Rethinking the Region

Systematic evaluation of residential location choice under disaster risk

Kotryna Valeckaite, November 2018

TU Delft ARUP

Rethinking the Region

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Story of my thesis

Motivation Framing Implementation Results Conclusions

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Natural disasters and extreme weather

The latest news and comment on natural disasters and extreme weather

November 2018

Typhoon Yutu: death toll reaches 15 after landslides hit Phillipines

Dozens more are missing, particularly in the northern region of Cordillera, as searches continue

1 Nov 2018

October 2018

Italy storms kill 11 and floods inundate St Mark's Basilica, Venice

Third day of storms bring widespread damage to towns as lagoon city baptistery is submerged by 90cm of water

30 Oct 2018

Wild weather across Europe leaves nine dead in Italy

30 Oct 2018

Venice flooded by high tide – in pictures

29 Oct 2018

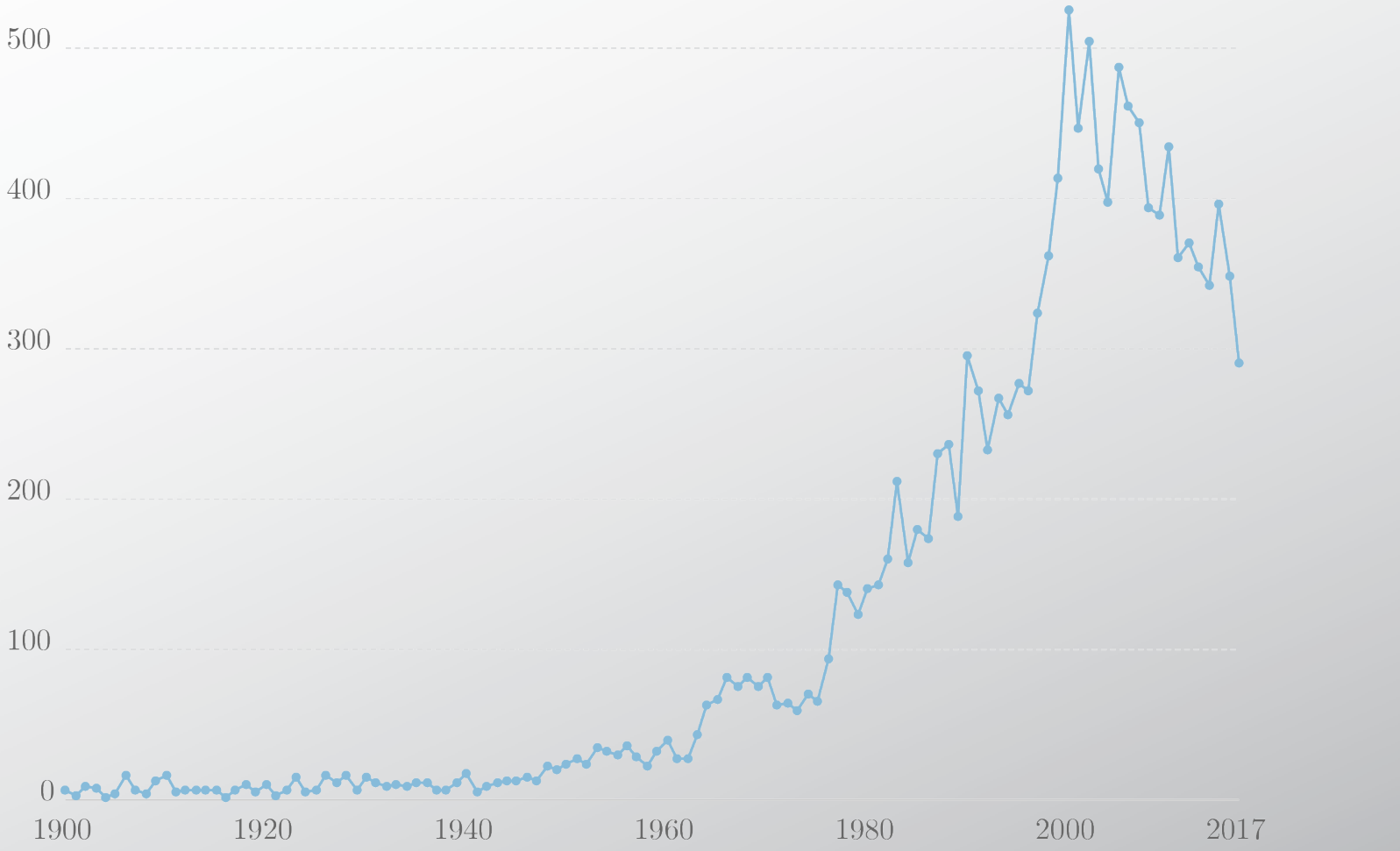
Three-quarters of Venice flooded by exceptional high tide

29 Oct 2018

Weatherwatch / Weatherwatch: Britain's wettest October on record

26 Oct 2018 | 5

Number of natural disaster events



Source: Natural disasters - EMDAT (2017) OurWorldInData.org/natural-catastrophes/ CC BY-SA

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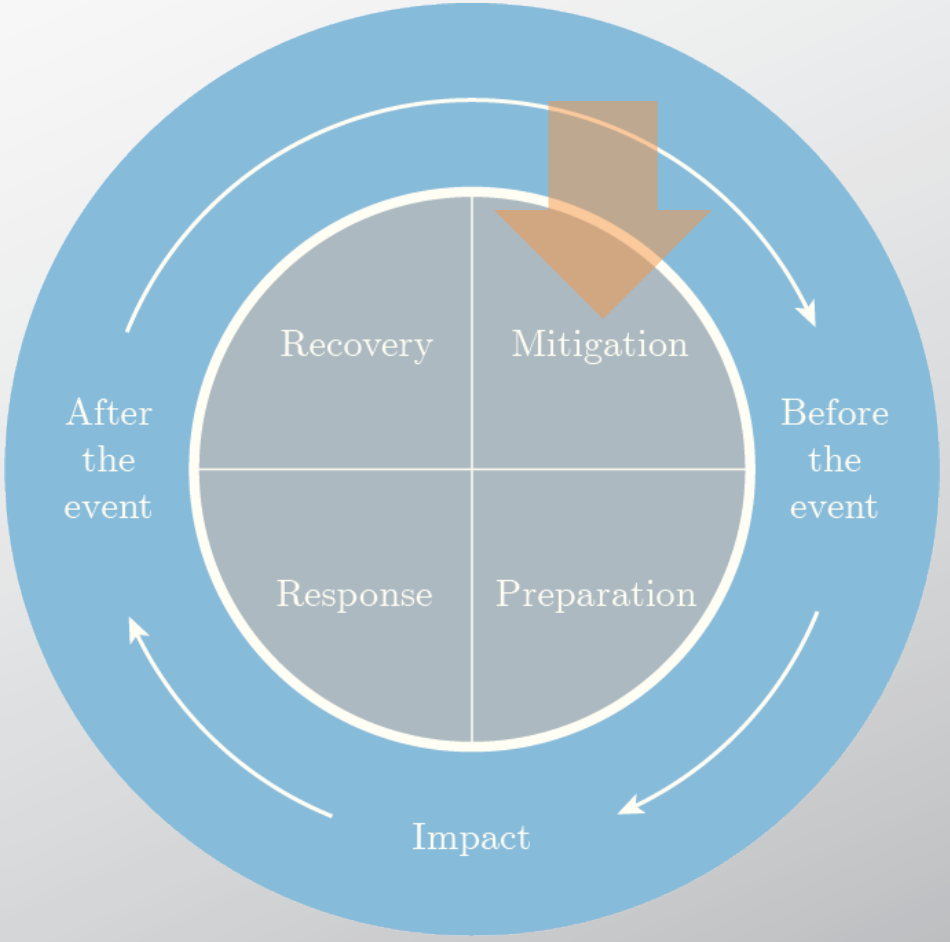
Disaster management cycle

