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

Lucas Conwell
Fabian Eckert
Ahmed Mushfiq Mobarak
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.
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.
• 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 \( \tau_i^m \) 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 \( \theta \))
Equilibrium System

- Worker $\omega$ 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 $i$:

\[
r_iA_i = \alpha w \sum_m \phi_i^m
\]

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

- **Welfare** with discrete commuting times, indexed by $\kappa$:

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

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

- **This paper**: compute $A^m(\kappa)$ 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
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

Minutes of Travel

0-15  15-30  30-45  45-60

17.9 million  Population  12.4 million
Public Transit

Los Angeles

Population: 17.9 million

Minutes of Travel: 0-15

London

Population: 12.4 million

Minutes of Travel: 0-15

Color Coding:
- 0-15 minutes
- 15-30 minutes
- 30-45 minutes
- 45-60 minutes
Driving

Boston

Barcelona

Minutes of Travel

0-15  15-30  30-45  45-60

4.4 million  Population  5 million
Public Transit

Population

Boston

Barcelona

Minutes of Travel

0-15

15-30

30-45

45-60

4.4 million

Population

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

<table>
<thead>
<tr>
<th>Min.</th>
<th>Car</th>
<th>Public Transit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>US</td>
<td>Europe</td>
</tr>
<tr>
<td>0-15</td>
<td>85.94</td>
<td>21.72</td>
</tr>
<tr>
<td>15-30</td>
<td><strong>725.95</strong></td>
<td><strong>256.05</strong></td>
</tr>
<tr>
<td>30-45</td>
<td>1493.27</td>
<td>863.23</td>
</tr>
<tr>
<td>45-60</td>
<td>2260.38</td>
<td>1702.59</td>
</tr>
</tbody>
</table>

*Note: Bold values indicate the time frame with the highest accessibility area for each mode.*
# Cars Always Greater Accessibility

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

<table>
<thead>
<tr>
<th>Min.</th>
<th>US</th>
<th>Europe</th>
<th>Ratio</th>
<th>US</th>
<th>Europe</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-15</td>
<td>85.94</td>
<td>21.72</td>
<td>3.96</td>
<td>3.86</td>
<td>6.65</td>
<td>0.58</td>
</tr>
<tr>
<td>15-30</td>
<td>725.95</td>
<td>256.05</td>
<td>2.84**</td>
<td>29.70</td>
<td>61.17</td>
<td>0.49***</td>
</tr>
<tr>
<td>30-45</td>
<td>1493.27</td>
<td>863.23</td>
<td>1.73***</td>
<td>91.18</td>
<td>160.05</td>
<td>0.57***</td>
</tr>
<tr>
<td>45-60</td>
<td>2260.38</td>
<td>1702.59</td>
<td>1.33***</td>
<td>149.93</td>
<td>262.01</td>
<td>0.57***</td>
</tr>
</tbody>
</table>
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
Housing vs. Land Supply

- Preferences over exogenously-supplied housing, not land \(\Rightarrow\) Welfare:

\[
\hat{u} = \sum_{m} \sum_{\kappa} \left(1 - \tau(\kappa)\right)^i \tilde{\psi}_m^m(\kappa) h^m(\kappa) A^m(\kappa)
\]

- Measure not only area, but also residential development density \(h^m(\kappa)\)!

Proxy \(\rightarrow\) population density.
...But *Population Densities* Differ Across US vs. Europe Accessibility Zones

*Table: Average Accessibility Zone Population Densities by Region, Mode*

<table>
<thead>
<tr>
<th>Min.</th>
<th>Car US</th>
<th>Car Europe</th>
<th>Ratio</th>
<th>Public Transit US</th>
<th>Public Transit Europe</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-15</td>
<td>2845.71</td>
<td>10156.64</td>
<td>0.28***</td>
<td>3953.04</td>
<td>11601.79</td>
<td>0.34***</td>
</tr>
<tr>
<td>15-30</td>
<td>1594.23</td>
<td>5054.32</td>
<td>0.32***</td>
<td>3303.13</td>
<td>7975.15</td>
<td>0.41***</td>
</tr>
<tr>
<td>30-45</td>
<td>740.52</td>
<td>1998.94</td>
<td>0.37***</td>
<td>2537.88</td>
<td>4258.53</td>
<td>0.60***</td>
</tr>
<tr>
<td>45-60</td>
<td>359.23</td>
<td>809.45</td>
<td>0.44</td>
<td>1999.14</td>
<td>2362.16</td>
<td>0.85</td>
</tr>
</tbody>
</table>
Europe: Better Access to Population

