A Pathway Linking Smart Growth Neighborhoods to Home-Based Pedestrian Travel

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A Pathway Linking Smart Growth Neighborhoods to Household-level Pedestrian Travel

Steven R. Gehrke
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Civil & Environmental Engineering | Portland State University | Portland, Oregon, USA
Land development patterns and urban design linked to travel behavior

- Smart growth policies and practice create activity-friendly, walkable communities
- Policy goal in 2009 Interagency Partnership for Sustainable Communities

Need to identify built environment indicators and set common standards

- Past active travel studies have adopted imperfect built environment measures
- Host of individual, societal, and contextual factors are hypothesized to predict walking behaviors for transportation and recreational purposes

Research context and motivation

Compact Development  High Activity Density  Walkable Design
Study objectives

Introduce a multidimensional construct of the built environment
- Reflect several heralded tenants of smart growth development
- Offer insight into measurement selection and packaging of different elements

Propose framework and method linking this construct to pedestrian travel
- Simultaneously account for various and confounding determinants of walking
- Extend understanding of link between smart growth development and walking
Individual perceptions of built environment
• Explore themes of neighborhood accessibility, arrangement and aesthetic, and sense of place to recognize their influence on auto ownership and mode choice
• Subject to reporting bias that may inflate connection and difficulty in translation

Objective measures of built environment
• Early studies explored limited number of indicators to reflect land use construct
• Recent studies test more indicators to examine short- and long-term decisions

Important gaps
• Few SEM studies exclusively reflect built environment with objective measures
• Studies largely examine built environment impact on auto-related outcomes

Structural equation models (SEM) of transport-land use link
Conceptual framework

**Built Environment**

Land Development Patterns
- Land Use Mix
- Density

Urban Design
- Arrangement
- Aesthetic

Transportation System
- Infrastructure
- Performance

**Sociodemographic, Economic, and Psychosocial**
- Individual
- Household
- Neighborhood

**Travel Behaviors and Patterns**
- Trip Distance
- Mode Choice

*Other Contextual Factors*
Data and methods

Study area and sample
- Multnomah, Clackamas, and Washington Counties in Oregon
- 2011 Oregon Household Activity and Travel Survey (OHAS)
  - One-day travel diary for a study sample of 4,416 households
  - Travel behavior and sociodemographic and economic information

Built environment measurement
- Set of 62 indicators measured within a one-mile areal buffer at home location
- Secondary data sources
  - 2011 Portland Metro Regional Land Information System (RLIS)
  - 2014 Longitudinal Employer-Household Dynamic (LEHD)
  - 2010 US Census and Topologically Integrated Geographic Encoding and Referencing (TIGER)
Built environment measurement

**Built Environment**

- **Land Development Patterns**
  - Land Use Mix
  - Density

- **Urban Design**
  - Arrangement
  - Aesthetic

- **Transportation System**
  - Infrastructure
  - Performance

**Land Use Mix: Composition**

- Land use percent for nine land use types
- Land use entropy index
- Land use balance
- Activity-related complementarity
- Employment entropy
- Employment-population balance
- Retail employment-population balance
- Land use patches for nine land use types

**Land Use Mix: Configuration**

- Maximum patch size for nine land use types
- Maximum patch size (overall)
- Contagion index
Built environment measurement

**Built Environment**

- Land Development Patterns
  - Land Use Mix
  - Density

- Urban Design
  - Arrangement
  - Aesthetic

- Transportation System
  - Infrastructure
  - Performance

**Density**

- Population
- Housing units
- Employment
- Office jobs
- Retail jobs
- Industrial jobs
- Service jobs
- Entertainment jobs
- Total activity (population and employment)
Built environment measurement

**Built Environment**

- Land Development Patterns
  - Land Use Mix
  - Density

- Urban Design
  - Arrangement
  - Aesthetic

- Transportation System
  - Infrastructure
  - Performance

**Urban Design and Transportation System**

- Census blocks
- Street blocks
- Connected node ratio
- Alpha index
- Beta index
- Gamma index
- Three- and four-way intersections
- Cul-de-sacs
- Miles of primary, secondary, and local roads
- Percent of primary, secondary, and local roads
- Sidewalk coverage
Analytic approach

Zero-order correlation matrix
  • Eliminate associated measures that point toward concept redundancy

Exploratory factor analysis
  • Identify sets of interrelated measures reflecting built environment dimensions
  • Generate theoretic understanding of internal structure of measures

Structural equation modeling
  • Confirmatory factor analysis
    • Identify latent constructs of built environment reflecting multiple indicators
  • Path analysis
    • Simultaneously test for direct and indirect effects of built environment on pedestrian travel
Confirmatory factor analysis

Built Environment

Land Development Patterns
- Land Use Mix
  - Density

Urban Design
- Arrangement
- Aesthetic

Transportation System
- Infrastructure
- Performance

CFA Fit Statistics:  CFI: 0.96 | TLI: 0.91

Activity-related complementarity
- Employment entropy
- Maximum patch size: Agricultural *
- Maximum patch size (overall) *
- Contagion index *