based on Alexander, 2002



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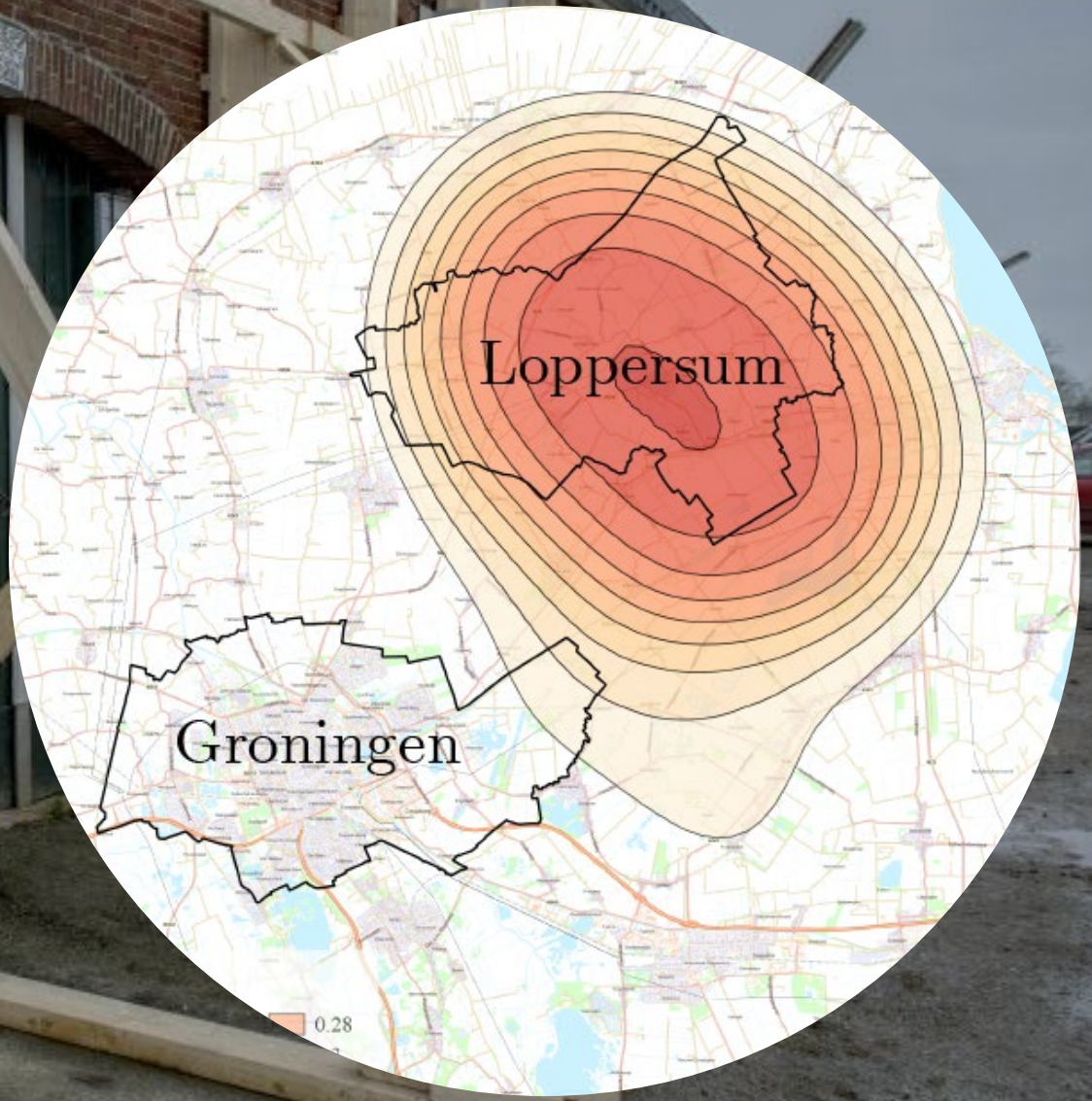
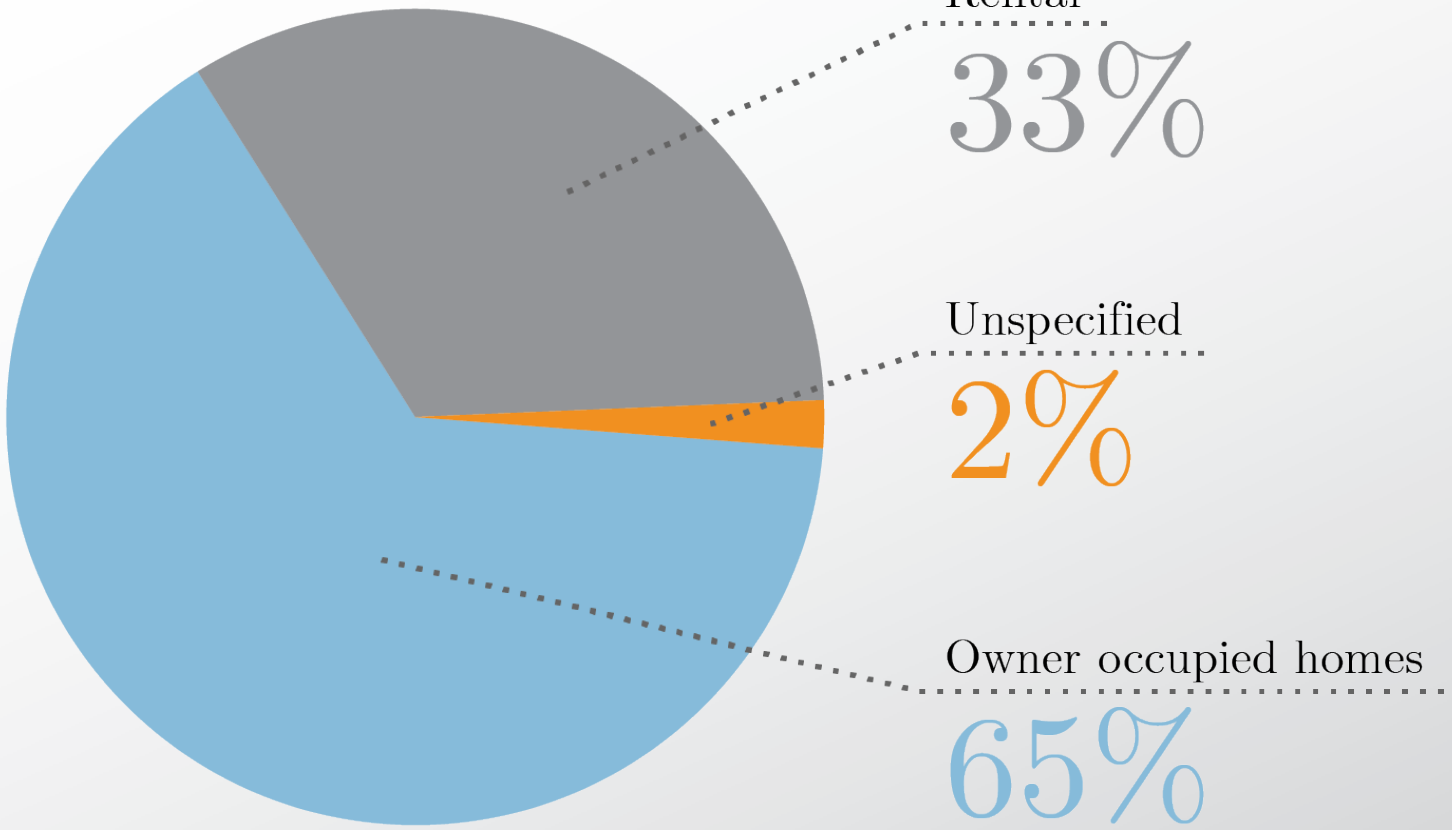
Case-study



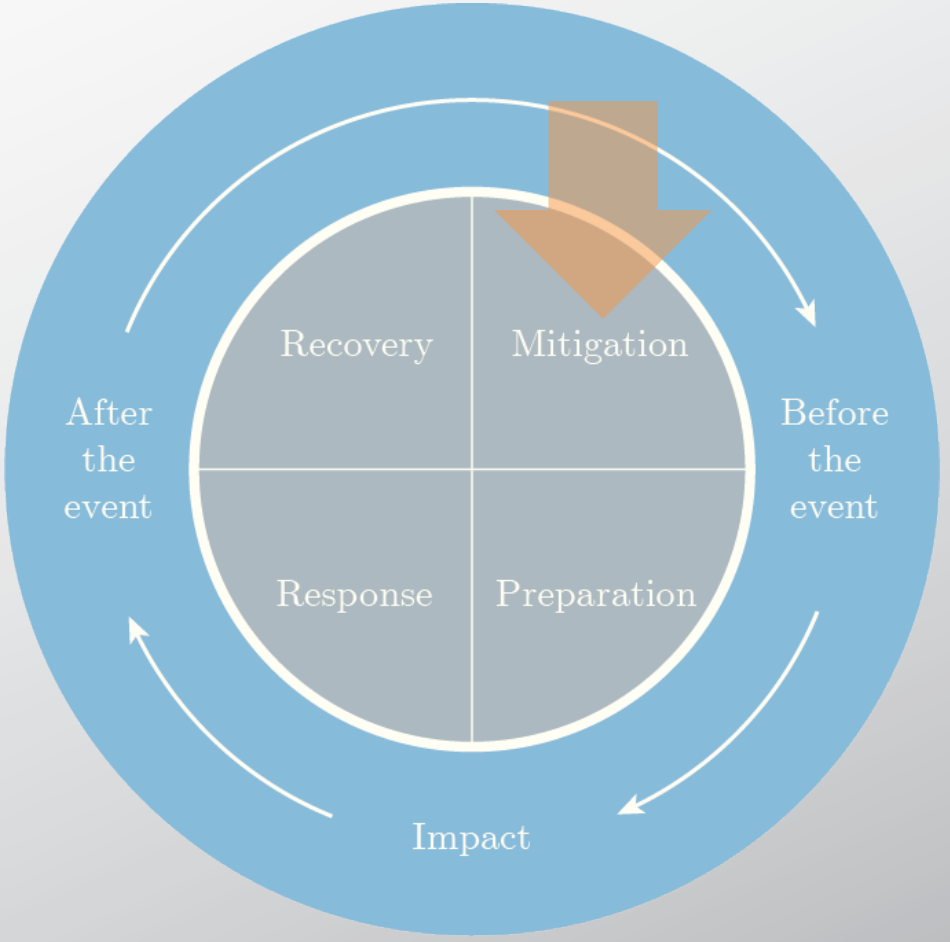
Temporary building supports in Groningen,
De Ingenieur, 2017



Case-study housing stock 2016

Disaster management cycle

based on Alexander, 2002



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Models enable experimention on urban contexts

ALSO:

They **illuminate** core dynamics, **educate** the public, **discipline** the policy dialog and **guide** data collection

Existing models

Is there something we could use/adapt?

