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Integrated Transport LandUse Simulation on the Canton of Zurich

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Integrated Transport LandUse Simulation on the Canton of Zurich

P. Schirmer
Zöllig Renner, C.
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Introduction – Simulation area and time period

Parcel level
Simulation start: 2000
Evaluation period: 2000-2010
(Simulation period: 2010-2030)
Introduction – City of Zürich

- 370,000 inhabitants in 2007
- 180 vacant apartments = 0.09% of stock (01.07.2007)
- 46,551 persons moved into the city
- 42,108 persons have changed their residence within the city
- 2,263 new dwellings have been built
- 40,437 persons moved out of the city, 3,480 persons died

=> almost \( \frac{1}{3} \) of the population has moved!  

Source: Thalmann (2010)

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**Income vs. Probability to Move**

- **<48000**
- **48000-96000**
- **>96000**

**Age of head**

- <30
- 30-44
- 45-64
- >64

2001
Introduction – Data model SustainCity
Data processing – spatial matching

- **GWR/GVZ**
  - Housing units
  - Construction year
  - Value

- **Soil coverage zones (AV)**
  - Surface information
  - Buildings footprints

- **Parcel**
  - Size
  - FAR covered

- **Land use zone**
  - Planning constraints
Data storage

Files
- Read-only

PostgreSQL + PostGIS
- Preprocessing
- Visualisation
- Analysis

UrbanSim
- Simulation
Data processing – import quality

Quality of matching jobs to buildings (%)  

Quality of all data-processings (%)  

Legend

- 45 - 50
- 50 - 55
- 55 - 60
- 60 - 65
- 65 - 70
- 70 - 75
- 75 - 80
- 80 - 85
- 85 - 90
- 90 - 95
- 95 - 100
General structure of the model system

UrbanSim
- Parcels, buildings, jobs

Demographic data
- Persons, households

MATSim
- Travel times + modes
- Accessibilities

every year

every 5 years
Run order of simulated models

1. External demography
2. Income and car ownership update
3. Workplace location choice
4. Employment transition
5. Employment relocation
6. Employment location choice
7. Household relocation
8. Accessibility

Agents / tables

Models

Residents

Living unit

Building

Parcels

Geographical aggregations
Plan types (development constraints)
Other parcel characteristics
Models – Real estate price

Share of foreigners
Distance to station
Slope of terrain
Built in 1981-1990
Building has an elevator
Bid-price of Quartal 2 in 2005
Bid-price of Quartal 2 in 2004
Has a balcony
Bid-price of Quartal 3 in 2004
Bid-price of Quartal 1 in 2005
Bid-price of Quartal 3 in 2004
Built in 1991-2006
Distance to highway < 100m
Aircraft noise above 52db
Built in 1921-1930
Bid-price of Quartal 1 in 2004
View of landscape (ha)
View of lake (ha)
Sunshine index (evening)
Constant
Size in SQM (ln)
Population density (ln)
Accessibility PT
Accessibility CAR
Is a single family building
Has a fireplace
Built before 1921
Has a terrace
Bid-price of Quartal 3 in 2004
Bid-price of Quartal 1 in 2005
Bid-price of Quartal 3 in 2004
Bid-price of Quartal 4 in 2004
Has a balcony
Bid-price of Quartal 2 in 2004
Bid-price of Quartal 2 in 2005
Building has an elevator
Built in 1981-1990
Slope of terrain
Distance to station
Share of foreigners
Constant
Sunshine index (evening)
View of lake (ha)
View of landscape (ha)

Monthly gross rent in CHF per sqm
- 12.01 - 16.00
- 16.01 - 18.00
- 18.01 - 20.00
- 20.01 - 25.00
- 25.01 - 35.00
- 35.01 - 45.00

