NP:	-45.0%	-13.8%	-13.6%	-16.0%

- 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.

# Other outcomes, robustness, and extensions

## Other outcomes:

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

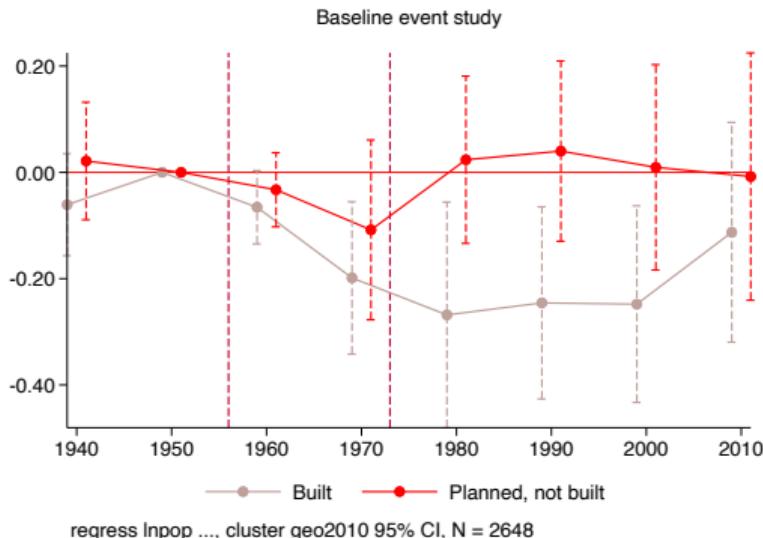
## Robustness:

- 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

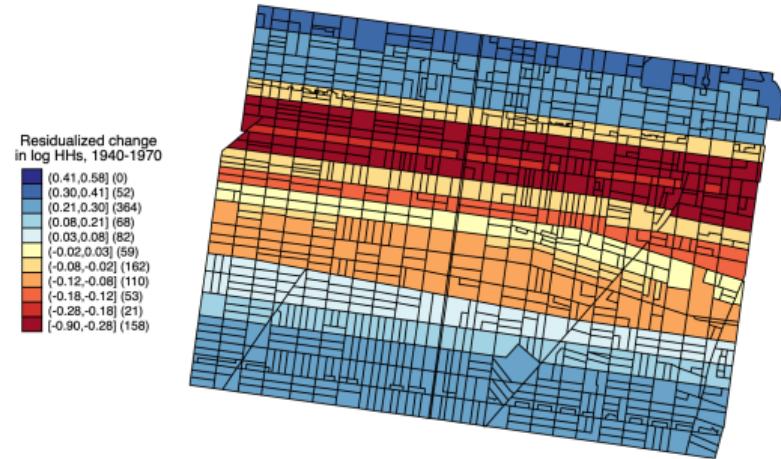


San Francisco and Baltimore were exceptional in that they had local control powers to stop highway construction.

- 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 trend.

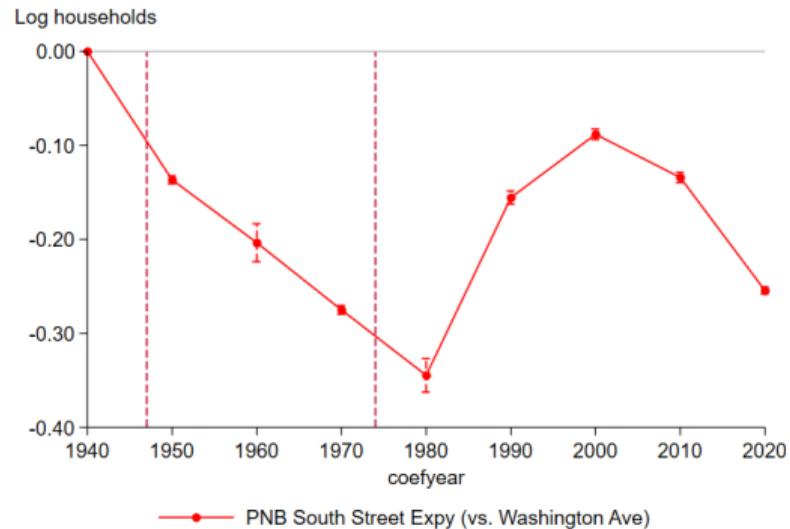
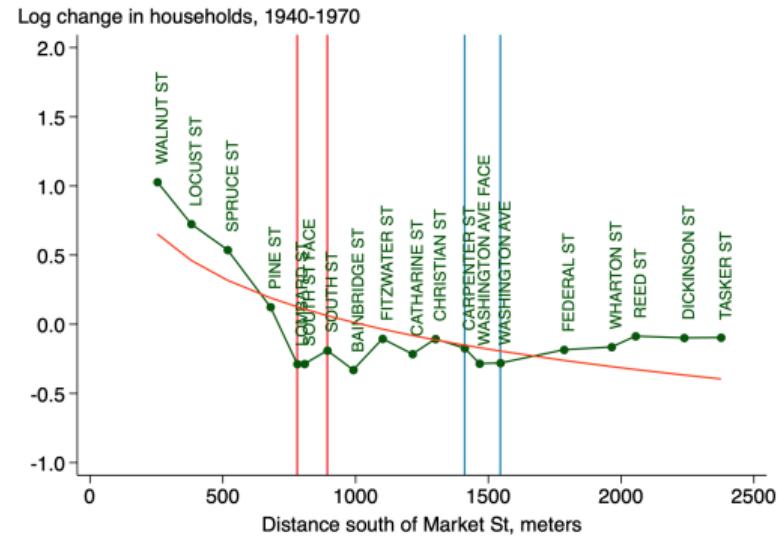
# Matched runner-up estimator