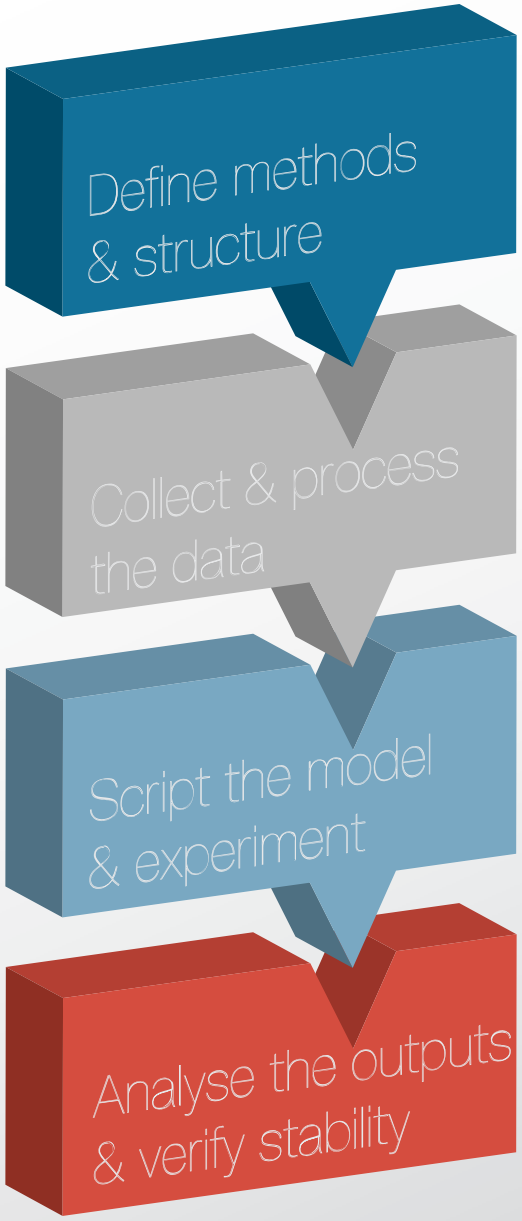
Lack transparency *(Beimborn et al., 1996, Parker et al., 2002, Pontius Jr and Spencer, 2005, Waddell, 2011)*

Are very **data 'hungry'** *(Waddell, 2011)*

Are **hard to use & tweak** *(Evans and Manson, 2007, Waddell, 2011)*

Research Question

How to **build a computational framework** examining the **residential location choice behavior** of households within a regional, **disaster** situation, given public sector agency-defined policy scenarios?



Implementation

Results

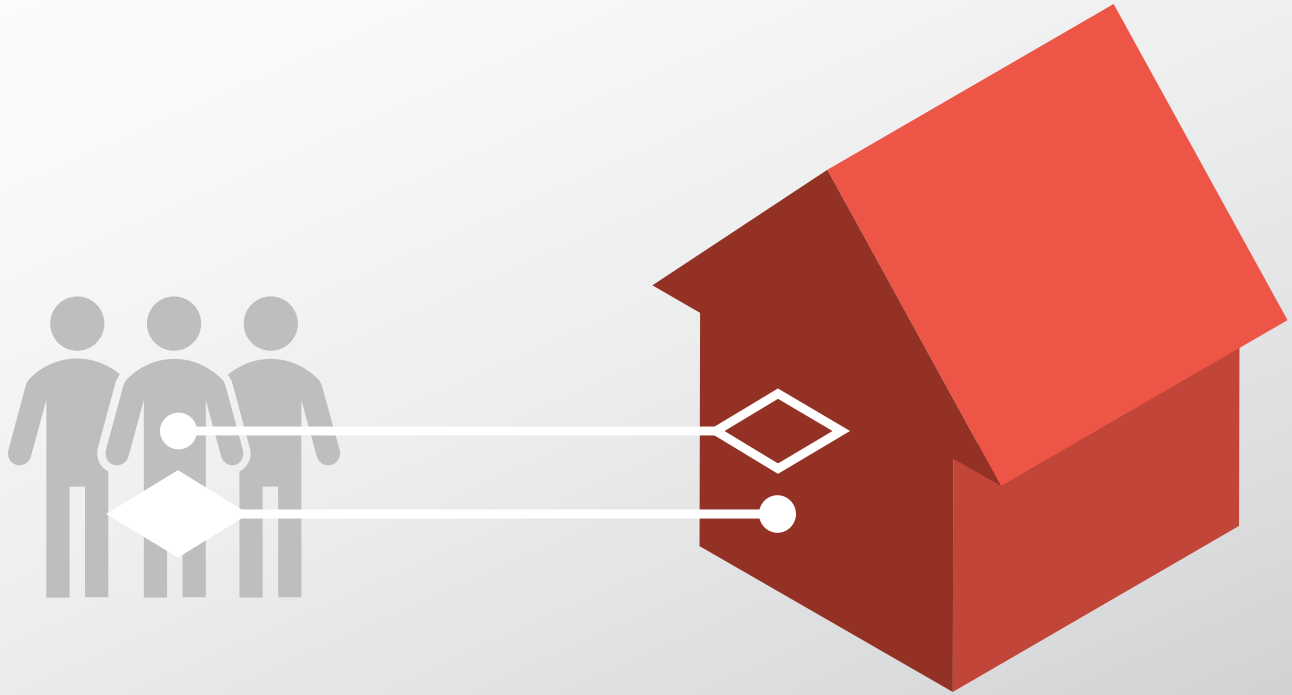
Implementation

Data, structure & algorithms

Cities are complex systems

Their "elements interact and affect each other so that it is difficult to separate the behavior of individual elements" *(Gershenson, 2008)*

