Network Design, Built & Natural Environments & Active Travel

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University of California, Berkeley

Civil Engineering
University of Toronto
Distinguished Lecture Series
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Active Transport/NMT

Why?

• Public Health Benefits

• The Cleanest/Greenest Modes

• Livability = Walkability

• Build Social Capital
Obesity and Active Transportation

SHIFT:
In Mobility Priorities
– FROM THIS

UN Habitat, Global Report on Sustainable Mobility, 2013.

SHIFT: ... TO THIS

In Mobility Priorities

UN Habitat, Global Report on Sustainable Mobility, 2013.
http://www.unhabitat.org/pmss/listItemDetails.aspx?publicationID=3503

Seoul: Freeway Removal-Stream Restoration
Cheong Gye Cheon

June 2003 Before Restoration
June 2004 Under Restoration
September 2005 After Restoration
The Place-Making Premium
Marginal Effects** of Freeway vs Greenway on Commercial Land Price

![Marginal Effects Graph]

**Effects relative to otherwise comparable site > 500m


Impact on Employment in “Creative Class” Sectors
Distance to Ramps or Pedestrian Entrances

![Marginal Effects Graph]

* 10% Probability Level
Atlanta adults: accelerometer showed people who live in walkable neighborhoods are more likely to meet recommended daily levels of physical activity.


BUILDING THE EVIDENCE

Matched Pair: Rockridge (TND) & Lafayette (AOD)

TND = Traditional Neighborhood Design
AOD = Auto Oriented Design

ACTIVE LIVING RESEARCH
Promoting activity-friendly communities
Two Contrasting Neighborhoods

<table>
<thead>
<tr>
<th>Community Type</th>
<th>TND</th>
<th>AOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>VMT/person/day</td>
<td>14.5</td>
<td>27.7</td>
</tr>
<tr>
<td>% Rail</td>
<td>23%</td>
<td>7%</td>
</tr>
<tr>
<td>% Walk/Bike</td>
<td>14%</td>
<td>3%</td>
</tr>
<tr>
<td>Out of Neighborhood Shop Vehicle Trips/Day</td>
<td>0.5</td>
<td>2.1</td>
</tr>
</tbody>
</table>

Travel & the “D”s

5D’s of the Built Environment

Density
Diversity
Distance to Transit
Destination Access
Design

Impacts

VKT/Capita
Non-Car 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

Walking/Built-Environment Elasticities

Meta-Evidence from Predictive Models:
Global Experiences (mainly U.S.)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Walking Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>Household/Population Density</td>
<td>0.07</td>
</tr>
<tr>
<td>Diversity</td>
<td>Land Use Mix (entropy)</td>
<td>0.15</td>
</tr>
<tr>
<td>Design</td>
<td>Intersection/Street Density/Connectivity</td>
<td>0.39</td>
</tr>
<tr>
<td>Destination Accessibility</td>
<td>Job Accessibility By Auto</td>
<td>0</td>
</tr>
<tr>
<td>Distance to Transit</td>
<td>Distance to Nearest Transit Stop</td>
<td>0.15</td>
</tr>
</tbody>
</table>

Elasticity = (% Δ Walk Trips) / (% Δ in Built Environment Metric)

NMT & Travel: *Meta-Review*

**Catalysts:**
- Dense, Compact Cities

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**Source:** A. Bertaud, World Bank, 2005.

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**First Year Impacts:**
- Reduction in car-NMT accidents and neighborhood crime
- Higher residential satisfaction and community rating
- Small shops prospering (though higher rents)
NMT & Travel

Catalysts:

- High Connectivity
- Low-Stress, Direct Paths

BUILDING A NETWORK

Bike lanes encourage bike commuting:

Portland, Oregon 1990

Black lines: 1990 bikeway network...

