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

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September 27, 2018

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

Why transit infrastructure?

Important **economic consequences**

- 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)

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)

Rail is 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!
  - Federal funding and agency?
- US cities not dense, less monocentric (Anas, Arnott, Small 1998)

Measuring the benefits of transit, I. Hedonics

Large literature studies indirect effects of commuting technology

- Housing/land prices, density, local income
- Hedonic DiD usually finds transit premium (Ahlfeldt 2009; Baum-Snow & Kahn 2005; Bowes & Ihlenfeldt 2001; Chen & Walley 2012; Gibbons & Machin 2005)

Does not *directly* accounted for commuting

i) Agents make joint decision on where to live and work
ii) Commuting can shift multiple channels (local characteristics)
   - Price effects cannot differentiate
iii) General equilibrium effects
   - Even untreated locations are influenced

Measuring the benefits of transit, II. Market Access

Recent rise in quantitative spatial equilibrium models with city

- Effect at i is weighted average of change in travel time from ij and characteristics of j
- Can be implemented with (relatively) little data (Ahlfeldt, Redding, Sturm, Wolf 2015; Donaldson & Hornbeck 2016; Tsivanidis 2018)

Very (too?) model dependent for evaluation:

i) Model 'market access' rather than commuting
    - Commuting usually is not measured well; use single travel survey to calibrate spatial model

ii) Recover wages at place of work from commuting flows
    - Bake in size/centrality

iii) Borrows parameters from trade literature

This paper

1. Bring **new data** to bear on this topic
   - Panel of census of commuting flows between tracts
   - Average wage at place of work

2. Provide first direct evidence of **transit's effect on commuting**
   - Use panel data design with historical data to select controls

3. Describe relatively simple quantitative **spatial GE model** of city structure

4. Develop new **identification strategy** for key structural parameters
   - Parameters are common in new urban EG literature
   - Clarify use of Bartik shocks within city

5. Calculate welfare: Does transit pass a **cost-benefit** test?

Summary of Results

Transit increases **commuting flows** between connected tracts by 6-13%

There is a lot of **heterogeneity** in where people want to live

- The world is lumpy even after controlling for geography
- Transit impacts correspond to large utility gains

Little evidence of non-commuting effects

Transit is **not cost-effective** after first decade or two, but may become cost-effective over **longer horizons**

1. Data and setting
2. Transit's effect on commuting flows (gravity)
3. Quantitative urban model with commuting
4. Structural identification and estimated elasticities
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Data

- Census Transportation Planning Package (1990, 2000)
  - Tract-to-tract commuter flows (large data)
  - Median wage at POW, employment by industry at POW

    CTPP vs. LEHD LODES
  - Perform geonormalization, 2000 data $\rightarrow$ 1990 geographies

    Additional Data Notes
- Other data sources:
  - LEHD LODES (2002, 2015)
  - NHGIS (1970 - 2000: housing values, covariates)
  - IPUMS (wage shocks, aggregate statistics)
  - SCAG (misc. GIS data, zoning, land use)
  - LACMTA (transportation data)
  - Historical document: Kelker, De Leuw and Company (1925)

    Comprehensive Rapid Transit Plan for the City and County of Los Angeles

Transit and commuting in LA

- **1963** Last LA area street/trolleycar shuts down
- **1990** LACMTA Blue line opens (July, downtown 1991)
- **1993** LACMTA Red line opens
- **1995** LACMTA Green line opens
- **1996** LACMTA Red line expands
- **1999** LACMTA Red line expands
- **2000** Total: 3(4) lines, 47 stations
- **2015** Total: 6 lines, 81 stations

Southern CA very automobile oriented

- Most commuting done via private automobile; difficult to reach many important locations without car

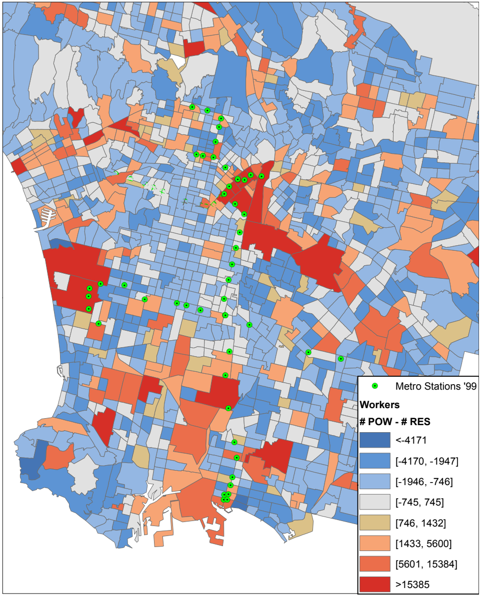
Descriptive statistics (1990)

	LA County		Full Sample	
	Centroid $< 500m$ (1)	Any $< 500m$ (2)	Centroid $< 500m$ (3)	Any $< 500m$ (4)
% workers receiving transit at POW	11.3%	20.7%	7.2%	13.1%
% workers receiving transit at RES	2.7%	8.1%	1.6%	4.8%
% workers receiving transit at RES&POW	0.6%	3.1%	0.4%	1.7%
% workers commuting via: Drive alone	71.8%		74.5%	
% workers commuting via: Carpool	15.8%		15.8%	
% workers commuting via: Bus	6.9%		4.6%	