Define methods & structure

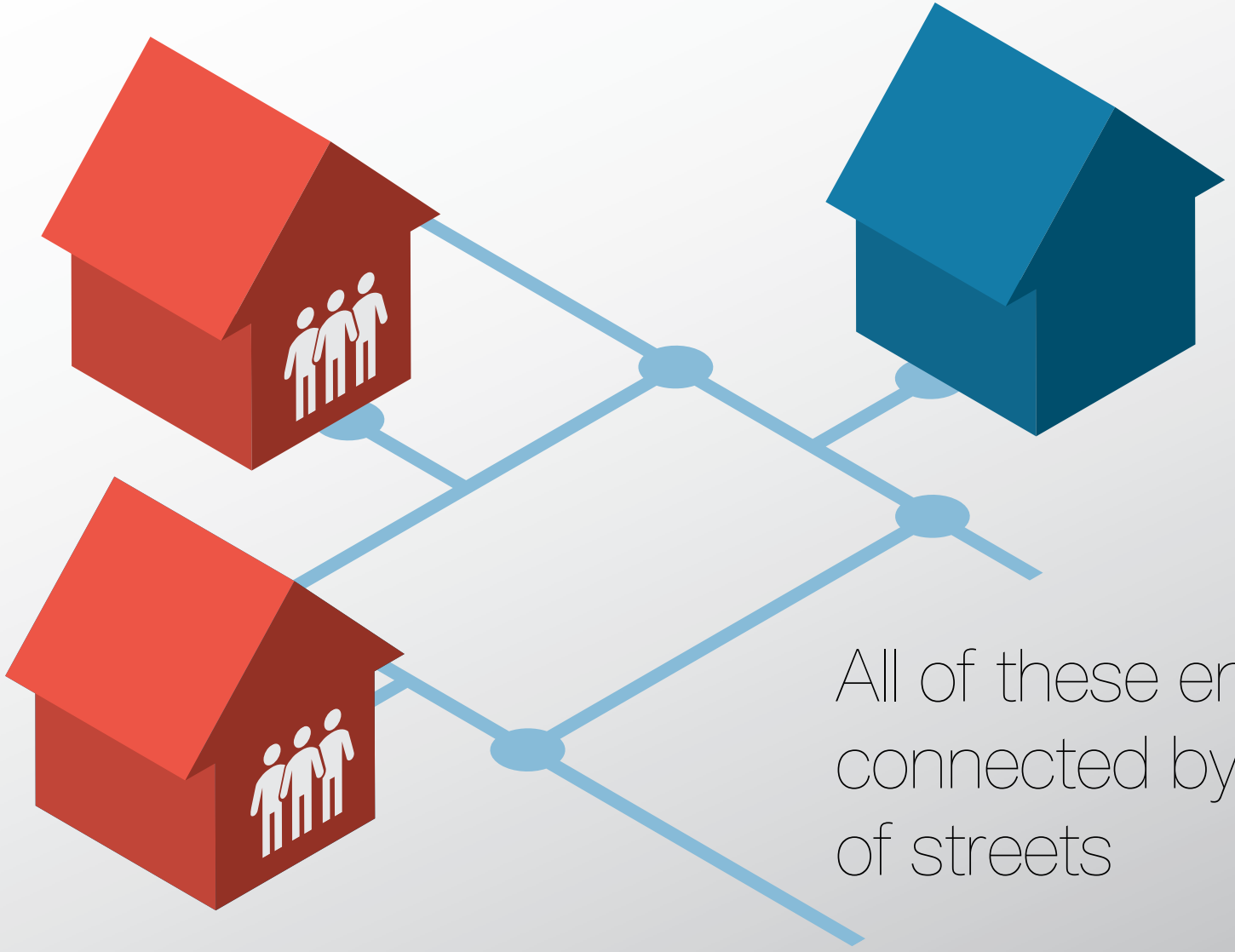


Households live in buildings
Buildings may have households

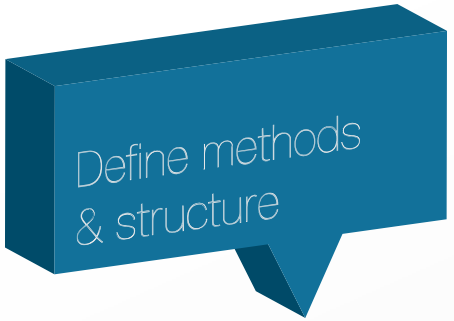
Define methods & structure

A settlement consists of many houses, some of which are inhabited

Define methods & structure

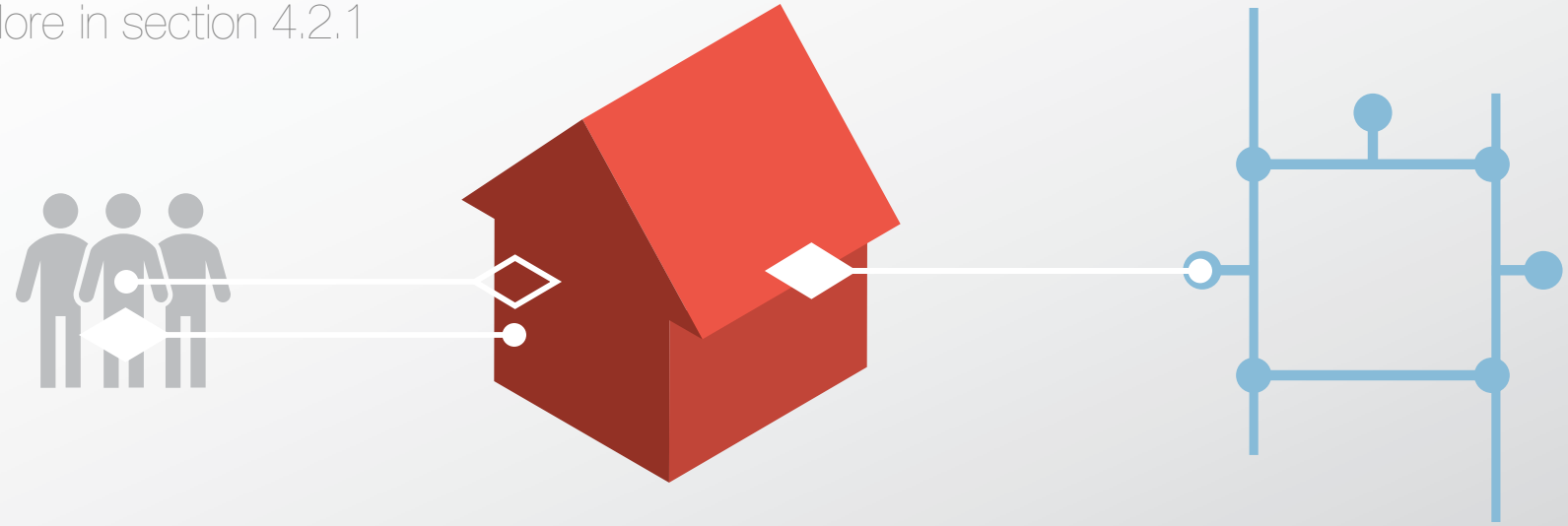


All of these entities are connected by a network of streets



Classes

More in section 4.2.1



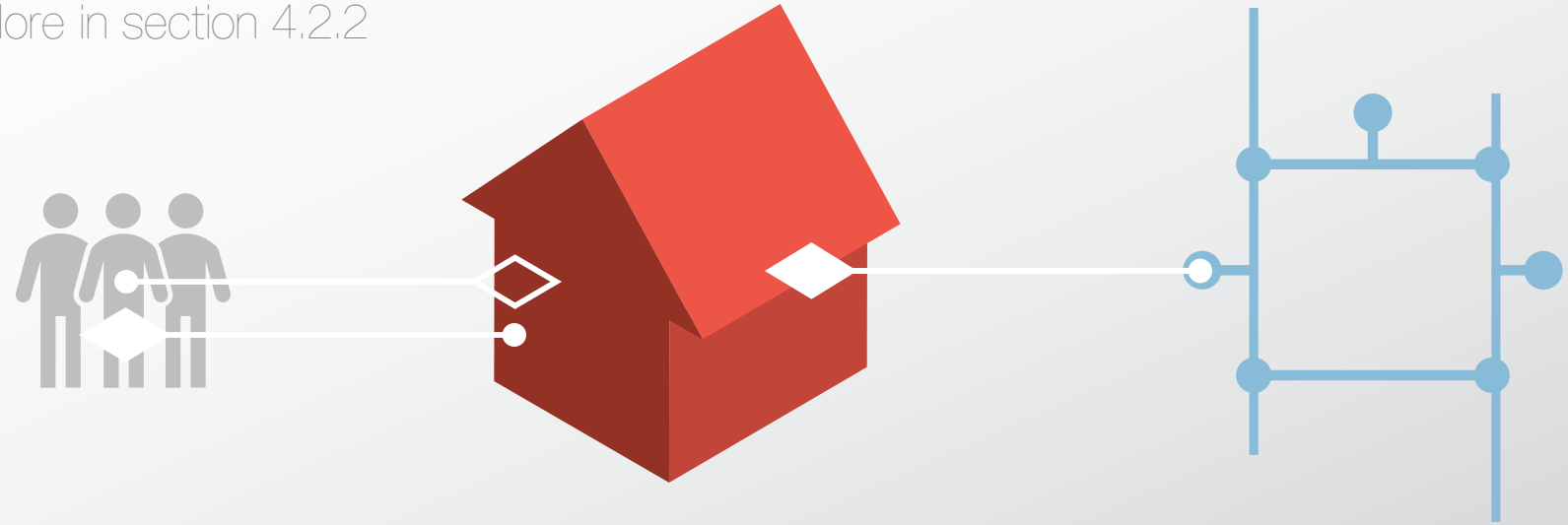
Households are agents

Buildings are discrete locations

All buildings are connected by a **network**

Data sources

More in section 4.2.2



Synthesized from aggregate datasets, *sources*:

- Central Bureau of statistics *(CBS)*
- Dutch Regional Transport model *(NRM)*

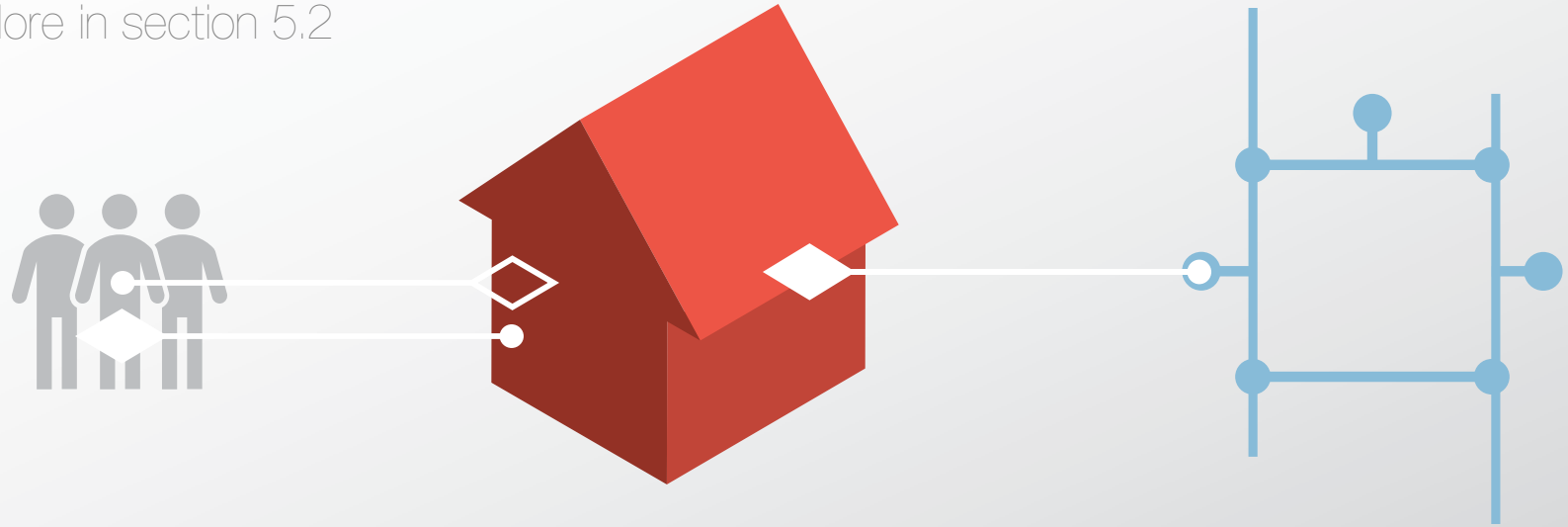
Based on highly detailed datasets, *sources*:

- Key Registries *(BAG, BRK)*
- *Arup* datasets & expert judgement

Represented as a **distance matrix**, generated from a spatial network from National Road Dataset *(NWB)*

