Expecting an Expressway

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What determines urban spatial structure?

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If spillovers $\rightarrow$ Future conditions depend on others' choices.

e.g., If everyone expects that a neighborhood will be attractive in the future because of its larger size $\rightarrow$ it will attract households today, proving expectations correct.

Our approach

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Our approach: Historical planned highway segments in US cities.

Broad support and few constraints in mid-1950s. Widely understood disamenities from noise, pollution, barrier effects. ▸ Details

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.

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

- Self-fulfilling expectations: Expected *future* decline in neighborhood QOL leads to neighborhood decline *today*.
- Strong externalities can lock in declines, even when expected decline in QOL is unrealized.

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Theory & evidence of self-fulfilling expectations in spatial structure

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

- Self-fulfilling expectations: Expected *future* decline in neighborhood QOL leads to neighborhood decline *today*.
- Strong externalities can lock in declines, even when expected decline in QOL is unrealized.

Evidence from 50 US central cities that planned highways caused decline & declines persisted after plans were canceled.

- Simple contrast, regression, matching, IV (dependent segments)

Why does this matter?

If expectations affect spatial structure, many outcomes are possible.

Krugman (1991), Bleakley & Lin (2012), Allen & Donaldson (2022).

Nature & history alone may not fully determine the future.

Evidence that expectations may play a decisive role in neighborhood development.

Owens, Rossi-Hansberg, & Sarte (2020), Hornbeck & Keniston (2017).

New channel through which highway planning may affect spatial structure.

Baum-Snow (2007), Duranton & Turner (2012), Brinkman & Lin (2022).

Model

Overview

Dynamic model of residential location choice with forward-looking households and local externalities.

Stylized, illustrative theory: Simplifying assumptions to deliver analytical expressions.

Goal (for now) is to develop testable implications and a framework for interpreting empirics.

Geography

Two neighborhoods, $j = 1, 2$.

Neighborhood amenity $A_{j,t} = a_{j,t} + \gamma N_{j,t}$.

- $a_{j,t}$ is *exogenous* component of amenity.
- $\gamma N_{j,t}$ is *endogenous* component of amenity.

Constant measure of $N = N_{1,t} + N_{2,t} = 1$ households.

Households and housing

Discounted lifetime utility for household in j at t:

$$V_{j,t} = \int_t^\infty e^{-(\beta+\eta)t}(A_{j,t} - R_{j,t})\,dt$$

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- Households exit and replaced exogenously at rate η.
- New households choose location, with perfect foresight.
- Households cannot move after they choose location.

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Housing is supplied elastically without adjustment costs.

- Rent depends on population according to:

$$R_{j,t} = \nu N_{j,t}$$

Steady-state equilibrium

Discounted lifetime utility for household in j at t:

$$V_{j,t} = \int_t^\infty e^{-(\beta+\eta)t} (\underbrace{a_{j,t} + \gamma N_{j,t}}_{A_{j,t}} - \underbrace{\nu N_{j,t}}_{R_{j,t}}) \, dt$$

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New HHs choose neighborhood 1 if $V_{1,t} - V_{2,t} > 0$, i.e.:

$$\int_t^\infty e^{-(\beta+\eta)t} [(a_1 - a_2) + (\gamma - \nu)(2N_{1,t} - 1)] \, dt > 0$$

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Suppose $a_1 > a_2$, i.e., $j = 1$ has persistent natural amenity advantage.
If $\gamma > \nu$, then a corner steady-state equilibrium exists where all HHs choose 1 for all t.

There may be multiple steady-state equilibria

For multiple steady states to exist, it must be that the endogenous amenity is strong enough to satisfy *both* $V_{1,t} > V_{2,t}$ & $V_{1,t} < V_{2,t}$.

$$\int_t^\infty e^{-(\beta+\eta)t}[(a_{1,t} - a_{2,t}) + (\gamma - \nu)(2N_{1,t} - 1)]\, dt \lessgtr 0$$

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$$\int_t^{\infty} e^{-(\beta+\eta)t}[(a_{1,t} - a_{2,t}) + (\gamma - \nu)(2N_{1,t} - 1)]\, dt \lessgtr 0$$

If $\gamma - \nu$ large vs. $a_{1,0} - a_{2,0}$, i.e.,

$$(\gamma - \nu)\frac{\beta}{\beta + 2\eta} > (a_{1,0} - a_{2,0}),$$

then (i) a steady-state equilibrium exists where all HHs choose 1 for all t
and (ii) a steady-state equilibrium exists where all HHs choose 2 for all t.