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



Sample area: Center City and South Philadelphia  
(Walnut–Tasker, 2nd–24th)

# Matched runner-up estimates



Estimated effect of PNB in 1970: -24.0%

## 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: A model to rationalize these results (and later, quantify parameters...)

Essential ingredients:

- Externalities
- Forward-looking households

Key results:

- 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.**  $p_j$ .
- Timing:
  - ▶ Initial allocation of population across neighborhoods.
  - ▶ Households choose location based on **expected** population  $\hat{p}_j$ .
  - ▶ Their choices determine **realized** population & next period's **initial** allocation.
- Equilibrium is fixed point in population,
  - ▶ i.e., when expected population = realized population.

## Value of a location depends on others' choices

... now and in the future. Value of a location  $j$  as viewed from  $k$  (at time of choice):

$$v_{j,k}(A_j^t, \hat{p}_j^t) = \underbrace{u(A_j^t, \hat{p}_j^t)}_{\text{flow util}} + \underbrace{c_{j,k}}_{\text{move cost}} + \beta \cdot \underbrace{V_j(A_j^t, \hat{p}_j^t)}_{\text{continuation value}} \quad (1)$$

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

$$u(A_j^t, \hat{p}_j^t) = A_j^t + \underbrace{u^-(\hat{p}_j^t)}_{\text{congestion}} + \underbrace{u^+(\hat{p}_j^t)}_{\text{agglomeration}}$$

Let's focus on **net agglomeration case**:  $u^- + u^+ > 0$ .

## Two-location model

Let's work with a simple example:

- 2 locations, 1 and 0.
- Closed economy with fixed population.
- Symmetric move costs.
- Symmetric exogenous amenities  $A_1 = A_2$  (for now).
- We'll study location 1 (WOLOG).

## Definition of equilibrium population

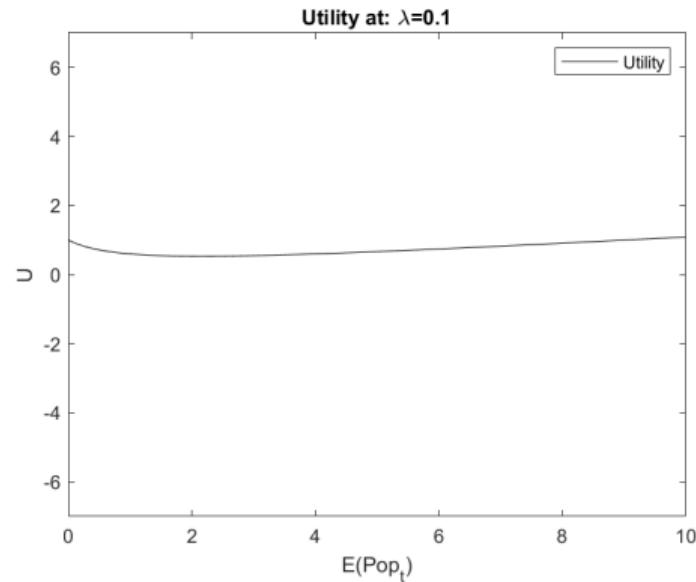
- Let choice probability from  $i$  to  $j$  be  $\sigma_{j,i}$ .
- Standard extreme value shocks (logit demand).
- Equilibrium population is fixed point:  $p_1^{*t} = \sigma_{1,0}(p_1^{*t}) p_0^{t-1} + \sigma_{1,1}(p_1^{*t}) p_1^{t-1}$ 
  - ▶ **Initial population allocations** affect the equilibrium allocation.