Resources

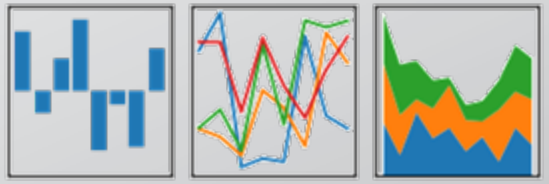
More in section 5.2



python™

pandas

$$y_{it} = \beta' x_{it} + \mu_i + \epsilon_{it}$$



plotly

The flowchart

Input

Household set

Intervention

Processes

Simulation

Output

Changelog

Visualization

Implementation

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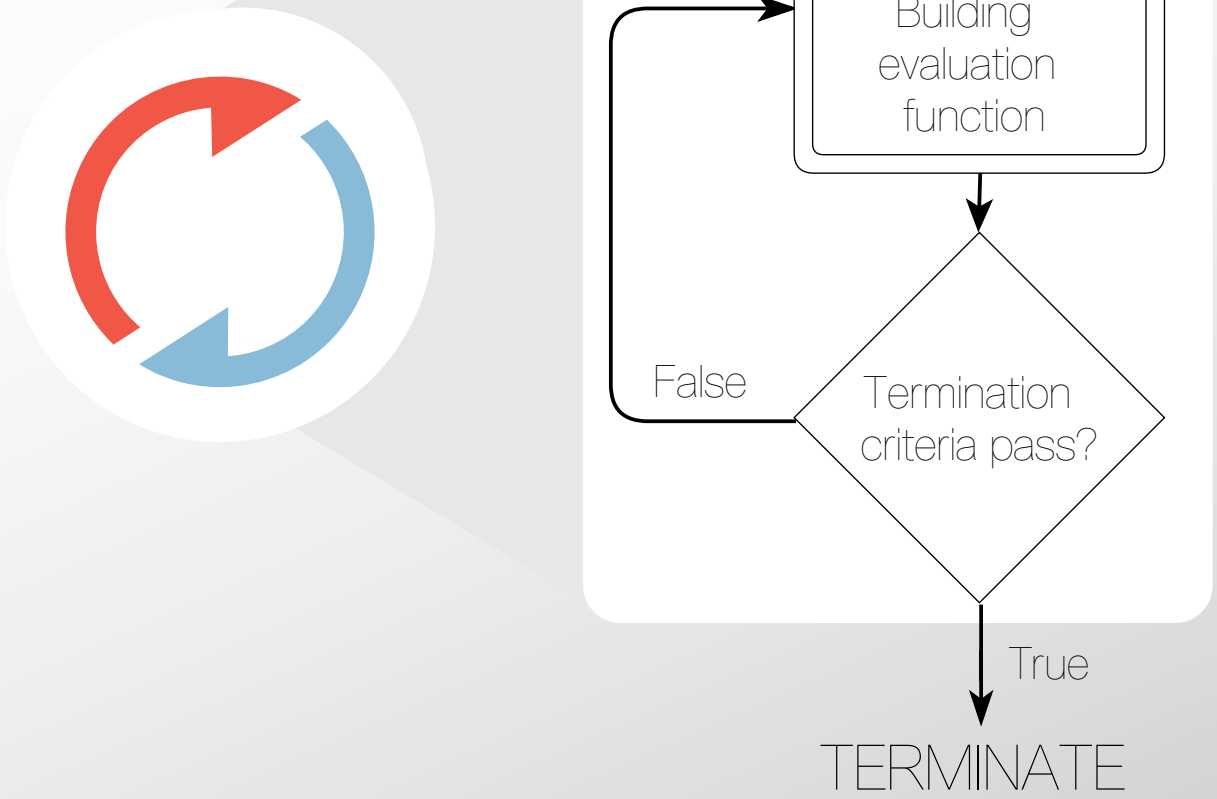

- Hierarchical structure of 3 functions:
  - **Run** controls the simulation
  - **Step** progresses through time & simulates *bidding*
  - **Building evaluation** represents the choice behavior of the agents
- **Termination** happens upon convergence

Building evaluation function

- **Regret** is experienced, when *non-chosen buildings perform better* than the chosen option on a single or more attributes
- Households choose a building that provides the **smallest regret**

Building evaluation function

– Discrete choice model, adapted from Random Regret Minimization *(Chorus, 2010):*

$$R_i^{\sigma} = \sum_{j \neq i} \sum_{m} \ln(1 + \exp(\beta_m^{\sigma} [\frac{x_{jm} - x_{im}}{\sigma_{im}}]))$$

Where:

– m attribute enumerator
– β_m preference weight, associated with the attribute
– σ_{im} standard deviation of the choice attribute set
– i the chosen alternative enumerator
– j the non-chosen alternatives enumerator

What attributes do people evaluate?

Criteria types

- Question impossible to answer without data on how people choose houses
- So from literature identify 3 types, that should be incorporated:
  1. **L -** Location related (i.e. distance to destinations everybody cares about)
  2. **LH -** Location and household related(i.e. distance to job, school)
  3. **B -** Building related(i.e. value, area, parcel area, *RISK*)

What attributes do people evaluate?

Criteria types

Type	Attribute	Notation	Units
L	Distance to amenities	d_amenities	m
LH	Distance to jobs	d_jobs	m
LH	Distance to schools	d_schools	m
B	Real estate value	v_house	10^3 x euro
B	House area	a_house	m^2
B	Parcel area	a_parcel	m^2
B	Risk	risk	%

The flowchart

Input

Processes

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Purpose of the interventions

To ***test*** the simulations and ***showcase*** the usability of the framework

Interventions

- Focus on questions public sector planning agencies **might** ask:
  - What would be the (spatial) **effects** of a **subsidy** targeting lowest income groups?
  - Is there a difference between different forms of subsidizing?
- But also:
  - Can we observe incremental structural rehabilitation of buildings?

Types of simulation runs

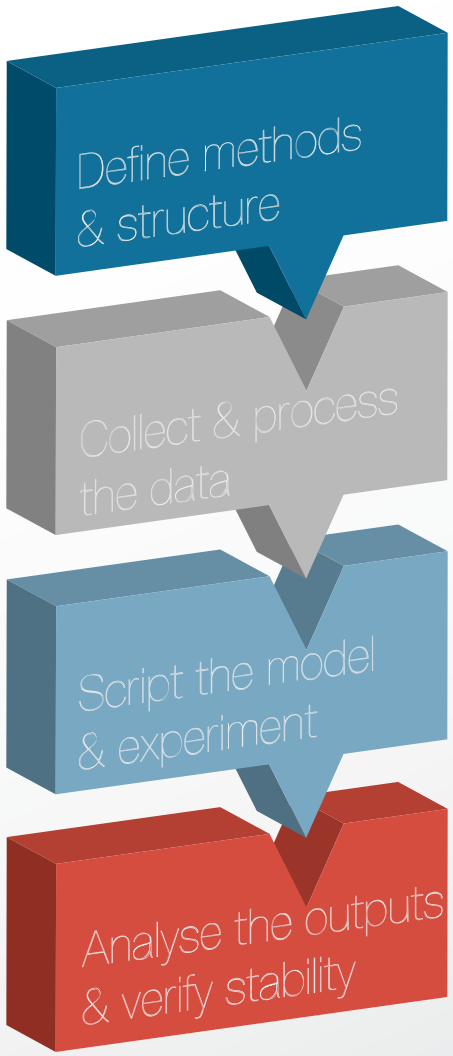
1. **Base:** no interventions, static risk