Transition dynamics: Effect of future shock

Under what conditions will HHs respond to future shock, before it is realized?

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Consider steady state with all HHs in 1 (ss_1) and $a_{1,0} > a_{2,0}$.

Negative shock announced for $t = T$, $a_{1,T} < a_{2,T}$.

Assume $ss_1 \to ss_2$ transition begins at $t = 0$, check consistency.

For all $t > 0$, new HHs choose 2 and population of 1 declines:

$$N_{1,t} = e^{-\eta t}$$

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Utility gap can be written as piecewise function for $t = 0$ to T:

$$U_{1,t} - U_{2,t} = (a_{1,0} - a_{2,0}) + (\gamma - \nu)(2e^{-\eta t} - 1)$$

and from $t = T$ to ∞:

$$U_{1,t} - U_{2,t} = (a_{1,T} - a_{2,T}) + (\gamma - \nu)(2e^{-\eta t} - 1)$$

Difference in value functions $(1-2)$ at the start of the transition:

$$DV_0 \equiv \frac{1}{\beta+\eta}\Big[\underbrace{(a_{1,0}-a_{2,0})(1-e^{-(\beta+\eta)T})}_{\text{Exogenous amenities before the shock}} + \underbrace{(a_{1,T}-a_{2,T})e^{-(\beta+\eta)T}}_{\text{Exogenous amenities after the shock}, <0} + \underbrace{(\gamma-\nu)\frac{\beta}{\beta+2\eta}}_{\text{Endogenous amenity from changing populations}}\Big]$$

This expression assumes $ss_1 \to ss_2$ transition begins at $t=0$. Need to check consistency w/ HH utility maximization, i.e. $DV_0 < 0$.

- If T such that:

$$(a_{2,T} - a_{1,T}) > (\gamma - \nu)\frac{\beta}{\beta + 2\eta}$$

$\rightarrow$ $DV_0 < 0$ and new HHs would begin choosing 2 at $t = 0 < T$.

i.e., If value of negative future shock exceeds positive current externality, then expectations about future amenities cause neighborhood change before the future shock.

Transition happens earlier (T larger) if:

- Announced exogenous amenity shock larger.
- HHs care more about future through lower β or η.
- Positive net externality $\gamma - \nu$ weaker.

History dependence after a cancelled shock

Suppose:

$(\gamma - \nu)\frac{\beta}{\beta+2\eta} > (a_{1,0} - a_{2,0})$, i.e., multiple s/s eq exist.

Negative shock *announced*, *transition begins*, shock *cancelled*.

Population of $j = 1$ at time of cancellation is:

$$N_{1,S} = e^{\eta S}$$

$S =$ time between start of transition, cancellation.

Derive DV at time of cancellation for two limiting cases.

If transition continues, new HHs choose 2, and:

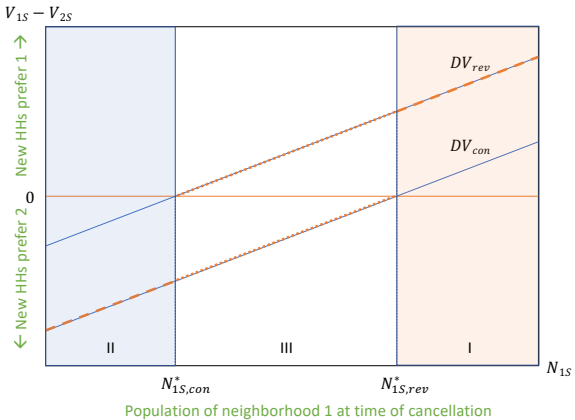
$$DV_{con} = \frac{1}{\beta + \eta}\left[(a_{1,0} - a_{2,0}) + (\gamma - \nu)\left(\frac{2(\beta+\eta)}{\beta + 2\eta}N_{1,S} - 1\right)\right]$$

If transition reverses, new HHs choose 1, and:

$$DV_{rev} = \frac{1}{\beta + \eta}\left[(a_{1,0} - a_{2,0}) + (\gamma - \nu)\left(\frac{2(\beta+\eta)}{\beta + 2\eta}N_{1,S} + \frac{\beta}{\beta + 2\eta}\right)\right]$$

- Both expressions are linear in $N_{1,S}$ and differ by only a constant; we can analyze dynamics graphically.

When does transition continue despite cancellation?



