Transportation Infrastructure and City-Center Accessibility in the US and Europe

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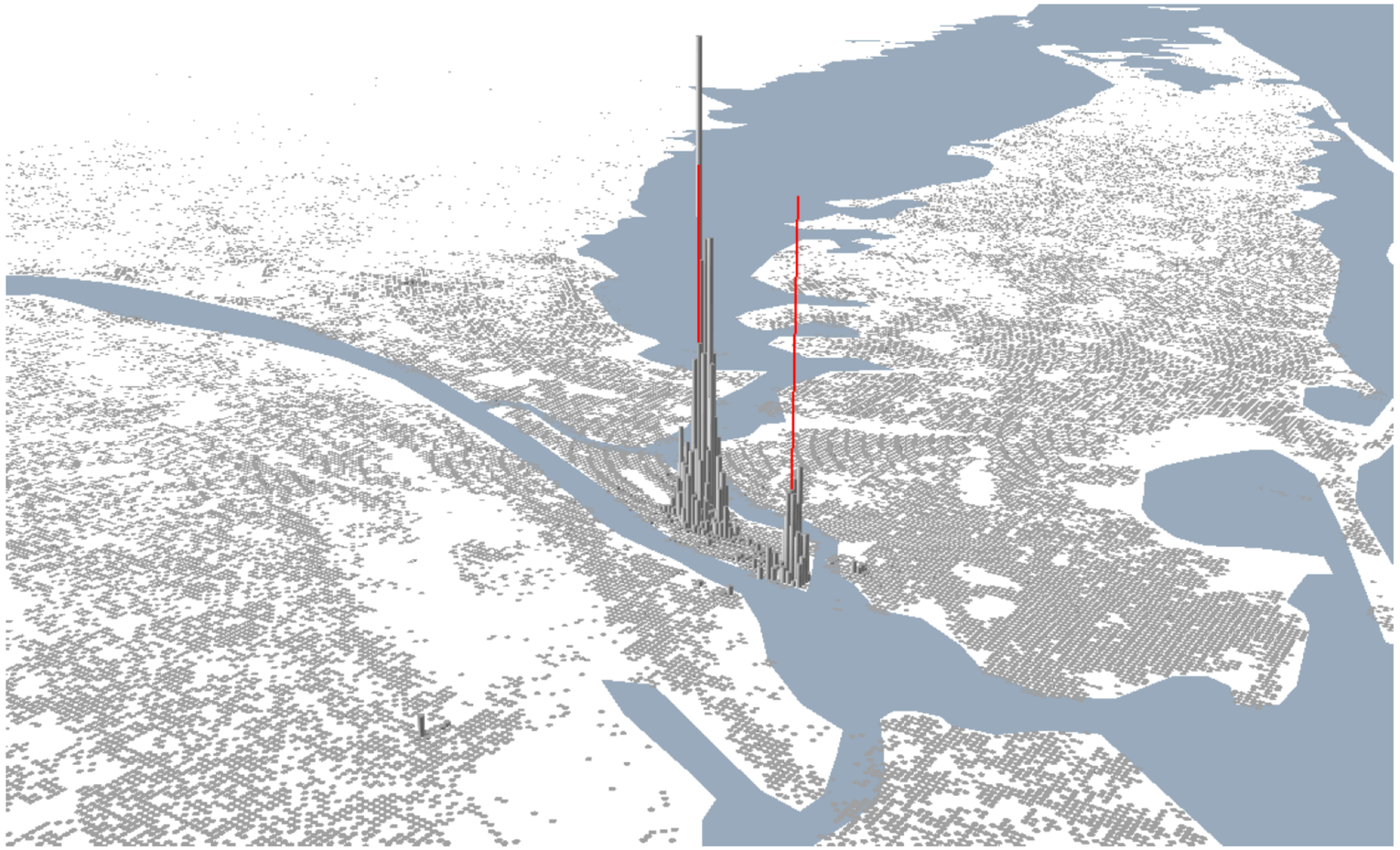
Productive Jobs in Central Business Districts



Geographic concentration of prime service employment in NY (Ahlfeldt et al. 2020)

Expanding Commute Access

1. **Housing supply?** Land use restrictions, political resistance.

   Hsieh and Moretti 2019; Ganong and Shoag 2017

2. **Transportation infrastructure?**

- **This paper:** car vs. transit-based access.
  - Define *Accessibility Zones (AZ):* area w/i x min. of CBD by car or transit.
  - Canonical Spatial Model: welfare-relevant measure of CBD accessibility.
  - Quantify car vs. transit accessibility and its implications.

Preview of Results

1. Public transit *accessibility zone* area in Europe > US, reverse for cars.

2. Car > transit accessibility zones (almost) everywhere.
   - US → greater access to area *in theory.*

3. Augment land areas with population density.
   - *In practice*, US provides fewer people access by car or transit.

4. Car orientation: tradeoffs, negative externalities [cross-city, Baum-Snow ’07 IV]
   - Less green space, higher emissions, worse health outcomes.

Literature

- Access to CBD
  - Hansen (1959); Ingram (1971); Wu and Levinson (2020); Bento, Cropper, Mobarak, Vinha (2005); Hsieh and Moretti (2019); Monte, Redding, Rossi-Hansberg (2018), Heblich, Redding, Sturm (2018)
- Using Optimal Public Transit and Driving Route Tools
  - Akbar, Couture, Duranton, Storeygard (2021); Kreindler (2022); Hanna, Kreindler, and Olken (2017); Akbar and Duranton (2018); Couture, Duranton, Turner (2018); Miyauchi, Nakajima, Redding (2021)
- Effects of new transportation infrastructure on…
  - Commuting (Ahlfeldt, Redding, Sturm, Wolf 2015; Heuermann and Schmieder 2018; Tsivanidis 2022), Collaboration (Dong, Kahn, Zheng 2018), Gender Wage Gap (Liu and Su 2020), Pollution (Gendron-Carrier, Gonzalez-Navarro, Polloni, Turner 2020; Chen and Walley 2012), Suburbanization (Baum-Snow 2007)
- Transportation and Urban Form → Health and Environment
  - Glaeser (2011); Glaeser, Kahn (2010); Gendron-Carrier, Gonzalez-Navarro, Polloni, Turner (2020); Currie, Walker (2011); Chay and Greenstone (2005); Davis (2008)

Part I:
Theory

A Closed City

- Closed city; mass $\bar{L} = 1$ of workers; single work location with wage w
- Residential locations indexed by $i = 1, \ldots, I$ differ in
  - …their land supply A_i
  - …their mode-m-specific commuting time τ_i^m to CBD
- Workers choose residential location and commuting mode
  - …Cobb-Douglas preferences over land and final consumption good
  - …Fréchet preference shock $\eta_i^m(\omega)$ for location-mode (dispersion θ)

Equilibrium System

- Worker ω chooses residential location + commuting mode to max utility:

$$\max_{i,m} \frac{w(1-\tau_i^m)}{r_i^\alpha} \eta_i^m(\omega) \Rightarrow \phi_i^m = \frac{(w(1-\tau_i^m) r_i^{-\alpha})^\theta}{\sum_{k,m} (w(1-\tau_k^m) r_k^{-\alpha})^\theta}$$

- The rental rate clears the land market in location i:

$$r_i A_i = \alpha w \sum_m \phi_i^m$$

- Two equations pin down equilibrium variables $\{r_i, \phi_i^m\}_{i,m}$.