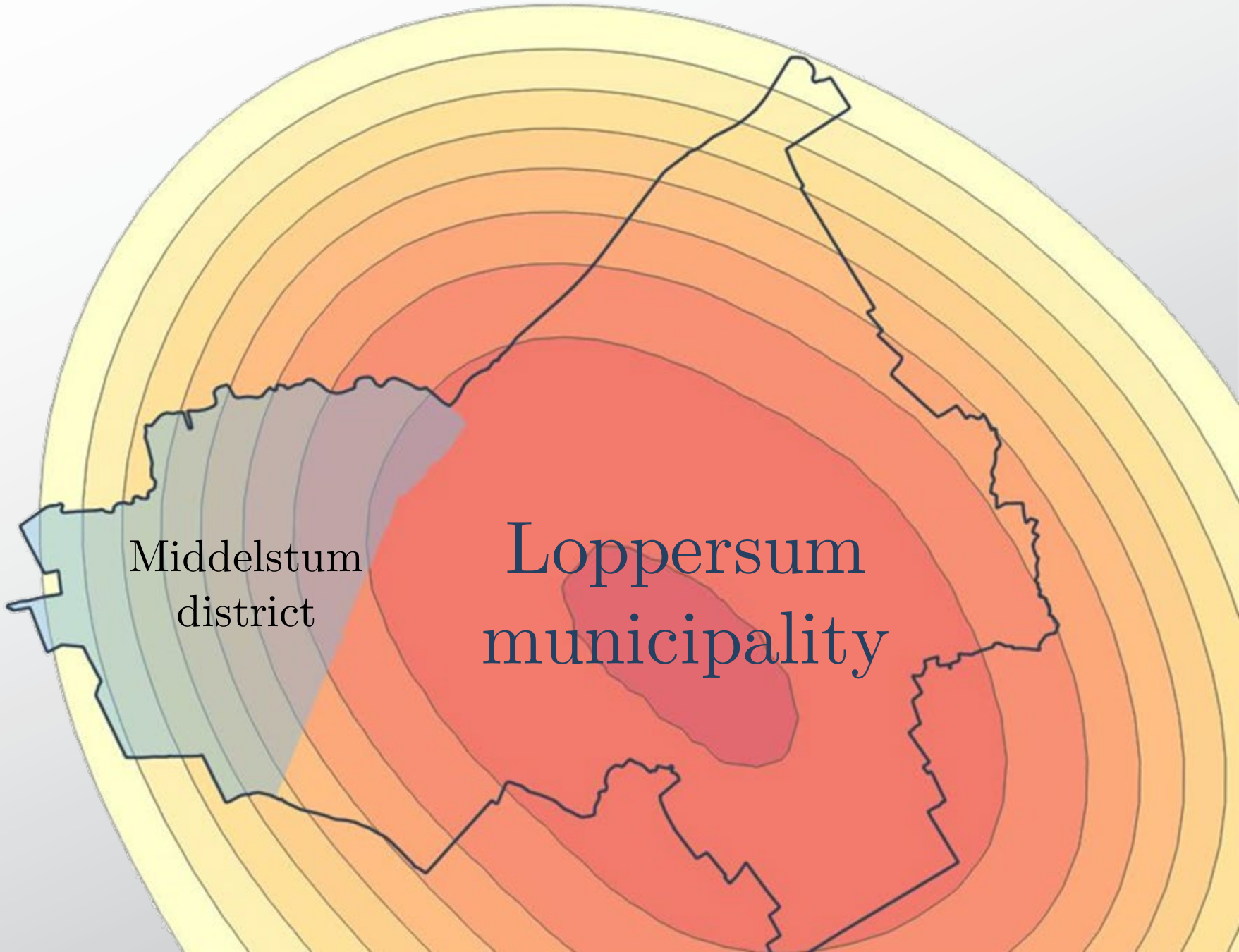
Interventions

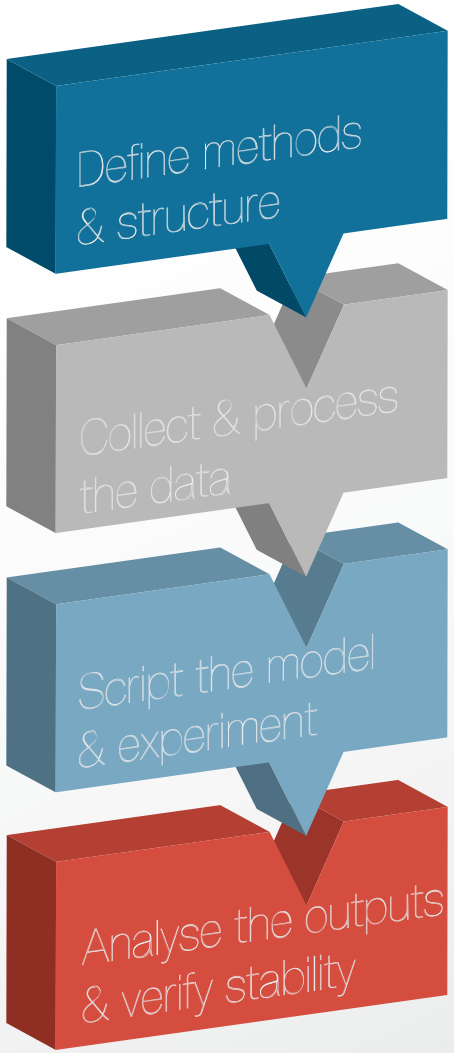
2. **Financial static:** same sum given to two lowest income bins
3. **Financial progressive:** 3 lowest income bins, with the lower the income, the higher the sum
4. **Adaptive risk:**
   - Intervention 90% subsidized
   - Observe the impact of preference weight

Results

Simulation performance & interventions


Define methods & structure
Collect & process the data
Script the model & experiment
Analyse the outputs & verify stability

