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The Zurich Case Study of UrbanSim

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ERSA 2011

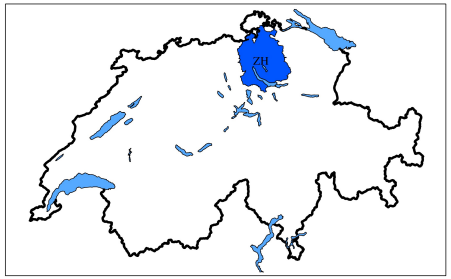
Outline

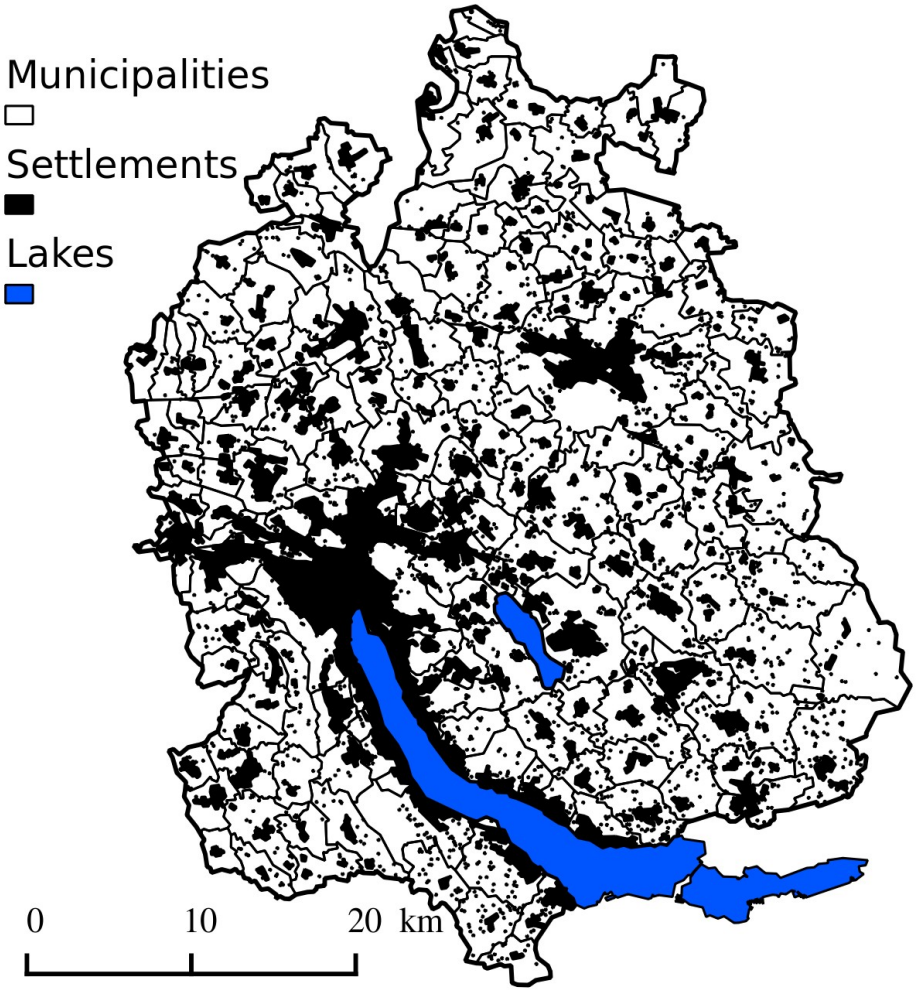
- Basis data
- Data processing
- First UrbanSim run
- Modelling
- Conclusions and Outlook

Basis data

Simulation area and time period

- Simulation start: 2000
- Evaluation period: 2000-2010
- Simulation period: 2010-2030





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

Basis data

Data used in the Zurich case study

Cross sectional

- Microscopic information for 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

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)

