The Built Environment and Motor Vehicle Ownership & Use
Evidence from Santiago de Chile

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Outline

■ Built Environment and Travel: A Rapid Overview
■ Empirical Case: Santiago de Chile
  ■ Snapshots of Urban Structure, Form, Design
  ■ A Few Transportation Indicators
■ The Built Environment and Household Travel
  ■ Influence on Motor Vehicle Ownership
  ■ Influence on Motor Vehicle Use
■ Implications and Research Extensions
The Built Environment and Travel Behavior… “Nothing New”

- Variations due to:
  - Scale of analysis, analytical techniques, built environment measures, data type, travel outcome measured

Built Environment and Motor Vehicle Ownership & Use: Direct Precedents

- Why Motor Vehicle Ownership & Use?
- Aggregate-level analyses
- Disaggregate-level analyses
- Crucial to explicitly link the two (ownership and use): endogeneity, selectivity bias
Santiago de Chile: A “Two-Minute Tour”

The Emerging Middle Class

Number of Households

Annual Income (US$2001)

Sources: Derived from SECTRA, 1992; 2002

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Urban Density (persons/hectare)

Per Capita Car Kms

Hong Kong

Sacramento, CA

13 US Cities

6 Australian Cities

7 Canadian Cities

11 European Cities

6 "Developing" Asian Cities

3 Wealthy Asian Cities

Santiago

Kenworthy & Laube, 1999 (except Santiago)
Urban Form: The CBD and its Eastern “migration”

Internal Patterns
Diversity/Dis-Similarity Index
Household Transportation: What Role of the Built Environment?

A Note on Data Sources

- Primary: Household travel survey (2001)
- 15,000 households (1% sample)
  - 12,000 during “normal season”
  - 3,000 during summer
  - Geo-coded at census block centroid
- 38 Municipalities; 780 Traffic Analysis Zones (TAZs)
- All Trips in public space, by all individuals in HH
- Trip origins and destinations geocoded at nearest street corner
Santiago’s Travel in Context

Motorization and Mode Share Evolution

Source: Kenworthy and Laube, 2001 (except Santiago)

SECTRA, 2002

What Role of the Built Environment?

- Discrete choice model (multinomial logit) of household vehicle ownership
  - Decision to own: 0, 1, 2, 3+ vehicles in the home
  - HH Vehicle Ownership:
    - 0 Vehicles: 59% of HHs
    - 1 Vehicle: 32% of HHs
    - 2 Vehicles: 8% of HHs
    - 3+ Vehicles: 2% of HHs
### HH Motor Vehicle Ownership Choice

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Variable</th>
<th>Number of Vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>HHs</td>
<td>Household Income</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td># Persons</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td># Adults</td>
<td>-</td>
</tr>
<tr>
<td>Urban Form</td>
<td>Auto:Bus Accessibility</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>CBD Dist</td>
<td>n.a.</td>
</tr>
<tr>
<td>Urban Design</td>
<td>Apartment</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Diversity Index</td>
<td>n.a.</td>
</tr>
<tr>
<td></td>
<td>Dwelling Unit Density</td>
<td>n.a.</td>
</tr>
</tbody>
</table>

n=14729. Rho-Square = 0.451. n.a.means variable was not significant for the relevant choice. In all other cases, significance at ≥ 95%

![Graph showing HH Income, Auto:Bus Accessibility, and Apartment Living for Choice to Own One Vehicle](image1)

![Graph showing HH Income, Auto:Bus Accessibility, Apartment Living, Dwelling Unit Density, Diversity Index, and Dist. to CBD for Choice to Own Two Vehicles](image2)

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Auto Ownership Results

- At least one vehicle seems a certainty as soon as income allows; some dampening effect from apartment living

*Micro-Level BE:*
- Dwelling unit density and land use mixing (diversity index) have strongest BE effect on additional (i.e., after first) vehicle
- Street patterns, block morphology, intersection density, etc. – no detectable effect

*Meso-/Metro-Level BE:*
- The “compact city” finds some support: distance to CBD effects

**Implication:** Incorporate BE variables in auto ownership forecasting for travel modeling

What Role of the Built Environment on Automobile Use?

- OLS model of total Household vehicle kilometers traveled
  - On day of survey
  - Distance derived from trip x,y coordinates and shortest path on road network

- HH VKT = f (HH Socio-demographics, Trip-Making, Urban Form, Urban Design)
  - But, need to control for “selectivity bias”
## Motor Vehicle Use Results

**Dependent variable:** Total HH vehicle use (measured in meters traveled)

R-Squared = .27; N=4279.

Heteroskedasticity-Consistent Standard Errors used to Determine Significance

### Variables and Coefficients

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>Stdz</th>
<th>Sig</th>
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</thead>
<tbody>
<tr>
<td><strong>Vehicles</strong></td>
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</tr>
<tr>
<td>Number Vehicles</td>
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<td>Avg. Vehicle Age</td>
<td>9130</td>
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<tr>
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<td>-255</td>
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<tr>
<td><strong>HHs</strong></td>
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<tr>
<td>HH Income (US$)</td>
<td>69.6</td>
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<td># Drivers License</td>
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<tr>
<td><strong>Trips</strong></td>
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<td><strong>Urban Form</strong></td>
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<tr>
<td>Dist to CBD</td>
<td>0.59</td>
<td>0.109</td>
<td>0.000</td>
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<td>Dist to Metro</td>
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<td>0.043</td>
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<td><strong>Urban Design</strong></td>
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<td>4-Way Int. per KM</td>
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<td>3-Way Int. per KM</td>
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<tr>
<td>Select. Bias Correction</td>
<td>5603</td>
<td>0.056</td>
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</table>

### HH Motor Vehicle Use

**Dependent variable:** Total HH vehicle use (measured in meters traveled)

R-Squared = .27; N=4279.

Heteroskedasticity-Consistent Standard Errors used to Determine Significance

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Implications for Planning/Design

- **Meso-Level BE**: Some support for:
  - The “compact city” (CBD effects)
  - Reducing development pressures in the foothills
  - “Transit-Oriented Development” (Metro proximity)
    - Auto-owning HHs within 1 km radius of existing stations, on average, travel ~2 kms less by auto than those living 4 kms from a station

- **Micro-Level BE**:
  - Local street network and public spaces (plazas) have some effect
  - *No Apparent Direct Effect* of Dwelling Unit Density, Land Use Mix

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**Metro Station Entries (Daily Average) and Population Density**
Analysis: In Summary

- Distance to CBD separately influences vehicle ownership and use
  - 1-KM further from CBD, increases use by ½ KM
- Relative attractiveness of auto use (to bus) influences additional vehicle purchases
- Dwelling unit density directly influences additional vehicle purchases; second-order impact on use
- Metro proximity influences vehicle use
- Local street design and public spaces influence vehicle use

Outlook for Santiago

Some Positive Signs

- Urban renewal (the “renovated” city)
- Impact Fees (slowing the sprawl, marginally)
- “New Town” regulations (ZODUCs)
  - Ostensibly will create a “poly-nucleated city”
- Some efforts focusing on renewing the de-industrializing swaths of the center city
- Strong technical capacity within centralized authorities (and universities) for transportation planning and evaluation and fairly good data
Research Extensions

- Correct for Endogeneity
  - In vehicle choice model
  - And vehicle use model
  - Via development of a residential choice model
- Examine alternative spatial units of analysis
  - To assess potential effect of Modifiable Areal Unit Problem (MAUP)