## Equilibrium under agglomeration

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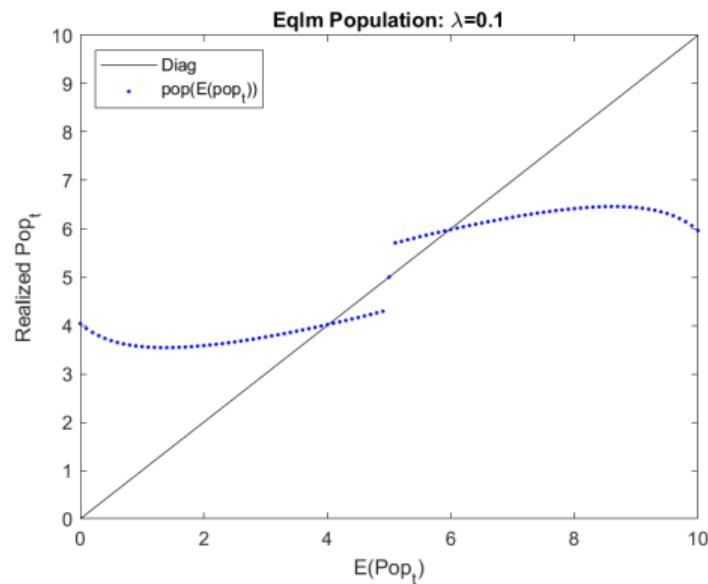
# Utility function slopes up

*Shape of utility under net agglomeration*



# Equilibrium population at given initial condition

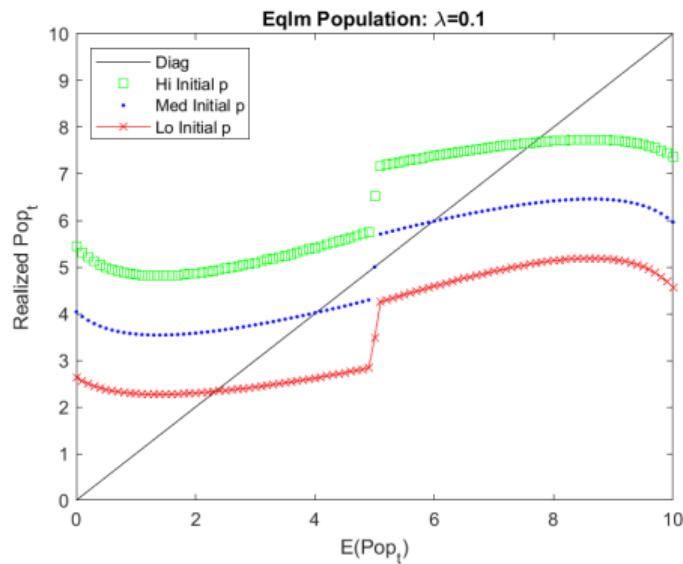
*Realized population as function of expected population*



Multiple intersections of diagonal → multiple equilibria.

# Equilibrium population, varying initial conditions

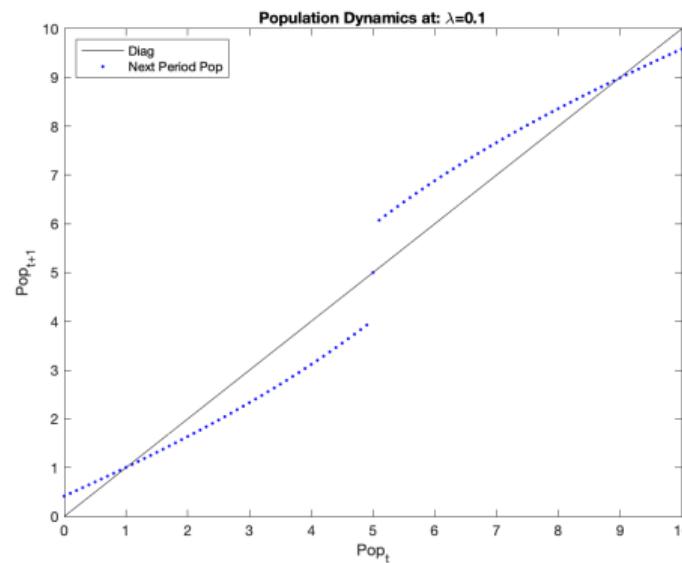
*Realized population as function of expected population*



Equilibrium configurations depend on initial population allocations.  
Some initial conditions reach multiple equilibria; some have only one.