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

<table>
<thead>
<tr>
<th>Min.</th>
<th>Car</th>
<th>Public Transit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>US</td>
<td>Europe</td>
</tr>
<tr>
<td>0-15</td>
<td>191</td>
<td>167</td>
</tr>
<tr>
<td>15-30</td>
<td>1036</td>
<td>801</td>
</tr>
<tr>
<td>30-45</td>
<td>1036</td>
<td>1053</td>
</tr>
<tr>
<td>45-60</td>
<td>696</td>
<td>1036</td>
</tr>
</tbody>
</table>
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
Direct Health Externalities

![Graph showing the relationship between different health indicators and transportation metrics in Arizona areas. The x-axis represents various health indicators such as share of physically inactive, share of poor or far from groceries, share of obese, traffic deaths per 1000, and obesity deaths per 1000. The y-axis represents transportation metrics such as log public transit and log driving in the AZ area. The graph indicates the influence of transportation on health outcomes.](image-url)
Pollution

Log Public Transit AZ Area

Log Driving AZ Area

Log CO$_2$ (t/year)  Log NOx (t/year)  Log PM2.5 (t/year)  Log Mean Noise  Aug. Temperature p90/p10

-2  0  .2  .4  .6  -.5  0  .5  -.5  0  .5  -0.01 -0.005  0  .005  .01  -1  -0.05  0  .05
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:**
  \[ \beta_{\text{rays}} = 0.102^{**}, \text{se} = 0.043 \]
  \[ F = 5.7 \Rightarrow \text{weak IV} \]
# Land Use and Pollution

<table>
<thead>
<tr>
<th>Log Motorway km per km²</th>
<th>Log Total Street km per km²</th>
<th>Log Bike Lane km per km²</th>
<th>Greenspace per km²</th>
<th>Walking Index</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Log Car Orientation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Log CO² (t/year)</th>
<th>Log NOx (t/year)</th>
<th>Log PM2.5 (t/year)</th>
<th>Log Mean Noise</th>
<th>Aug. Temperature p90/p10</th>
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<td>0</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>8</td>
</tr>
</tbody>
</table>

| 0 | 2 | 4 | 6 | 8 | 0 | .05 | .1 | -2 | -1.5 | -1 | -.5 | 0 |

- Log Motorway km per km²
- Log Total Street km per km²
- Log Bike Lane km per km²
- Greenspace per km²
- Walking Index

- Log CO² (t/year)
- Log NOx (t/year)
- Log PM2.5 (t/year)
- Log Mean Noise
- Aug. Temperature p90/p10
Health Externalities

Log Car Orientation

<table>
<thead>
<tr>
<th>Share Physically Inactive</th>
<th>Share Poor + Far From Groceries</th>
<th>Share Obese</th>
<th>Traffic Deaths/1000</th>
<th>Obesity Deaths/1000</th>
</tr>
</thead>
</table>

Asthma Deaths/1000 | COPD Deaths/1000 | Total Deaths/1000 | Log Premature Life Years Lost/100k | Log Life Expectancy |

Log Car Orientation

-5 0 .5 1 0 5 10 15 0 50 100 .5 1 1.5 2 -15 -1 -0.5 0
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!
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<th>Car US</th>
<th>Car UK</th>
<th>Public Transit US</th>
<th>Public Transit UK</th>
<th>Driving+Train or Public Transit US</th>
<th>Driving+Train or Public Transit UK</th>
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<tr>
<td>0-15</td>
<td>85.94</td>
<td>34.66</td>
<td>3.86</td>
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<td>29.70</td>
<td>35.21</td>
<td>13.52***</td>
<td>27.48</td>
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<td>30-45</td>
<td>1493.27</td>
<td>1008.06</td>
<td>91.18</td>
<td>143.19</td>
<td>87.98</td>
<td>231.15**</td>
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<td>45-60</td>
<td>2260.38</td>
<td>1822.47</td>
<td><strong>149.93</strong></td>
<td><strong>286.80</strong></td>
<td><strong>165.94</strong></td>
<td><strong>561.66</strong>*</td>
</tr>
</tbody>
</table>

Scatterplot  Back
Multiple Employment Centers

Driving

Public Transit

Mean Accessibility Zone Area (‘000 km²)

Minutes

0-15  15-30  30-45  45-60

0  1  2  3

Mean Accessibility Zone Area (‘000 km²)

Minutes

0-15  15-30  30-45  45-60

0  0.1  0.2

Monocentric (US)  Polycentric (US)

Monocentric (US)  Polycentric (US)
“Park & Ride”? Gains in Cities with Rail

45-60 Minutes

Accessibility Zone Area
Driving+Train or Bus+Train, ‘000 km²

Accessibility Zone Area
Public Transit (Train+Bus), ‘000 km²