Welfare → Empirical Measure

- **Welfare** with discrete commuting times, indexed by κ:

$$\tilde{u} = \sum_{m} \sum_{\kappa} \left(1 - \tau(\kappa)\right)^{l} \bar{\psi}^{m}(\kappa) \mathscr{A}^{m}(\kappa)$$

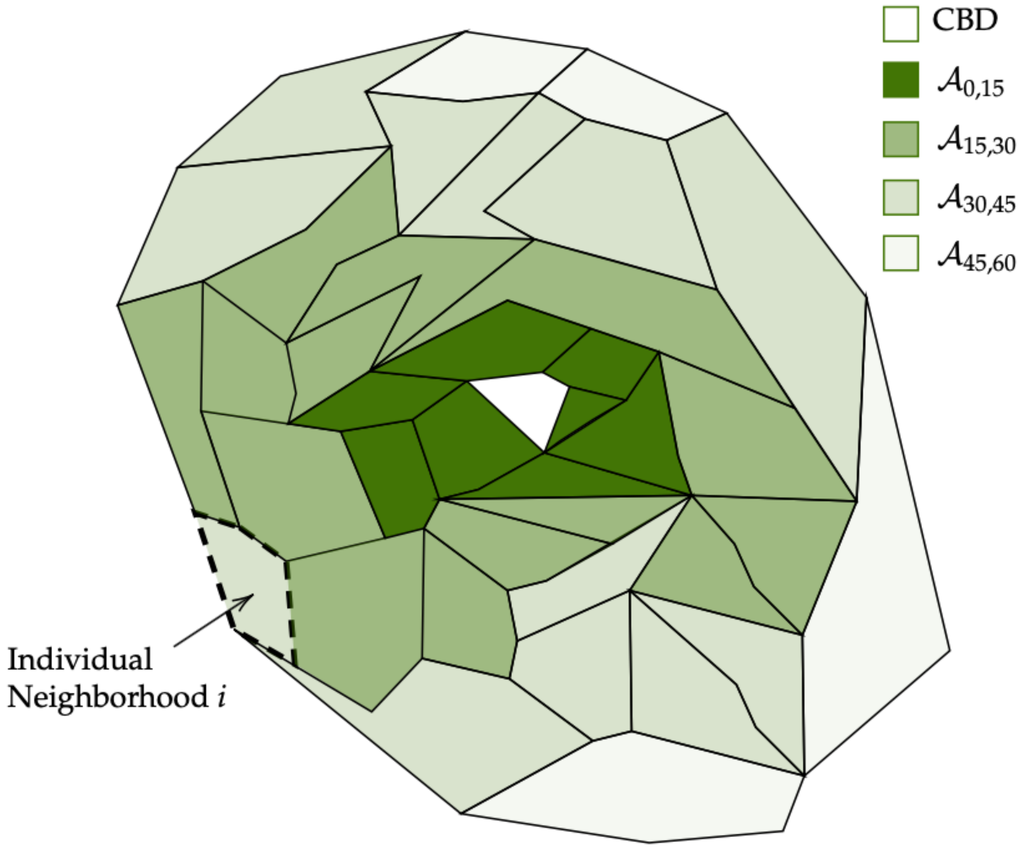
- **Accessibility Zones** $\mathscr{A}^{m}(\kappa)$: area s.t. reach CBD in $\tau(\kappa)$ min. on mode m
  - ↑ land w/i short commute → ↓ rents, commute times → ↑ welfare.
  - $\mathscr{A}^{m}(\kappa)$ = **welfare-relevant measure** of CBD accessibility.

- **This paper**: compute $\mathscr{A}^{m}(\kappa)$ for many commuting times, modes, cities

Part II:
Measuring CBD-Accessibility

Accessibility Zones

- x to x+15-minute commuting “catchment” area of a city’s CBD on given mode



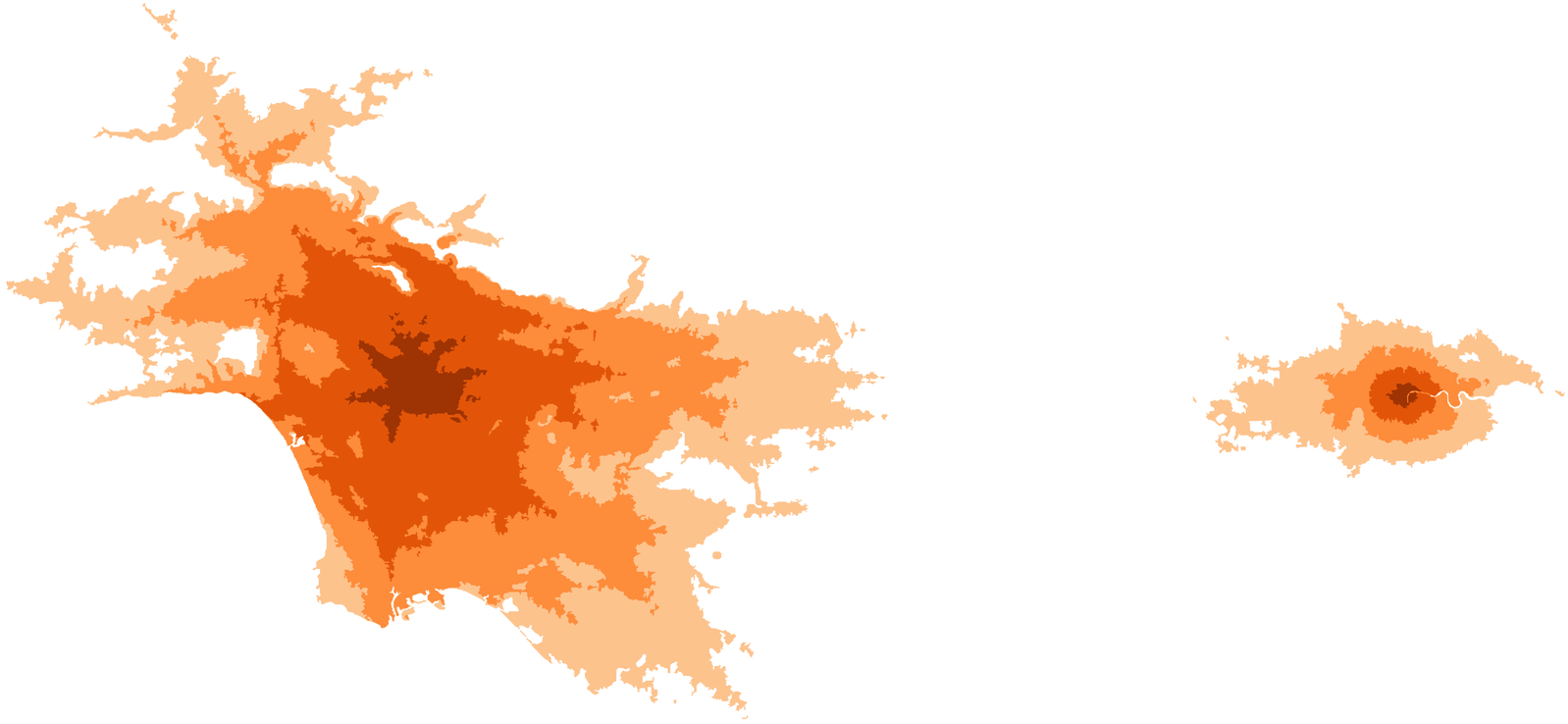
Computation

- **Use TravelTime** Isochrone API to compute for
  - Public transit and car
  - Different times of the day (rush hour and non-rush)
  - 0-15/15-30/30-45/45-60 minute commutes
  - 50 largest US and 50 largest European cities

