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
Kelly J. Clifton

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
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
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

Land Use Mix

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Activity-related complementarity</td>
<td>0.97</td>
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<tr>
<td>Employment entropy</td>
<td>0.54</td>
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<tr>
<td>Maximum patch size: Agricultural *</td>
<td>0.87</td>
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<tr>
<td>Maximum patch size (overall) *</td>
<td>0.86</td>
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<tr>
<td>Contagion index *</td>
<td>0.94</td>
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</table>

CFA Fit Statistics: CFI: 0.96 | TLI: 0.91

* 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>
<td>0.15</td>
<td>0.00</td>
<td>0.15</td>
</tr>
<tr>
<td>Number of adults</td>
<td>0.10</td>
<td>0.00</td>
<td>0.07</td>
</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>
<td>-0.08</td>
<td>0.01</td>
<td>-0.11</td>
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<tr>
<td>Household workers: 3 or more</td>
<td>-0.05</td>
<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>
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<tr>
<td>Transit passes per adult</td>
<td>0.00</td>
<td>0.90</td>
<td>0.01</td>
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<tr>
<td>Bikes per person 6 years or older</td>
<td>0.03</td>
<td>0.04</td>
<td>0.06</td>
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<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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### 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>
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</thead>
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<tr>
<td>Number of children under 6 years</td>
<td>-0.02</td>
<td>0.34</td>
<td>-0.02</td>
</tr>
<tr>
<td>Number of children 6 years or older</td>
<td>0.06</td>
<td>0.01</td>
<td>0.06</td>
</tr>
<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>
</tr>
<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>
<td>0.03</td>
<td>-0.04</td>
</tr>
<tr>
<td>Education: Graduate degree</td>
<td>0.05</td>
<td>0.09</td>
<td>0.07</td>
</tr>
<tr>
<td>Vehicles per licensed driver</td>
<td>-0.02</td>
<td>0.12</td>
<td>-0.07</td>
</tr>
<tr>
<td>Transit passes per adult</td>
<td>-0.03</td>
<td>0.04</td>
<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>
<tr>
<td><strong>Smart Growth Neighborhood</strong></td>
<td><strong>0.15</strong></td>
<td><strong>0.00</strong></td>
<td><strong>0.17</strong></td>
</tr>
</tbody>
</table>
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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