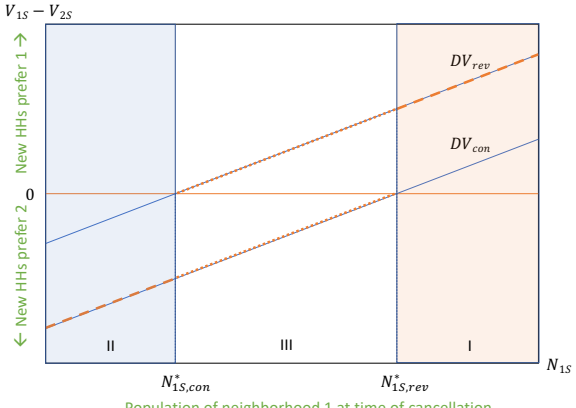
Case I.

DV_{rev} and $DV_{con} > 0$.

All households prefer 1.

$\rightarrow$ Only possible path is reversal back to ss_1.

If negative shock canceled quickly, or 1's population still large, then reversal to initial ss_1.



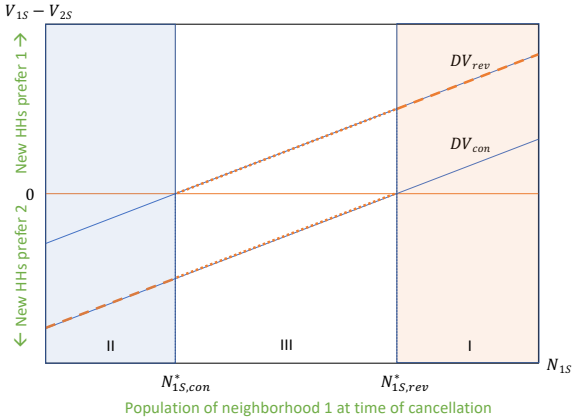
Case II.

DV_{rev} and $DV_{con} < 0$.

All households prefer 2.

$\rightarrow$ Only possible path is continue to new ss_2.

When externality large, and negative shock canceled late or 1's population small, then transition to ss_2 continues.



Case III.

$DV_{rev} > 0$ & $DV_{con} < 0$.

Reversal & continuation consistent w/ utility max.

If transition reverses, new HHs would choose 1.

If transition continues, new HHs would choose 2.

Uniqueness not a general feature of this type of model.

Summary of model predictions

If time elapsed is large between initial announcement of negative shock and cancellation, and externality is large relative to initial amenity difference,

then temporary negative shock to expectations $\rightarrow$ persistent neighborhood decline.

Data

Overview

Highway plans

- Digitized “Yellow Book,” 1955 — Brinkman & Lin, 2020
- First nat’l publication describing planned *intracity* routes.

Built highways

- National Highway Planning Network v14.05

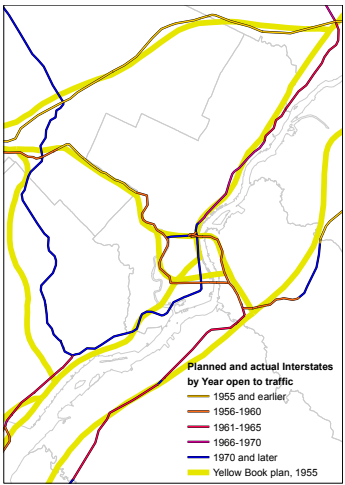
Consistent-boundary census tract panel database, 1940–2010

- Demographic and fixed characteristics. — Lee & Lin, 2018

Brief history of Interstate planning and construction

1910s	Earliest attempts to develop nat'l highway network. Patchwork of federal, state, and local planning.
1944	Congress authorizes Interstate system (but no $).
1955	BPR w/ state DOTs publish Yellow Book plans.
1956	Congress authorizes and funds Interstate system. State DOTs given wide latitude in implementation.
1965	$\approx 1/2$ of Interstate system completed.
1970	$\approx 3/4$ of Interstate system completed.
c.1970+	Policy reforms lead to cancellation of some segments.
1973	Revised Highway Act allows for de-designation of routes.
c.1980	Near-completion of Interstate system.

Yellow Book plans predict built highways



n.b. Other state & local plans

$\rightarrow$ YB is “fuzzy” treatment; likely some misclassification.

Empirics

Sample selection

Consistent-boundary census tracts, 1940–2010.

Tracts with 5 miles of city centers.

Consistent with net negative effects of highways.

Brinkman and Lin, 2019

Metropolitan areas with digitized Yellow Book plans.

Neighborhoods that expected highways.