Driving

Los Angeles

London



17.9 million

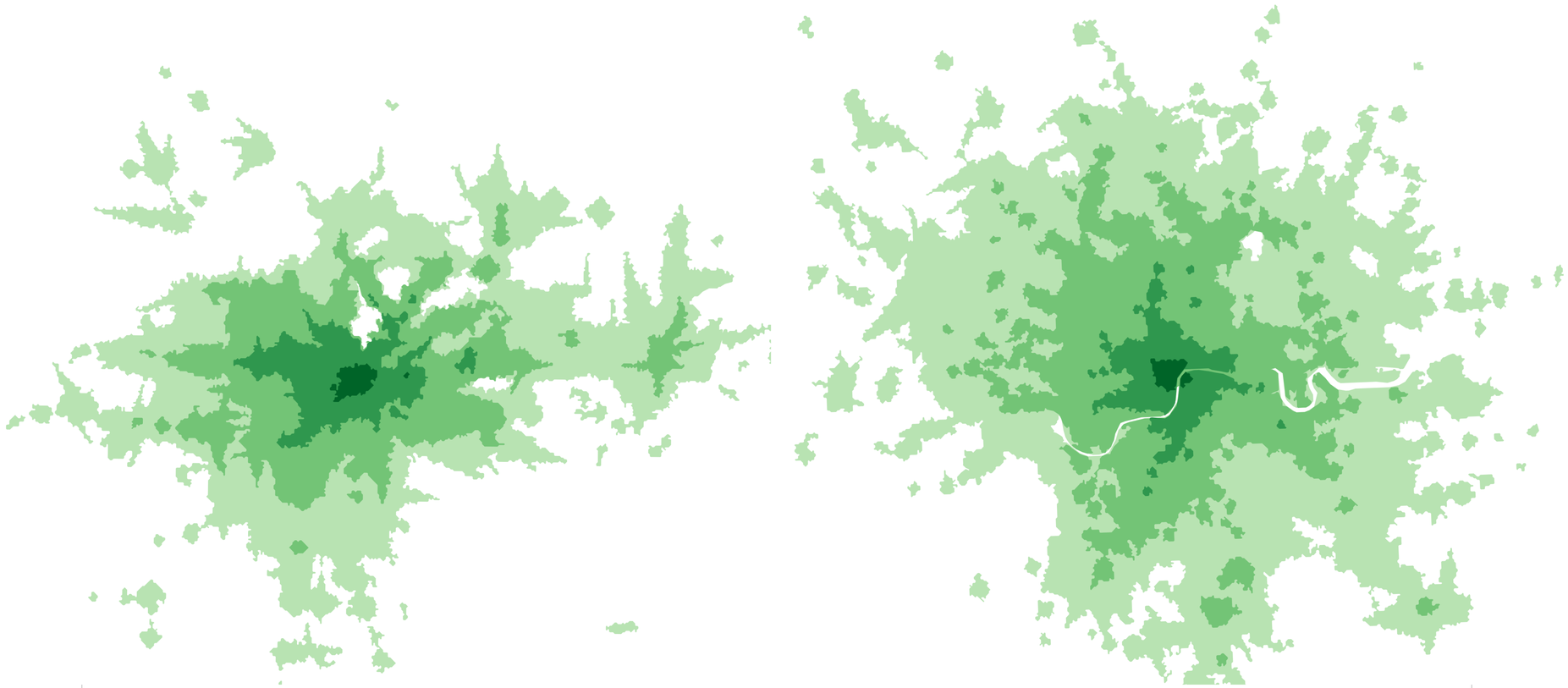
Population

12.4 million

Public Transit

Los Angeles

London



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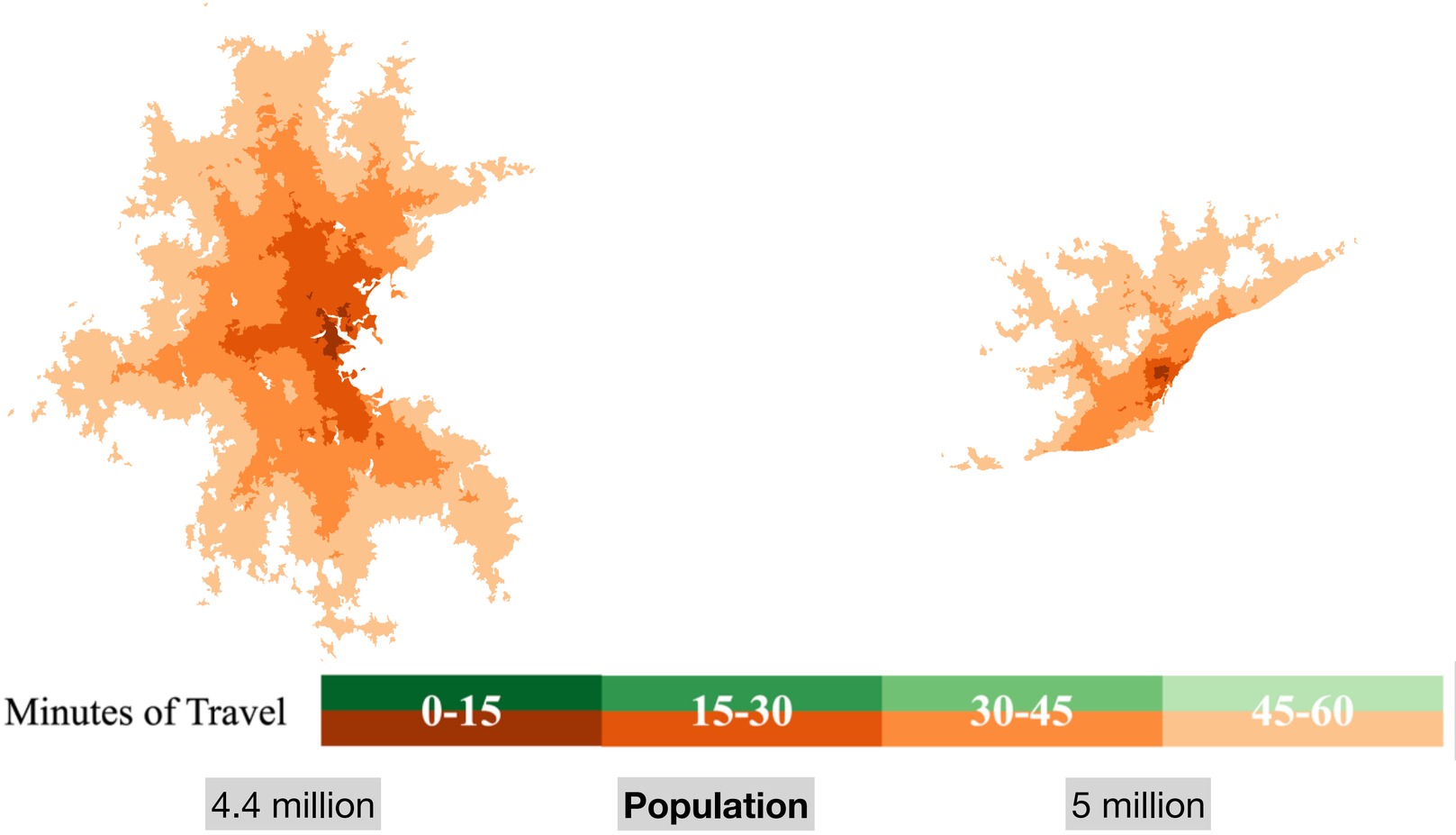
Population