POW tract of work; RES tract of residence; [1] CTPP; [2] Census Microdata

Mobility (Census Mobility Report 1995)

- Moving hazard rate (annual): 0.16
- Moving hazard rate in West (annual): 0.21
- Portion of movers that move within county, West: 69%



Map shows net commuting:

$$\begin{array}{rr} & \text{Workers at POW} \\ - & \text{Workers at RES} \\ \hline & \text{Net Commuting} \end{array}$$

Note: Full sample includes five counties

- Los Angeles
- Orange
- Riverside
- San Bernardino
- Ventura

Weekday Ridership (2000): 139k

▸ Stats & Ridership

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Transit and commuting flows

Approach: Estimate reduced form effect from bilateral commuting flows (gravity)

- Difference-in-difference strategy
- High-dimensional fixed effects

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

Treatment: Pairs of census tracts that each near LA Metro by 1999

- Narrow: Tract centroids $\leq$ 500m from station
- Broad: Any part of tract $\leq$ 500m from station

Control: Use planned transit routes to select

- Supplement with regional trends, controls for highway proximity

Transit and commuting flows: controls

Use tracts near lines from Kelker/De Leuw Plan (1925)

- Defeated because skepticism over private mgmt (Fogelson 1967)

Goal: pick out tract pairs that are not (yet) treated for exogenous reasons

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1. Planned routes follow historic streetcars routes
   - Similar historical evolution of land use near street car lines
2. Metro built first routes for political expediency
   - First lines/stations easiest ROW or control
   - Many control locations became treated post-2000
3. Methane explosion in 1985 limits Red/Purple line growth westward
   - Basement of a Ross Dress for Less store
4. Inconsequential units – incidentially untreated

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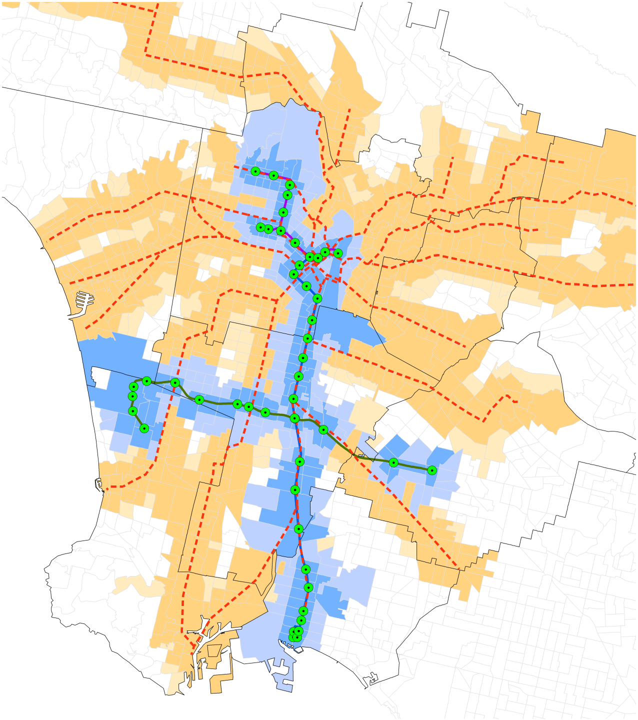
Alternative 1: tracts near old PER trolley lines

- Path dependence through institutions, zoning (Brooks & Lutz 2016)

Alternative 2: Tracts adjacent to treated tracts provide lower bound (Dube, Lester, Reich 2010)



Effects of stations; 1990–2000

	1925 Plan Sample				
	n_{ijt} (1)	n_{ijt} (2)	n_{ijt} (3)	n_{ijt} (4)	n_{ijt} (5)
A. Narrow treatment definition					
1[Transit]	0.102*	0.138*	0.138*	0.126*	0.135*
	(0.049)	(0.055)	(0.055)	(0.055)	(0.055)
B. Broad treatment definition					
1[Transit]	0.044^{+}	0.065*	0.065*	0.047	0.058^{+}
	(0.025)	(0.031)	(0.031)	(0.032)	(0.033)
Tract Pair FE	Y	Y	Y	Y	Y
POW- & RES-X-Yr FE	Y	Y	Y	Y	Y Y
Travel Time	-	-	Y	Y	Y
Highway Control	-	-	-	Y	Y
Sbcty-X-Sbcty-X-Yr FE	-	-	-	-	Y
N	291,000	49,996	49,996	49,996	49,992

Metro **increases commuting by 13%** between connected tracts by 2000

- PER lines generates similar estimates
- Adjacency exercise: lower bound is 0.08

Contrast with market access approach

Market access

1. Model change in *travel time* using ArcGIS
2. Estimate travel costs (κ) from travel survey
3. Multiply by characteristics of destination
4. Sum over destinations

Measuring

- Access to potential markets
- Without travel costs, flat world

My approach

1-4. Estimate change in commuting flows

Measuring

- Commuting flows
- Lumpiness in travel behavior

Is this a big difference?

