Commuting, Labor, & Housing Market Effects of Mass Transportation: Welfare and Identification

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Question: What are the welfare effects of urban rail infrastructure in car-oriented Los Angeles?

1. Establish the causal effect of rail infrastructure on commuting flows between locations connected by LA Metro

2. Develop and estimate parameters of (relatively) simple quantitative, spatial GE model of internal city structure
   - Novel identification for elasticities (common in urban EG lit)
   - Disentangle commuting effect of transit from other margins

3. Quantify welfare effects of rail infrastructure in Los Angeles
   - After 10 years: Clean answer, costs > benefits
   - After 25 years: More speculative, still costs > benefits

+ Assess common methods/assumptions in urban economic geography
   - Differences between commuting and trade

Why transit infrastructure?

Rail systems seen as beneficial, but expensive **policy option**

- Light rail is 10-20x cost of roadway, subway is 30-100x
- Large US cities on a transit building spree!
- US cities not dense, less monocentric (Anas, Arnott, Small 1998)

Households care: high commuting costs limit residential/job access

- Households spend 10-15% of income & 220 hrs/yr commuting
- Increasing congestion (commutes times up 230% since 1985)

Transportation infrastructure in the aggregate

- Trade between cities & growth (Fogel 1964; Donaldson 2018)
- Commuting within cities, urban form, neighborhood growth (Bento et al. 2003; Gibbons & Machin 2005; Gonzalez-Navarro & Turner 2016)
- Ease congestion, but Fundamental Law of Congestion –
- So transit improves cities by allowing more people to fit in

Transit and commuting in LA

Setting: Los Angeles in 1990 and 2000

- No rail $\rightarrow$ 47 stations on 4 lines by 2000
- Historically automobile-oriented

Data: Census Transportation Planning Package (1990, 2000)

- Develop **panel** of all **bilateral commuting flows** for LA (tract-tract)
- Median wage at place (tract) of work

Other data sources

- Housing and population variables (IPUMS)
- LEHD LODES for more recent commuting (not directly comparable to CTPP)

Standardize to 1990 geographies to minimize information loss

Identification of commuting effect

$$\ln(N_{ijt}) = \delta_{it} + \delta_{jt} + \delta_{ij} + \boldsymbol{\lambda} T_{ijt} + \varepsilon_{ijt}$$

Gravity style diff-in-diff isolates **commuting effect** of transit

- Origin-by-year, Destination-by-year fixed effects
  - Capture non-commuting effects of transit (i.e. amenities)
  - Control for standard concerns about location selection
- Pair-fixed effects capture time-invariant chars., like distance

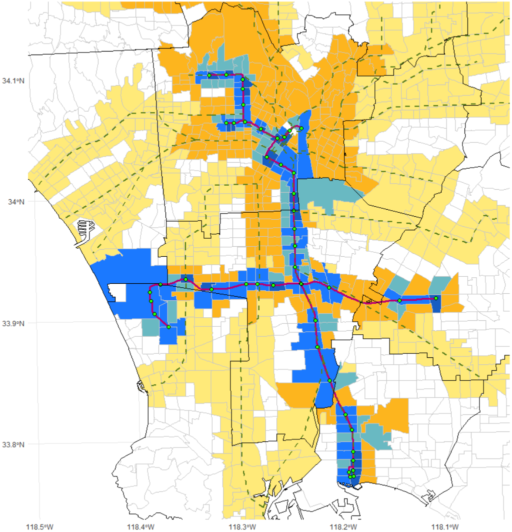
Identification: parallel counterfactual trends in commuting flows between treated pairs & control pairs

- Use proposed subway plan (1925); streetcar routes (PER)
- Lower bound by adjacencies (Dube, Lester, & Reich 2010), adapted for flows

Identification of commuting effect

Arguments:

- Staggered rollout based on political expediency
- Inconsequential units along routes
- Geologic shock: Ross Dress for Less blew up!
- Similar evolution of built environment (Brooks & Lutz 2016)



Pre-trends? Cannot directly test, but

- Mostly (not perfectly) parallel pre-trends in residential commuting (tracts, not tract pairs – NCDB)

