Preferred citation style for this presentation

Landuse simulation on the Canton of Zurich using UrbanSim
– Current State and First Run,
Landuse simulation on the Canton of Zurich using UrbanSim

Current State and First Run

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IVT
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Overview

Introduction
Data preparation
Integrated models
Simulations
Next steps / problems
SustainCity
EU-funded research-project (2010-2012)
12 research institutions participating
3 case-studies of UrbanSim: Brussels, Paris, Zurich
Previous UrbanSim-experience in all cities (Zurich: Zukunft Urbaner Kulturlandschaften, 2007)
Homepage: www.SustainCity.org
Aim of Project:
• adapt 'UrbanSim' to European conditions => version 'UrbanSimE'
• include additional models (demographics, developers, MatSim-exchange,...)
• evaluate and compare results of case-studies
Introduction

**UrbanSim**
Opensource software developed by P. Waddell and colleagues ([www.UrbanSim.org](http://www.UrbanSim.org))
Simulation of land use development with interaction to traffic and accessibility
Microsimulation representing the choice of households, businesses and landowners
Previously gridcell-based approach, now geometries (zoning and parcel) as reference objects
Various case studies world wide (in Zurich: Zukunft Urbaner Kulturlandschaften, 2007)

(a) Basic model structure of grid cell version

(b) Basic model structure of parcel version

Basis data

Simulation area and time period
Simulation start: 2000
Evaluation period: 2000-2010
Simulation period: 2010-2030
Basis data

Needs of UrbanSim

Simulation tables
- Simulated entities (e.g. parcels, buildings, households, persons, jobs)
- Travel data (zone to zone skims)
- Geographies for aggregation, analysis, visualisation

Model estimation tables

Definition tables
- Assumptions/boundary conditions
- Classifications
Basis data

Data used in the Zurich case study

*Geometries*
Spatial entities including form
Basis for spatial joins
Cadastral information
  - 171 municipalities
  - Inconsitancy
  - Demands backward editing starting in 2010 (buildings)
  - Changes in networks & parcels not accounted for

<table>
<thead>
<tr>
<th>Table name</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>buildings</td>
<td></td>
</tr>
<tr>
<td>parcels</td>
<td></td>
</tr>
<tr>
<td>zones</td>
<td></td>
</tr>
<tr>
<td>cities</td>
<td></td>
</tr>
</tbody>
</table>
Basis data

Data used in the Zurich case study

*Cross sectional*

Microscopic information on agents and objects

Objects (buildings) based on

- Federal register of buildings (GWR)
  - mainly residential
- Cantonal building assurance (GVZ)
  - Snapshot of year 2000
  - New buildings, but no construction

Agents (households, persons, jobs) based on census data

- Representing different years
- Use of population synthesiser envisioned

<table>
<thead>
<tr>
<th>Table name</th>
<th>Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>persons</td>
<td>populations census, microcensus (transportation)</td>
</tr>
<tr>
<td>households</td>
<td>populations census, microcensus (transportation)</td>
</tr>
<tr>
<td>jobs</td>
<td>enterprise census</td>
</tr>
<tr>
<td>buildings</td>
<td>GWR, GVZ, Documedia</td>
</tr>
</tbody>
</table>
Basis data

Data used in the Zurich case study

*Longitudinal*

Control totals in UrbanSim

Based on aggregated information from statistic departments

Additional specific statistics collected in previous ZUK-project
  * Probability to move (Beige and Axhausen, 2005)

<table>
<thead>
<tr>
<th>Table name</th>
<th>Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>annual_employment_control_totals</td>
<td>statistic information, prognosis</td>
</tr>
<tr>
<td>annual_household_control_totals</td>
<td>statistic information, prognosis</td>
</tr>
<tr>
<td>annual_relocation_rates_for_households</td>
<td>Survey data (Beige, 2008)</td>
</tr>
<tr>
<td>annual_job_relocation_rates</td>
<td>ZUK definitions (Loechl et al. 2007)</td>
</tr>
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</table>
Data preparation – Raw data to integrated US structure

Datamodell UrbanSim
Data preparation – data quality

Example: No geometry data available

Example: Missing building separation
Data preparation – processing framework

Data processing
Spatial Joins
Attribute Joins
Imputations
Populations Synthesis
Approximations
Classification

Data preparation – processing framework

*Generic*
*Flexible*
*Scalable*
*Accurate*
Data preperation- Relative import quality by assert error rate
Overview

Introduction
Data preparation
Integrated models
Simulations
Next steps / problems
Models – UrbanSim Choice Models