Contrast with market access approach

Consider panel gravity equation:

$$\ln(n_{ijt}) = \alpha + \xi_{ij} + \xi_{jt} + \delta_{ij} - \kappa t_{ijt} + u_{ijt}$$

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 t_{ijt} and estimate δ_{ij}

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

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

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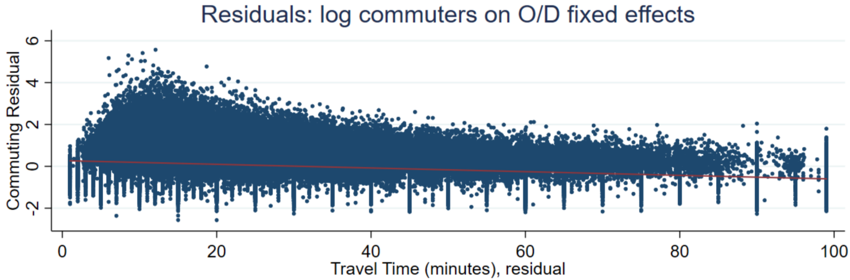

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What about welfare? Model summary

To translate into welfare, need **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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Locations: N locations (census tracts) in city

- Each containing a labor market, and a housing market
- Described by exogenous S&D primitives

Agents: Three types of agents (all massless)

- Workers/HHs: decide where to live and where to work
- Firms: hire workers
- Builders: use land & materials to produce housing

Model: Household problem

HH ω choose place of residence (work) i (j), consumption, and housing:

$$\max_{\mathcal{C},H,ij} \frac{\nu_{ij\omega}}{\delta_{ij}} \left(\frac{\mathcal{C}}{\zeta}\right)^{\zeta} \left(\frac{H}{1-\zeta}\right)^{1-\zeta} \quad \text{s.t.} \quad \mathcal{C} + Q_i H = W_j$$

Idiosyncratic preference for location pair ij, assume $\nu_{ij\omega} \sim$ Fréchet

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Idiosyncratic preference for location pair ij, assume $\nu_{ij\omega} \sim$ Fréchet

cdf $F_{ij}(\nu) = e^{-B_i E_j D_{ij} \nu^{-\epsilon}}$

- B_i: residential amenity, E_j: work amenity, D_{ij} average utility of commute (net of time)
- $\delta_{ij} = e^{\kappa \tau_{ij}}$ travel cost of commuting between i and j, time τ
- Together describe *absolute advantage*

Shape parameter is key: ϵ

- Homogeneity of location preference (higher=more uniform)
- ϵ strength of *comparative advantage*

Model: Household problem (and gravity)

Share residing at i and POW j is $(\Pr[v_{ij} \geq \max\{v_{rs}\}; \forall rs])$

$$\pi_{ij} = \frac{B_i E_j D_{ij} W_j^{\epsilon} \left(\delta_{ij} Q_i^{1-\zeta}\right)^{-\epsilon}}{\sum_{r=1}^{N} \sum_{s=1}^{N} B_r E_s D_{rs} W_s^{\epsilon} \left(\delta_{rs} Q_r^{1-\zeta}\right)^{-\epsilon}}$$

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Commuting flows: $\pi_{ij} N_t = N_{ijt}$, (N_t is aggregate pop.)

$$\ln(N_{ijt}) = \underbrace{\epsilon \ln(W_{jt}) + \ln(E_{jt})}_{\omega_{jt}} - \underbrace{\epsilon(1-\zeta)\ln(Q_{it}) + \ln(B_{it})}_{\theta_{it}} - \underbrace{\epsilon \kappa \tau_{ijt} + \ln(D_{ijt})}_{\delta_{ij} + \lambda T_{ijt} + \varepsilon_{ijt}} - g_{1t}$$

Closing the model

Production: Cobb-Douglas in labor and land

- Perfect competition, produce nationally trade good
- Multiplicatively separable productivity term A_i, can add agglomeration, etc.

$$W_i = \alpha A_i \left(L_i^Y / N_i^Y \right)^{1-\alpha}$$

Housing produced using land, materials

- Perfect competition among builders, Cobb-Douglas production
- No interaction with other land uses (restrictive zoning)
    - No evidence of any zoning changes
- Multiplicatively separable housing efficiency C_i

$$Q_i = C_i (H_i / L_i^H)^{\psi}$$

Equilibrium

City nested in closed economy with fixed population

- No spatial arbitrage condition
- Labor and housing markets clear
- Variant – open economy: population adjusts

Result 1

An equilibrium always exists, and is unique if

- *Housing supply elasticity is high enough*
- *Location preference is heterogeneous (small) enough*

Result 2

Given parameters and data, there exists a unique set of fundamentals $\mathbf{A}$, $\mathbf{C}$, *and* $\mathbf{\Lambda} = \mathbf{BDE}$ *consistent with a model equilibrium.*

Welfare

Simulate results of X', with $\hat{X} = X'/X$

- Plug in relative changes in primitives A, B, C, D, E
- Find new fixed point of the system Eq. System

Change in welfare in closed economy:

$$\ln \hat{\hat{U}} = \frac{1}{\epsilon} \ln \left(\frac{\hat{B}_i \hat{E}_j \hat{D}_{ij} \hat{W}_j^{*\epsilon} \hat{Q}_i^{*-\epsilon(1-\zeta)}}{\hat{\pi}_{ij}^*} \right)$$

Technical issue: only defined for $\epsilon > 1$

- Can show that above expression is equivalent to multinomial logit
- Equivalent formulation valid for $\epsilon > 0$