→ ≈5,000 tracts in 50 metros that have YB *and* 1940 tract data.

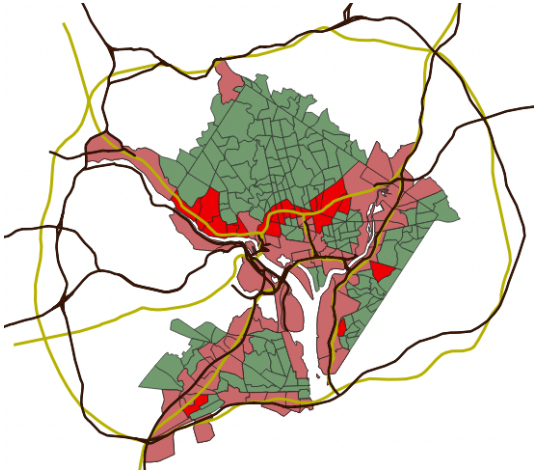
Treatment and comparison groups and example

Three mutually exclusive groups:

B "Built" — Highway intersects tract

PNB "Planned, Not Built" — YB plan intersects tract, but not built

NP "Not Planned" — Neither B nor PNB



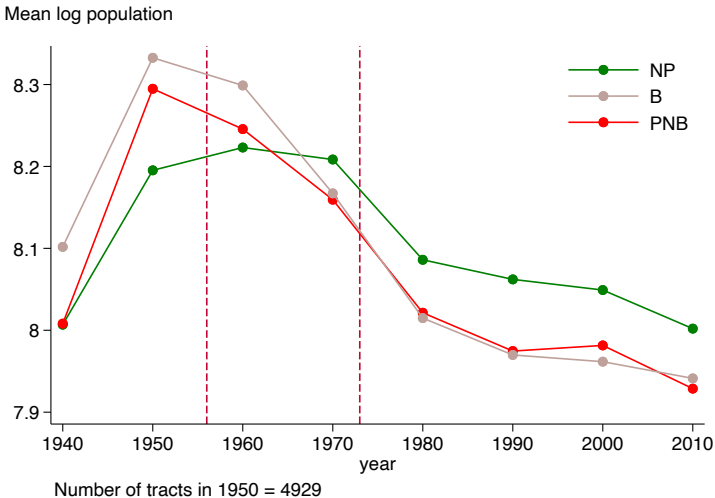
n.b. Analysis sample excludes tracts $>$ 5 miles from city center.

Highway treatment summary

	Freq.	Percent
NP	2,605	52.85%
PNB	508	10.31%
B	1,816	36.84%
Total	4,929	100.00%

n.b. Analysis sample excludes tracts $>$ 5 miles from city center.

Simple contrast

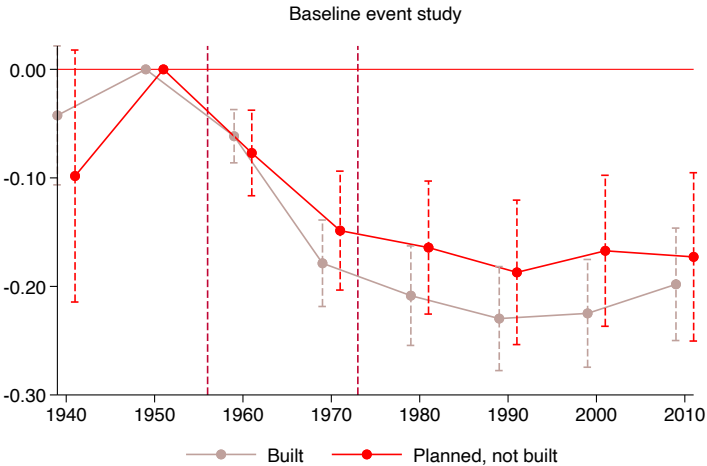


Average log population in each group and census year.

Similar dynamics across groups, growth then decline.

PNB and B initially more populous and decline more.

Event study



Regress log population of tract–year on highway treatments $\times$ year interactions.

Differences in 1970:
PNB -13.8% vs. NP.
B -16.4% vs. NP.

Declines persists through 2010.

Causal inference

Main concern is *negative* selection on growth factors into plan.

- Highways planned in nbhds expected to decline most.
- Highways cancelled in nbhds expected to decline the most, conditioned on plan.

But ...

- Pre-highway growth rates exhibit opposite ordering: PNB $>$ B $>$ NP (and > 0).
- Narrative evidence suggests positive selection into plan.
- Narrative and statistical evidence suggests cancellations in higher-SES neighborhoods.