Multinomial Logit Utility Equation (j)

\[ V^j(x) = \sum_{i} \beta_i X_{ij} + \beta_{ij} X_{ij} \]

Multinomial Logit Probability Equation (j)

\[ \Pr^j(x) = \frac{e^{\sum_{i} \beta_i X_{ij}}}{\sum_{j} e^{\sum_{i} \beta_i X_{ij}}} \]

Choice Process

Cumulative Probability Random Number Choice

0 - 0.15
0.15 - 0.40
0.40 - 0.77
0.77 - 1.0

Dimensions for Submodel k: N Choosers x J Alternatives x I Variables

Read Specifications → Read Coefficients → Get Choosers → Get Choice Set → Compute Alternative Variables → Get Chooser Characteristics

Post Results → Select Choice → Draw Random Number → Compute Probabilities → Compute Utilities → Compute Interaction Variables

Source:
Opus_Userguide (p.18)
Models for first run

Demographic events model
Home-based job choice model
Workplace location choice model
Household transition model
Household relocation model
Household location choice model
Sub-model: dwelling cooperatives

Real estate price model
Parcel transition model
Recalculation accessibility
Transition planning zones

Geographical aggregations
Plan types (development constraints)
Accessibility
Other parcel characteristics

Agents / tables
models
First run
2nd priority

Economic Transition Model
Employment transition model
Employment relocation model
Employment location choice model
Building transition model
Building location choice model
Nonresidential Project LCM
Residential Project LCM
Building construction Model
Sub-model: Urban shape options
Sub-model: dwelling cooperatives
Models for first run

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- Residential Project LCM
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- Sub-model: Urban shape options
- Sub-model: dwelling cooperatives

Geographical aggregations
Plan types (development constraints)
Accessibility
Other parcel characteristics
Models – Real Estate Price Model REPM

Structure

• Model: OLS regression (estimation of rent prices)
• Dataset: building
• Filter_attribute: building is residential (numpy.logical)
• Estimation: *external estimation & import of specifications*
  • *Based on the PhD-Thesis of M.Löchl(2010)*
• Configuration:
  • Dependent Variable: ln(zurich_parcel.building.building_cost)
## Models – Real Estate Price Model REPM

<table>
<thead>
<tr>
<th>Coeff_names</th>
<th>estimate</th>
</tr>
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<tbody>
<tr>
<td>Constant</td>
<td>3.638</td>
</tr>
<tr>
<td>Ln (sqm per unit)</td>
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</tr>
<tr>
<td>Is House</td>
<td>0.125</td>
</tr>
<tr>
<td>Built before 1921</td>
<td>0.109</td>
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<tr>
<td>Built between 1921 and 1930</td>
<td>0.094</td>
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<tr>
<td>Built between 1981 and 1990</td>
<td>0.018</td>
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<tr>
<td>Built between 1991 and 2005</td>
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<tr>
<td>Accessibility by car</td>
<td>0.119</td>
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<tr>
<td>Accessiblity by public transport</td>
<td>0.011</td>
</tr>
<tr>
<td>Ln (distance to station)</td>
<td>-0.012</td>
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<tr>
<td>Boolean (highway within in 100m)</td>
<td>-0.067</td>
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<tr>
<td>Ln(jobs in Hotels and Restaurant)</td>
<td>0.032</td>
</tr>
<tr>
<td>Ln (population density per ha)</td>
<td>-0.026</td>
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<tr>
<td>Foreigner density per ha (logit)</td>
<td>-0.023</td>
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<tr>
<td>Ln (taxlevel)</td>
<td>-0.223</td>
</tr>
<tr>
<td>slope (logit)</td>
<td>0.026</td>
</tr>
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</table>
## Models – Real Estate Price Model REPM

<table>
<thead>
<tr>
<th>Coeff_names</th>
<th>estimate</th>
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</thead>
<tbody>
<tr>
<td>Lift</td>
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<tr>
<td>Fireplace</td>
<td>0.776</td>
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<tr>
<td>Balcony</td>
<td>0.125</td>
</tr>
<tr>
<td>GTErrace</td>
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<tr>
<td>Airnoise</td>
<td>0.094</td>
</tr>
<tr>
<td>Ln(View Lake)</td>
<td>0.018</td>
</tr>
<tr>
<td>Ln(View All)</td>
<td>0.067</td>
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<tr>
<td>Ln(Solar_eve)</td>
<td>0.119</td>
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<tr>
<td>1Q_04</td>
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<tr>
<td>2Q_04</td>
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<tr>
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<tr>
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</tr>
<tr>
<td>3Q_05</td>
<td>-0.223</td>
</tr>
</tbody>
</table>