Effects of stations on commuting flows; 1990–2000

	(1)	(2)	(3)	(4)	(5)
Subway Plan (All) Sample					
O & D contain station	0.127**	0.147**	0.152**	0.162**	0.146**
	(0.044)	(0.044)	(0.044)	(0.046)	(0.044)
O & D <250m from station			0.115*	0.122*	0.101*
			(0.049)	(0.050)	(0.051)
O & D <500m from station		0.054	0.018	0.023	0.013
		(0.035)	(0.044)	(0.042)	(0.042)
N	74046	74046	74046	74040	74040
Tract Pair FE	Y	Y	Y	Y	Y
POW-X-Yr FE	Y	Y	Y	Y	Y
RES-X-Yr FE	Y	Y	Y	Y	Y
Sbcty-X-Sbcty-X-Yr FE	-	-	-	Y	Y
Highway Control	-	-	-	-	Y

Metro **increases commuting by 15% (10%)** between connected tracts

- Consistent across various strategies & functional form (PPML)

Toward welfare? Model summary

To translate into welfare, turn to **quantitative, spatial GE model**

- HH dual location choice (similar to Ahlfeldt et al. 2015)
- **Bonus 1!** Generates reduced form commuting flow equation
- **Bonus 2!** Can test for other margins of effects from subway

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Generate within city Rosen-Roback model with commuting

- Simple, competitive labor and housing markets in each location
- Frechet-distributed idiosyncratic preference over locations pairs

Labor $$\underbrace{\ln(W_{jt})}_{\text{Wage}} = \tilde{\alpha} \ln\left(\sum_r N_{rjt}\right) + \underbrace{\ln(A_{jt})}_{\text{Productivity}}$$

Housing $$\underbrace{\ln(Q_{it})}_{\text{H. Price}} = \psi \ln\left(\sum_s N_{ist}\right) + \underbrace{\ln(C_{it})}_{\text{H. Eff.}}$$

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$$\text{Labor} \quad \underbrace{\ln(W_{jt})}_{\text{Wage}} = \tilde{\alpha} \ln\left(\textstyle\sum_r N_{rjt}\right) + \underbrace{\ln(A_{jt})}_{\text{Productivity}}$$

$$\text{Commut.} \quad \underbrace{\ln(N_{ijt})}_{\text{Flow}} = \epsilon \ln(W_{jt}) + \epsilon\tilde{\zeta} \ln(Q_{it}) + \epsilon\kappa\tau_{ijt} + \underbrace{\ln(B_{it}E_{jt}D_{ijt})}_{\text{Amenities}}$$

$$\text{Housing} \quad \underbrace{\ln(Q_{it})}_{\text{H. Price}} = \psi \ln\left(\textstyle\sum_s N_{ist}\right) + \underbrace{\ln(C_{it})}_{\text{H. Eff.}}$$

Identification

ϵ is key: *Location preference homogeneity* $\equiv$ ***Local labor supply elast.***

- Existing estimates use cross-sectional variation or calibrate (ARSW 2015; Monte, Redding, & Rossi-Hansberg 2018; Allen, Arkolakis, & Li 2018)
- Model (or parameter) dependent identification

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Two special ingredients here:

1. Panel of **average wage at place of work**
2. Employment by industry at place of work

$\Rightarrow$ Tract-of-work based shift-share instrument (**local** Bartik variant)

- Standard approach takes wage as D-by-year FE; performs poorly
- Here, much less reliance on Frechet commuting behavior

IV identification of ϵ: labor supply & pref. homogeneity

$\mathbb{E}[\Delta z_{jt} \cdot \Delta \ln(E_{jt})] = 0, \ \forall j$

- Changes in non-pecuniary workplace amenity orthogonal to shock

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Flexible assumption, as compared with literature

- Weaker assumption than standard city-level Bartik
- Permits variation in workplace amenities (unlike ARSW)
- Does not require correct travel costs (unlike AAL, ARSW, MRR-H)
- Does not condition on model components being correct (unlike MRR-H)

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$\hat{\epsilon} = 1.83^{*}$ (± 0.78)

- Locations decisions heterogeneous and sticky even within cities
  - Conditions on residential structure of city and commuting
- Smaller than cross-sectional trade-style estimates (~ 6.7)
- More in line with LS elasticity (Falch 2010; Suarez Serrato & Zidar 2014)

Bonus! Interact with geography to plausibly identify **all elasticities**!