## Models – Real estate price

<table>
<thead>
<tr>
<th>Factor</th>
<th>UrbanSim Effect</th>
<th>Sign</th>
<th>Löchel (2007) Effect</th>
<th>Sign</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>+</td>
<td>**</td>
<td>+</td>
<td>**</td>
</tr>
<tr>
<td>Car accessibility</td>
<td>+</td>
<td>**</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>PT accessibility</td>
<td>+</td>
<td>**</td>
<td>+</td>
<td>**</td>
</tr>
<tr>
<td>Built in 1921 to 1930</td>
<td>+</td>
<td>**</td>
<td>+</td>
<td>**</td>
</tr>
<tr>
<td>Built in 1981 to 1990</td>
<td>+</td>
<td></td>
<td>+</td>
<td>**</td>
</tr>
<tr>
<td>Built after 1991</td>
<td>+</td>
<td>**</td>
<td>+</td>
<td>**</td>
</tr>
<tr>
<td>Built before 1921</td>
<td>+</td>
<td>**</td>
<td>+</td>
<td>**</td>
</tr>
<tr>
<td>Distance to station</td>
<td>-</td>
<td>**</td>
<td>-</td>
<td>**</td>
</tr>
<tr>
<td>Proximity to highway (&lt; 100 m)</td>
<td>-</td>
<td>**</td>
<td>-</td>
<td>**</td>
</tr>
<tr>
<td>Is a single family house</td>
<td>+</td>
<td>**</td>
<td>+</td>
<td>**</td>
</tr>
<tr>
<td>Jobs in hotels and gastronomy</td>
<td>+</td>
<td>**</td>
<td>+</td>
<td>**</td>
</tr>
<tr>
<td>View of lake (ha)</td>
<td>+</td>
<td>**</td>
<td>+</td>
<td>**</td>
</tr>
<tr>
<td>Population density (ln)</td>
<td>-</td>
<td>**</td>
<td>-</td>
<td>**</td>
</tr>
<tr>
<td>Size in m² (ln)</td>
<td>+</td>
<td>**</td>
<td>+</td>
<td>**</td>
</tr>
<tr>
<td>Slope of terrain</td>
<td>+</td>
<td>**</td>
<td>+</td>
<td>**</td>
</tr>
<tr>
<td>Sunshine index (evening)</td>
<td>+</td>
<td>**</td>
<td>+</td>
<td>**</td>
</tr>
<tr>
<td>Foreigners within 300 m</td>
<td>+</td>
<td>**</td>
<td>(-)</td>
<td>(**)</td>
</tr>
<tr>
<td>Adj. Likelihood ratio index:</td>
<td>0.78173</td>
<td></td>
<td>0.85</td>
<td></td>
</tr>
<tr>
<td>Number of observations:</td>
<td>6497</td>
<td></td>
<td>8592</td>
<td></td>
</tr>
</tbody>
</table>
# Models – Employment location choice

<table>
<thead>
<tr>
<th>Type</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average zonal income</td>
<td>− **</td>
<td>− **</td>
<td>− **</td>
<td>− **</td>
<td>− **</td>
<td>− **</td>
<td>− **</td>
<td>− **</td>
</tr>
<tr>
<td>Car accessibility</td>
<td>+ **</td>
<td>+ **</td>
<td>+ **</td>
<td>+ **</td>
<td>+ **</td>
<td>+ **</td>
<td>+ **</td>
<td>+ **</td>
</tr>
<tr>
<td>PT accessibility</td>
<td>+ **</td>
<td>+ **</td>
<td>+ **</td>
<td>+ **</td>
<td>+</td>
<td>+</td>
<td>+ **</td>
<td>+</td>
</tr>
<tr>
<td>Distance to motorway access</td>
<td>− **</td>
<td>− **</td>
<td>− **</td>
<td>− *</td>
<td>+</td>
<td>− **</td>
<td>+ **</td>
<td>+ **</td>
</tr>
<tr>
<td>Distance to station</td>
<td>− **</td>
<td>− **</td>
<td>− **</td>
<td>− **</td>
<td>− **</td>
<td>− **</td>
<td>− **</td>
<td>− **</td>
</tr>
<tr>
<td>Distance to Zürich CBD</td>
<td>+ **</td>
<td>+</td>
<td>+ **</td>
<td>+ **</td>
<td>+</td>
<td>+ **</td>
<td>−</td>
<td>− **</td>
</tr>
<tr>
<td>Household density (km²)</td>
<td>− **</td>
<td>− **</td>
<td>− **</td>
<td>− **</td>
<td>− **</td>
<td>− **</td>
<td>− **</td>
<td>− **</td>
</tr>
<tr>
<td>Job density (km²)</td>
<td>+ **</td>
<td>+ **</td>
<td>+ **</td>
<td>+ **</td>
<td>+ **</td>
<td>+ **</td>
<td>+ **</td>
<td>+ **</td>
</tr>
<tr>
<td>Share of same jobs (zone)</td>
<td>+ **</td>
<td>+ **</td>
<td>+ **</td>
<td>+ **</td>
<td>+ **</td>
<td>+ **</td>
<td>+ **</td>
<td>+ **</td>
</tr>
<tr>
<td>Adj. likelihood ratio index</td>
<td>0.17</td>
<td>0.11</td>
<td>0.23</td>
<td>0.18</td>
<td>0.13</td>
<td>0.26</td>
<td>0.21</td>
<td>0.17</td>
</tr>
<tr>
<td>Number of observations</td>
<td>15714</td>
<td>9187</td>
<td>11895</td>
<td>10143</td>
<td>7038</td>
<td>14390</td>
<td>33170</td>
<td>12382</td>
</tr>
</tbody>
</table>