12.4 million

Driving

Boston

Barcelona



4.4 million

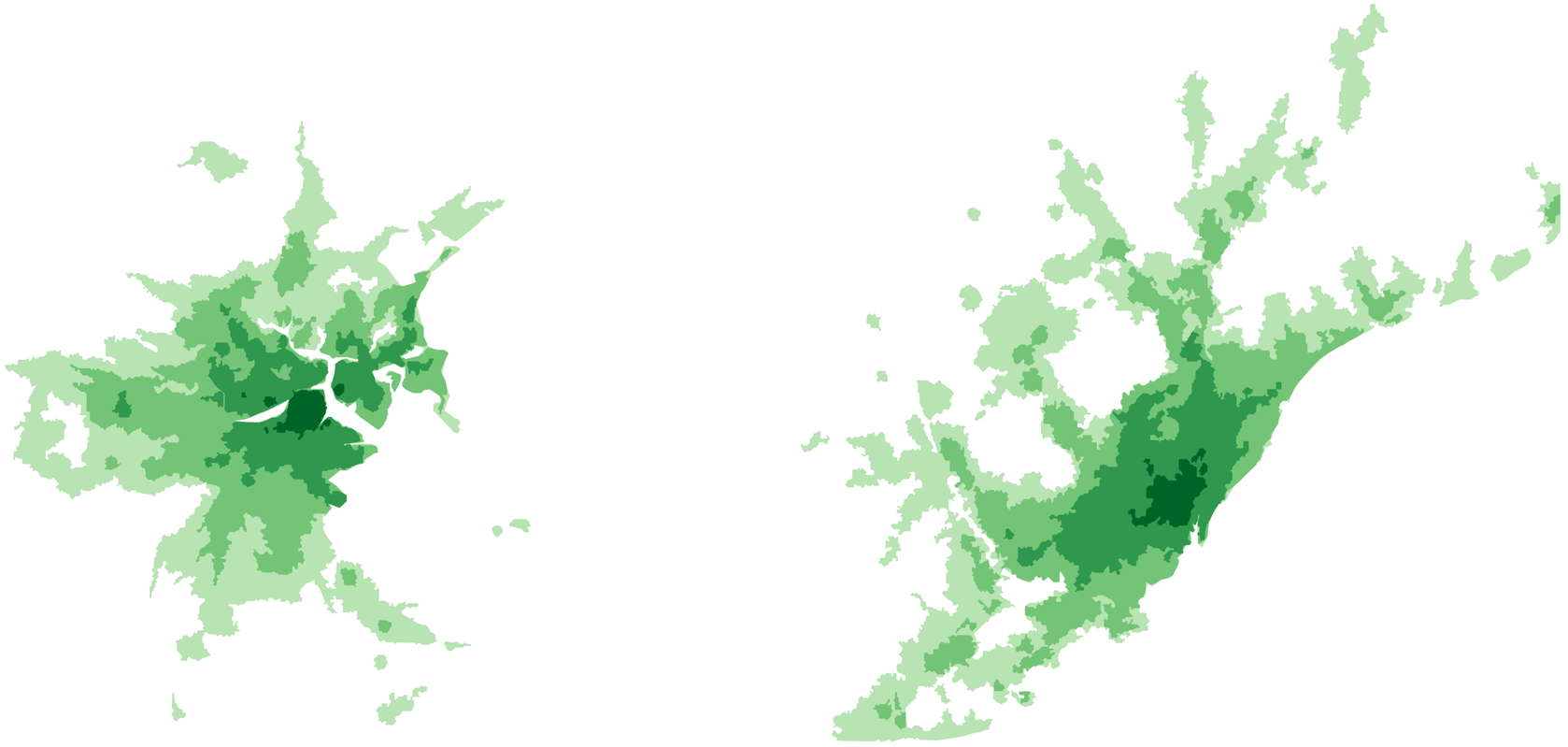
Population

5 million

Public Transit

Boston

Barcelona



4.4 million

Population

5 million

US Better Car Accessibility, Europe Better Transit

Table: Average Accessibility Zone Areas by Region, Mode (km²)

	Car			Public Transit		
Min.	US	Europe	Ratio	US	Europe	Ratio
0-15	85.94	21.72	3.96	3.86	6.65	0.58
15-30	725.95	256.05	2.84**	29.70	61.17	0.49***
30-45	1493.27	863.23	1.73***	91.18	160.05	0.57***
45-60	2260.38	1702.59	1.33***	149.93	262.01	0.57***

Cars Always Greater Accessibility

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Highways Facilitate Bus Trips

"Speed refutes one of the most pervasive myths about metropolitan transit systems in the U.S. — that no one rides the bus in Los Angeles — with its economically and racially diverse ensemble of riders, who must work together and with Jack Traven to keep the bus going until the bomb is dismantled." — The Outline

Park & Ride Polycentricity

Housing vs. Land Supply

- Preferences over *exogenously-supplied* **housing**, not land ⇒ Welfare:

$$\tilde{u} = \sum_{m} \sum_{\kappa} \left(1 - \tau(\kappa)\right)^{l} \bar{\psi}^{m}(\kappa) h^{m}(\kappa) \mathscr{A}^{m}(\kappa)$$

- Measure not only area, but also residential development density $h^{m}(\kappa)$!
  Proxy → population density.

…But *Population Densities* Differ Across US vs. Europe Accessibility Zones

Table: Average Accessibility Zone Population Densities by Region, Mode

	Car			Public Transit		
Min.	US	Europe	Ratio	US	Europe	Ratio
0-15	2845.71	10156.64	0.28***	3953.04	11601.79	0.34***
15-30	1594.23	5054.32	0.32***	3303.13	7975.15	0.41***
30-45	740.52	1998.94	0.37***	2537.88	4258.53	0.60***
45-60	359.23	809.45	0.44	1999.14	2362.16	0.85

Europe: Better Access to *Population*

Table: Average Accessibility Zone Populations by Region, Mode (in 000s)

	Car			Public Transit		
Min.	US	Europe	Ratio	US	Europe	Ratio
0-15	191	167	1.14	18	85	0.22
15-30	1036	801	1.29	119	501	0.24***
30-45	1036	1053	0.98	269	660	0.41***
45-60	696	1036	0.67***	359	627	0.57***

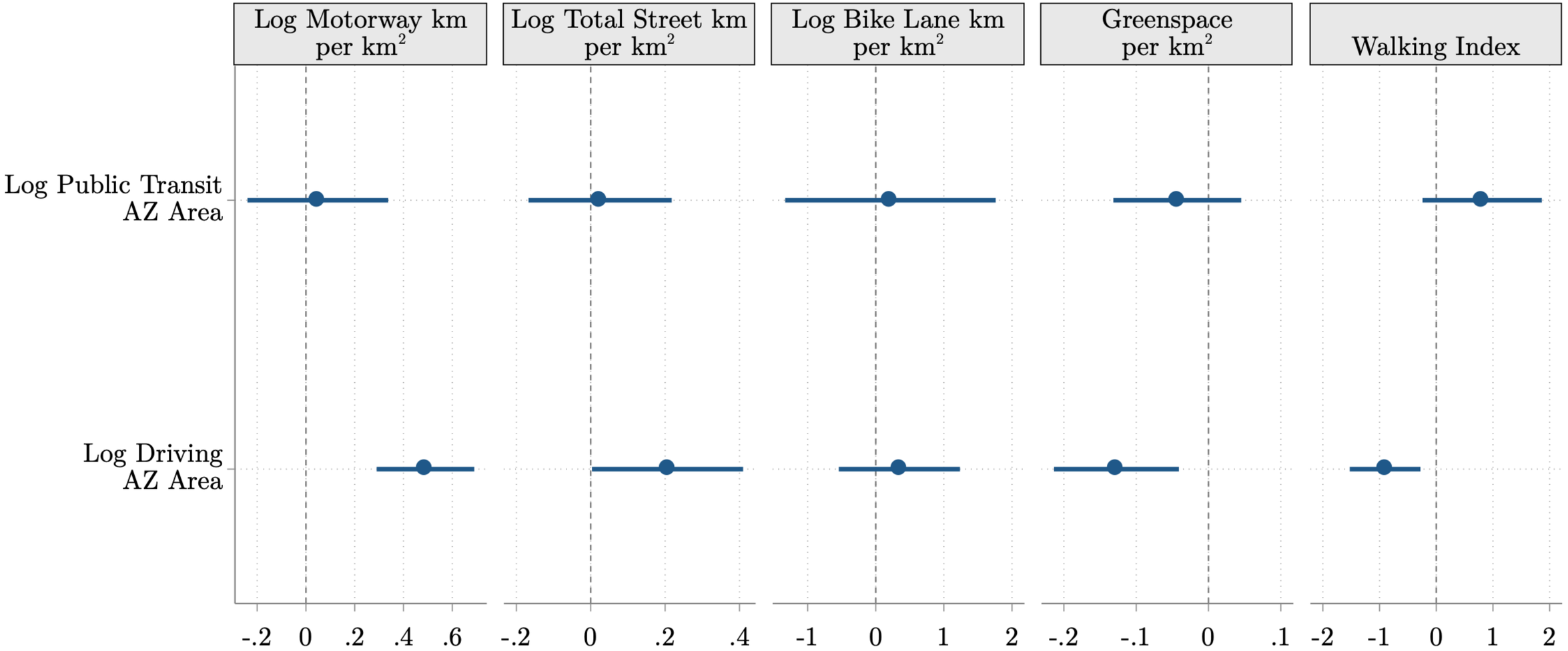
Part III:
Implications of Car Orientation