# Equilibrium locus determines population dynamics

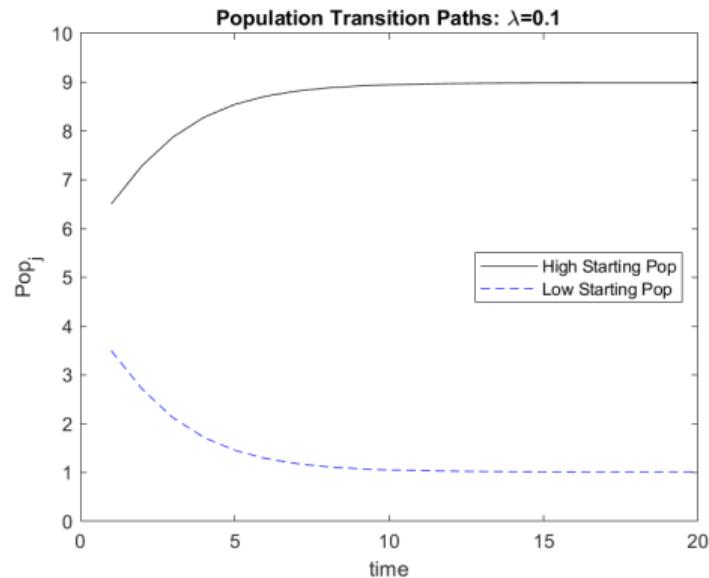
*Population transition function, t to t + 1*



There are multiple steady states in this scenario.

# Dynamics depend on initial conditions

*Population transition time series*



Population converges to nearest stable steady state.

## **Shock to future amenities**

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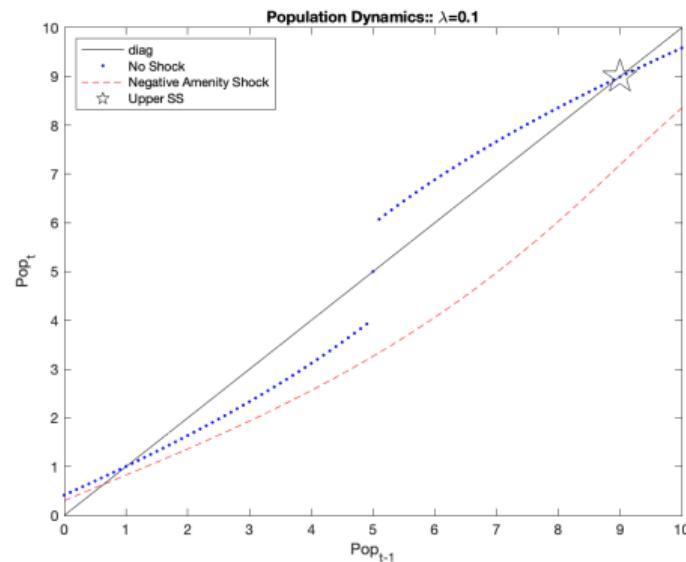
## Bad news shock

Starting from a high steady state population:

- Consider an announced **future negative shock**.
  - ▶ 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 on date  $t$  information.
  - ▶ Including their expectation of future population.
- In some cases, the shock is **cancelled** at  $t+s' < t+s$ .
  - ▶ But if  $s' > 0$ , households have begun acting on the news.