Three strategies: (1) Control variables, (2) Matching, (3) Instrumental variables.

Historical evidence on planned route selection

Routes were favored that:

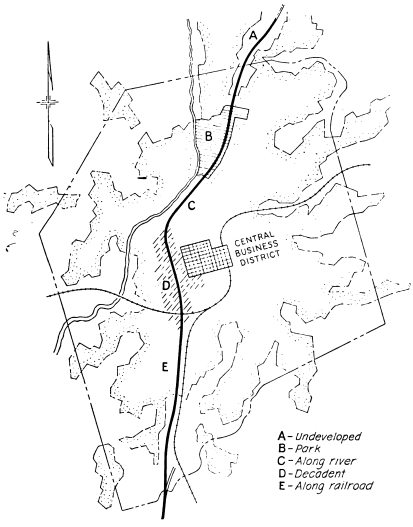
- Penetrated downtown or circumvented cities via beltway.
- Used undeveloped land.
- Linked to other modes such as rail stations and ports.
- Followed forecasted demand.
- Followed topography and physical features such as rivers.
- Were compatible with existing land use.
- National defense.

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

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

Historical evidence on canceled route selection

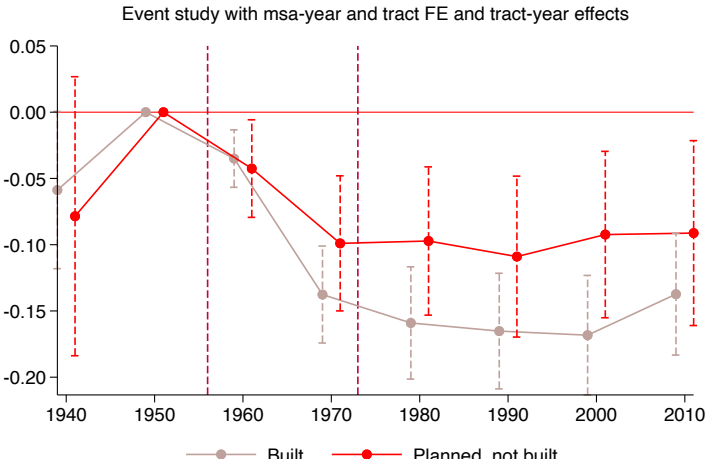
Vs. nbhds with built highways, nbhds with *unbuilt* YB plans:

- More educational attainment in 1950.
- Lower black share in 1950.
- Higher population density in 1950.
- Far from coastlines or rivers.

Brinkman & Lin, 2020

$\rightarrow$? Conditioned on plan, canceled routes might have been *negatively* selected on nbhd growth factors.

Event study with controls



Metro–year FE, tract FE, natural & historical factor×year effects.

e.g., coasts, lakes, rivers, hills, distance to city center.

Differences in 1970:

PNB -9.4% vs. NP.

B -12.9% vs. NP.

Matching estimates

IPWRA estimator using natural, historical and 1940 & 1950 demographics.

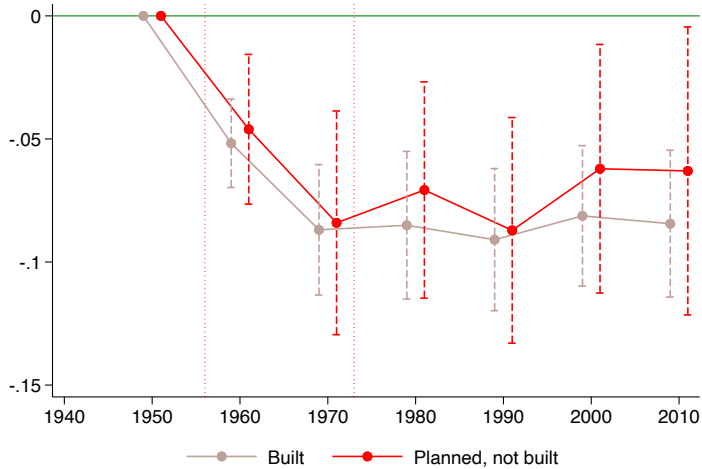
▸ Details

Quantitatively similar effects as simple contrast and event study.

By 1970,

PNB -8.2% vs. NP.

B -8.3% vs. NP.