Quantifying Implications of Car Orientation

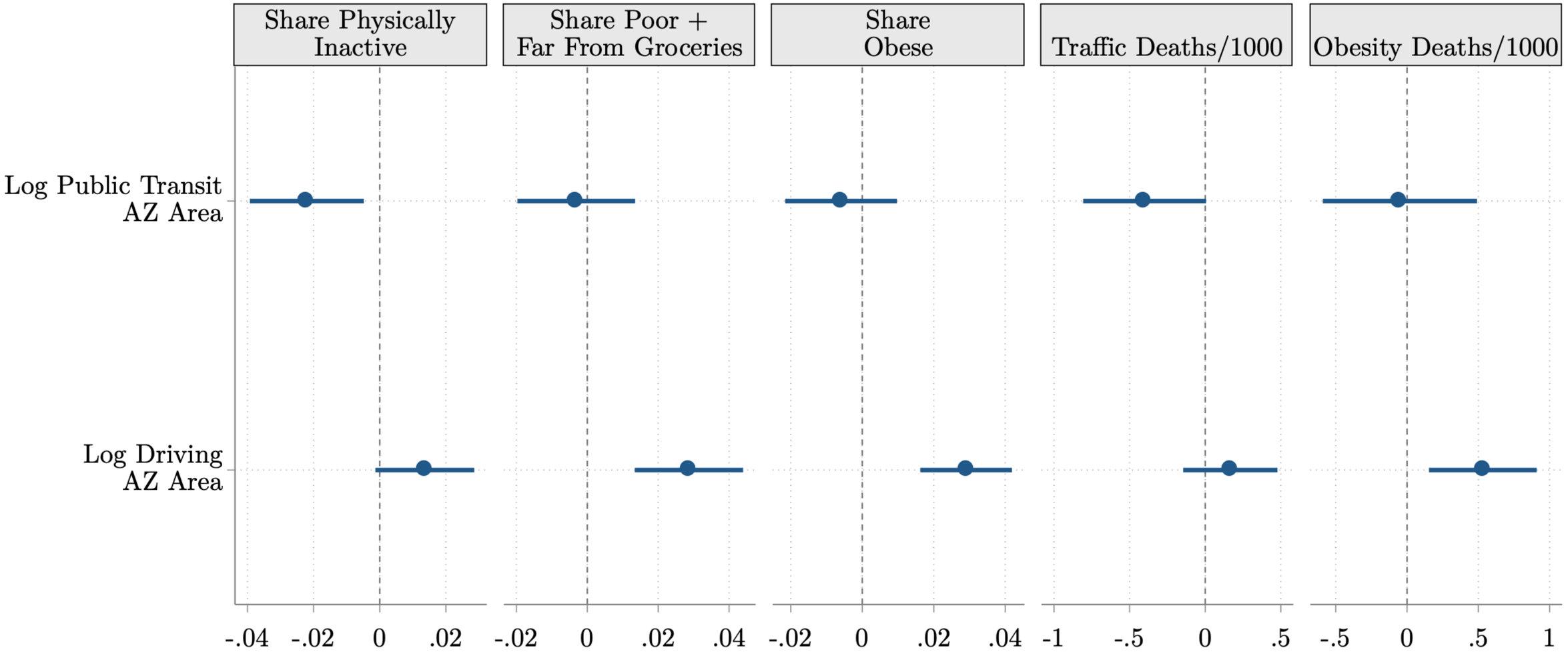
1. **Residualize** land use, health, emissions outcomes *at county level*
   - demographic, environmental, sectoral controls

2. **Regress** average residual on 0-60’ AZ areas *at metro-area level*
   - OLS + Baum-Snow (’07) 1947 highway plan IV

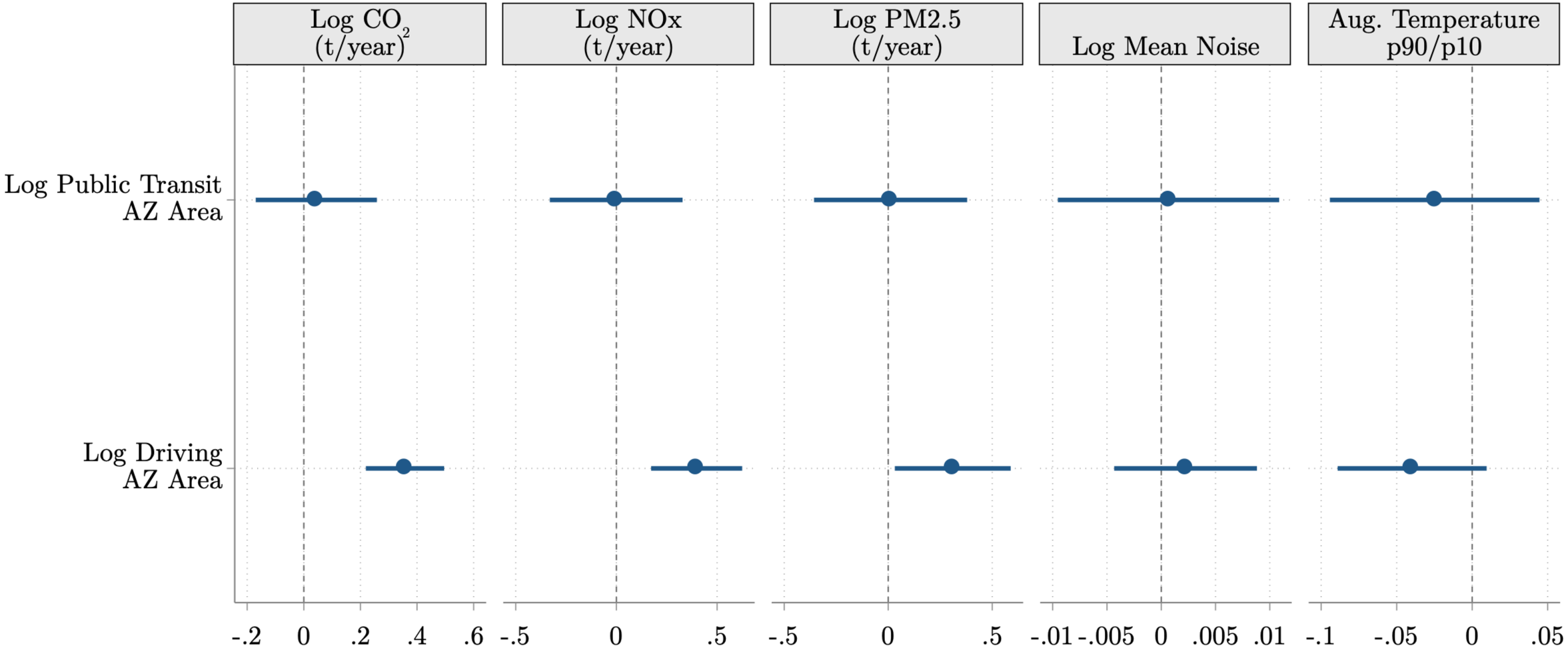
Land Use


Log Motorway km per km^2
Log Total Street km per km^2
Log Bike Lane km per km^2
Greenspace per km^2
Walking Index
Log Public Transit AZ Area
Log Driving AZ Area
-.2 0 .2 .4 .6
-.2 0 .2 .4
-1 0 1 2
-.2 -.1 0 .1
-2 -1 0 1 2