# Expected amenity shock affects dynamics

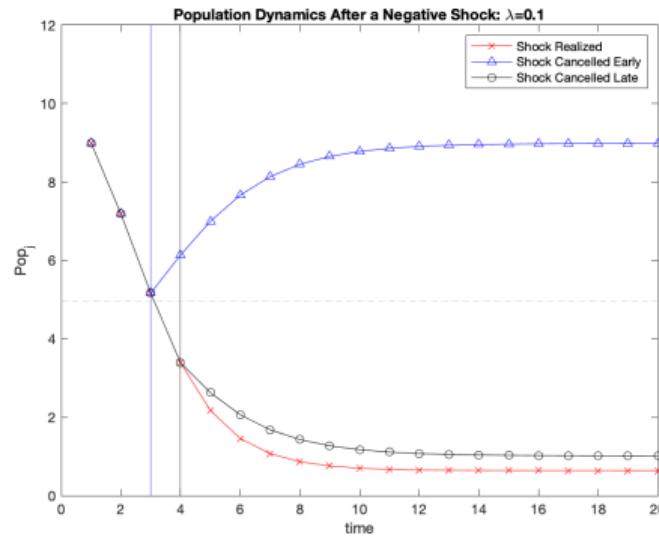
*Population Transition Function,  $t-1$  to  $t$ , with and without expected amenity shock*



After “bad news shock,” there is only one steady state, eliminating  $\star$ .

# Population dynamics after shock and cancellation

*Population dynamics under 3 cancellation scenarios*



Reversal depends on extent of transition: **permanent effects** of expectations shock  
Steady-state size: Cancelled early > Cancelled late > Shock realized.

## Summary of model results

- Externalities and forward-looking HHs → multiple equilibria and **multiple steady states** in spatial structure.
- Shocks to future fundamentals can alter the **number** and **location** of steady states.
- Implications:
  - ▶ Even **partial transitions** can alter the economy's point of convergence.
  - ▶ Consistent with the experience of expected expressways in U.S. cities.

## Conclusion

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## Summary and next steps

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

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

- Shocks to expectations can cause transition to a new steady state.

On the agenda:

- Housing investment in the data and the model.
- Quantifying externalities.

## 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.

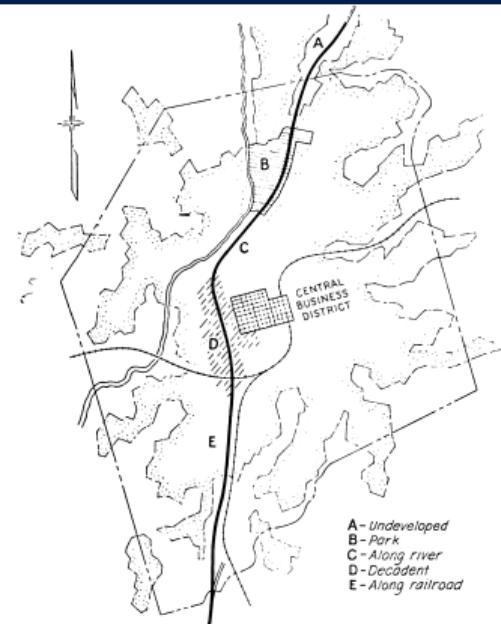
"Criteria for Selection of Interstate System Routes," testimony of CPR C.D. Curtiss, 4/15/1955.