Not integrated in UrbanSim

**Likelihood ratio index**  
0.5990

*(including additional variables of original model!)*
Models for first run

- Demographic events model
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- Sub-model: Urban shape options
- Sub-model: dwelling cooperatives

Geographical aggregations
- Plan types (development constraints)
- Accessibility
- Other parcel characteristics
Models – building location choice model BLCM

Structure

• Locations: parcels
• Agents: buildings
• Estimation: *estimation inside UrbanSim based on baseyear data*
  • *Agents for estimation: buildings built in 2000*
• Choices: `opus_core.random_choices_from_index`
• Configuration:
  • Sampler: `opus_core.samplers.weighted_sampler`
  • Choices: `opus_core.random_choices_from_index`
  • Procedure: `AgentLocationChoiceModel` from template
  • Capacity: undeveloped land of parcel
  • Filter: undeveloped parcels in construction zone
## Models – building location choice model BLCM

<table>
<thead>
<tr>
<th>Coeff_names</th>
<th>estimate</th>
<th>std err</th>
<th>t-values</th>
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<tbody>
<tr>
<td>Slope</td>
<td>-0.02</td>
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<tr>
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<tr>
<td>jobs_within_ha_of_parcel</td>
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<td>-11.24</td>
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<tr>
<td>building_fit_parcel</td>
<td>-7.30E-05</td>
<td>1.50E-06</td>
<td>-48.32</td>
</tr>
</tbody>
</table>
Models for first run

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SustainCity
Models – Household Transition (HTM) and Relocation (HRM)

Household control totals:
  • Scenario: assumption 10% growth
  • \textit{(observed data)}

Annual relocation rates of households:
  • \textit{Survey and census data; S.Beige(2005) used in ZUK (2008)}
  • Grouped into 12 categories based on age of head and income
Models – Household Location Choice Model HLCM

Structure

- Dependancies: HRM, HTM
- Locations: building
- Agents: household
- Estimation: *external estimation & import of specifications*
- Configuration:
  - Sampler: opus_core.samplers.weighted_sampler
  - Choices: urbansim.lottery_choices
  - Procedure: opus_core.bhhh_mnl_estimation
  - Capacity: Vacant_residential_units
  - Filter: building_is_residential & residential_sqm! = 0
  - Choice set size: 30
Models – Household Location Choice Model HLCM

<table>
<thead>
<tr>
<th>Coeff_names</th>
<th>estimate</th>
<th>std err</th>
<th>t-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age_of_House</td>
<td>0.01</td>
<td>0.00</td>
<td>10.38</td>
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<tr>
<td>Job Density in 1km²</td>
<td>-0.69</td>
<td>0.04</td>
<td>-16.63</td>
</tr>
<tr>
<td>Pop_density</td>
<td>0.03</td>
<td>0.00</td>
<td>14.31</td>
</tr>
<tr>
<td>Distance_to_station</td>
<td>-0.23</td>
<td>0.07</td>
<td>-3.45</td>
</tr>
<tr>
<td>historical building</td>
<td>1.32</td>
<td>0.14</td>
<td>9.75</td>
</tr>
<tr>
<td>Accessibility of PT* no_car_ownership</td>
<td>0.15</td>
<td>0.05</td>
<td>3.21</td>
</tr>
<tr>
<td>Rent Vacancy in municipality</td>
<td>-0.11</td>
<td>0.05</td>
<td>-2.24</td>
</tr>
<tr>
<td>Traveltime to Zürich CBD by car</td>
<td>0.00</td>
<td>0.00</td>
<td>5.21</td>
</tr>
<tr>
<td>Distance to last residence</td>
<td>3.76</td>
<td>0.19</td>
<td>19.82</td>
</tr>
<tr>
<td>Distance to workplace</td>
<td>1.57</td>
<td>0.29</td>
<td>5.41</td>
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<tr>
<td>ETA_last residence</td>
<td>-0.15</td>
<td>0.01</td>
<td>-14.60</td>
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<tr>
<td>ETA_distance to workplace</td>
<td>-0.09</td>
<td>0.02</td>
<td>-5.65</td>
</tr>
</tbody>
</table>

Not integrated in UrbanSim

Log-likelihood is  -1749.81
Null Log-likelihood is  -2679.74
Likelihood ratio index  0.35
Adj. likelihood ratio index  0.34
Number of observations  685.00
Number of alternatives  50.00
Models for first run

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Geographical aggregations
Plan types (development constraints)
Accessibility
Other parcel characteristics
Models – Employment Transition (ETM) and Relocation (ERM)