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Model summary

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

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

Model summary

$$
\begin{aligned}
&\text{Labor} && \underbrace{\ln(W_{jt})}_{\text{Wage}} = \tilde{\alpha}\ln\left(\textstyle\sum_r N_{rjt}\right) + \underbrace{\ln(A_{jt})}_{\text{Productivity}} \\
&\text{Commut.} && \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} && \underbrace{\ln(Q_{it})}_{\text{H. Price}} = \psi\ln\left(\textstyle\sum_s N_{ist}W_{st}\right) + \underbrace{\ln(C_{it})}_{\text{H. Eff.}}
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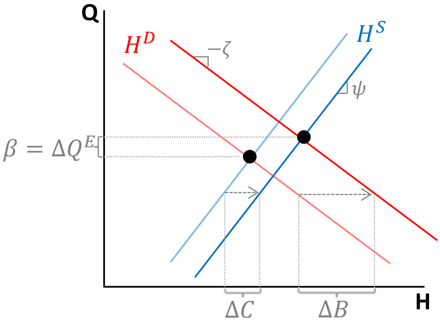
Describes

1. **Slopes**: ϵ, ψ, $\epsilon\tilde{\zeta}$, $\tilde{\alpha}$
   - Local elasticities
2. **Shifts**: Changes to primitives A, B, C, D, E
   - Effects of transit



Identification of ϵ

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)

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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

Bartik

Construct local variant of shift-share demand shock (Bartik 1991):

- Pred. growth in local (*census tract*) labor demand using nat. trends
- Plausibly exogenous local variation in labor demand (identifies ϵ)

$$\Delta z_{jt}^{LD,R} = \sum_q \frac{\Delta R_t^{q,Nat}}{R_0^{q,Nat}} \times \frac{N_{j,0}^q}{N_{j,0}}$$

$$\underbrace{\textit{National-level industry trends 1990-2000}}_{\text{Change in national ave. by 2-digit SIC (excl. CA)}} \times \underbrace{\textit{Ex-ante industrial composition}}_{\text{2-digit SIC at tract of work, 1990}}$$

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Use $\Delta z_{jt}^{LD,R}$ as an instrument for $\Delta \ln(W_{jt})$:

$$\Delta\widehat{\omega_{jt}} = \epsilon\Delta \ln(W_{jt}) + \Delta \ln(E_{jt})$$

Moment conditions

A1-a: $\mathbb{E}[\Delta z_{jt} \cdot \Delta \ln(E_{jt})] = 0, \ \forall j$

- Identifies labor supply elasticity ϵ
- Changes in non-pecuniary workplace amenity orthogonal to shock:
  (i) national industry trends, (ii) ex-ante industrial composition
- Driving variation likely: Trade shocks & decline of garment industry

Compare with standard Bartik assumption:

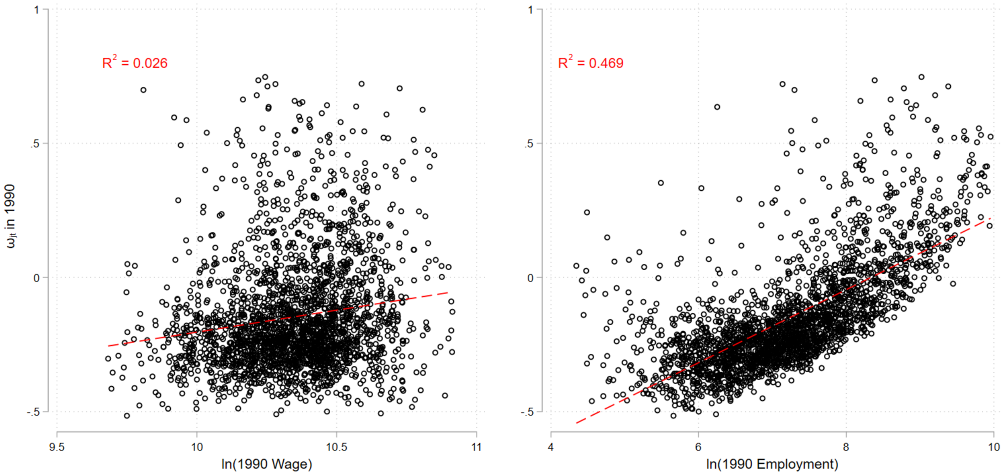
- $\mathbb{E}[\Delta z_{jt} \cdot \Delta f_j(B_{it}, E_{jt}, D_{ijt}, \delta_{ij})] = 0$
- Typically at city level: $\mathbb{E}[\Delta \bar{z}_{ct} \cdot \Delta \overline{\ln(B_{ct} E_{ct} D_{ct})}] = 0$

Assumptions required to recover wage or shape:

- $\mathbb{V}[\ln(E_{jt})] = 0$ is necessary condition in ARSW (2015)
- $\mathbb{E}[\ln(A_{jt}(\sigma)) \cdot \ln(E_{jt} D_{ijt}) \mid \sigma] = 0, \ \forall ij$ (as in Monte, Redding, Rossi-Hansberg 2018)
- Tsivanidis (2018) requires precise estimate of travel cost (κ)

What are recovered wage?