* Reverse Coded
Confirmatory factor analysis

Built Environment

Land Development Patterns
- Land Use Mix
- Density

Urban Design
- Arrangement
- Aesthetic

Transportation System
- Infrastructure
- Performance

Employment Concentration

- Employment-population balance: 0.83
- Office jobs: 0.91
- Retail jobs: 0.87

CFA Fit Statistics: CFI: 0.99 | TLI: 0.99
Confirmatory factor analysis

Built Environment

Land Development Patterns
- Land Use Mix
- Density

Urban Design
- Arrangement
- Aesthetic

Transportation System
- Infrastructure
- Performance

Pedestrian-Oriented Design

- Land use patches: Retail: 0.92
- Connected node ratio: 0.91
- Sidewalk coverage: 0.72

CFA Fit Statistics: CFI: 0.99 | TLI: 0.99
Structural equation model

Built Environment

- Land Use Mix
- Employment Concentration
- Pedestrian-Oriented Design

Smart Growth Neighborhood

Sociodemographic and Economic
- Number of children under 6 years
- Number of children 6 years or older
- Number of adults
- Non-related household
- Annual household income
- Number of household workers
- Oldest household member
- Highest household educational attainment
- Vehicles per licensed adult
- Transit passes per adult
- Bikes per person 6 years or older

Travel Behaviors and Patterns
- Trip Distance
  - Walk Mode: Transportation
  - Walk Mode: Discretionary

SEM Fit Statistics: CFI: 0.85 | TLI: 0.80 | RMSEA: 0.08
### Results: Walk for transportation purposes

**Outcome:** Household-level decision to participate in ≥ 1 home-based walk trip for *transportation* purposes

<table>
<thead>
<tr>
<th>Indicator Name</th>
<th>Direct Effect</th>
<th>p-value</th>
<th>Total Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of children under 6 years</td>
<td>0.04</td>
<td>0.05</td>
<td>0.04</td>
</tr>
<tr>
<td>Number of children 6 years or older</td>
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<td>0.00</td>
<td>0.15</td>
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<tr>
<td>Number of adults</td>
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<td>0.00</td>
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</tr>
<tr>
<td>Annual Income: $50,000 to $99,999</td>
<td>-0.06</td>
<td>0.04</td>
<td>-0.06</td>
</tr>
<tr>
<td>Annual Income: $100,000 or more</td>
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<td>0.01</td>
<td>-0.11</td>
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<tr>
<td>Household workers: 3 or more</td>
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<td>0.01</td>
<td>-0.05</td>
</tr>
<tr>
<td>Education: Graduate degree</td>
<td>0.05</td>
<td>0.10</td>
<td>0.09</td>
</tr>
<tr>
<td>Vehicles per licensed driver</td>
<td>-0.05</td>
<td>0.00</td>
<td>-0.11</td>
</tr>
<tr>
<td>Transit passes per adult</td>
<td>0.00</td>
<td>0.90</td>
<td>0.01</td>
</tr>
<tr>
<td>Bikes per person 6 years or older</td>
<td>0.03</td>
<td>0.04</td>
<td>0.06</td>
</tr>
<tr>
<td><strong>Smart Growth Neighborhood</strong></td>
<td><strong>0.22</strong></td>
<td><strong>0.00</strong></td>
<td><strong>0.26</strong></td>
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</table>
### Results: Walk for discretionary purposes

#### Outcome: Household-level decision to participate in ≥ 1 home-based walk trip for *discretionary* purposes

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<th>Total Effect</th>
</tr>
</thead>
<tbody>
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<td>Number of children under 6 years</td>
<td>-0.02</td>
<td>0.34</td>
<td>-0.02</td>
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<td>Number of children 6 years or older</td>
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<tr>
<td>Number of adults</td>
<td>0.08</td>
<td>0.00</td>
<td>0.05</td>
</tr>
<tr>
<td>Annual Income: $50,000 to $99,999</td>
<td>0.03</td>
<td>0.24</td>
<td>0.01</td>
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<tr>
<td>Annual Income: $100,000 or more</td>
<td>0.01</td>
<td>0.84</td>
<td>-0.01</td>
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<tr>
<td>Household workers: 3 or more</td>
<td>-0.04</td>
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<td>-0.04</td>
</tr>
<tr>
<td>Education: Graduate degree</td>
<td>0.05</td>
<td>0.09</td>
<td>0.07</td>
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<tr>
<td>Vehicles per licensed driver</td>
<td>-0.02</td>
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<tr>
<td>Transit passes per adult</td>
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<td>-0.02</td>
</tr>
<tr>
<td>Bikes per person 6 years or older</td>
<td>0.02</td>
<td>0.27</td>
<td>0.04</td>
</tr>
</tbody>
</table>

| Smart Growth Neighborhood                           | 0.15          | 0.00    | 0.17         |
Conclusions

Study contributions and potential implications

- Introduced second-order construct of smart growth reflecting three key tenets
  - Provided planners an identified set of indicators reflecting built environment efficiencies
  - Guide land development discussion away from contentious debates focused on density
- Demonstrated link between smart growth residential environments and walking
  - Strong direct and total effect on household-level choice to participate in a walk trip
  - Highlight continued prospect of smart growth policies facilitating more physical activity

Next steps

- Additional non-built environment variables and complexity to SEM analysis
  - Sociodemographic and economic characteristics as formative construct
  - Hierarchical framework to model individual-level travel behaviors
- Further attention to choice of geographic scale used to operationalize indicators
Thank you. Questions?

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