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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  
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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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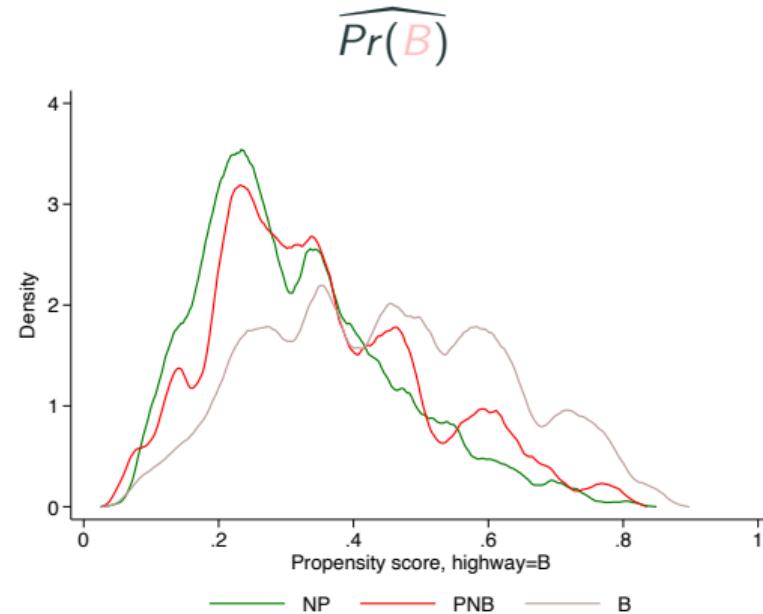
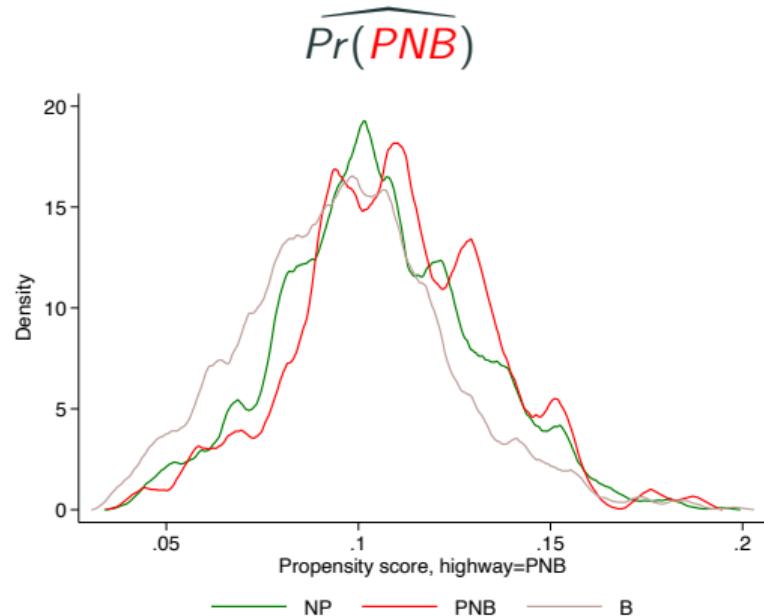
## Matching estimator

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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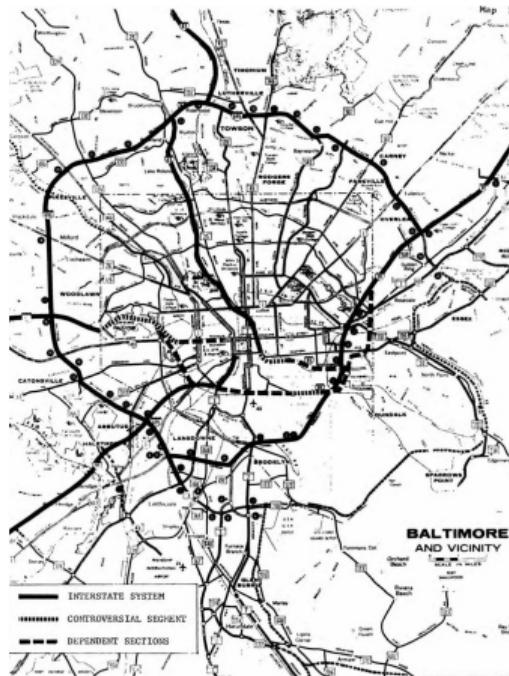
# Dependent segments

In 1970, FHWA produced a report on controversial urban Interstate segments.

Report distinguished controversial vs *dependent* segments.

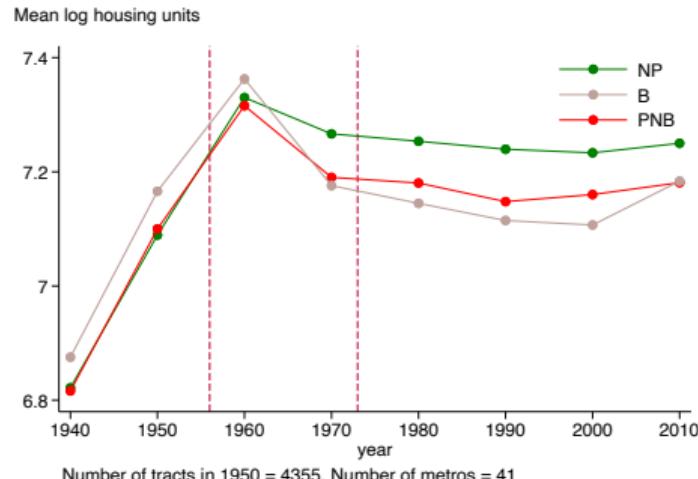
Dependent segments were not themselves controversial, but were likely to be cancelled if controversies were not resolved.

- ! Only 8 cities; mainly Baltimore, Boston, Cleveland, New York.