Mainly just employment (not actually wages)



ϵ – Preference homogeneity & Labor supply elasticity

	Mean utilty of place of work			
	$\hat{\omega}_{it}$ (1)	$\hat{\omega}_{it}$ (2)	$\hat{\omega}_{it}$ (3)	$\hat{\omega}_{it}$ (4)
ln(Wage)	0.544** (0.210)	0.501 (0.412)	0.774** (0.214)	1.030* (0.407)
F-stat	19.87	17.48	17.14	13.39
F-stat (KP)	17.67	15.28	15.17	11.52
Wage instrument	X	X	X	X
Empl. instrument			X	X
ω estimated	Yr-by-yr	Panel	Yr-by-yr	Panel
N	4,822	4,708	4,822	4,708

- High degree of heterogeneity
  - embeds situational detail and **stickiness** of location decision
  - mobility frictions important **even within city**
- Smaller than cross-sectional trade-style estimates (~ 6.7); more similar to LS elasticity (Falch 2010; Suarez Serrato & Zidar 2014)

Moment conditions

Interact with distance between tracts

- Spatial structure generates variation in *local economic conditions*
- Strength of interaction governed by decay parameter ρ
- High-dimensional FE result in more plausible moment conditions

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Combine to generate instruments; moments simplify to:

A2: $\mathbb{E}[\Delta z_{jt}^{LD,R} \Delta \ln(C_{it})] = 0, \ \forall \ i, j$

A3-a: $\mathbb{E}[\Delta z_{j't}^{LD,R} \Delta \ln(B_{it})] = 0, \ \forall \ ij' \neq ij$

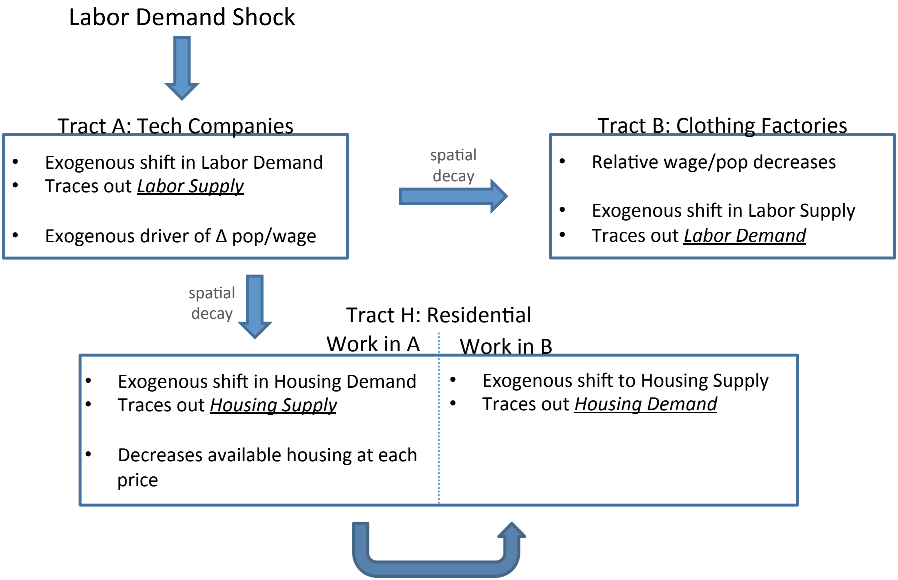
A4: $\mathbb{E}[\Delta z_{j't}^{LD,R} \Delta \ln(A_{jt})] = 0, \ \forall \ j' \neq j$

Result 2

Assume that moment conditions A1-a, A2, A3-a, and A4 are true, $\rho > 0$, and all instruments are relevant (housing and labor demand and supply slopes are well defined).

Elasticity identification: Toy example

Derive additional instruments by interacting with distance



ψ – Inverse housing supply elasticity

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

- Shocks only affect housing prices through housing demand
- Local adaptation of Saiz (2010); Guerrieri, Hartley, Hurst (2013)
- *Violations:* local construction costs correlated with shocks

ψ – Inverse housing supply elasticity

	ln(House Value)				
	q_{it} (1)	q_{it} (2)	q_{it} (3)	q_{it} (4)	q_{it} (5)
ln(Population)	1.476**	1.465**	1.973**		
	(0.391)	(0.398)	(0.606)		
ln(Hous. Consump.)				1.181**	1.626**
				(0.284)	(0.451)
ln(Res. Land)			-1.183		-1.335
			(0.748)		(0.821)
Housing Supply Elasticity ($1/\psi$)	0.678	0.683	0.507	0.847	0.615
F-stat	26.95	27.58	16.89	23.55	14.02
F-stat (KP)	21.87	20.50	15.78	19.27	13.84
Empl. instrument	All	Not i	All	All	All
N	4,560	4,556	4,554	4,510	4,504

- Less elastic than longer run median across US cities (Saiz 2010)
- CA has inelastic housing supply (Quigley & Raphael 2005)
- Coefficient on land $\approx$ housing (matches model)

Moment conditions

Demand parameters can be taken from microdata, but can be estimated:

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

- Labor demand shocks uncorrelated with changes in residential amenities *elsewhere*
- *Violations:* Endogenous spillovers in residential amenities, agglomeration

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

- Valid if not productivity spillovers
- *Violations:* agglomeration

Other elasticities

$\widehat{\epsilon(1-\zeta)} = [-0.83, -0.59]$: Housing demand elasticity

- Given $\hat{\epsilon}$, suggests mobility responses as if housing expenditure share is 40%-100%
- If commit value to value of ζ, provides overidentification test of ϵ

$(\alpha - 1) = [-0.39, -0.20]$: $1 -$ Labor's share of income

- Implies labor share of income is 61-80%
- Coefficient on land $\approx$ employment (matches model)

1. Data and setting
2. Transit's effect on commuting flows (gravity)
3. Quantitative urban model with commuting
4. Structural identification and estimated elasticities
5. Non-commuting effects and welfare
6. Habituation and network returns

Non-commuting effects?