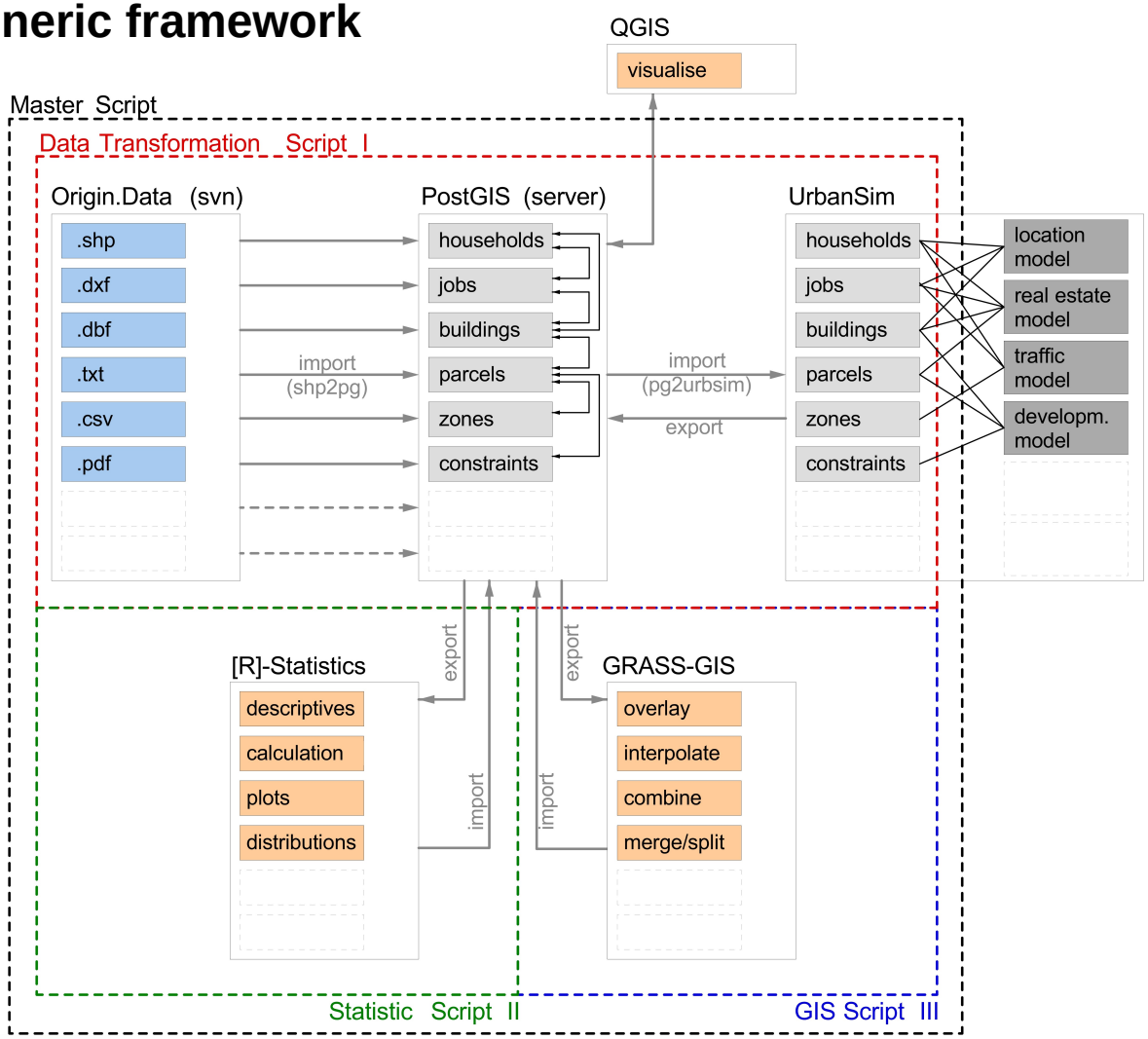
Table name	Status
annual_employment_control_totals	linear extrapolation from enterprise census
annual_household_control_totals	Prognosis statistical office canton Zurich
annual_relocation_rates_for_households	Survey data (Beige, 2008)
annual_job_relocation_rates	ZUK definitions (Loechl et al. 2007)

Basis data

Entity described	Number of objects	Data set	Data owner	Spatial resolution	Date
Buildings	255801 (2010)	GWR-BFS	Federal Statistic Department	Addresses and coordinates [m]	2004-2010
	212497 (2010)	GWR-ARV	Canton Zürich	Coordinates [m]	2010
	286468 (2000)	GVZ	Cantonal Building Assurances	Addresses	2010
	534594 (2010)	Vector 25	Swisstopo	Polygon in projected coordinate system	2010
Appartments	671169 (2010)	GWR-BFS	Federal Statistic Department	Building (via EGID)	2004-2010
	478378 (2010)	GWR-ARV	Canton Zürich	Building (via EGID)	2010
Entrances	261650 (2010)	GWR-BFS	Federal Statistic Department	Addresses and coordinates [m]	2004-2010
	237481 (2010)	GWR-ARV	Canton Zürich	Coordinates [m] (and addresses)	2010
New buildings	40849 (2000-2010)	GVZ	Cantonal Building Assurances	Addresses	2001-2010
Development projects	57734 (2010)	GWR-ARV	Canton Zürich	Building (via EPROID)	1967-2015
	60056 (1998-2012)	Documedia	DOCUMEDIA (Baublatt)	Addresses	1998-2012
Parcels	367314 (2010)	Cadastral plans	Canton Zürich	Polygon in projected	2005, 2007-201

Data processing

Introducing a generic framework



Data processing

Data import/Linking the data

- Data issues
  - Geocoding and linking
    - Primary keys (e.g. EGID)
    - Adress match via reference data (cadastral information)
    - Spatial join by geocoordinates
  - Different years
    - Backward editing
  - Aggregated information (VZ, building)
    - Random distribution

=>creation of rough baseyear, but with reduced number of objects

Data processing

Calculation-routines: example plan_types

- **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 processing

Geolocating households

- Population census coordinates of ha
- Buildings have meter-coordinates and geometrie
- Options for match:
  - extend UrbanSim to include appartments => distribute via location choice model
  - random allocation of households through appartments

Population synthesis

Persons and households: Current state

Full disaggregate census data available to the project

- Persons grouped into households
- Year: 2000 = simulation base year
- Includes almost all required attributes
- Spatial resolution: hectare
- Education, employment status and employment sector
- Limited information on job location

Population synthesis

Persons and households: Augmenting the census data

Missing attributes available via transportation microcensus

- Income and car ownership
- Year: 2000 or 2005
- Imputation (e.g., Poisson regression)

Buildings

- Allocating individuals to apartments within the hectare or neighboring hectares

Jobs

- Allocation to available jobs using ELCM (or a modified version)