Labor Demand Shock

Tract A: Tech Companies

- Exogenous shift in Labor Demand
- Traces out ***Labor Supply***
- Exogenous driver of Δ pop/wage

spatial decay

Tract B: Clothing Factories

- Relative wage/pop decreases
- Exogenous shift in Labor Supply
- Traces out ***Labor Demand***

spatial decay

Tract H: Residential

Work in A

- Exogenous shift in Housing Demand
- Traces out ***Housing Supply***
- Decreases available housing at each price

Work in B

- Exogenous shift to Housing Supply
- Traces out ***Housing Demand***

Other elasticities IV estimates

$\mathbb{E}[\Delta z_{jt} \cdot \Delta \ln(C_{it})] = 0, \ \forall i \neq j$: housing supply

- Local adaptation of Saiz (2010); Guerrieri, Hartley, Hurst (2013)

$1/\hat{\psi} \approx 0.62^{**}$ (± 0.17): Housing supply elasticity

- Less elastic than longer run median across US cities (Saiz 2010)
- CA has inelastic housing supply (Quigley & Raphael 2005)

Reasonable estimates for other elasticities

$\mathbb{E}[\Delta z_{j't} \cdot \Delta \ln(B_{it} D_{ijt})] = 0, \ \forall ij' \neq ij$: housing demand

$\mathbb{E}[\Delta z_{j't} \cdot \Delta \ln(A_{jt})] = 0, \ \forall j' \neq j$: labor demand

Welfare effects in GE

Model suggests structural interpretation of residuals:

- Define Proximity$_{it} \in [0, 1]$, so $0 \rightarrow$ station > 500m away
- Estimate the effect of transit on these primitives, e.g.

$$\widehat{\ln(B_{it})} = \lambda^B \text{Proximity}_{it} + \delta_i + \varepsilon_{it}^B$$

No evidence of non-commuting effects

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No evidence of non-commuting effects

Some evidence of **small decreases** in automobile commute times for routes $\leq$2km from stations, no effect $\in (2, 4]$ km out

- Can include in welfare calcs (given κ) to provide bounds

Use structural effects $\{\lambda^A, \lambda^B, \lambda^C, \lambda^D, \lambda^E\}$ and elasticities (LS, LD, HS, HD) to simulate counterfactual model and determine welfare

- ϵ key to valuation

Welfare effects of system in 2000 (in \$2016)

	(1)	(2)	(3)	(4)
Parameters				
α	0.680	0.680	0.680	0.680
ϵ	1.830	1.830	1.830	1.830
ζ	0.650	0.650	0.650	0.650
ψ	1.693	1.693	2.290	2.290
$\epsilon\kappa$	-	-0.020	-	-0.020
Change in fundamentals				
λ^D, O & D contain station	0.146	0.146	0.146	0.146
λ^D, O & D <250m from station	0.101	0.101	0.101	0.101
λ^τ, O & D <2km from station	-	-0.033	-	-0.033
Closed Economy				
Annual Δ in welfare	0.051%	0.069%	0.051%	0.069%
(in millions of \$2016)	108.9	145.7	108.9	145.6
Open Economy				
Population Δ	0.109%	0.146%	0.106%	0.141%
Op. subsidy + capital cost (6%, 30yy)	-\$797 mil.			
Op. subsidy + capital cost (5%, 50yr)	-\$641 mil.			
Op. subsidy + capital cost (5%, ∞)	-\$597 mil.			
Op. subsidy + capital cost (2.5%, ∞)	-\$380 mil.			
Operation subsidy only	-\$162 mil.			

Welfare effects of system, other margins

Benefits $<$ Costs

Other margins?

- If Fundamental Law of Congestion doesn't take hold (or slow):
  - Air pollution benefits, roughly ~\$182 million per year (using generous estimates from Gendron-Carrier et al. 2018)
  - Congestion benefits already incorporated, though I find/use smaller κ than (Anderson 2014)
- Non-rail or non-commuter benefits
  - Equity: Unemployed/injured? Elderly/school
  - Better bus integration and service
  - Other trips?
- Dynamics: adjustment might be slower than decadal
  - Challenge to measuring: (i) data changed, (ii) network grew
  - Best attempt at this, assuming all changes due to habituation, yields additional ~\$70 million per year by 2015

Evaluating some assumptions in the new urban EG literature

1. How well do standard implementations of "market access" reflect observed commuting behavior?
   - Modeled commuting ignores persistent, pair-specific factors
   - Market access terms indicate smoother geography and interventions
2. Are measures of gravity reasonable?
3. How do model-derived wages accord with observed wages?
   - Not very well
   - Model-derived wages actually reflect population

Market Access

How does market access compare with direct commuting flow measure?

