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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

Research context and motivation
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
- Activity-related complementarity: 0.97
- Employment entropy: 0.54
- Maximum patch size: Agricultural: 0.87
- Maximum patch size (overall): 0.86
- Contagion index: 0.94

* Reverse Coded

CFA Fit Statistics: CFI: 0.96 | TLI: 0.91
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

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

Built Environment

- Land Use Mix
  - 0.63

- Employment Concentration
  - 0.53

- Pedestrian-Oriented Design
  - 0.85

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>
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<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>
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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>
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<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>Smart Growth Neighborhood</td>
<td>0.22</td>
<td>0.00</td>
<td>0.26</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>
<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>
</tr>
<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>
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<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>
</tbody>
</table>

**Smart Growth Neighborhood**

- **Direct Effect:** 0.15
- **p-value:** 0.00
- **Total Effect:** 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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