Development of prototype UrbanSim models

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Introduction

- Importance of integrated modeling
- UrbanSim (Wadell, 2002): appealing platform
- Most implementations done by UrbanSim's developers
- Effort required to develop an operational model? (very high, probably)
- Prototype models help to evaluate the application of a fully implemented UrbanSim model
Outline

1. Literature review
2. Brief UrbanSim description
3. Brussels case study
4. Lausanne case study
5. Developing a Prototype UrbanSim model
   - Familiarization
   - Data preparation
   - Sub-model estimation
   - Simulation and analysis
   - Evaluation
6. Conclusions
Literature review

- Descriptions of UrbanSim
- Computer science (software and user interface)
- Discrete choice innovations related to location choice (UrbanSim as a tool to test hypotheses)
- UrbanSim applications (by developers)
- Independent UrbanSim applications (Nguyen-Luong, 2008)

Little information on how to evaluate UrbanSim as an integrated model
UrbanSim

- Why UrbanSim?
  - Open source
  - Very disaggregate
  - Dynamic disequilibrium approach

- Disadvantages:
  - High data requirements (because of disaggregation)
  - Learning costs
  - Complexity of model preparation, estimation and calibration
UrbanSim

How UrbanSim works?

DEMAND

- Economic transition model
- Employment and household relocation model
- Demographic transition model

SUPPLY

- Development project transition model
- Real-estate location choice model
- Land-price model

New jobs
Relocating agents
New households

Located real-estate supply
Development constraints

Transport model

Transport system performance

Accessibility model

Swiss Transport Research Conference 2008
Fundamental Data

- Gridcells
- Households
- Jobs
- Buildings
- Development event history
- Development Constraints

“The Six Tables”
Two case studies

Brussels, Belgium

Lausanne, Switzerland
Brussels case study

- Data from an already implemented TRANUS model:
  - Households by zone and socio-economic cluster for 1991 and 2001
  - Employment by zone and economic sector (13) for 1991 and 2001
  - Land-value (3 land-uses) by zone for 2001
  - Interzonal travel time and logsums for 2001
  - GIS layer of road infrastructure
  - GIS layer of zoning
Brussels case study

Data preparation

- Standard gridcell of 150 x 150 meters
- Households and jobs were disaggregated into gridcells
- One building of each required type were created in each gridcell
- Number of residential units and non-residential surface was adjusted to account for vacancy rates
- Employment and population change between 1991 and 2001 was used to create a synthetic development event history
- Development constraints were derived from “observed” development in the city
Brussels case study

**Results** (Household Location Choice Model)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Cos t: Income</td>
<td>-0.0661</td>
<td>0.0307</td>
<td>-2.2</td>
</tr>
<tr>
<td>2 % High Inc. If High Inc.</td>
<td>0.0334</td>
<td>0.00150</td>
<td>22.3</td>
</tr>
<tr>
<td>3 % Low Inc. If High Inc.</td>
<td>0.00400</td>
<td>0.00138</td>
<td>2.9</td>
</tr>
<tr>
<td>4 % Low Inc. If Low Inc.</td>
<td>0.0603</td>
<td>0.00109</td>
<td>55.4</td>
</tr>
<tr>
<td>5 Travel Time to CBD</td>
<td>-0.000622</td>
<td>0.000148</td>
<td>-4.2</td>
</tr>
<tr>
<td>6 In Flanders</td>
<td>-0.0267</td>
<td>0.00856</td>
<td>-3.1</td>
</tr>
</tbody>
</table>

Null Log-likelihood is: -440982.247
Log-likelihood is: -439242.311
LR Test: 3479.871
Number of observations: 129655
Convergence statistic is: 7.617E-05
Brussels case study

Results:

Difference between observed and predicted population growth by comune (2000 – 2007)
Lausanne case study

- Available data
  - Swiss census of households (2000)
  - Swiss census of enterprises (2001)
  - GIS layers for geographical data
  - Transportation model (EMME)

- No info on land prices
- Imperfect data on household income
Lausanne case study

Data preparation

- Households: directly from census
- Jobs: a record for each job in each enterprise
- Buildings: from households and jobs tables
- Development event history: directly from census
- Development constraints were derived from observed development in the city
Lausanne case study