Given elasticities, recover local fundamentals (residuals)

- Estimate the effect of transit on these primitives, e.g., for $Y = \ln(A), \ln(B), \ln(C), \ln(E)$, estimate:

$$\hat{\mathbf{Y}}_{it} = \boldsymbol{\lambda} T_{it} + \varsigma_i + \boldsymbol{\epsilon}_{it}$$

  to recover other effects $\boldsymbol{\lambda} = \lambda^A, \lambda^B, \ldots$
- Estimate separately to use historical DiD controls

No evidence of non-commuting effects Tables

- Commuting effect of LA Metro (+13%) retains structural interp.
- No evidence that LA Metro reduced car transit times Tables

Primary effect: increase commuting flows (not decrease congestion)

- Fundamental law of congestion (Downs 1962; Duranton & Turner 2011)

Welfare effects in GE

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

1. The system as a whole (as of 2000)
2. The commuting benefits of individual stations
   - Build chronologically/out from city center
   - Heterogeneity by RES/POW share connected

Welfare effects of system in 2000 (in $2016)

Parameters				
α	0.680	0.680	0.680	0.680
ϵ	0.544	1.030	0.544	1.030
ζ	0.700	0.700	0.700	0.700
ψ	1.180	1.180	1.180	1.180
Change in fundamentals	Narrow	Narrow	Broad	Broad
λ_D	0.135	0.135	0.058	0.058
Closed Economy				
Annual Δ in welfare	0.116%	0.061%	0.205%	0.109%
(in millions of $2016)	246.4	130.5	435.3	230.5
Open Economy				
Population Δ	0.269%	0.143%	0.341%	0.181%
Annual cost (6%, 30yr)	-$797 mil.			
Annual cost (5%, 50yr)	-$641 mil.			
Annual cost (5%, ∞)	-$435 mil.			

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

Benefits $\leq$ Costs

- Depends on taste for discounting

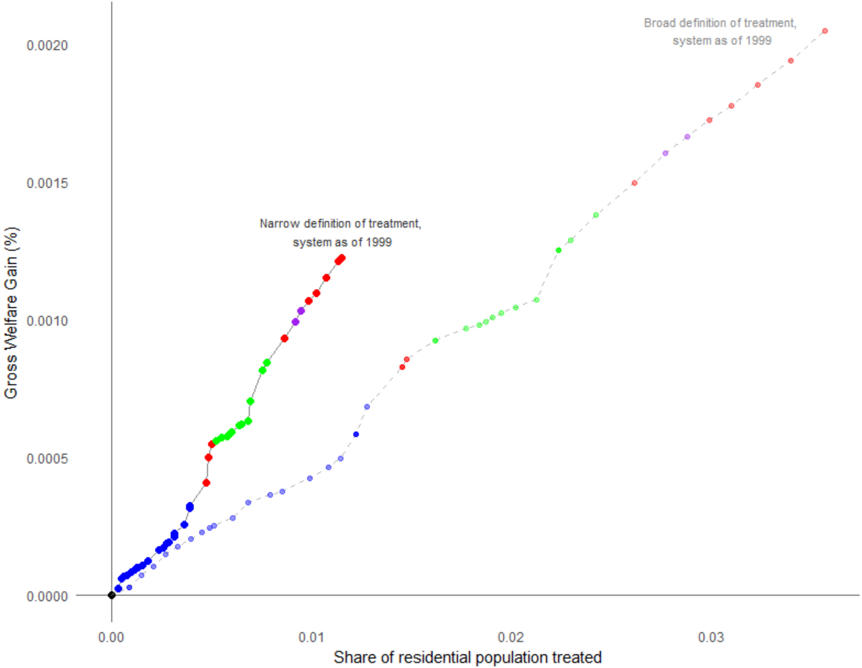
Compare

- Anderson (2014) uses driver strike to find short run benefit of about \$1 billion per year, but SR $\gg$ LR benefits because of adjustment
- Much smaller than number than Tsivanidis (2018)
- Redfearn? Schultz

Other margins/caveats?

- Air pollution benefits $\sim$\$182 million py (using Gendron-Carrier et al. 2018)
- Non-workers? Long run dynamics?