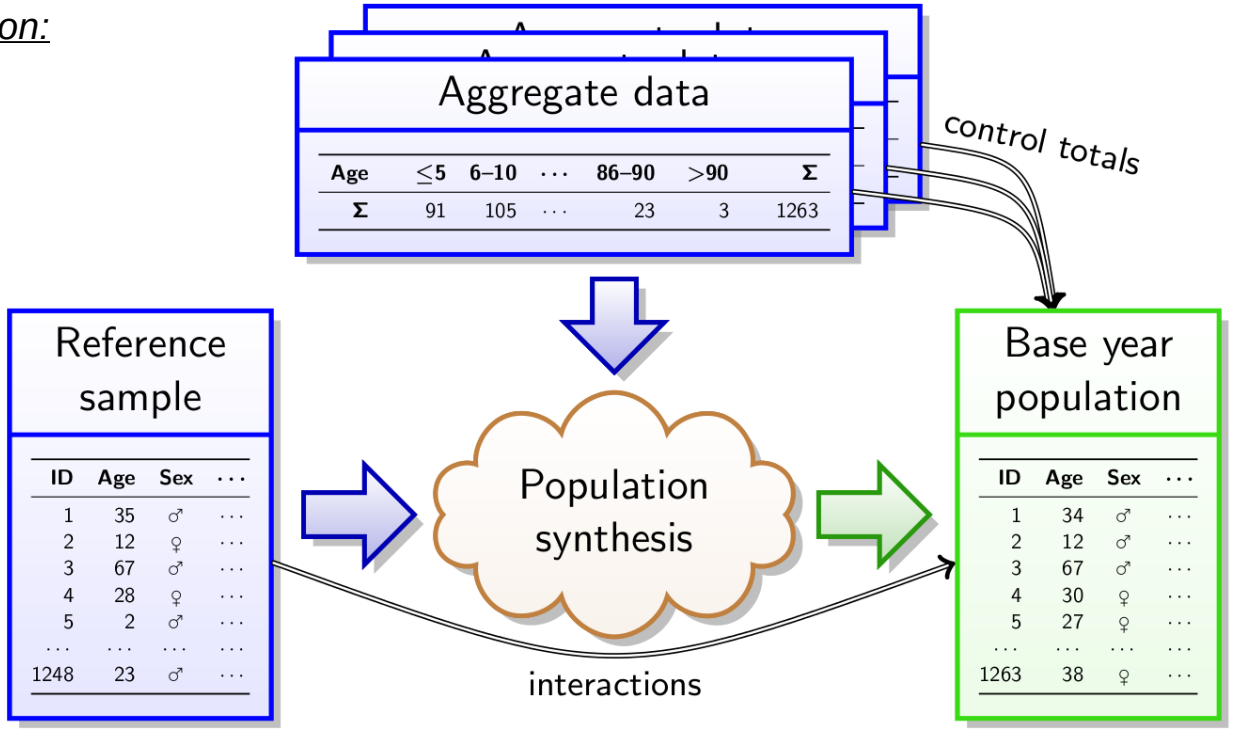
Population synthesis

Persons and households: Replacing the census data

Disaggregate census data is very sensitive

- Highly confidential, cannot be given away easily

Solution:



Population synthesis

Synthetic population

- Combine a disaggregate reference sample and aggregate data
- No confidentiality issues
- Accurate replication of the household structure
  - Hierarchical IPF: Müller and Axhausen, 2011
  - Iterative Proportional Updating: Ye *et al.*, 2009
  - Entropy maximization: Bar-Gera *et al.*, 2009
- **Validation** against the full census possible

Population synthesis

P**ersons and households: Input for synthetic data**

Reference sample

- Transportation microcensus
  - + Household structure
  - – No full attribute set for each household person
- Public Use Sample
  - + Full attribute set for each person
  - – No household structure

Control totals

- Average income by hectare
- Other attributes by commune

Data processing

Non-residential sqm in building

- Basis data for buildings
  - federal building register – only residential
  - cantonal fire assurance – one use per building, e.g. residential and other
  - cadastral information – no further information
- Non-residential sqm estimated through jobs located in building
  - represents 2005
  - assumptions on sqm per job
- Definitions to zonal defintions in plan types based on assumption

Data processing

Enriching the data

Variablename	Reference year	Scale
Aggregated variables		
Tax income of municipality per resident/1000	2006	municipality
Tax index of municipality	2006	municipality
Rent vacancy rate in municipality	2006	municipality
Share of persons with university degree in municipality	2006	municipality
Portion of buildings build before 1971	2006	municipality
Inhabitants in Municipality	2006	municipality
Portion of retired persons	2006	municipality
Percentage of 'foreigners' (foreign language as mother language)	2006	municipality
Location variables		
Mean sunshine index (mean of nine points of time per year)	2006	gridcell 100mx100m
Slope	2006	gridcell 100mx100m
(Ln) Euclidean distance to next highway accesspoint	2010	centroid of parcel [m]
(Ln) Euclidean distance to next station	2010	network-axes
Euclidean distance to highway is smaller than 100m	2010	centroid of parcel [m]
Euclidean distance to railways is smaller than 50m	2010	network-axes