IV estimator

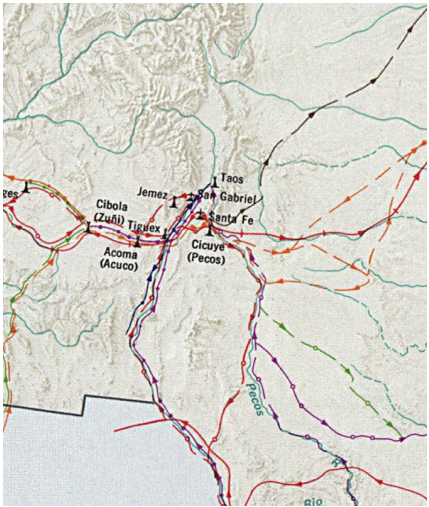
Remaining concern that ignorability of highway planning & construction conditioned on observables is *still* a strong assumption.

If we had valid IVs for PNB, B, we could estimate their (L)ATE under the (weaker) assumptions of IV.

We propose and use 2 types of IVs:

- Historical and planned *intercity* routes (4).
- Dependent segments (1) — This is new.

Historical routes



Pre-1675 explorer routes near Santa Fe, NM

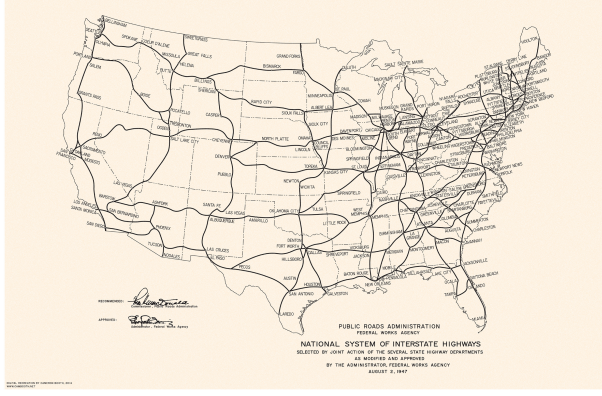
Pre-1898 rail and 16th-19th c. explorer routes. Duranton and Turner, 2012

Least-cost routes based on obsolete topography + history dependence.

Planned routes

1947 intercity plan. Baum-Snow, 2007

Planners connected distant cities for reasons of interregional trade and national defense.



1947 intercity plan

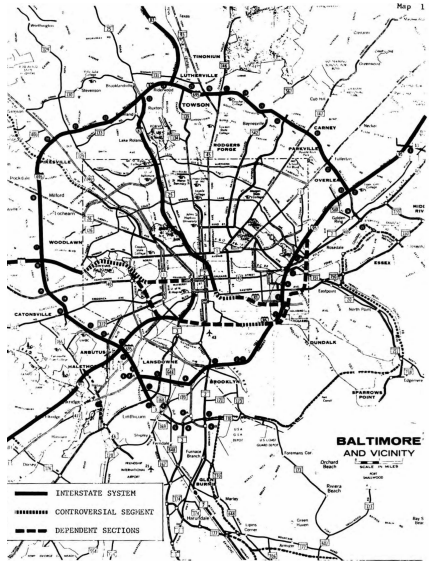
Dependent segments

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 4 cities (916 tracts) with dependent segments: Baltimore, Boston, Hartford, New York.



Baltimore controversies and dependent segments

IV estimates of PNB, B on log population

Differences in 1970:

PNB -42.7% vs. NP.

B -25.6% vs. NP.

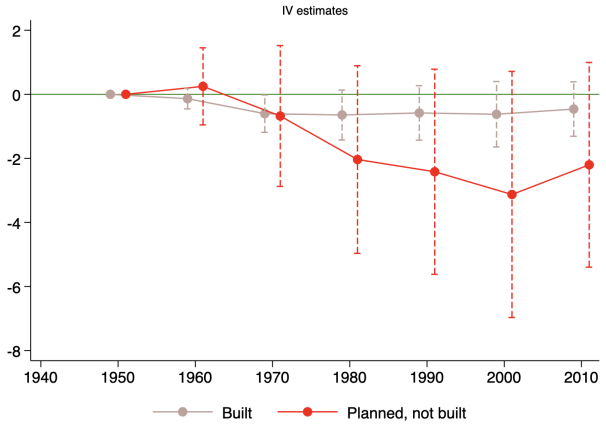
Larger than simple contrast, matching.

$\approx 2.5\times$ larger than ES in IV sample.

LATE? Compliers likely dense, developed neighborhoods.

Misclassification bias in OLS?

$\rightarrow$ Suggestive evidence that negative selection for cancellation is not a major concern.