Welfare effects of stations (by 2000)



1. Data and setting
2. Transit's effect on commuting flows (gravity)
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Effects of stations; 2002–2015

			Commuting Flows, 1925 Plan Sample			
	n_{ijt}	n_{ijt}	n_{ijt}	n_{ijt}	n_{ijt}	n_{ijt}
	(1)	(2)	(3)	(4)	(5)	(6)
A. Tract centroid within 500 meters of station						
1[New Transit]	0.102**	0.106**	0.093**	0.101**	0.085**	0.093**
	(0.023)	(0.023)	(0.025)	(0.025)	(0.025)	(0.025)
1[Existing Transit]		0.082**		0.080**		0.072**
		(0.024)		(0.026)		(0.026)
B. Any part of tract within 500 meters of station						
1[New Transit]	0.044**	0.050**	0.038**	0.052**	0.032*	0.044**
	(0.012)	(0.012)	(0.014)	(0.014)	(0.014)	(0.014)
1[Existing Transit]		0.059**		0.056**		0.047**
		(0.011)		(0.013)		(0.014)
Pair, POW- & RES-Yr FE	Y	Y	Y	Y	Y	Y
Sbcty-X-Sbcty-X-Yr FE	-	-	-	-	Y	Y
N	1,993,198	1,993,198	237,438	237,438	237,424	237,424

- Different data, LEHD LODES – not comparable to CTPP
- Decreasing returns to new stations
- Existing station growth: habituation or increasing returns (network)

Welfare effects of stations (to 2024)

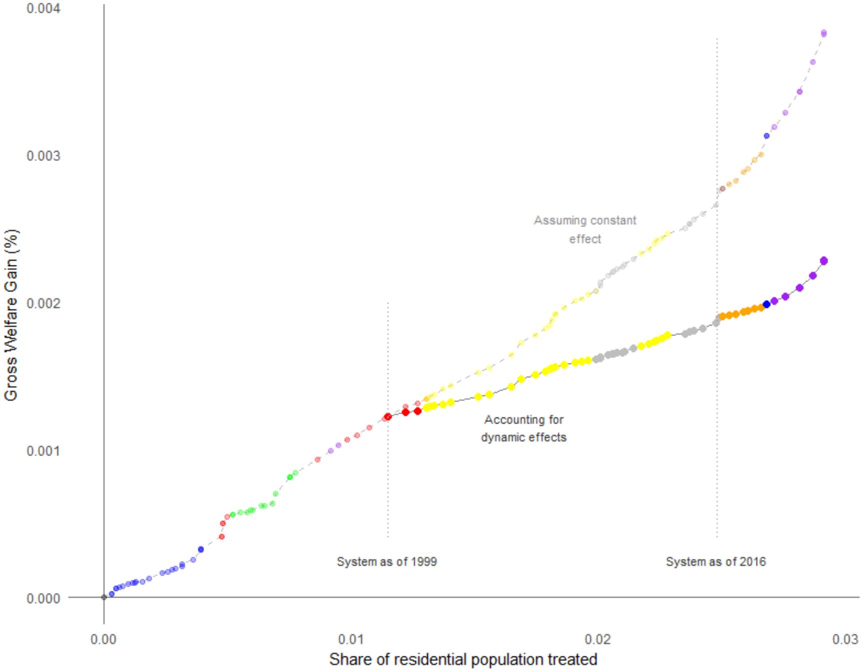
Welfare analysis with same cost basis if

- Assume all existing station growth due is habituation
- Assume persistence of *no non-commuting* effects

Narrow: \$379 million annually

Broad: \$788 million annually

Welfare effects of stations (to 2024)



Conlusion

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 likely larger
- ...depends on time horizon
- ...continued growth of system

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
Lake
Allen
Sierra Madre Villa
Arcadia
Monrovia
Duarte/City of Hope
Irwindale
Azusa Downtown
APU/Citrus College
Memorial Park
Del Mar
Fillmore
South Pasadena
Highland Park
Southwest Museum
Heritage Sq
Lincoln/Cypress
Chinatown
LAC+USC Medical Ctr
Cal State LA
El Monte
Little Tokyo/Arts Dist
Pico/Aliso
Mariachi Plaza
Soto
Indiana
Maravilla
East LA Civic Ctr
Atlantic
Pico
LATTC/Ortho Institute
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
5th St
1st St
Pacific Av
Downtown Long Beach
Rosecrans
Harbor Gateway Transit Ctr
Carson
Pacific Coast Hwy
San Pedro
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
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
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
MAY 2016
Subject to Change
Metro

Extra slides

Effect of transit on travel times

Table 10: Effect of transit on commute time, historical comparison

	Commute time, 1925 Plan Sample					Commute time, PER Sample			
	τ_{ijt} All (1)	τ_{ijt} All (2)	τ_{ijt} All (3)	τ_{ijt} All (4)	τ_{ijt} Drivers (5)	τ_{ijt} All (6)	τ_{ijt} All (7)	τ_{ijt} All (8)	τ_{ijt} Drivers (9)
A. Tract centroid within 500 meters of station									
1[Transit]	-1.50	-0.93	-0.88	-0.66	-1.44	-0.74	-0.72	-0.44	-0.82
	(1.08)	(1.20)	(1.20)	(1.21)	(2.05)	(1.17)	(1.17)	(1.17)	(1.81)
B. Any part of tract within 500 meters of station									
1[Transit]	-0.83	-0.25	-0.19	-0.00	1.17	-0.14	-0.10	0.19	1.11
	(0.57)	(0.73)	(0.74)	(0.76)	(1.23)	(0.67)	(0.68)	(0.69)	(1.05)
Tract Pair FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
POW-X-Yr FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
RES-X-Yr FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Highway Control	-	-	Y	Y	Y	-	Y	Y	Y
Sbcty-X-Sbcty-X-Yr FE	-	-	-	Y	Y	-	-	Y	Y
N	311,340	53,468	53,468	53,468	15,090	78,424	78,424	78,400	23,562