Employment control totals:
- Scenario: assumption 5% growth
- *(observed data)*

Employment relocation rates:
- *Based on Definitions used in ZUK (Loechl et al.2007)*
- Grouped into 8 categories of NOGA-codes
Models – Employment Location Choice Model (ELCM)

Structure (Model created by EPFL)
- Dependancies: ERM, ETM
- Locations: building
- Agents: job
- Estimation: *estimation inside UrbanSim based on baseyear data*
- Submodels: *categories used in relocation rates*
- Configuration:
  - Sampler: *opus_core.samplers.weighted_sampler*
  - Choices: *urbansim.lottery_choices*
  - Procedure: *opus_core.bhhh_mnl_estimation*
  - Capacity: *vacant_SSS_job_space*
  - Filter: *building_.non_residential_sqft*
  - Choice set size: 10
**Models – Employment Location Choice Model (ELCM)**

Assumptions on occupied space:
- Manufacturing, Trade, Retail, Hotel & Restaurant: 50
- Construction, Transport: 100
- Services: 15
- Health: 25
- Other: 100

<table>
<thead>
<tr>
<th>Coeff_names</th>
<th>manufacturing</th>
<th>construction</th>
<th>trade</th>
<th>retail</th>
<th>hotel&amp;gastro</th>
<th>transport</th>
<th>services</th>
<th>health</th>
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<tbody>
<tr>
<td>ln(non_residential_sqm in building)</td>
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<td>-33.66</td>
<td>-38.12</td>
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<td>-52.29</td>
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<td></td>
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<tr>
<td>avg_income_in_zone</td>
<td>+8.12</td>
<td>-0.593</td>
<td>4.18</td>
<td>0.52</td>
<td>-0.53</td>
<td>-12.33</td>
<td>-13.92</td>
<td>-8.97</td>
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<tr>
<td>number_of_jobs_in_same_sector</td>
<td>+44.92</td>
<td>+25.06</td>
<td>38.04</td>
<td>20.4</td>
<td>28.3</td>
<td>39.17</td>
<td>67.51</td>
<td>47.56</td>
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<tr>
<td>number_of_jobs_sector1</td>
<td>***</td>
<td>***</td>
<td>+5.45</td>
<td>-0.62</td>
<td>-2.3</td>
<td>5.34</td>
<td>-8.42</td>
<td>-0.99</td>
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<td>number_of_jobs_sector2</td>
<td>+1.52</td>
<td>***</td>
<td>***</td>
<td>-2.7</td>
<td>+0.72</td>
<td>-1.09</td>
<td>-9.13</td>
<td>-1.79</td>
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<tr>
<td>number_of_jobs_sector3</td>
<td>+6.47</td>
<td>+5.25</td>
<td>***</td>
<td>***</td>
<td>+3.8</td>
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<td>+3.18</td>
</tr>
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<td>number_of_jobs_sector4</td>
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<td>-1.17</td>
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<td>***</td>
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<td>+12.21</td>
<td>+8.19</td>
</tr>
<tr>
<td>number_of_jobs_sector5</td>
<td>-4.10</td>
<td>+4.23</td>
<td>+1.57</td>
<td>*8.77</td>
<td>***</td>
<td>***</td>
<td>-3.74</td>
<td>+2.52</td>
</tr>
<tr>
<td>number_of_jobs_sector6</td>
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<td>-8.5</td>
<td>+1.91</td>
<td>-3.33</td>
<td>-5.53</td>
<td>***</td>
<td>***</td>
<td>+3.71</td>
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<tr>
<td>number_of_jobs_sector7</td>
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<td>+0.28</td>
<td>+2.85</td>
<td>+4.42</td>
<td>-1.76</td>
<td>***</td>
<td>***</td>
</tr>
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<td>-5.48</td>
<td>-4.67</td>
<td>-5.07</td>
<td>-1.07</td>
<td>-4.48</td>
<td>-9.42</td>
<td>***</td>
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<tr>
<td>distance_to_highwayaccess</td>
<td>-3.74</td>
<td>-5.59</td>
<td>-2.95</td>
<td>-1.83</td>
<td>-2.56</td>
<td>-2.12</td>
<td>-7.7</td>
<td>+7.63</td>
</tr>
<tr>
<td>distance_to_station</td>
<td>-0.99</td>
<td>-4.84</td>
<td>-7.9</td>
<td>-11.5</td>
<td>-4.41</td>
<td>-14.82</td>
<td>-20.94</td>
<td>-9.96</td>
</tr>
</tbody>
</table>
Models – Workplace Location Choice Model WLCM