Early Cancellation

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

San Francisco

- CA State law gave power to close roads to local government
- SF Board of Supervisors had veto power over freeway system

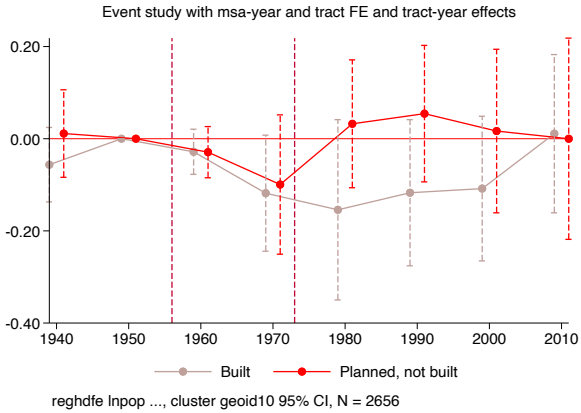
→ Board of Supervisors cancelled further highway construction in 1959

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 cancellation: No persistent effects



Differences in 1970 are similar, but PNB then returns to trend.

Summary of empirical results

Announced expressway construction led to significant *population declines* relative to unaffected neighborhoods.

- Even when expressways were not built!

Populations *did not recover*, even decades after cancellation.

- Except in cases where the highway plan was *cancelled early*.

Main margin affected was population, housing units.

- Effects on rents, income or sorting and segregation were more muted. ▸ Add'l outcomes

Conclusions

An expected large negative shock to neighborhood amenity can cause permanent decline, even if shock is never realized.

This result is consistent with forward-looking behavior and strong externalities in residential location choice.

→ Self-fulfilling expectations can shape city structure.

Next steps

More predictions — Planning timelines.

Exploring outcomes and mechanisms — housing disinvestment, rents, race, and income.

Quantifying the model; Estimating size of externality.

Improving IV inference.

Digitizing historical block statistics.

Case study of Crosstown Expressway, Philadelphia

1911	Earliest proposals selecting South St. alignment.
1953–1964	South St. alignment repeatedly approved. State completes engineering, surveying studies.
1964–1967	Opposition first emerges and organizes.
1967	Mayor announces opposition.
1968	City deletes South St. from plan. State continues work.
1973	MPO deletes South St. from plan.
1974	State DOT deletes South St. from plan.
1977	South St. cancellation leads to cancellation of dependent segments.

Timing of expectations:

1953 latest date when plan was widely known.

1967 earliest date when completion might have been in doubt.

Thus, South St Expwy was expected for 14–63 years.

Historical background

Back to approach

Broad consensus behind 1956 Federal-Aid Highway Act.

In 1956, certainty that planned Interstates would be completed.

Urban highways caused big declines in local QOL. Brinkman & Lin 2019

By early 1970s, policy reforms allowed cancellation of *some* plans.

Consensus and certainty

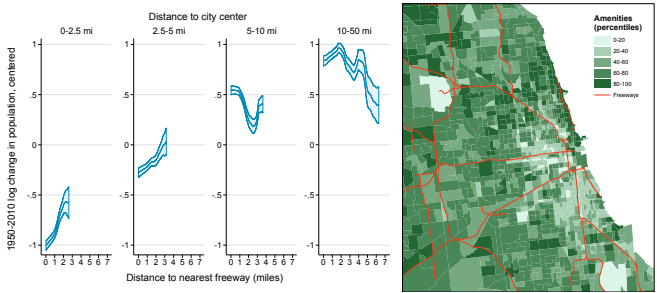
Consensus and growing federal support up to 1956. DiMento & Ellis, 2013

- "Parkway ambience" in concepts by Le Corbusier et al.
- State highway officials had only rural experience.
- Mumford on highways: "beneficent liberators of urban dwellers."
- City planners, mayors thought freeways would revive downtowns.

Aggressive timeline; Funding window was 41K miles by 1969.

- State DOTs faced few constraints, little opposition, and
- "believed they had to finish the entire mileage within the 13-year funding framework. No one anticipated the urban battles ahead"

Negative quality of life effects



Brinkman & Lin (2019) find large negative effects of urban Interstates on population, income, prices. A highway reduces neighborhood amenity by $\approx \frac{3}{4}$ of one standard deviation.

Results consistent with large negative QOL effects exceeding modest accessibility benefits in central cities.

Households learned quickly (freeway revolts in 50+ cities).