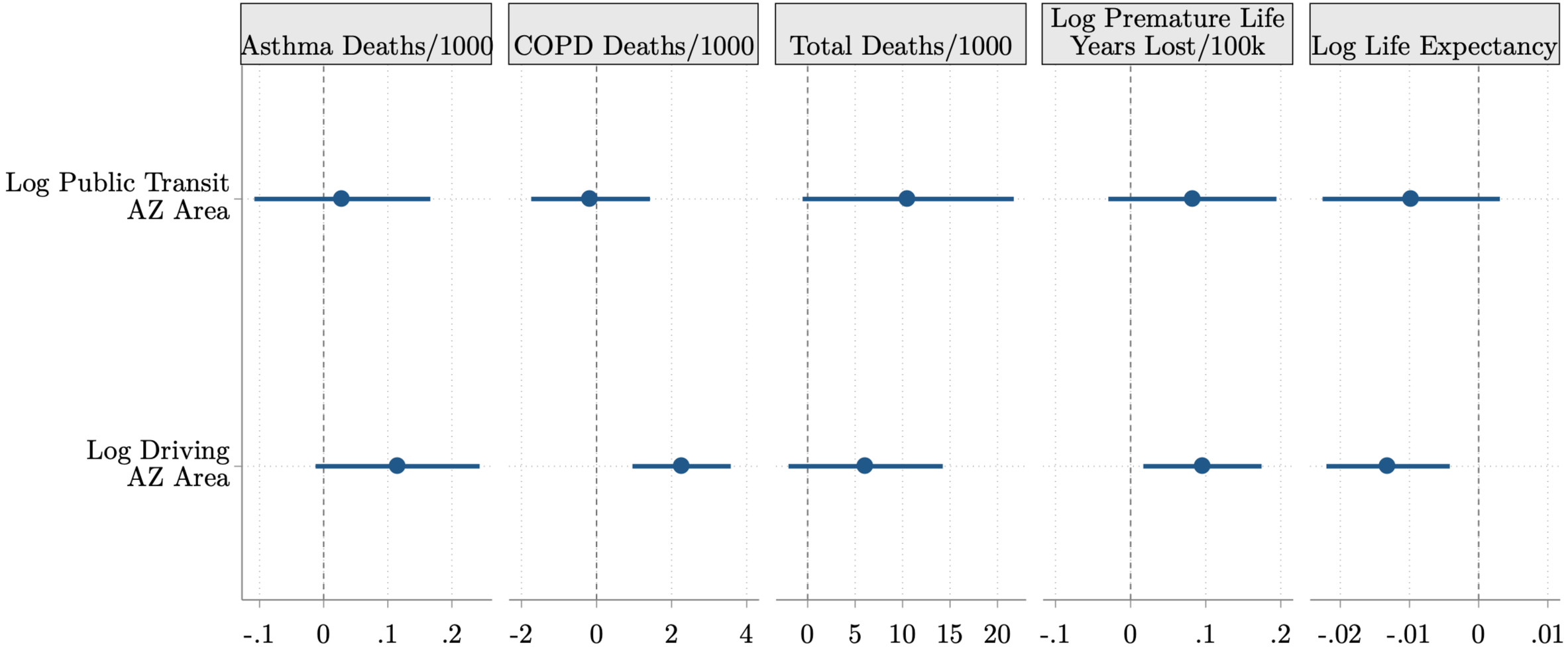
Direct Health Externalities



Pollution


Log CO_2 (t/year)^2
Log NOx (t/year)
Log PM2.5 (t/year)
Log Mean Noise
Aug. Temperature p90/p10
Log Public Transit AZ Area
Log Driving AZ Area
-.2
0
.2
.4
.6
-.5
0
.5
-.5
0
.5
-.01
-.005
0
.005
.01
-.1
-.05
0
.05

Indirect Health Externalities

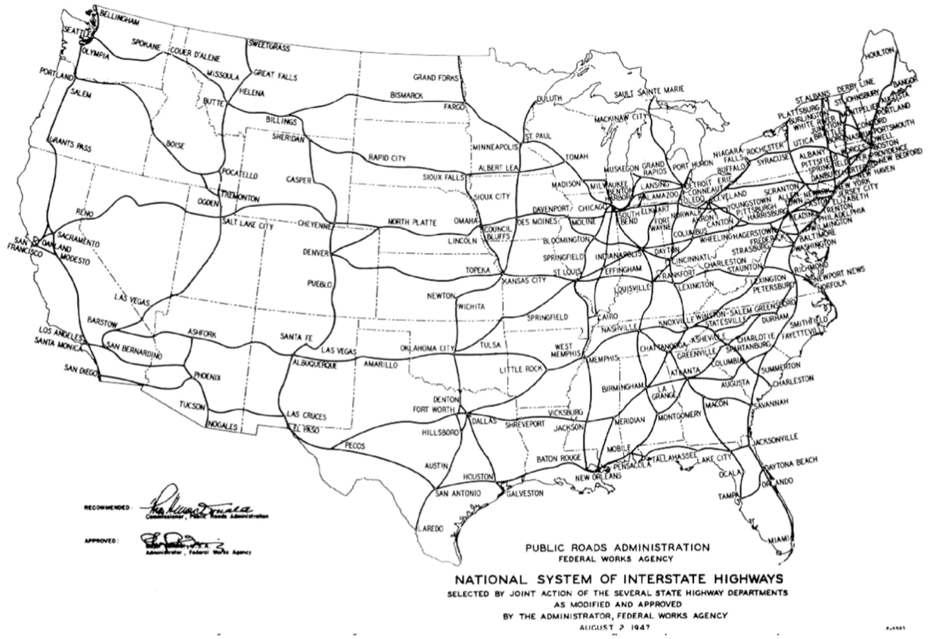


IV: 1947 Interstate Highway Plan (Baum-Snow '07)

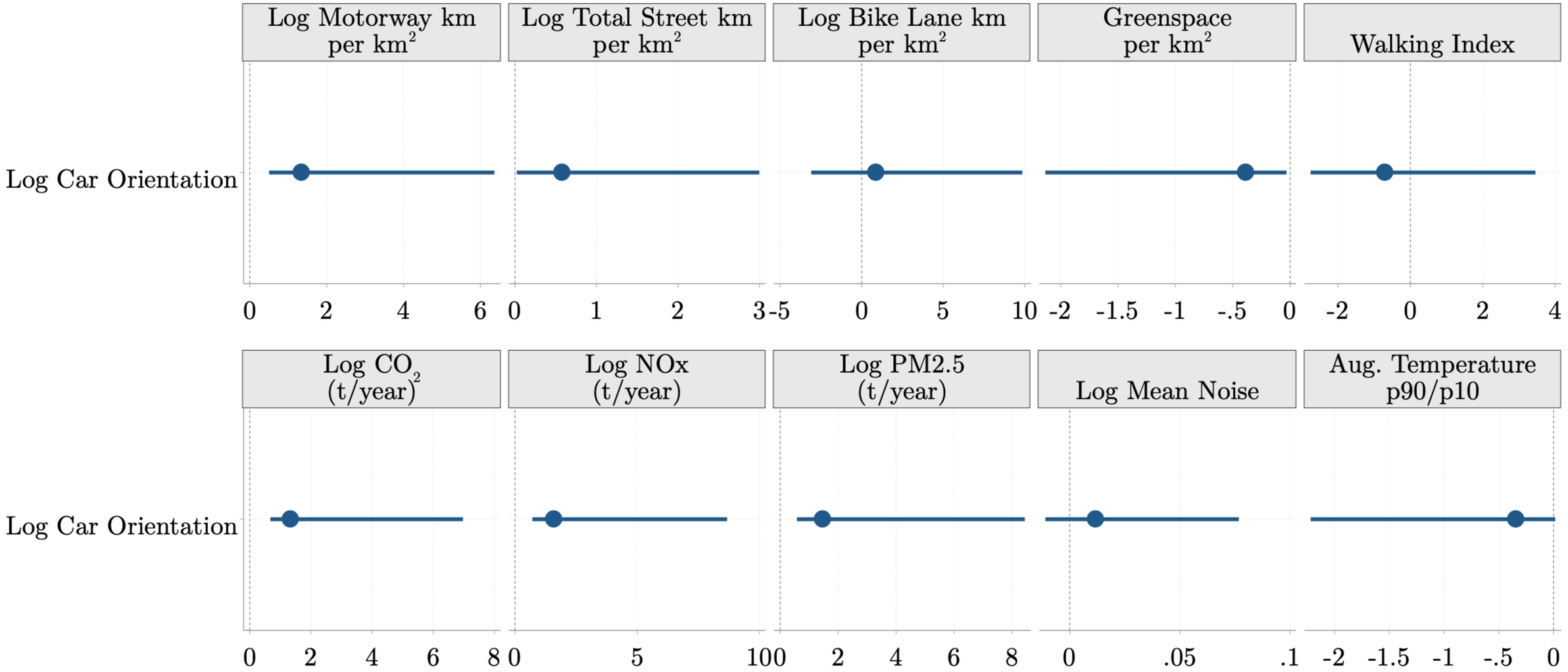
- Defense and trade, not local commuting
- **Independent variable =** *car orientation*
  - (0,60)-minute car/transit AZ area
- **IV =** # planned highway rays thru CBD
- **First stage:**