- Define relative change in accessibility from residential places

$$\Delta CF = \frac{\sum_s N_{is}}{\sum_s (1-\lambda^D T_{is}) N_{is}} - 1 \ , \quad \Delta MA = \frac{\sum_s e^{-\tilde{\kappa}\tau_{is}} Y_s}{\sum_s e^{-\tilde{\kappa}\tau_{is}} (1-\lambda^D T_{is}) Y_s} - 1$$

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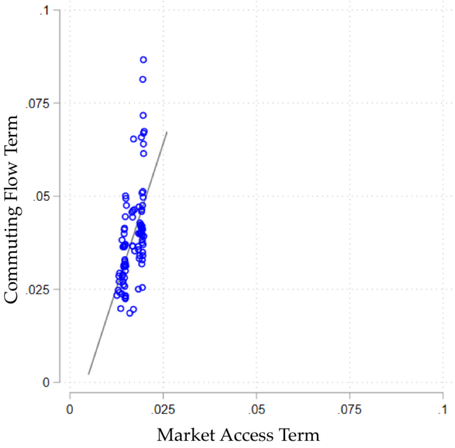

Benefits of CF terms:

1. No need to know $\tilde{\kappa}$ or τ
2. Preserves heterogeneity; idiosyncratic factors (besides distance) determine commuting
3. "**Observed**" accessibility

Benefits of MA terms:

1. Can scrape/model travel time data
2. Smooths spatial economy, like spatial weights? (Sp. E/metrics)
3. "**Potential**" accessibility

Gravity and $\epsilon\kappa$

Consider panel gravity equation:

$$\ln(N_{ijt}) = \theta_{it} + \omega_{jt} + \delta_{ij} - \tilde{\kappa}\tau_{ijt} + u_{ijt}$$

1. R^2 without δ_{ij} is 0.20, R^2 with δ_{ij} 0.80
   - Time-invariant characteristics of pairs $\gg$ changes in travel time
2. Now run (1) excluding τ_{ijt} and estimate δ_{ij}

$$\hat{\delta}_{ij} = \alpha - \tilde{\kappa}\tau_{ij} + u_{ij}$$

   - $R^2 \approx 0.20$, travel time $\ll$ time-invariant determinants of flows

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Different estimates of $-\tilde{\kappa}$:

LA 1-yr	LA Panel	**LA 2-step**	ARSW Gravity	ARSW GMM	MRR-H
-0.053	0.000	**-0.024**	-0.077	-0.099	≈ -0.1
(0.002)	(0.000)	**(0.001)**	(0.003)	(0.002)	

Model wages vs. observed wages

(Step 1) $$\ln(N_{ij}) = \omega_j + \theta_i - \epsilon\kappa\tau_{ij} + d_{ij}$$

(Step 2: Standard) $$\omega_j = \epsilon w_j$$

(Step 2: Here) $$\omega_{jt} = \epsilon w_{jt} + e_{jt}$$
$$0 = \mathbb{E}[\Delta z_{jt} \cdot \Delta \ln(E_{jt})]$$

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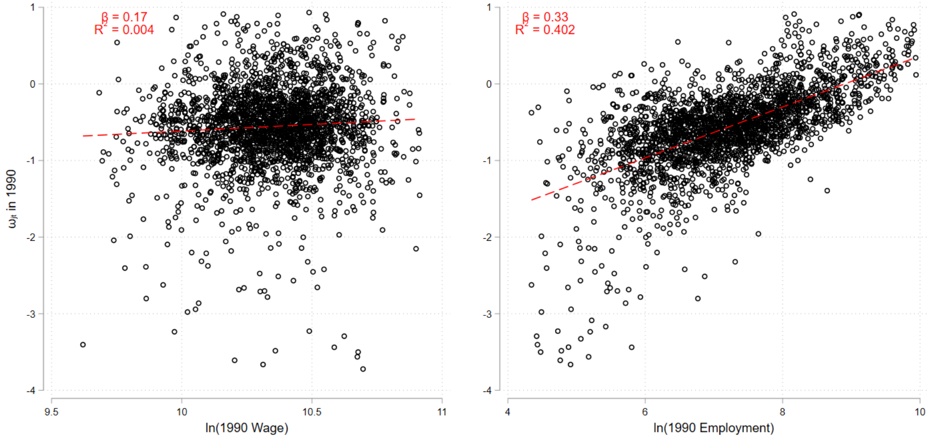