By 1970s, reforms led to some cancellation of some plans

1958	At least 1 public hearing, economic impact study.
1962	"Local cooperation."
1966	Oversight by new DOT. Environmental protection. Historical preservation.
1967	First Transportation Sec'y Alan Boyd became "most effective national spokesman for the freeway revolt." Mohl, 2004
1968	More environmental and historical regulation. Relocation assistance & replacement housing.
1970	More environmental regulation. More relocation assistance.
1973	De-designation of 190 planned miles. Exchange federal funds for other transp. projects.

Source: DiMento & Ellis, 2013

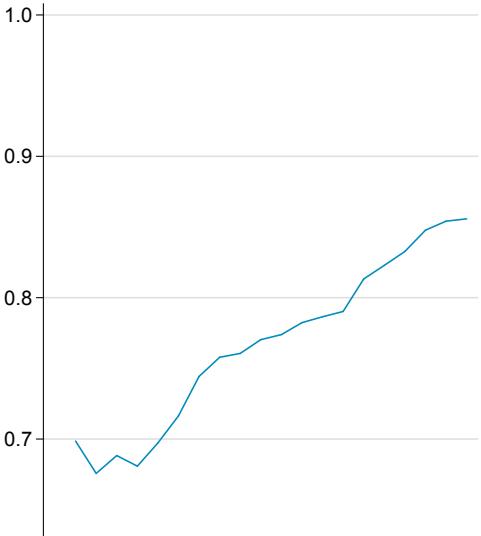
Cancellations a surprise, from perspective of HHs, planners in 1956.

By 1970, three-quarters of system had already been completed.

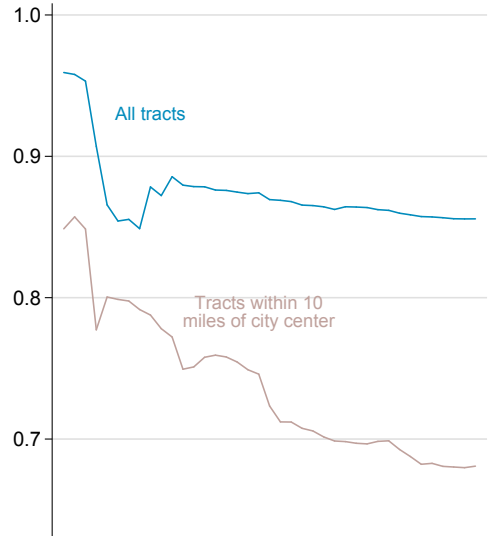
Some potentially exogenous variation from *dependent segments*.

Plan deviations downtown, later construction

Correlation between distance to nearest 1955 plan freeway and distance to nearest built Interstate



Correlation between distance to nearest 1955 plan freeway and distance to nearest built Interstate



IPWRA estimator

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Estimator of multi-level treatment effects that combines matching and regression. Wooldridge, 2007; Cattaneo, 2010

(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.

IPWRA estimator

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(1) Estimate probability of treatment h conditioned on W.

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$\widehat{ATE}$ 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.

X and W

Land area

Distance to city center

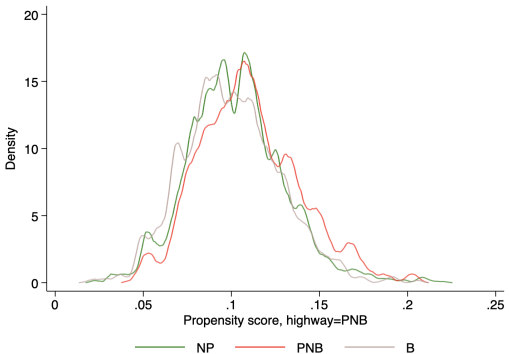
Natural amenities (coastline, rivers, slope, etc.)

Log population in 1940 and 1950

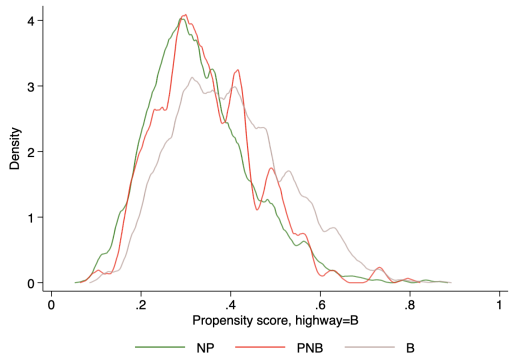
Demographics in 1940 and 1950

Good overlap: PNB, B similar to NP $|W$

$\widehat{Pr(PNB)}$



$\widehat{Pr(B)}$



Other Outcomes

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