High-dimensional fixed effects estimates of the effect of transit on commute times. All estimates include tract of work-by-year, tract of residence-by-year, and tract pair fixed effects. Travel time is measured in minutes, and is for all commuters or drivers only as indicated. Standard errors clustered by tract pair in parentheses: $^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

Return

Model: Equilibrium definition

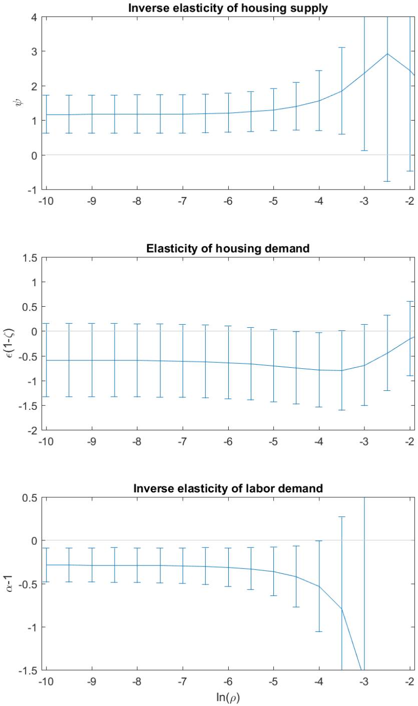
$$\pi_{ij} = \frac{B_i E_j D_{ij} W_j^{\epsilon} \left(\delta_{ij} Q_i^{1-\zeta}\right)^{-\epsilon}}{\sum_r \sum_s B_r E_s D_{rs} \delta_{rs} W_s^{\epsilon} \left(\delta_{rs} Q_r^{1-\zeta}\right)^{-\epsilon}} \qquad N_i^Y = \sum_r \bar{N} \pi_{ri}$$

$$W_i = \alpha A_i \left(\frac{L_i^Y}{N_i^Y}\right)^{1-\alpha} \qquad H_i = (1-\zeta) \sum_s \bar{N} \pi_{is} \frac{W_s}{Q_i}$$

$$Q_i = \tilde{C}_i \left(\frac{H_i}{L_i^H}\right)^{\psi}$$

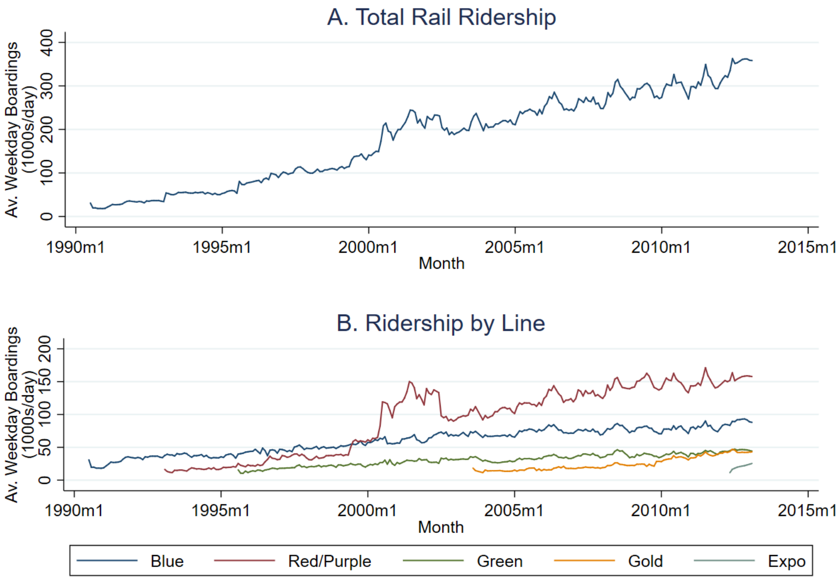
$$\bar{U} = \Gamma\left(\frac{\epsilon}{\epsilon - 1}\right) \cdot \left[\sum_r \sum_s B_r E_s D_{rs} W_s^{\epsilon} \left(\delta_{rs} Q_r^{1-\zeta}\right)^{-\epsilon}\right]^{1/\epsilon}$$

Return



Inverse elasticity of housing supply
ψ
4
3
2
1
0
-1
-10
-9
-8
-7
-6
-5
-4
-3
-2
Elasticity of housing demand
ϵ(1-ζ)
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-10
-9
-8
-7
-6
-5
-4
-3
-2
Inverse elasticity of labor demand
α-1
0.5
0
-0.5
-1
-1.5
-10
-9
-8
-7
-6
-5
-4
-3
-2
ln(ρ)

LA Metro Ridership



▸ Return

Additional Data Notes

Geographic Normalization: Normalized all data to 1990 census tracts

- In 1990, there are 2,542 tracts
- In 2000, use either:
  - 3,452 census tracts, or
  - 9,545 block groups
- Spatial overlay to determine assignment
- Split by land area percentage if multiple
- Discard small splits percentages

Harmonize rounding: Apply strictest rounding rules

- Ensure 1990 data matches 2000 data
- Roughly: round to nearest multiple of 5

Return

CTPP vs. LEHD LODES

CTPP Advantages

- Survey response from census, captures establishments
- Available in 1990 and 2000
- Includes wage at place of work
- Includes much commuting data: mode/times/car ownership

LEHD LODES Advantages

- Time consistent geography annually from 2002/2009
- Reports at block (but randomized within block group)
- Recent years have some local caracteristics

▸ Return