Colors areas: 1990 mode splits (by census tract)

Bike Commute Mode Split
- 0 - 2%
- 2 - 3%
- 3 - 5%
- 5 - 8%
- 8 - 10%
- 10+%
BUILDING A NETWORK
Bike lanes encourage bike commuting:
Portland, Oregon 2000

Black lines: 2000 bikeway network...
Colors areas: 2000 mode splits (by census tract)

City of Portland Dept. of Transportation

Bridge Bicycle Traffic
Bikeway Miles

Network Effects: Regional Links = Cordon Counts

Cyclists Per Day Crossing Bridge
Bikeway Miles

1991:
78 miles of bikeways
2,850 daily trips

2006:
263 miles of bikeways
11,956 daily trips

Bridge Bicycle Traffic: 2,850 3,885 3,207 5,225 5,910 8,250 8,875
Bikeway Miles: 78 96 113 156 215 304 360 426 513 650 760 846 962 1,062 1,156 1,263

Cordon Counts
NMT & Travel Catalysts:

- **Hardware - Infrastructure** (“Build It and They Will Come”)
  - Paris Velib
  - Tokyo Automated Underground Bike Parking
  - Dutch Rail Bike Parking
  - Copenhagen Green Wave Bike App
  - Secure Bike Lockers BART

Catalysts:

- **Software – Pro Active-Transport Public Policies**
  - Bike-Friendly Copenhagen

Inclusive Cycling
NMT & Travel Catalysts:

- Design; Art; Aesthetics; Amenities – Green & Blue

- Land-Use Mixes

Study: Sidewalk conversations, photos, pause to admire & ‘strangers chatting’ increased to 32% of users vs. 7% at similar intersection w/o a Mural; Many cyclists took detours

Mixed Uses: walking & cycling advantageous for intermediate stopping

Built Environments & Active Transport in Bogotá

Influences of Built Environments on Walking and Cycling: Lessons from Bogotá

Robert Cervero, Ph.D., University of California, Berkeley
Olga L. Sarmiento, M.D., Los Andes University, Bogotá
Enrique Jacoby, M.D., PanAmerican Health Organization, Washington
Luis Fernando Gomez, M.D., Fundacion Social, Bogotá


Physical Activity & Travel Data: weekly dairies completed from International Physical Activity Survey (IPAQ) of 1335 HHs; validated by accelerometers
### Sample & Scales of Analysis for Built Environment Variables:
**Applied Multi-Level Modeling**

#### Stratified Sample of 30 Neighborhoods

#### Dimension | Candidate Variables
---|---
(1) **DENSITY** | Persons per hectare; dwelling units per hectare; % of land area occupied by buildings; average building floor height; plot ratio (building m²/land m²)
(2) **DIVERSITY** | Entropy index of land-use mix (0-1 scale); proportion of buildings vertically mixed; proportion of total floorspace in buildings with 2+ uses
(3) **DESIGN Amenities** | Public park area as % of total land area; average park size (hectares); % of road links with median strips; traffic light density (traffic lights/street length); tree density (trees/street length);
(3) **DESIGN Site & Street Design** | Average lot size (m²); quadrilateral lots as % of total; percent of blocks with contained housing and access control; street density (street area/land area); proportion of intersections with: 1 point (cul de sac), 3 points, 4 points, 5+ points; bike lane density (lineal m of bikelane/lineal m of streets); route directness (0-1 scale measuring shortest street distance/straightline distance between neighborhood centroid and 8 compass points); connectivity index (intersection nodes/street links); number of bridges; ciclovia twoway length (lineal m)
(3) **DESIGN Safety** | Number of pedestrian bridges; pedestrian accidents per year; average automobile speeds on main streets; deaths (all types) in traffic accidents per year; number of reported crimes per year
(4) **DESTINATION ACCESSIBILITY** | Number of: public schools; hospitals; public libraries; shopping centers (> 500m²); churches; banks
(5) **DISTANCE TO TRANSIT** | Number of TransMilenio (BRT) stations; shortest network distance to closest TransMilenio station; number of feeder TransMilenio stations.
Site & Street Design: Walking Quality