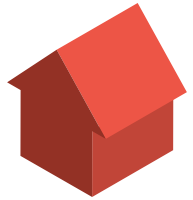

Middelstum district
Loppersum municipality



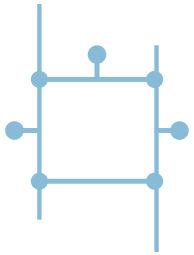
Model input

Properties

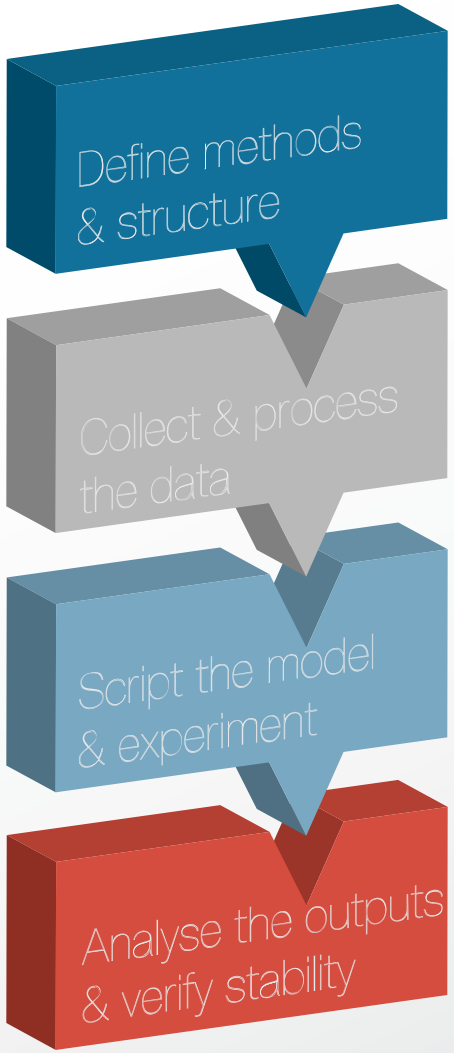
984 households



1100 residential buildings

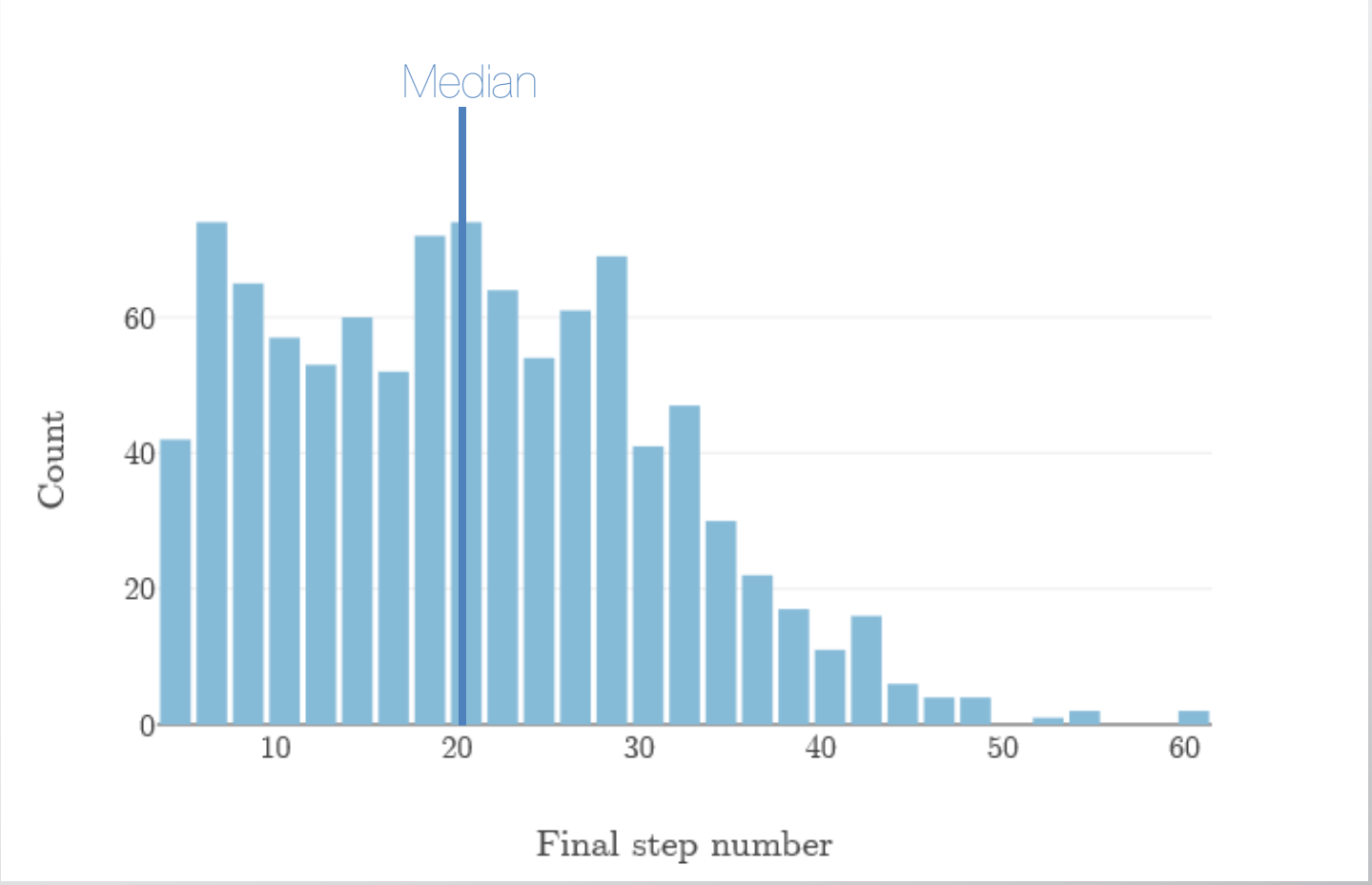


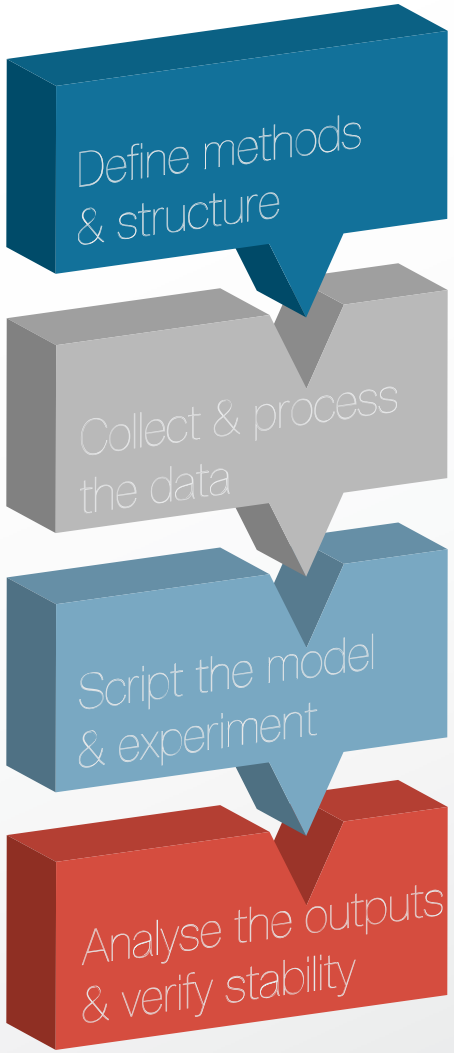
2918 nodes in the network



Base run

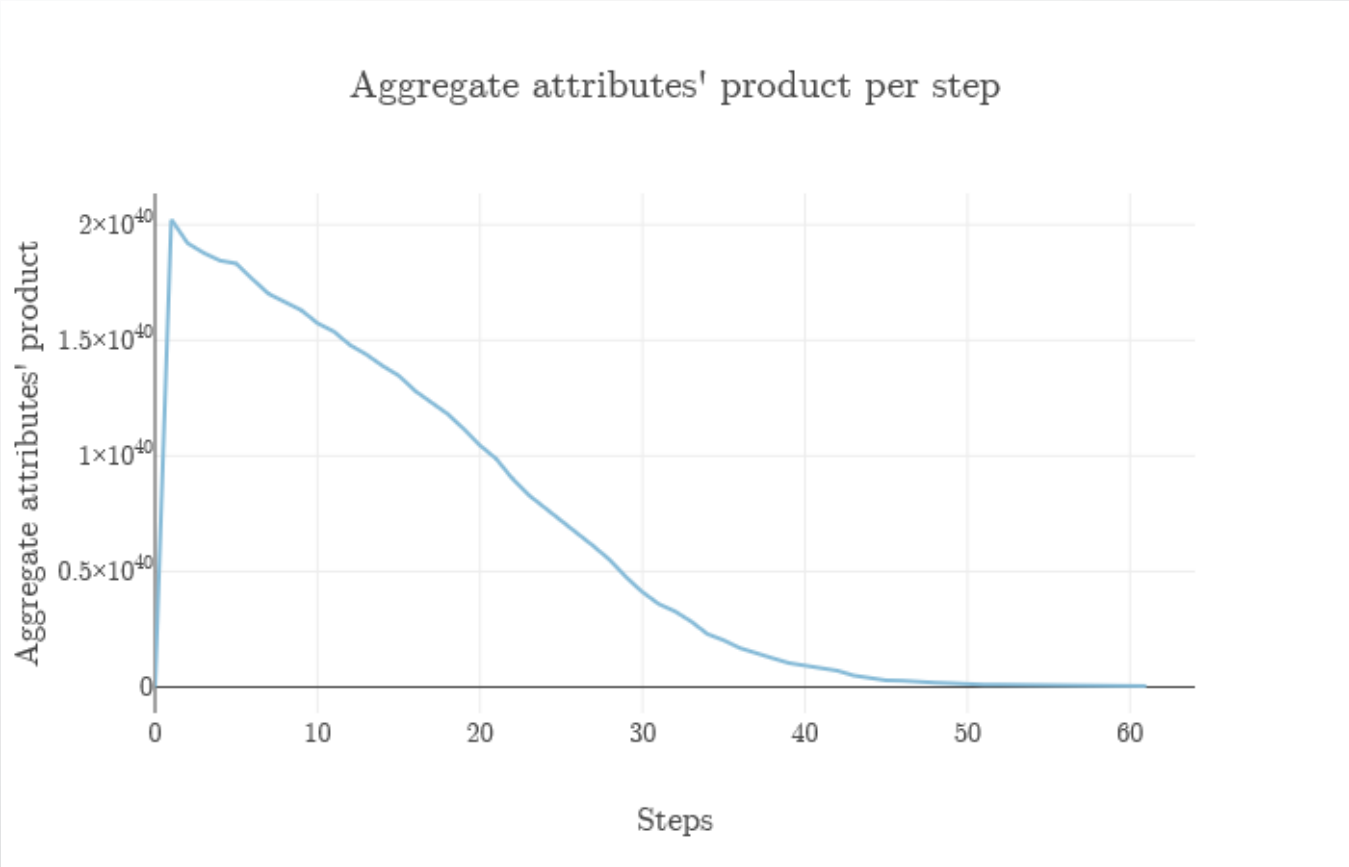