Data processing

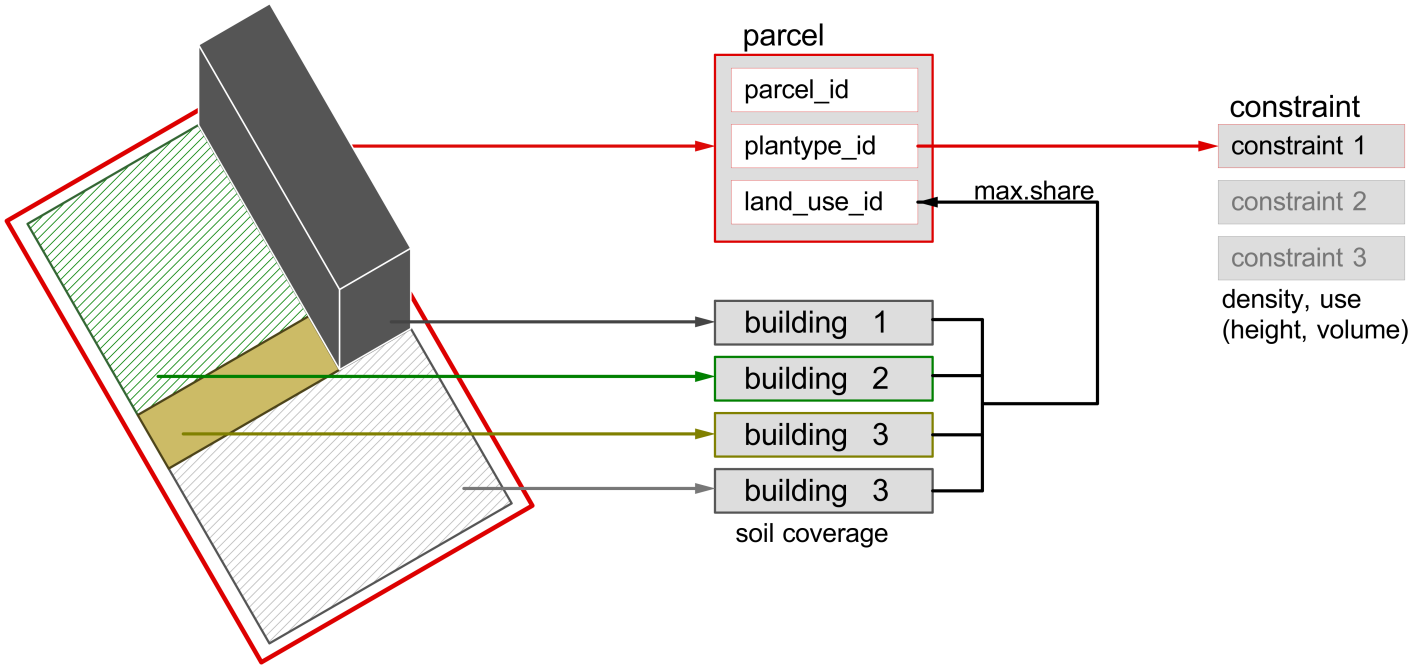
Enriching the data

Variablename	Reference year	Scale
Location variables		
Distance to primaryschool	2010	centroid of gridcell100mx100m
Distance to CBD Zürich	2010	centroid of gridcell100mx100m
Distamce to CBD Wintertur	2010	centroid of gridcell100mx100m
Distance to closest kindergarten	2010	centroid of gridcell100mx100m
Distance to power line	2010	centroid of gridcell100mx100m
Distance to lake	2010	centroid of gridcell100mx100m
Distance to shopping_facility	2010	centroid of gridcell100mx100m
aircraft noise	2009	
Households of size 'X' in radius of 1km (X=[1:10])	2000	gridcell 100x100m
Density of children (per ha in radius of 500m)	2000	gridcell 100x100m
Density of Population (per ha in 1km radius)	2000	gridcell 100x100m
Density of open space (per ha in radius of 2km)	2006	gridcell 100x100m
Density of jobs (jobs in retail trade; per ha in 1km radius)	2006	gridcell 100x100m
Density of jobs (jobs in hotel and catering industry;amount in 1km radius)	2006	gridcell 100x100m
Travel time to Bürkliplatz (car travel-time, regional transport model)	2008	link (matsim)
Travel time to Bürkliplatz (public transport)	2008	link (matsim)
Public transport accessibility (based on regional transport model)	2005	zone
Private vehicular traffic accessibility	2005	zone

Data processing

Definitions and Classifications

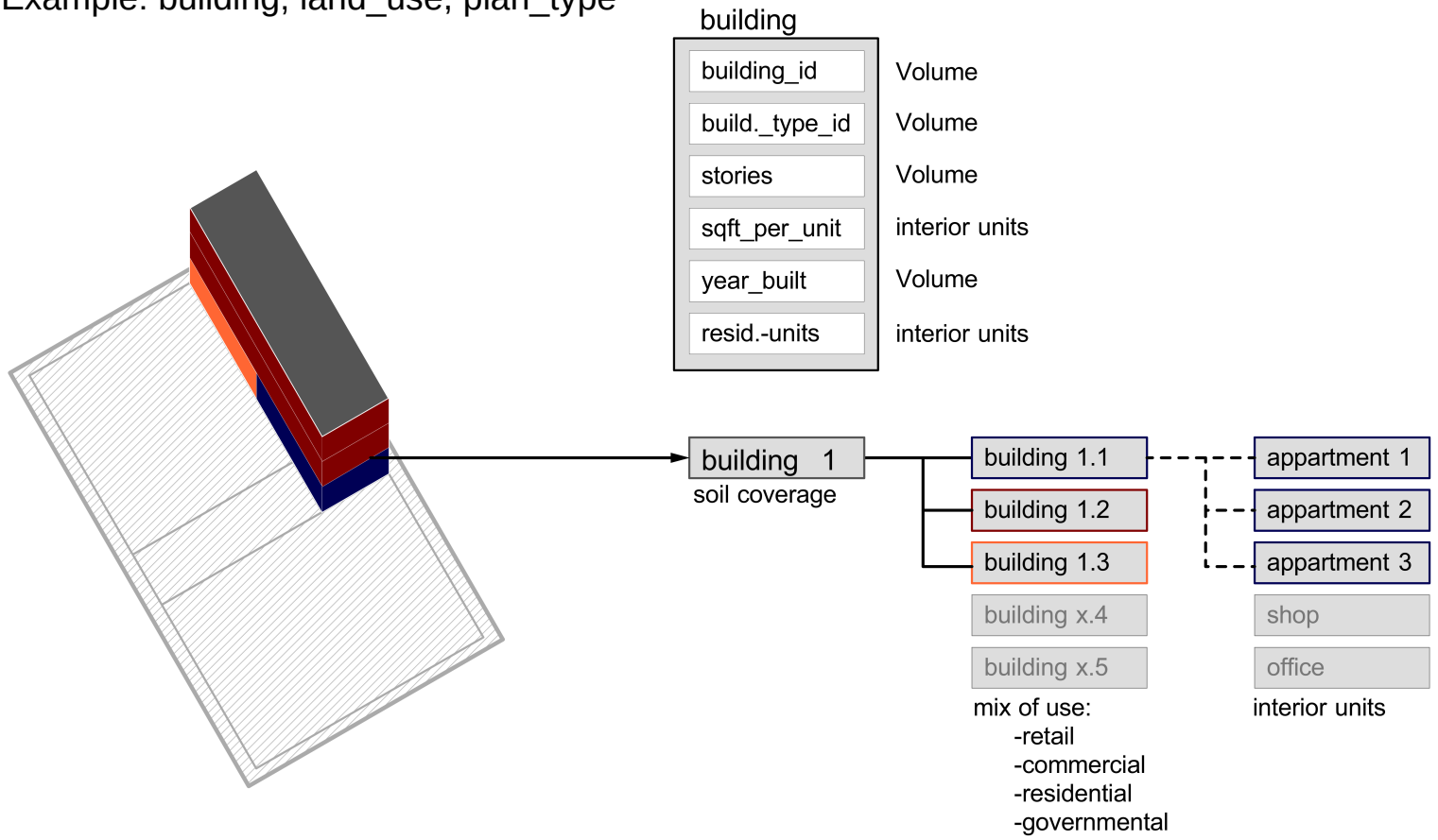
- Example: building; land_use, plan_type