- **Lighting**: # street lights/road length (centerline)
- **Trees**: # street trends/road length
- **Furniture**: # benches/road length
- **Prop. of signals with**:
  - Ped phase
  - Marked crosswalks
- **Ped Signal Lengths**: average of:
  - (Duration of Ped. Lights / Signal Cycle Length)
- **Average block length**
- **Average street width**
- **Prop. of road links with median strips**
- **Bike-lane density**: bikelane distance (centerline) / km² of land
- **Distance between overhead lights**
- **Ped. Accident rates**
- **Average auto speeds**

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**Bogota’s Green Connectors -- CICLORUTA**
(Today: 344 kms; 285K daily bicyclists (2% of trips); 70% BRT access by Biking or Walking)
Odds Ratios & 95% Conf. Intervals for MLM on
Walking ≥ 30 Minutes per Weekday
for Utilitarian Purposes

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Odds Ratio

- **1.5**
- **1.5**
- **2.0**
- **2.2**
- **0.4**
- **0.5**
- **0.7**

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500m radius

1000m radius

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Low walking incidence & Bus Feeders

High walking incidence & Transmilenio Stations
Adjusted OR and 95% CI for MLM on
Cycling ≥ 30 Minutes per Weekday
for Utilitarian Purposes

1000m-- Neighborhood

LEGEND
Bike Path (Cicloruta)
Street density ≥ 0.20
Deaths in traffic acc
Car
Men

Low Biking incidence neighborhood
High Biking incidence neighborhood

Hillside
Adjusted OR and 95% CI for MLM on Ciclovia Participation in Past 30 Days

<table>
<thead>
<tr>
<th>Ciclovia meters</th>
<th>Park area: &gt;2500m²</th>
<th>Male</th>
<th>Car</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.9</td>
<td>0.5</td>
<td>2.6</td>
<td>0.5</td>
</tr>
</tbody>
</table>

1000m buffer

Ciclovia network

High Ciclovia participation neighborhood

Low Ciclovia participation neighborhood
TransMilenio (BRT) & Active Transport

Minibus Feeders

< 5km

TransMilenio (BRT)

> 5km

Policy Choices:
Invest in Feeder Buses or “Green Connectors”?

From Parking-&-Ride to Bike-&-Ride & Walk-&-Ride

Robert Cervero, University of California, Berkeley
Why NMT Access?
Walk & Ride/Bike & Ride

- Environmental/Energy Benefits
- Less station-area traffic congestion/improved TOD environment
- Land Conservation/Reduced Impervious Surface
- Active Transport = Improved Fitness
- Social Justice/Pro-poor policy

Elasticity Estimates for BART (Bay Area):
percentage change in probability of Walk-and-Ride travel with a one-percent increase in explanatory variable

<table>
<thead>
<tr>
<th>Explanatory Variables:</th>
<th>Mid-point elasticities for:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Walk-Access</td>
</tr>
<tr>
<td>Employment Density</td>
<td>.220</td>
</tr>
<tr>
<td>Residential Density</td>
<td>.269</td>
</tr>
<tr>
<td>Street Connectivity</td>
<td>.733</td>
</tr>
<tr>
<td>(Links/Nodes)</td>
<td></td>
</tr>
<tr>
<td>Land-Use Diversity</td>
<td>.119</td>
</tr>
<tr>
<td>Park-and-Ride spaces</td>
<td>-.484</td>
</tr>
<tr>
<td>at station</td>
<td></td>
</tr>
<tr>
<td>Transit Service Levels</td>
<td>.474</td>
</tr>
<tr>
<td>Terminal or Near-</td>
<td>-.093</td>
</tr>
<tr>
<td>Terminal Station</td>
<td></td>
</tr>
<tr>
<td>Station in Freeway</td>
<td>-.134</td>
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<tr>
<td>Median</td>
<td></td>
</tr>
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</table>