Summary

Develop new data sources to estimate effects of LA Metro:

- **Positive** effect on commuting between connected tracts
- Little adjustment on other margins

Carefully identify elasticities that populate econ. geo. model

- New identification strategy based on tract-level shift-share instrument
- Local stickiness, limited mobility even within city
- Permits more retention of unmodeled heterogeneity

Calculate welfare benefits of LA Metro

- Significant benefits, but **costs are larger**
- Even after 25 years...

Critically examine urban EG modeling

Thank you

Metro Rail & Busway
metro.net
SAN FERNANDO VALLEY
SAN GABRIEL VALLEY
CENTRAL LA
WESTSIDE
DOWNTOWN LA
EASTSIDE
SOUTH LA
SOUTH BAY
GATEWAY CITIES
Chatsworth
Nordhoff
Roscoe
Sherman Way
Warner Ctr
Canoga
De Soto
Pierce College
Tampa
Reseda
Balboa
Woodley
Sepulveda
Van Nuys
Woodman
Valley College
Laurel Canyon
North Hollywood
Universal City/Studio City
Hollywood/Highland
Hollywood/Vine
Hollywood/Western
Vermont/Sunset
Vermont/Santa Monica
Vermont/Beverly
Wilshire/Vermont
Wilshire/Western
Wilshire/Normandie
Westlake/MacArthur Park
7th St/Metro Ctr
Pershing Square
Civic Ctr/Grand Park
Union Station
Little Tokyo/Arts Dist
Pico/Aliso
Mariachi Plaza
Soto
Indiana
Maravilla
East LA Civic Ctr
Atlantic
Chinatown
Lincoln/Cypress
Heritage Sq
Southwest Museum
Highland Park
South Pasadena
Fillmore
Del Mar
Memorial Park
Lake
Allen
Sierra Madre Villa
Arcadia
Monrovia
Duarte/City of Hope
Irwindale
Azusa Downtown
APU/Citrus College
LAC+USC Medical Ctr
Cal State LA
El Monte
Downtown Santa Monica
17th St/SMC
26th St/Bergamot
Expo/Bundy
Expo/Sepulveda
Westwood/Rancho Park
Palms
Culver City
La Cienega/Jefferson
Expo/La Brea
Farmdale
Expo/Crenshaw
Expo/Western
Expo/Vermont
Expo Park/USC
Jefferson/USC
LATTC/Ortho Institute
Pico
Grand/LATTC
San Pedro St
37th St/USC
Washington
Vernon
Slauson
Florence
Manchester
Firestone
103rd St/Watts Towers
Willowbrook/Rosa Parks
Compton
Artesia
Del Amo
Wardlow
Willow St
Pacific Coast Hwy
Anaheim St
Pacific Av
5th St
1st St
Downtown Long Beach
Harbor Gateway Transit Ctr
Rosecrans
Carson
Pacific Coast Hwy
San Pedro
LAX
Mariposa
El Segundo
Douglas
Redondo Beach
Aviation/LAX
Hawthorne/Lennox
Crenshaw
Vermont/Athens
Harbor Fwy
Avalon
Long Beach Bl
Lakewood Bl
Norwalk
N
Rail Station
Transfer Station
Busway Station
Busway Street Service
Metro Rail
Red Line
North Hollywood to Union Station
Purple Line
Wilshire/Western to Union Station
Blue Line
Downtown LA to Long Beach
Expo Line
Downtown LA to Santa Monica
Green Line
Redondo Beach to Norwalk
Gold Line
East Los Angeles to Azusa
Metro Busway
Orange Line
Chatsworth to North Hollywood
Silver Line
Regional Rail
Amtrak
Metrolink
Airport Shuttle
LAX FlyAway
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