Data processing

Definitions and Classifications

- Example: building; land_use, plan_type



Data processing

Definitions and Classifications

		SC				Max Fractions (%)					Min Fractions (%)				
Plan type -- main class	Description/Comment	PLAN TYPE (SC)	Generic Use (SC)	Developable for UrbanSim		Residential	Commercial	Retail	Industrial	Governmental	Residential	Commercial	Retail	Industrial	Governmental
Residential	100% Residential	1000	1	1		100					90				
	Residential district (> 90%)	1100	1	1		100	10	10			90				
	Residential district (< 90%)	1200	1	1		90	30	30			70	10		10	
Residential & Commercial	Residential with (loud) commercial and industrial	2000	2	1		100	10		10		90				
	Residential (< 90%) with (loud) commercial and industrial	2100	2	1		90	30		30		70	10		10	
Center	Central area; Mix of residential, commercial, retail	3000	3	1		100	100	100		100					
	Urban center: Mix of residential, commercial, retail	3100	3	1		100	100	100		100					
Governmental	Public/Governmental	4000	4							100					
Industry & Commercial	Industry & Commercial/Industrial	5000	5	1			80		80			20		20	
Industry	Industry	6000	6	1			20		100					80	
Open Space	Recreation area	7000	7												
	Conservation area	7100	7												
	Reserve	7200	7												
	Agricultural	7300	7												
	Forest	7400	7												
	Water	7500	7												
Infrastructure	Infrastructure	8000	8												
	Airport	8100	8												
Undefined	Unzoned	9000	9												
	Undefined	9100	9												