$$\beta_{\#rays} = .102^{**}, \text{se} = 0.043$$

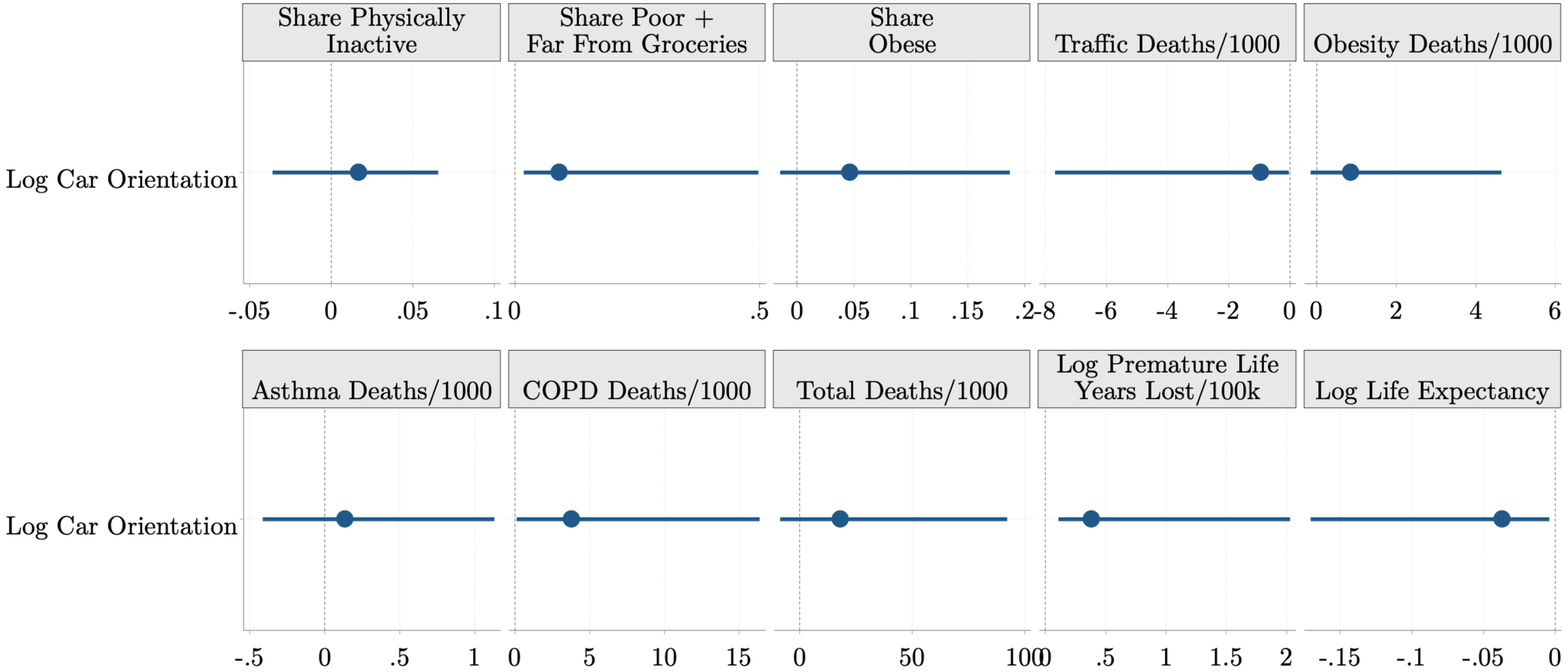
$$F = 5.7 \Rightarrow \textit{weak IV}$$



Land Use and Pollution



Health Externalities



Policy Insights

1. **Cars, versus public transit:**

   + provide city-center access to larger areas and populations

   - negative externalities (land use, pollution) + health costs

2. Road investments need **complementary land-use policy changes.**

- *Accessibility Zones* = easily replicable ⇒ **guide policy evaluations.**

Thank you!