Structure

• Dependancies: *ELCM, HLCM (implicit through missing link)*
• Locations: job
• Agents: person
• Filter: number_of_agents(person)==0
• Estimation: *definition based on observed distribution*
• Configuration:
  • Module: urbansim.models.agent_location_choice_model
  • Sampler: opus_core.samplers.weighted_sampler
  • Choices: urbansim.lottery_choices
  • Utilities: opus_core.linear_utilities
  • Probabilities: opus_core.mnl_probabilities
  • Choice set size: 30
Models – Workplace Location Choice Model WLCM

Distance to residence (distanceR): \[ U = 0.1629 \times \exp(-0.00008 \times \text{distanceR}) \]
Overview

Introduction
Data preparation
Integrated models
Simulations
Next steps / problems
Models – Real Estate Price Model REPM

Running the simulation (2001)
• Number of agents: 173318 (total residential: 173692)
• Number of calculations loops: 1
• Total time for run: 6min

=> Works as expected
=> Resulting values for rent price still to be checked
=> Only rent prices created.... other uses?
Models – building location choice model BLCM

Running the simulation (2001)

- “nothing to be done”
- Vacancy rates have error?

```python
numpy.logical_and(building.year_built > 1990, building.building_type_id<>7)....0.0 sec
```

<table>
<thead>
<tr>
<th>building_type</th>
<th>actual</th>
<th>target</th>
<th>difference</th>
<th>action</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0</td>
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Running the simulation (2001)

- Number of agents: 30,570 (total: 521,148)
- Available capacity: 109,585 units (total: 549,820)
- Number of chunks: 2 in first loop
- Number of distribution loops: 2
- Successful distribution: yes
- Total time for run: 1h 11min

=> Works as expected
=> Capacities seem to be very high
Models – Employment Location Choice Model (ELCM)

Running the simulation (2001)

- Number of agents: 624,622 (total: 720,819)
  - Ignored because of missing relocation rates: 103,405
- Available capacity: 724,931 units (total: 67,465,215 sqm)
  - min: 674,652 jobs, max: 4,497,681 jobs
- Number of chunks: 13 in first loop
- Number of distribution loops: 3
- Successful distribution: yes
- Total time for run: 10min 18sec

=> works as expected, but...
=> all jobs redistributed every year
Models – Workplace Location Choice Model WLCM

Running the simulation (2001)

- Number of agents: 1,016,601 (total: 1,089,858)
- Available capacity: 408,657 units (total: 720,819 sqm)
- Number of chunks: 21 in first loop
- Number of distribution loops: 2
- Successful distribution: no (abortion when no capacities remaining)
- Total time for run: 2h 4min

=> All Agents redistributed every year
=> No filtering of “workers”
=> Number of jobs does not fit expectation
Simulation - Buildings

Simulated Data 2010:
Buildings per km² (Zone)
Simulation - Persons

Observed Data 2010:
Persons per km² (Municipality)

Simulated Data 2010:
Persons per km² (Municipality)
Simulation - Jobs

Simulated Data 2010:
Jobs per km² (Zone)
Overview

Introduction
Data preparation
Integrated models
Simulations

Next steps / problems
Simulation - summary

Many errors remain to be solved in this “first run”....

Agents

• BLCM does not run due to vacancy rates (or error of units)
• ELCM & WLCM distribute all agents
• ELCM seems to have very high available capacities

Modeling

• Control totals are an approximation
• REPM & HLCM include only parts of original variables
• REPM price only for residential
• BLCM is a dummy model
• Weighted sampler vs. random sampling of external estimations
Simulation - summary

And still results are somewhat promising....

Simulation

- Finally: NO ERRORS any more!
- ELCM runs (and filters)
- REPM seems to run as expected (to be checked on values)
- HLCM seems to run as expected
- Employment location seems to filter as expected

- Distribution of jobs and households mainly fit to real world observation
  - Airport not included
  - “holes” in simulation?
Further steps

Baseyear

• Include whole canton
• Account for border problem
• Improve data (income, car-ownership, buildings, parcel merge,...)

Sensivity

• Definition of categories/Change of control totals
• Order of Models/Interaction of models
• Impact of single variables (and quality in baseyear)

Models

• Demography
• MatSim-exchange
• Developers

Evaluation

• Comparability to observed data: lags, subsets, ...
Further steps

Policy scenarios

• New transport infrastructure (Motorway A50/A51)
• Land use (Limitation of settlement area)
• Designation of a new building zone area (Airport Dübendorf)
• Real estate market (real estate prices bubble: economic decline)
References