Data processing

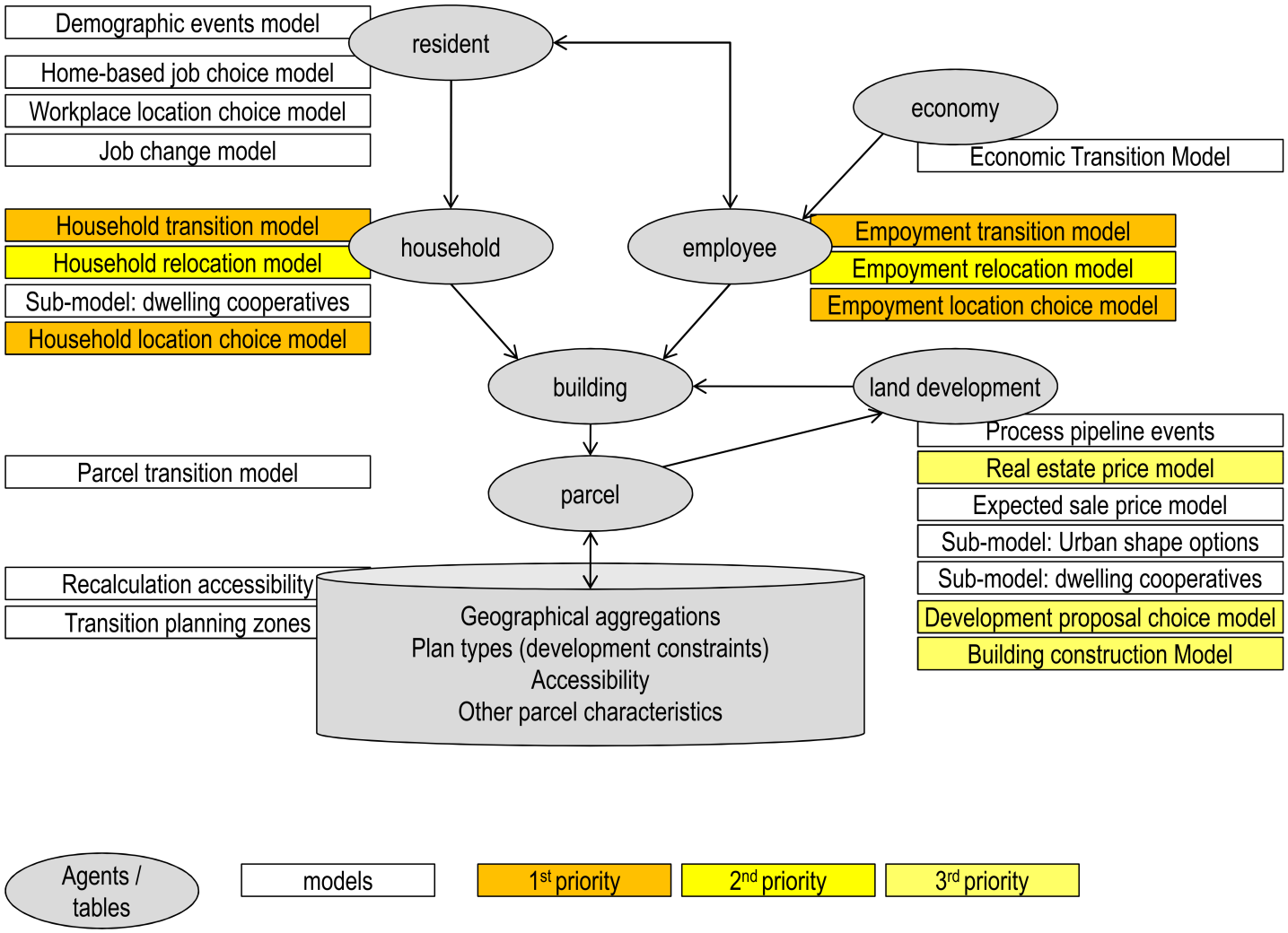
Definitions and Classifications

- building_types
  - In first approach use predefined building types
    - *single family detached/attached*
    - *multifamily detached/attached*
    - *mixed use (residential, commercial)*
    - *commercial low/high*
    - *residential urban/edge*
    - *industrial flat/multistory*

  - later define building types based on:
    - size, mix of use
    - behaviour of agents
    - behaviour of developes
    - building volume and relation to other shapes, e.g. parcel