Type 1 = Manufacturing (NOGA-code C - E)  
Type 2 = Construction (NOGA-code F)  
Type 3 = Wholesale Trade (NOGA-code G 45, G46)  
Type 4 = Retail Trade (NOGA G47)  
Type 5 = Hotel & Gastronomie (NOGA-code I)  
Type 6 = Transport & Communication (NOGA-code J)  
Type 7 = Service & Finance (NOGA-code K - N)  
Type 8 = Health (NOGA-code Q)
Models – Workplace location choice

Source: Populations Census (2000)
Models – Household transition and relocation

Relocation probability

Reason to move

Source: Beige (2005)  
## Models – Household location choice

<table>
<thead>
<tr>
<th>Effect</th>
<th>Sign.</th>
<th>Effect</th>
<th>Sign.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building age</td>
<td>+</td>
<td>**</td>
<td>Proximity to main road and railway (noise)</td>
</tr>
<tr>
<td>Building is new build (dummy)</td>
<td>+</td>
<td>**</td>
<td>Distance to Zurich CBD</td>
</tr>
<tr>
<td>Share of rent to income</td>
<td>-</td>
<td>**</td>
<td>Distance to motorway on-ramp (car owners)</td>
</tr>
<tr>
<td>Rooms per person</td>
<td>-</td>
<td>**</td>
<td>Distance to station (car non-owners)</td>
</tr>
<tr>
<td>Space per room (m²)</td>
<td>+</td>
<td>**</td>
<td>Denisty of retail jobs</td>
</tr>
<tr>
<td>Distance to previous location (beta *dist ^eta)</td>
<td>-</td>
<td>**</td>
<td>Distance to school</td>
</tr>
<tr>
<td>Distance to workplace (beta *dist ^eta)</td>
<td>-</td>
<td>**</td>
<td>Density of service jobs</td>
</tr>
<tr>
<td>Car accessibility</td>
<td>-</td>
<td>**</td>
<td>Share of households in same age</td>
</tr>
<tr>
<td>PT accessibility</td>
<td>+</td>
<td>**</td>
<td></td>
</tr>
</tbody>
</table>

| Adj. likelihood ratio index | 0.522 |
| Number of observations | 1065 |

Schirmer, van Eggermond and Axhausen (2013)
Models – Household location choice

- Distance to previous location
- Distance to workplace
- Share of rent to income
- PT Accessibility (car non-owners)
- Car accessibility (car owners)
- Building age
- Rooms per person
- Distance to Zurich CBD
- Building is new build (dummy)
- Share of households in same age
- Distance to station (noncarowners)
- Distance to motorway on-ramp (carowners)
- Distance to school
- Proximity to main road and railway (noise)
- Density of retail jobs
- Density of service jobs
- Space per person (m²)

Share of Utility

Source: Schirmer, van Eggermond and Axhausen (2013)
### Choice sets – Household location choice

<table>
<thead>
<tr>
<th></th>
<th>UrbanSim (mean)</th>
<th>Survey (mean)</th>
<th>Diff (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car accessibility (car owner)</td>
<td>9.89</td>
<td>9.07</td>
<td>9.03</td>
</tr>
<tr>
<td>PT accessibility (car non-owner)</td>
<td>11.97</td>
<td>11.16</td>
<td>7.33</td>
</tr>
<tr>
<td>Building is new build (dummy for &lt;10)</td>
<td>0.10</td>
<td>0.24</td>
<td>-55.96</td>
</tr>
<tr>
<td>Building age (log)</td>
<td>3.46</td>
<td>3.03</td>
<td>14.25</td>
</tr>
<tr>
<td>Distance to motorway on-ramp (c)</td>
<td>2147.81</td>
<td>2333.57</td>
<td>-7.96</td>
</tr>
<tr>
<td>Distance to school</td>
<td>420.50</td>
<td>446.98</td>
<td>-5.93</td>
</tr>
<tr>
<td>Distance to station (car non-owner)</td>
<td>800.86</td>
<td>723.72</td>
<td>10.66</td>
</tr>
<tr>
<td>Distance to Zurich CBD</td>
<td>10299.55</td>
<td>12104.99</td>
<td>-14.91</td>
</tr>
<tr>
<td>Proximity to main road and railway</td>
<td>0.02</td>
<td>0.08</td>
<td>-76.38</td>
</tr>
<tr>
<td>Density of retail jobs</td>
<td>83.82</td>
<td>16.46</td>
<td>409.24</td>
</tr>
<tr>
<td>Density of service jobs</td>
<td>255.84</td>
<td>61.10</td>
<td>318.75</td>
</tr>
<tr>
<td>Share of rent to income</td>
<td>0.00</td>
<td>0.24</td>
<td>-98.92</td>
</tr>
<tr>
<td>Rooms per person</td>
<td>1.93</td>
<td>1.89</td>
<td>1.90</td>
</tr>
<tr>
<td>Share of households with age (&lt;4)</td>
<td>0.38</td>
<td>0.37</td>
<td>1.30</td>
</tr>
<tr>
<td>Share of households with age (40-65)</td>
<td>0.37</td>
<td>0.46</td>
<td>-20.91</td>
</tr>
<tr>
<td>Share of households with age &gt;65</td>
<td>0.21</td>
<td>0.20</td>
<td>7.07</td>
</tr>
<tr>
<td>Space per person (m²)</td>
<td>26.48</td>
<td>28.32</td>
<td>-6.52</td>
</tr>
</tbody>
</table>