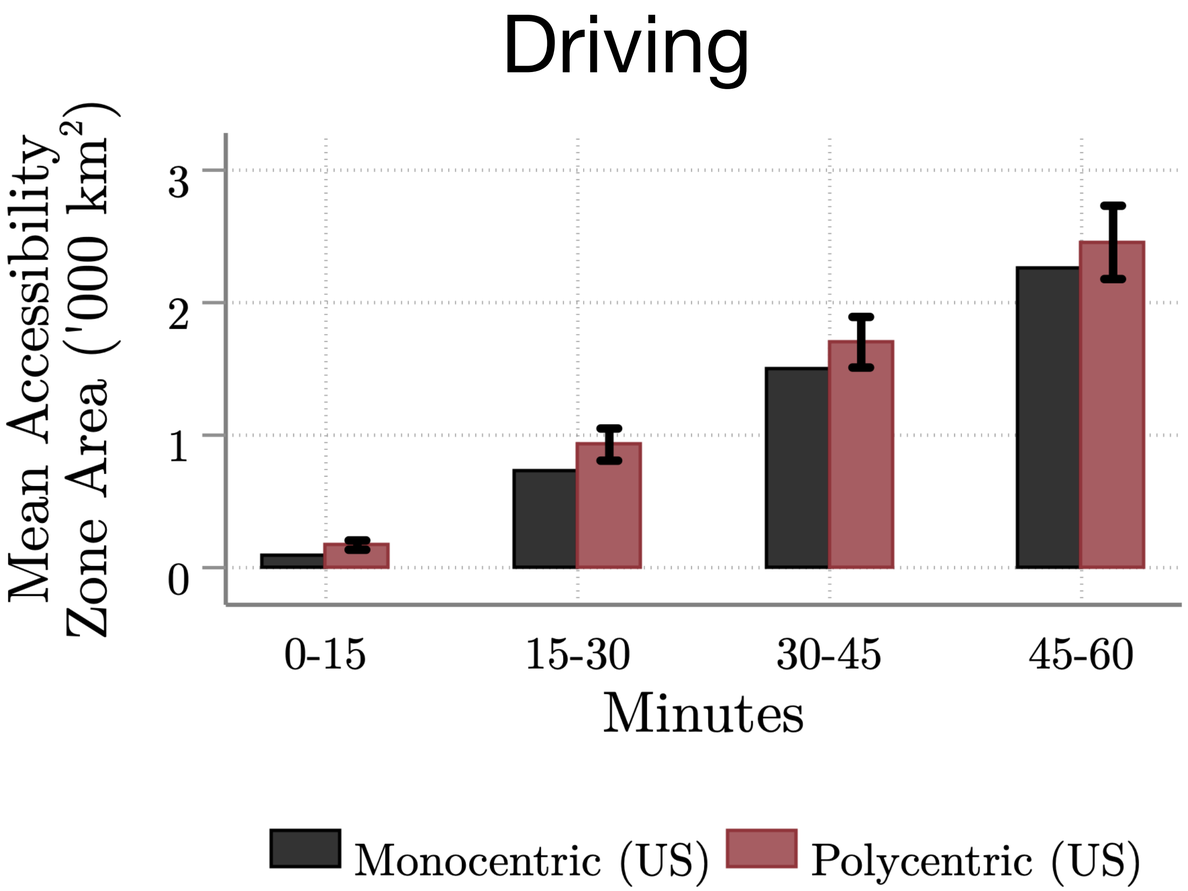
Park & Ride Not Much Better

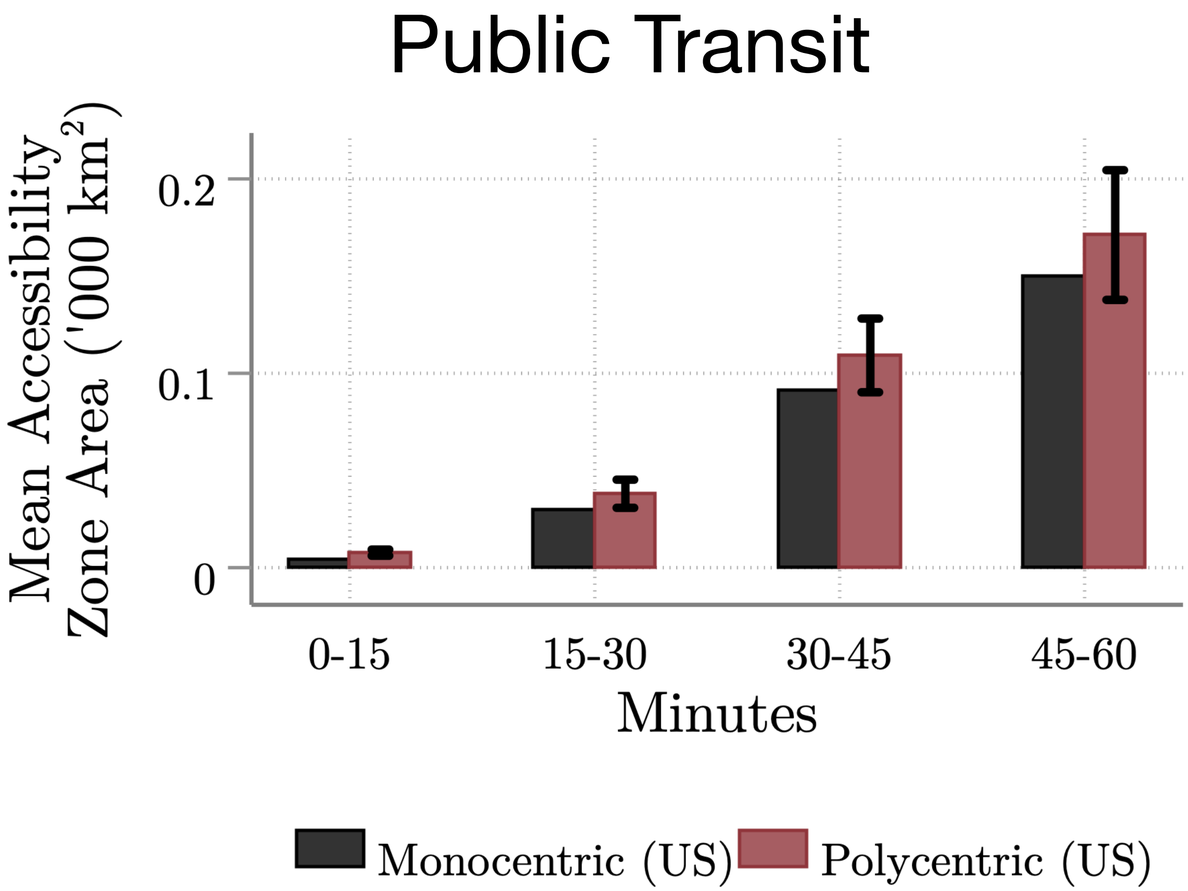
Table: Average Accessibility Zone Areas by Region, Mode (km^2)

	Car		Public Transit		Driving+Train or Public Transit	
Min.	US	UK	US	UK	US	UK
0-15	85.94	34.66	3.86	3.85	84.39***	34.93***
15-30	725.95	343.19	29.70	35.21	13.52***	27.48
30-45	1493.27	1008.06	91.18	143.19	87.98	231.15**
45-60	2260.38	1822.47	149.93	286.80	165.94*	561.66***

Scatterplot Back

Multiple Employment Centers





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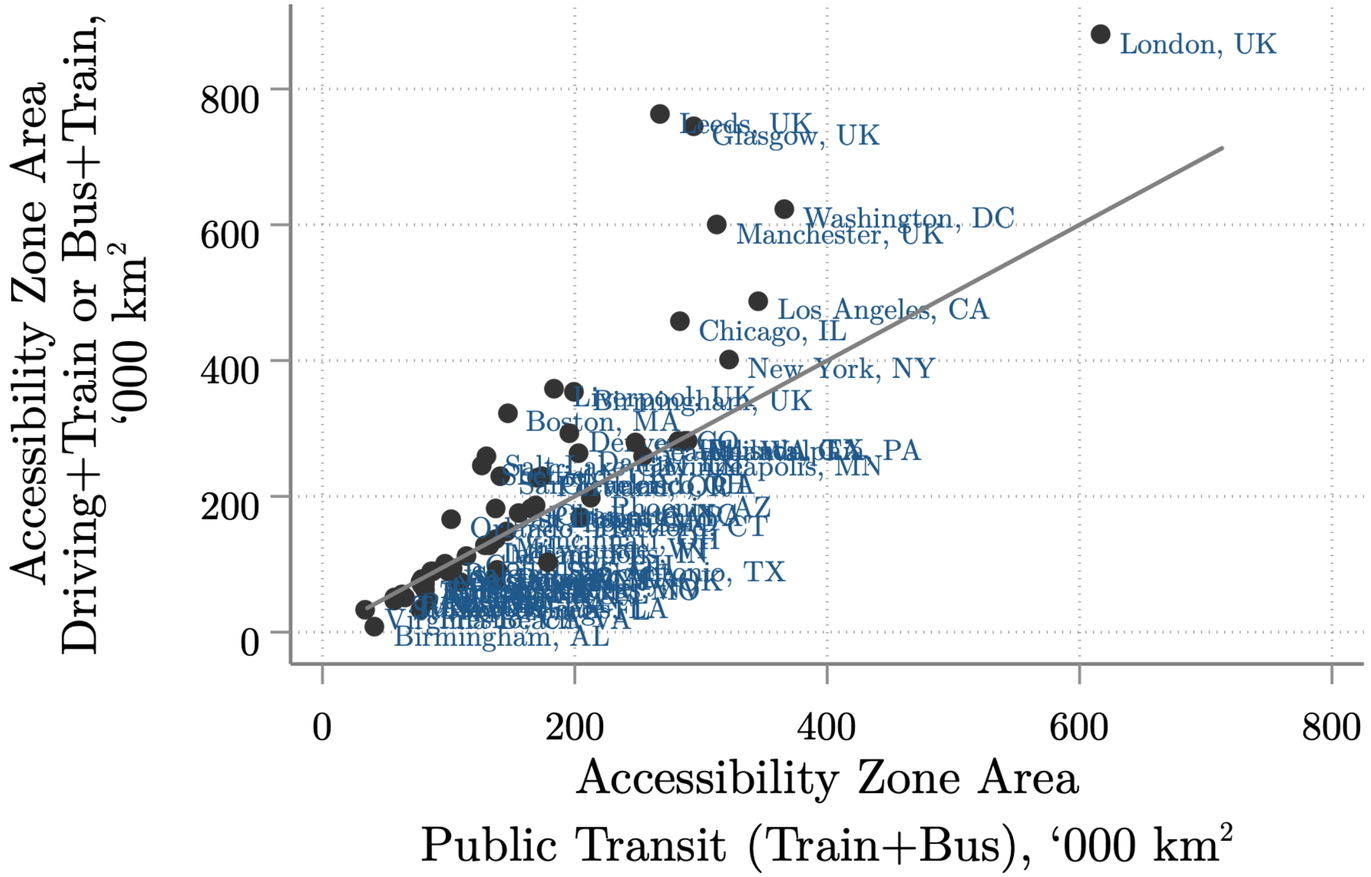
“Park & Ride”? Gains in Cities with Rail

45-60 Minutes



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