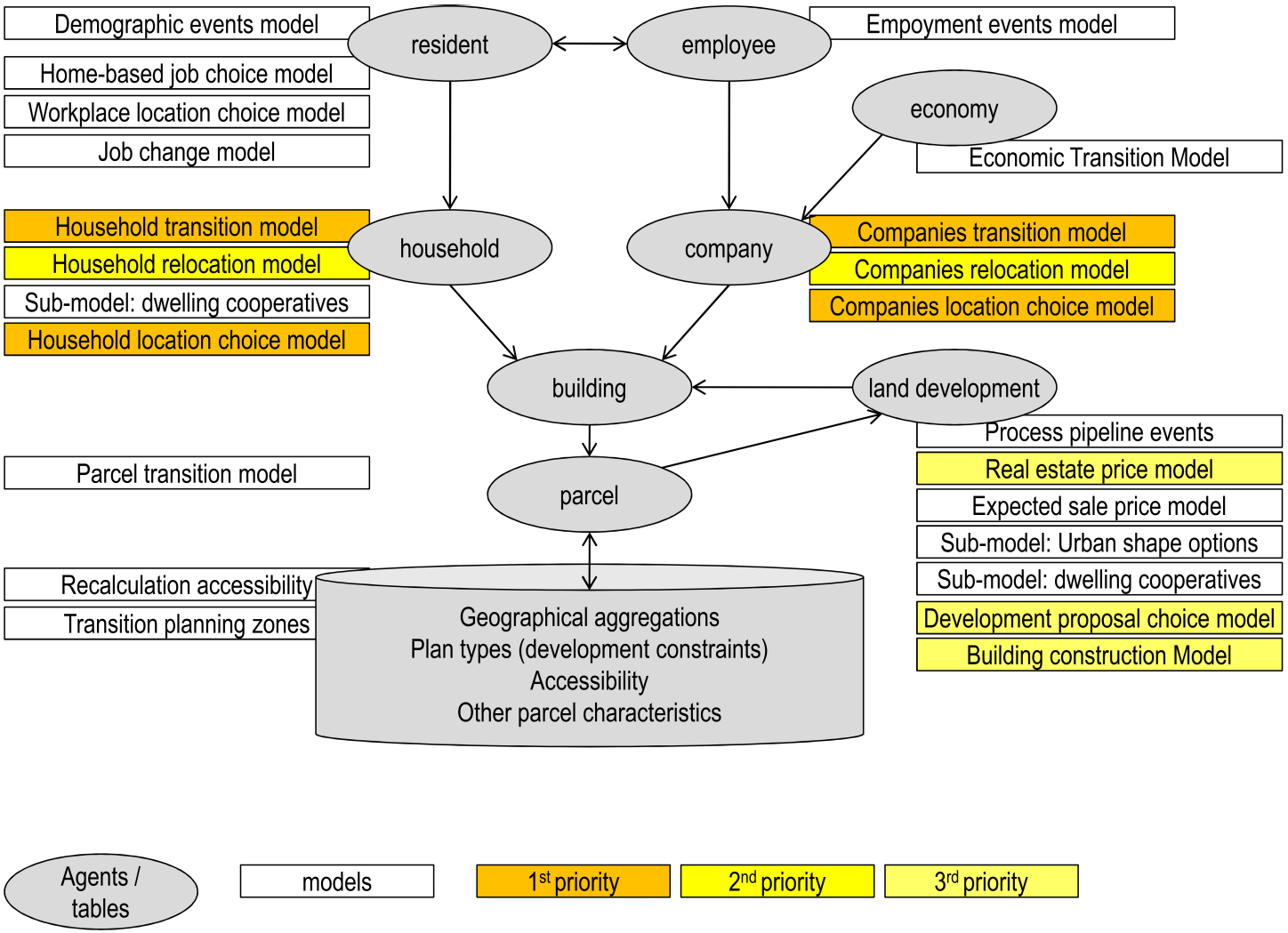
Modelling

Phase 1



Modelling

Phase 2



Modelling

Household location, transition and relocation choice

- New survey end of 2010 (Belart, 2011)
  - 1090 observation of recent movers
  - integration of lifestyle and social contacts
- Integration into generic framework for link to UrbanSim data (Schirmer et al 2011)
- Literatur review of variables used in Household location choices (Virani 2011)
  - new model with better results
    - common variables found in Literature
    - variables used in UrbanSim

Household location choice

Hypothesis

- Results of Bürgle (2006) to re-evaluate:
  - Different models for sale and rent

- Test additional Hypothesis:
  - Households tend to search residential locations close to the members of their social network
  - Households with employed persons prefer housing locations close to each of the places of employments
  - Different lifestyles have different location choices?

Household location choice

Comparison (rent)

	Bürgle 2006		Survey 2010	
Variable	**β**	***β(i)/β(rent/inc)***	**β**	***β(i)/β(rent/inc)***
Ratio rent/income	-2.159	-	-3.880	-
Floorpace divided by square root of household size	0.006	*-0.003*	0.004	*-0.001*
Distance to workplace [km]	-4.302	*1.993*	-1.850	*0.477*
Exponent of distance to workplace	0.201	*-0.093*	0.308	*-0.079*
Traveltime to Bürkliplatz in min (by car)	0.053	*-0.025*	0.013	*-0.003*
Ln of accessibility to population by public transport *	0.550	*-0.255*	0.508	*-0.131*
Population density * young household dummy	0.006	*-0.003*	0.014	*-0.004*
Density of children * family with young children dummy	0.042	*-0.019*	0.000	*0.000* ***
Proximity to major roads or high railway noise level	-0.177	*0.082*	0.302	*-0.078*
Rental vacancy of municipality	-0.162	*0.075*	-0.103	*0.027*
Tax index of municipality	-0.028	*0.013*	0.000	*0.000* ***
number of observations	*878*		*683*	
ρ2	*0.190*		*0.112*	

(***)= not significant on 95% interval of confidence

Household location choice

Basis model (rent)

Variable	β	t-test	p-value
Ratio rent/income	-5.430	-11.210	0.000
Log(net-area per household-member)	0.943	7.970	0.000
Distance to workplace [km]	-2.050	-2.550	0.010
Exponent of distance to workplace	0.292	3.910	0.000
Traveltime (by car) to Bürkliplatz in min	0.010	2.490	0.010
Log(accessibility of PT4) * dummy „no car“	0.457	4.440	0.000
Log(accessibility of PVT5) * dummy „car availal	-0.232	-3.120	0.000
Portion of households of same size (r=1km)	0.013	1.610	0.110 *
Population density in r=1km [Personen/ha]	0.010	4.760	0.000
Rent vacancy in municipality	-0.120	-2.380	0.020
Number of obsercations	*683*		
LL(0)	*-2671.9*		
LL(max)	*-2342.5*		
ρ2	*0.123*		

Household location choice

Extensions

Model R4:

$V(j) = ... + \beta_{Distance\ to\ work} * (Average\ distance\ to\ work\ of\ all\ hh\text{- }members)\ \hat{}\ Exponent\ distance\ to\ workplace + \ldots$

Model R7:

$V(j) = ... + \beta_{Distance\ to\ social\ contact} * (Weighted\ average\ distance\ to\ social\ contact)\ \hat{}\ Exponent\ distance\ to\ social\ contact + ...$

Household location choice

Model Belart

Variable	β	t-test	p-value
Ratio rent/income	-5.510	-11.070	0.000
Log(net-area per household-member)	0.982	8.010	0.000
Distance to workplace [km]	-1.590	-2.760	0.010
Distance to social contacts	-8.160	-1.810	0.070
Exponent of distance to workplace	0.374	4.720	0.000
Exponent of distance to social contacts	0.223	2.660	0.010
Portion of households of same size (r=1km)	0.016	1.770	0.080
Traveltime (by car) to Bürkliplatz in min	0.020	4.380	0.000
Log(accessibility of PT) * dummy „no car“	0.410	3.770	0.000
Log(accessibility of PVT) * dummy „car availabl	-0.298	-3.990	0.000
Population density in r=1km [Personen/ha]	0.010	4.370	0.000
Rent vacancy in municipality	-0.106	-2.030	0.040
Number of observations	*683*		
LL(0)	*-2671.9*		
LL(max)	*-2103.4*		
ρ2	*0.212*		