(1) recent movers of survey are located in new buildings
(2) recent buildings are at peripherical areas and closer to highway
(3) recent buildings are at peripherical areas and have a low density of other uses
(4) corrected error: income categories and log(rent_price)
Models - Summary

Achievements
Combining 6 main datasets (census data, cadastral data and register data)
Interaction of:
• 5 discrete-choice-models (12 submodels)
• 2 regression models
• 5 rate based models

Current limitations
all: estimation on distribution, vs. estimation on RP/SP
BLCM: templates can include mixed use (no link to job type)
ELCM: needs to include taxes
HLCM: no social groups; no bidprices
REPM: not including market; not including taxes
WLCM: choice only distance based, due to missing observations
Models – Interaction (influence of transport)
Simulation – Persons

Observed development 2001 - 2008:
Persons per km² of municipality

Simulated development 2001 - 2008:
Persons per km² of municipality

Legend:
- < -100%
- -100% - -90%
- -80% - -70%
- -60% - -50%
- -40% - -30%
- -20% - -10%
- 0% - 10%
- 20% - 30%
- 40% - 50%
- 60% - 70%
- 80% - 90%
- >100%
Simulation – Persons

Difference of simulation to validation 2001: Persons per km² of municipality

Difference of simulation to validation 2008: Persons per km² of municipality

Legend

-100% - 90%  
-80% - 70%  
-60% - 50%  
-40% - 30%  
-20% - 10%  
0% - 10%  
20% - 30%  
40% - 50%  
60% - 70%  
80% - 90%  
>100%
Simulation – Jobs

Observed development 2001 - 2008: Jobs per km² of municipality

Simulated development 2001 - 2008: Jobs per km² of municipality

Legend

- < -100%
- -100% - -90%
- -80% - -70%
- -60% - -50%
- -40% - -30%
- -20% - -10%
- 0% - 10%
- 20% - 30%
- 40% - 50%
- 60% - 70%
- 80% - 90%
- >100%
Simulation – Jobs

Difference of simulation to validation 2001:
Jobs per km² of municipality

Difference of simulation to validation 2008:
Jobs per km² of municipality

Legend

- < -100%
- -100% - -90%
- -80% - -70%
- -60% - -50%
- -40% - -30%
- -20% - -10%
- 0% - 10%
- 20% - 30%
- 40% - 50%
- 60% - 70%
- 80% - 90%
- >100%
Findings

**Methodological**
Reproducible research with big data?
Harmonised data / Synthetisation

Estimation of model in UrbanSim (base year)
Estimation of model using surveys (RP and SP)

Simulation of households fits to observation
Simulation of employment reflects limited data quality

Evaluation of scenario effects
Calibration and correlation of models
Simulation – Persons

Movie persons
Scenario: Densification

**Topic**
- Cantonal directive plan (11 densification areas)
- Densification of centers

**Implementation**
- Increase FAR of parcels in densification zones

**Expected effects**
- Increased building activity
- Less vehicle miles travelled
Scenario: New infrastructure

**Topic**
New infrastructure facilities from cantonal directive plan

**Implementation**
Adaptation of MATSim network

**Expected effects**
Locally increased accessibility
According local growth

Source: Canton Zurich (2007), Cantonal Directive Plan
Data processing

Total quality by name

assigned comparid
jobs_08: building_id
buildings_final: stories
buildings_final: building_quality_id
buildings_final: building_egid
jobs: building_id
mothers unique
person jobs
fathers unique
buildings_final: improvement_value
living units
assigned ganzwhg
households: living_unit_id
parcels: zone_id
parcels
buildings_final: parcel_id
buildings_final: building_type_id
buildings: non_residential_sqft
development_event_history: non_residential_sqft

Percentage

0 20 40 60 80 100
Attachments

Model details