Results (Household Location Choice Model)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Cost: Income</td>
<td>-5.935</td>
<td>0.747</td>
<td>-7.9</td>
</tr>
<tr>
<td>2 Retail Employment WWD</td>
<td>0.0298</td>
<td>0.00328</td>
<td>9.1</td>
</tr>
<tr>
<td>3 % High Inc. If High Inc.</td>
<td>0.0298</td>
<td>0.000616</td>
<td>48.4</td>
</tr>
<tr>
<td>4 % Low Inc. If Low Inc.</td>
<td>0.0236</td>
<td>0.00113</td>
<td>21.0</td>
</tr>
<tr>
<td>5 High Density if Young</td>
<td>0.428</td>
<td>0.0177</td>
<td>24.1</td>
</tr>
<tr>
<td>6 Mixed Use if Young</td>
<td>0.454</td>
<td>0.0217</td>
<td>21.0</td>
</tr>
<tr>
<td>7 Res. Units with Children</td>
<td>-0.00472</td>
<td>0.000103</td>
<td>-45.6</td>
</tr>
<tr>
<td>8 Accessibility to Population</td>
<td>0.400</td>
<td>0.0455</td>
<td>8.8</td>
</tr>
<tr>
<td>9 Travel Time to CBD</td>
<td>-0.0211</td>
<td>0.00259</td>
<td>-8.1</td>
</tr>
<tr>
<td>10 Travel Time to Station</td>
<td>0.0320</td>
<td>0.00210</td>
<td>15.2</td>
</tr>
</tbody>
</table>

Log-likelihood is:                      -440830.606
Null Log-likelihood is:                 -444383.444
LR Test:                                7105.676
Number of observations:                 130655
Convergence statistic is:               5.398E-04
Lausanne case study

Results

Difference between observed and predicted population growth by comune (2000 – 2007)
Lausanne case study

Results

Increase in household location if the M2 line is built (2020)
Developing a Prototype UrbanSim model

- UrbanSim Example (e.g. Eugene)
  - Data Requirements
    - Local Data
  - Data Preparation
    - Submodel Estimation
      - Transport Model Integration
        - Simulation
          - Qualitative & Quantitative Analysis

- Implementation
  - 1.5 – 2 person-months

- Evaluation
  - 0.5 – 1 person-months
    - Requirements for Full Model
      - Effort/Cost for Full Model
        - Go, No-go Decision
Developing a Prototype UrbanSim model

- **Familiarization**
  - With UrbanSim
  - With local data
    - Run simulations with provided example (Eugene)
    - Explore data of provided example
    - Identify required data
    - Analyze “fit” between required and available data
Developing a Prototype UrbanSim model

**Data preparation**

- Concentrate on the “six tables”
- Build tables starting from available examples
- Focus on readily available data
- Identify missing data
- If necessary, use simulated data or simplifying assumptions
Developing a Prototype UrbanSim model

- **Submodel estimation**
  - Quality of models is difficult to evaluate without seeing simulation results
  - Estimate quickly in order to be able to run simulations soon (models can be improved later)

- **Transport model integration**
  - Continual interaction is not strictly necessary
  - Clearly identify inputs and outputs of the transport model
Developing a Prototype UrbanSim model

- **Simulation**
  - Start to run simulations early, even if data is incomplete (helps to identify possible errors and improvements)
  - Use the latest stable release

- **Analysis**
  - Population growth by area?
  - Simulation results comply with expectations?
  - Problems with data?
  - Problems with submodels?
Developing a Prototype UrbanSim model

**Evaluation**
- Desired characteristics of the operational model
  - Level of disaggregation (Data requirements)
  - Interaction with transport model
- Effort required to implement a complete model
  - Data gathering
  - Submodel estimation
  - Transport model (Is there an appropriate, available model?)
- Priority identification
  - Disaggregate projections ➔ UrbanSim
  - Aggregate projections ➔ Other models may be better (easier)
Conclusions

- Best way to evaluate UrbanSim is developing a prototype model
- Even with incomplete data results can be reasonable
- Developing a prototype model is possible within 3 – 5 months of one person’s effort
Conclusions

Recommendations:
- Learn by doing
- Start with provided examples and available data
- Concentrate on the “six tables”
- Continual interaction with transport model is not strictly necessary
- Run simulations early, even if data is incomplete
- Concentrate on general results
- Identify desired characteristics and data requirements for an operational model
Questions?