Bikeshed Analysis

<table>
<thead>
<tr>
<th>Bike Infrastructure (lineal km)</th>
<th>1998-2008 % Δ</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 Percentile Bike-shed</td>
<td>172.4%</td>
</tr>
<tr>
<td>75 Percentile Bike-shed</td>
<td>200.0%</td>
</tr>
<tr>
<td>95 Percentile Bike-shed</td>
<td>217.7%</td>
</tr>
</tbody>
</table>
Bikeshed Analysis

Fruitvale BART Station
Urban Parking Station

<table>
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<th>Bike Infrastructure (lineal km)</th>
<th>% Δ 1998-2008</th>
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<tbody>
<tr>
<td>50 Percentile Bike-shed</td>
<td>827.3</td>
</tr>
<tr>
<td>75 Percentile Bike-shed</td>
<td>242.5</td>
</tr>
<tr>
<td>95 Percentile Bike-shed</td>
<td>352.5</td>
</tr>
</tbody>
</table>

First/Last Mile Connectivity

New Age Access: Smart Mobility

Autonomous Shuttles
Autonomous Vehicles/Self-Driving Cars/Connected Vehicles – **Game Changer?**

**Impacts:**

- **Safety ✓**
- **Traffic/Urbanization?**

  **Could increase VKT/Car-Oriented Growth**
  - Lowering generalized costs of travel & parking, inducing travel
  - Reduce non-recurrent congestion from fewer collisions
  - Enabling car users to be more comfortable and productive while traveling
  - Provide automobility to seniors, youth, disabled

**Could reduce VKT/Promote Ped-Friendly Growth**
- Car-sharing
- Smart pricing

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**Marriage of Self-Driving Cars & Car Sharing: Shared, Smart Urban Mobility**

- **Accelerated by Megatrends:** Millennials; Urban Regeneration; Collaborative Consumption; Shifting Lifestyle Preferences
- **Google’s Vision:** Car-Sharing Subscription Service
- **Reduce demand and urban space for parking**

  **ITF Study:** could eliminate 90% of existing cars, reducing congestion; totally remove on-street parking; medium-sized cities – obviate the need for public transport (replaced by Smart Microtransit)
Micro-Mobility/Dynamic Ridesharing

- **Growth Market:**
  - Achieved Scale Economies
  - UberPool in > U.S. 30 cities;
  - > 50% trips in many cities; SF, LA, NY
    > >100,000 trips per week

- **Transit Complement:**
  First/Last Mile connectivity
  - LA – 14% trips start/end at Metro
  - SF – 10% trips start/end at BART

- **Hot Spots:** operational efficiencies; smart jitneys

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**SINGAPORE:**

*People-Mover*

**Autonomous Station Cars:**

Pilot Test Delphi Cars on 3 *routes* ... First-Mile/Last-Mile Feeders

*Extended TOD*
Next generation ERP: Global Navigation Satellite System (GNSS) -- overcomes the inflexibility of physical gantries and makes distance-based congestion charging possible.

Fairer since ERP charges will be based on the actual length of congested roads used by motorists. More dynamic adjustments of charges with time (tied to changing levels of congestion) will also be possible.

• **Run Commuting**: popular in *London, Washington DC*: Natural habitats: traffic congestion; crowded subways; legions of fitness-minded professionals; workplaces that offer showers, downtown gyms; linear networks of parks, bike paths, and trails that feed into the business districts; well landscaped, run-inspiring riverfronts.

• **Main Reasons**: (SurveyMonkey: N=77)
  - Get in a Workout (68%)
  - Mental: better mood; elation (38%)
  - Efficient: saves time (26%)
  - Being outdoors (23%)
  - Save $ (19%)
  - Reduce Stress (15%)
Network Design, Built and Natural Environments and Active Commuting

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University of California, Berkeley

Moderator
Paul Hess
Professor, Geography and Planning, University of Toronto

Panelists
Geoff Wright
Commissioner of Transportation and Works, City of Mississauga

Barbara Gray
General Manager, Transportation Services, City of Toronto

Steven Farber
Assistant Professor, Department of Human Geography, UTSC