Urban Planning & Sustainable Mobility
Robert Cervero, UC Berkeley

5D’s of the Built Environment

Density

Distance to Transit

Diversity

Design

Destination Access

Impacts

VKT/Capita

Transit Trips /Capita

R. Cervero & K. Kockelman, Travel Demand and the 3Ds: Density, Diversity, Design, Transportation Research, 1996; R. Ewing & R. Cervero, Built Environment and Travel, TRR, 2001; JAPA, 2010
## Meta-Evidence on 5Ds & VKT in US Vehicle Kilometers Traveled (VKT)

### Elasticities from Regressions & Logits

<table>
<thead>
<tr>
<th>Category</th>
<th>Urban Form Description</th>
<th>Elasticity for Change in VMT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>Household/Population Density</td>
<td>-0.04</td>
</tr>
<tr>
<td>Diversity</td>
<td>Land Use Mix (entropy)</td>
<td>-0.09</td>
</tr>
<tr>
<td>Design</td>
<td>Intersection/Street Density</td>
<td>-0.12</td>
</tr>
<tr>
<td>Destination Accessibility</td>
<td>Job Accessibility By Auto</td>
<td>-0.20</td>
</tr>
<tr>
<td>Distance to Transit</td>
<td>Distance to Nearest Transit Stop</td>
<td>-0.05</td>
</tr>
</tbody>
</table>


**Elasticity** = \((\% \Delta \text{ VKT}) / (\% \Delta \text{ in “D” Variable})\)
Jobs Accessibility Index (OM) = # of jobs in employed-resident’s occupation (exec/prof; support/service; blue collar) ≤ 4 miles

San Francisco Bay Area Job Accessibility 2000

Elasticity: (% Δ VKT) / (% Δ Access)

-0.338 Work Trip VMT & Job Access

-0.168 Shop Trip VMT & Retail Access
Balanced Growth

Downtown Vancouver 2004

140,000 jobs
100,000 residents

Jobs: CBD

VKT/capita of Core Residents ~ 40% regional average
China’s Urban Transformation

Compact, Mixed Uses, Bike/Ped Friendly

Shanghai, 1987

Prior Residence

New Residence

Isolated, Gated Superblocks in Suburbs:

Shanghai Suburbs, 2007

2008 Study: Suburban Relocation & Travel in Shanghai

Previous residences (2002-2004)

SURVEYED:
19 Housing Projects
900 households
2820 individuals

2008 Study: Suburban Relocation & Travel in Shanghai

Current Residences (2005-2007)

SURVEYED: 19 Housing Projects 900 households 2820 individuals

38% ↑ in VKT among movers; 22% ↑ among HHs living < 1 KM of Metrorail Station

Urban Design & Pedestrian Access to Metros

New York: 1,739,500 jobs accessed by foot within 20 minutes from a major CBD metro station.

London: 352,800 jobs.

Beijing: 157,200 jobs.

Study of VMT & Carbon Footprint across 370 U.S. Metropolitan Areas, 1990-2004

GHG Emissions = Gallons Mile x Carbon Gallon x Vehicle Miles Traveled

Sustainable Mobility

Sustainable Urbanism

Source: Cervero and Murakami (2010), Environment and Planning A.
Density & VMT/Capita

Structural Equation Path Model

[Diagram showing the structural equation model with nodes and arrows representing relationships between variables such as Autocom\%, VMT/cap, Popden, Railpaxmi/Cap, Urbanarea, etc.]
Density & Roads

Elasticities

“The Los Angeles Effect”

Density’s VMT-Reducing Impacts Moderated by Road Design ~ 1/3
<table>
<thead>
<tr>
<th>Category</th>
<th>Los Angeles</th>
<th>Stockholm</th>
</tr>
</thead>
<tbody>
<tr>
<td>VKT (000s)/capita/year</td>
<td>20.4</td>
<td>8.5</td>
</tr>
<tr>
<td>% Trips: Walk/Bike</td>
<td>4</td>
<td>27</td>
</tr>
<tr>
<td>Ped. Fatalities/100K Pop.</td>
<td>18</td>
<td>3</td>
</tr>
<tr>
<td>Workdays Lost to Pollution/Person</td>
<td>5</td>
<td>0.5</td>
</tr>
</tbody>
</table>

2000-2004
# Meta-Evidence on 4 Ds & Transit Use in US

## Transit Ridership

*Elasticities from Regressions & Logits*

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Metric</th>
<th># Studies</th>
<th>Elasticity</th>
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<tbody>
<tr>
<td>Density</td>
<td>Population Density</td>
<td>10</td>
<td>.07</td>
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<tr>
<td></td>
<td>Job Density</td>
<td>6</td>
<td>.01</td>
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<tr>
<td>Diversity</td>
<td>Land Use Mix <em>(0-1)</em></td>
<td>6</td>
<td>.12</td>
</tr>
<tr>
<td>Design</td>
<td>Intersections/Street Density</td>
<td>4</td>
<td>.23</td>
</tr>
<tr>
<td></td>
<td>Connectivity <em>(4-way inter.)</em></td>
<td>5</td>
<td>.21</td>
</tr>
<tr>
<td>Distance to Transit</td>
<td>Distance</td>
<td>3</td>
<td>.29</td>
</tr>
</tbody>
</table>

_Elasticity = (\% ∆ Ridership) / (\% ∆ in “D” Variable)_

Arlington County
America’s Success Story
TOC: Transit Oriented Corridor
“String of Pearls”

• VMT/capita of TOD Residents: 40% below regional average
• “Balanced Development” = “Balanced Flows”
Are Land Use Planning and Congestion Pricing Mutually Supportive? Evidence From a Pilot Mileage Fee Program in Portland, OR
Zhan Guo, Asha Weinstein Agrawal, and Jennifer Dill

- **2006 Experiment of VMT Charge in Portland OR**
- **183 HHs** – some paid flat VMT rate; others paid rate that varied by time and location – **10¢/mile peak; 0.5¢/mile off-peak** (congestion charge)
- Found **greater VMT reduction** in denser, mixed-use neighborhoods with congestion charges
Urban Regeneration & BRT in Seoul, Korea

Redesign of Seoul Plaza “Calmed” Traffic with a Pedestrian Oval

Before: 2003

After: 2005

Cheong Gye Cheon Freeway Removal/Stream Restoration
Seoul, Korea

BRT: Key to absorbing traffic displaced by road capacity losses

Before (2004)

After: 2005

Exclusive median bus lanes: 7 lines/ 84 km

Curbside bus lanes: 293.6 km
- Greening of Central Seoul

**Thermal Intensity in CBD**

Average Lowering of Temperature of 2%~5%
Figures refer to actual maximum passenger demand, not theoretical maximum capacity. Figures are from ITDP field surveys.

Source: itdp-china.org
Multi-modal (NMT) Integration was a conscientious part of system planning...NOT an Afterthought

Perpendicular “Green Connectors”
Seamless Pedestrian Connectivity through same-grade footbridges and BRT/Commercial Building integration
Integration of BRT station bridge & building, with double-tier bike parking under the bridge.
Hong Kong’s “R+P” (Rail + Property)

MTRC’s property developments along rail line

MTR’s Revenue Sources

Place-making & Value

1980s-90s “Pre-Place-making” Station Access

Post-2000s “Place-making” Station Access

Ped-Friendly Access & Place-making Designs
Increased profits ~ 25%; Ridership Bonus ~ 20%
Transit Value Capture in So. California

1906

1912
Back to the Future

30 Year Plan
Transit Extensions

Total Fixed-Guideway Transit:
197-205 stations
236.2+ miles