Modelling

Model Virani

Variable	β	t-test	p-value
Age of the House	1.02	8.75	0
Age of the House is unknown	*0*	*fixed*	
Jobs available in the municipality	-0.589	-13.11	0
Population Density (1 km) * Young Household Dummy	0.0266	7.1	0
distance to station	-0.293	-3.5	0
Proximity to previous location	6.52	21.74	0
Proximity to social contacts	6.24	2.18	0.03
Proximity to work	6.3	2.03	0.04
ETA previous location	-0.203	-9.08	0
ETA_sociqal contracts	-0.0291	-1.25	0.21 *
ETA_work	-0.0272	-1.31	0.19 *
Dummy of historical building (construction before 1941)	1.97	11.9	0
Log (net floor space divided by household size)	1.83	12.1	0
Accessibility to public transport * dummy of " no car available "	0.65	5.32	0
Rent Vacancy in the municipality	-0.213	-3.66	0
Ratio of rent to income	-4.99	-8.76	0
Rooms per person	-1.41	-23.46	0
Travel time to Burkliplatz by Car	0.0281	5.1	0
Number of observations	*685*		
LL(0)	*-2615.898*		
LL(max)	*-1170.4*		
ρ2	*0.563*		

Modelling

Model Virani (UrbanSim)

Variable	β	t-test	p-value
Age of the House	0.911	8.84	0
Age of the House is unknown	0 fixed		
Jobs available in the municipality	-0.617	-14.69	0
Population Density (1 km) * Young Household Dummy	0.0287	8.57	0
distance to station	-0.288	-3.87	0
Proximity to previous location	7.2	29.61	0
Proximity to work	6.48	2.03	0.04
ETA previous location	-0.199	-11.53	0
ETA_work	-0.0259	-1.34	0.18 *
Dummy of historical building (construction before 1941)	1.7	11.52	0
Households with one member * dummy of same hh in 1 km²	0.0582	4.45	0
Accessibility to public transport * dummy of " no car available "	0.161	3.25	0
Rent Vacancy in the municipality	-0.16	-2.83	0
Travel time to Burkliplatz by Car	0.0305	6	0
Number of observations	*685*		
LL(0)	*-2621.038*		
LL(max)	*-1629.14*		
ρ2	*0.392*		

Modelling

Employment location, transition and relocation choice

- Initial estimation of simple model UrbanSim – joint model
  - log density population
  -

    => no meaningful results yet

- Different specification alternatives:
  - per sector (NOGA-code)
  - joint specification?
-
-

Land Developments

Land price model

- Transaction data on individual level not available
- Estimation directly from comparis data?
- Applying method of residual values (market value - costs)

Rent price models

- Residential, adoption models Löchl (2006, 2010)
- Office, adoption model Haase (2011)

Sale prices (single family residential)

- Estimation from offered prices (comparis data)
- Compare with mean of transaction prices

Land Developments

Development Templates

Assume development templates

- Single family residential
- Multifamily residential
- Mixed office
- etc.

Take realised projects

Estimate costs from project data

Land Developments

Development Project Location Choice Model

Parcels with capacity left > developable parcels

No redevelopment

Random selection of developable parcels for choice set

Development type

- residential, non-residential

Considering developer type

- Promoter, self-owning

Land Developments

Building Construction Model

Assume construction time per floor area

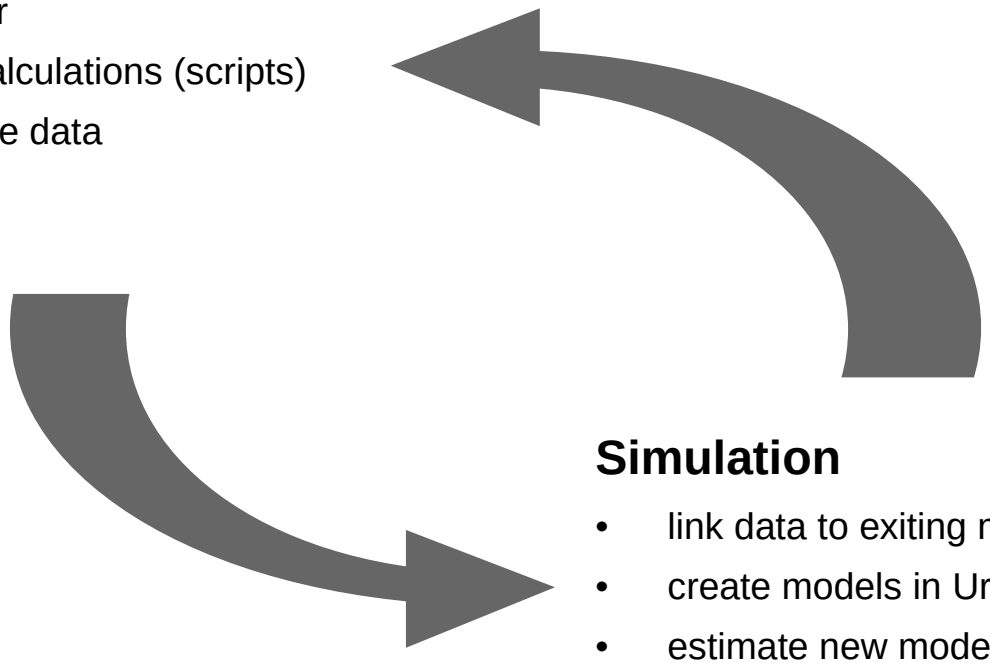
Estimate velocity functions from dataset on building projects

What about construction delays?

Conclusions and Outlook

Processing

- data collection
- clean data
- create base year
- include ZUK - calculations (scripts)
- include new base data
- derive new data
- ....



Simulation

- link data to exiting models
- create models in UrbanSim
- estimate new models
- (inside outside UrbanSim)
- .....

Conclusions and Outlook

Scenarios

- Stadttunnel Zürich
- A50/A51
- Limitation of settlement area
- Rising mortages
- Flughafen Dübendorf

Categories

- Transport Infrastructure (traffic)
- Change of Zoning/Regulation of real estate market (politics)
- Population (economics, demography)

End

Questions?