Baltimore controversies  
& dependent segments

# Housing units



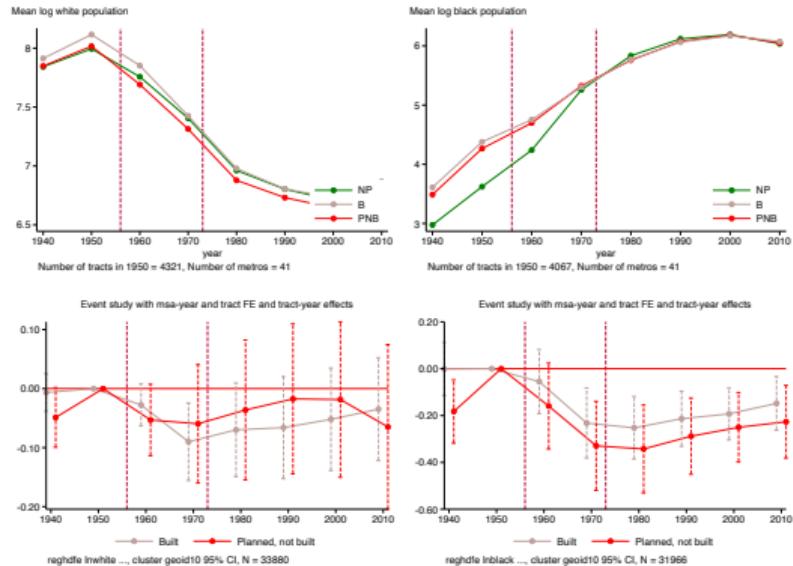
Evidence of substantial housing disinvestment.

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

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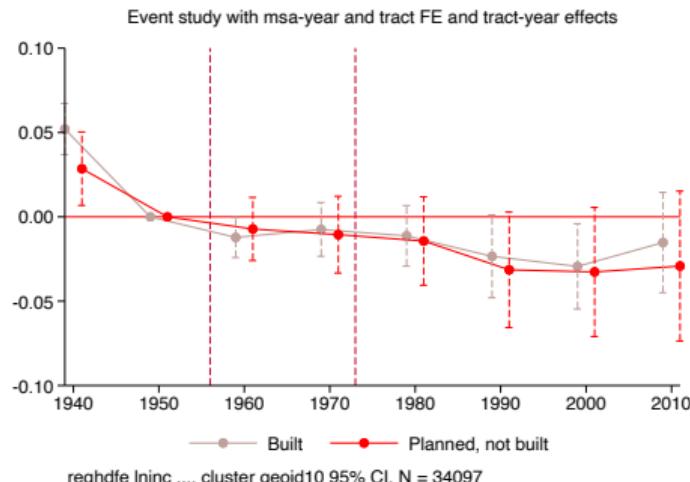
# Race

- 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

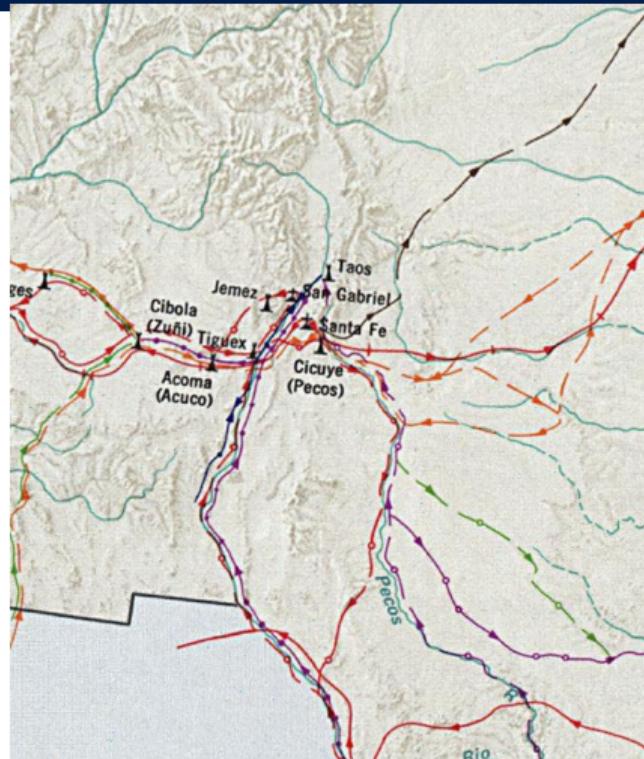


Modest and insignificant decline in income.

- Theory is ambiguous w/ multiple dimensions of heterogeneity.

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# Historical routes



Pre-1675 explorer routes near Santa Fe, NM

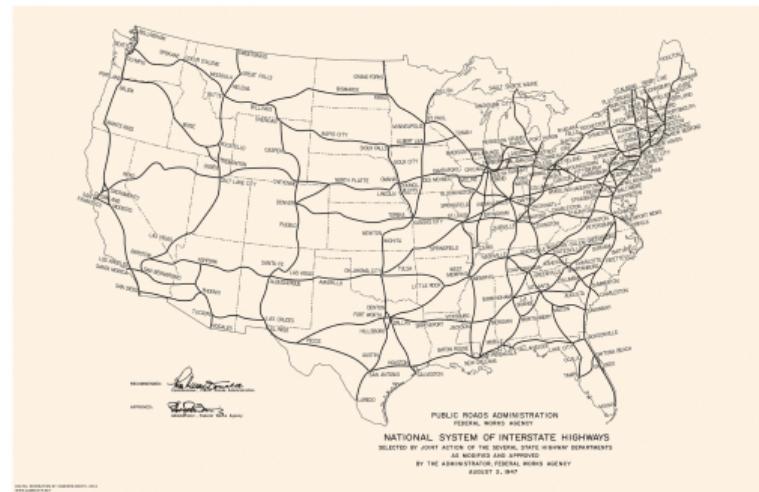
Least-cost routes based on obsolete topography + history dependence. Duranton & Turner, 2012

- 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.

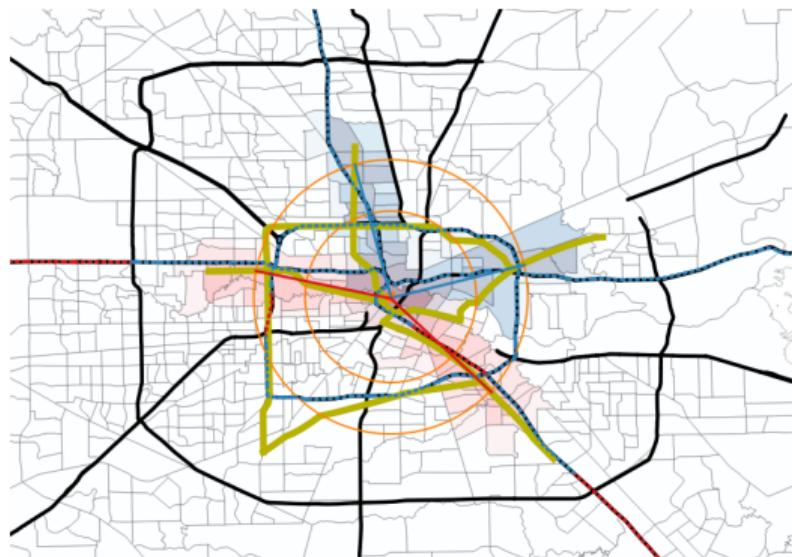
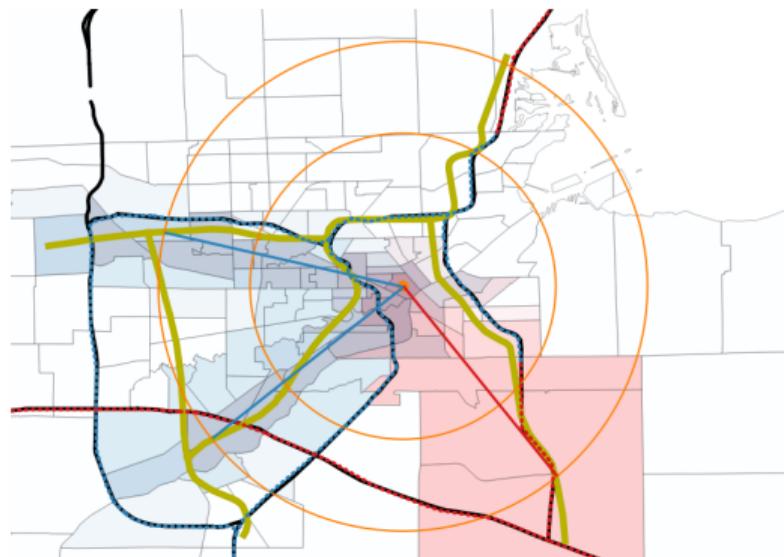
### San Francisco

- 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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