Step count histogram

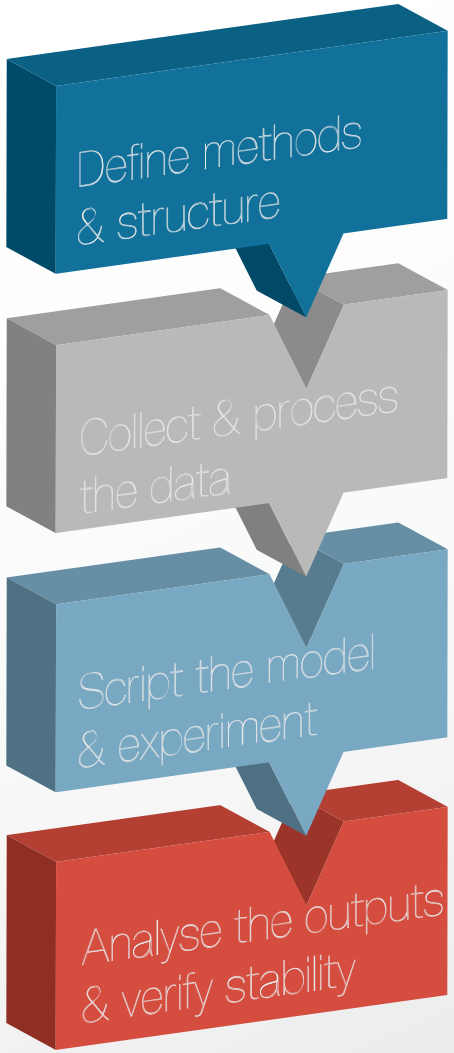




Base run

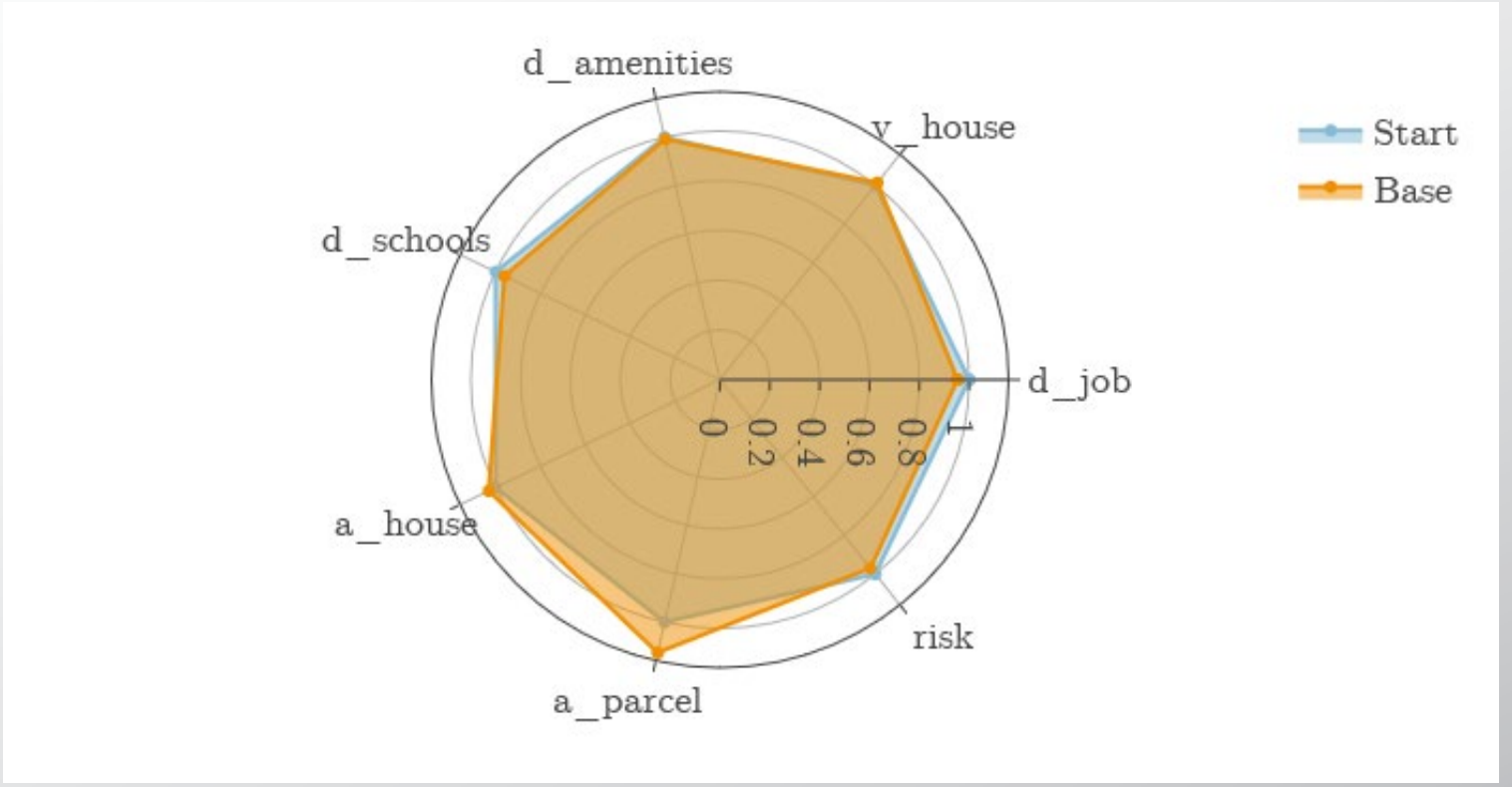
Average product of all attributes: strong minimizing behavior

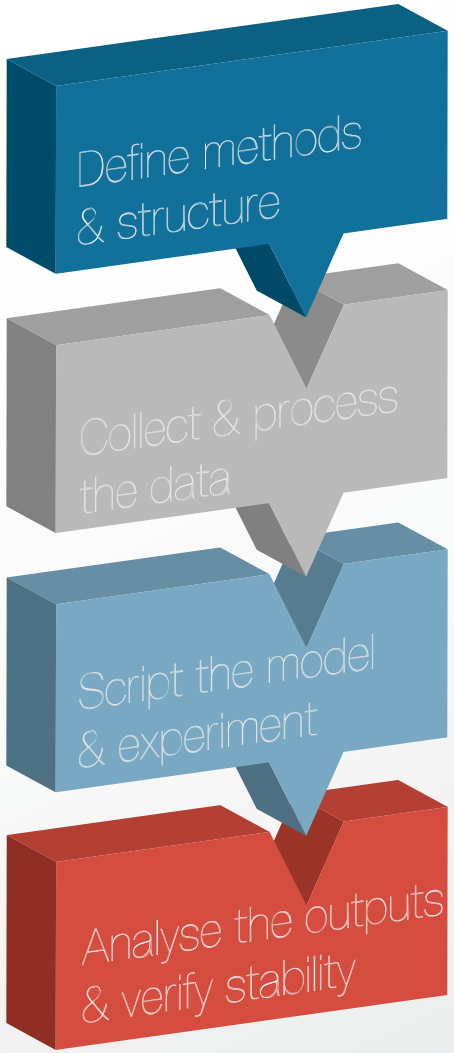




Base run

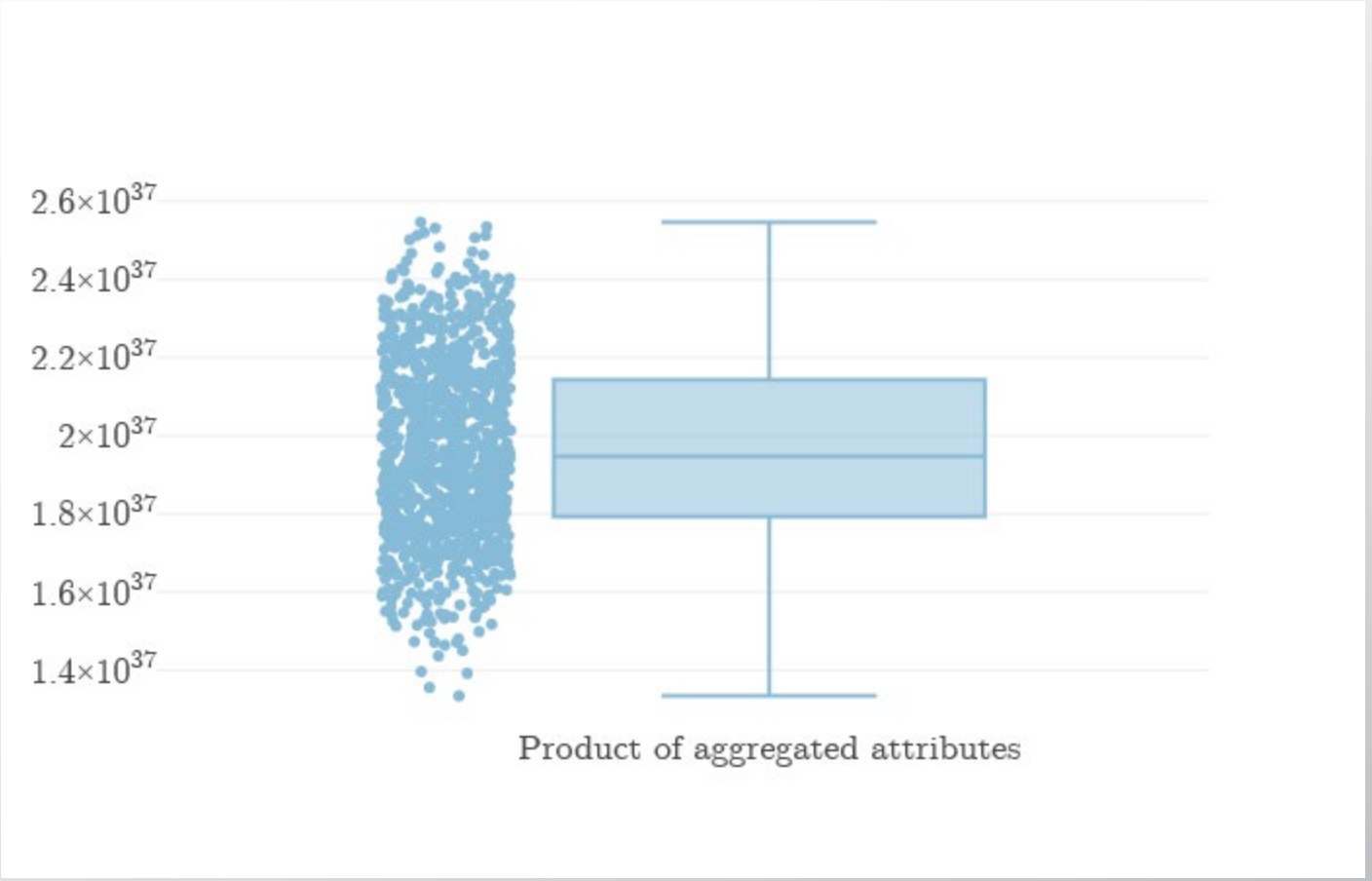
Relative average criteria optimization

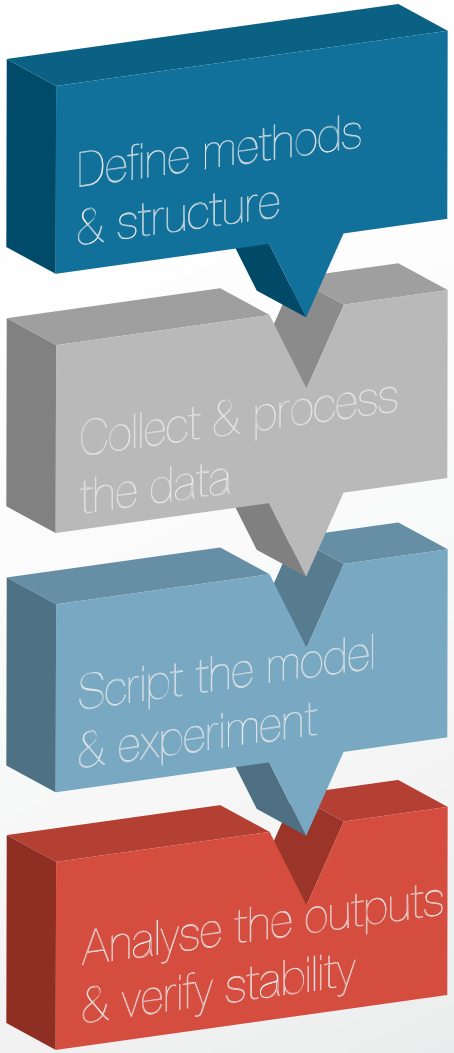




Base run

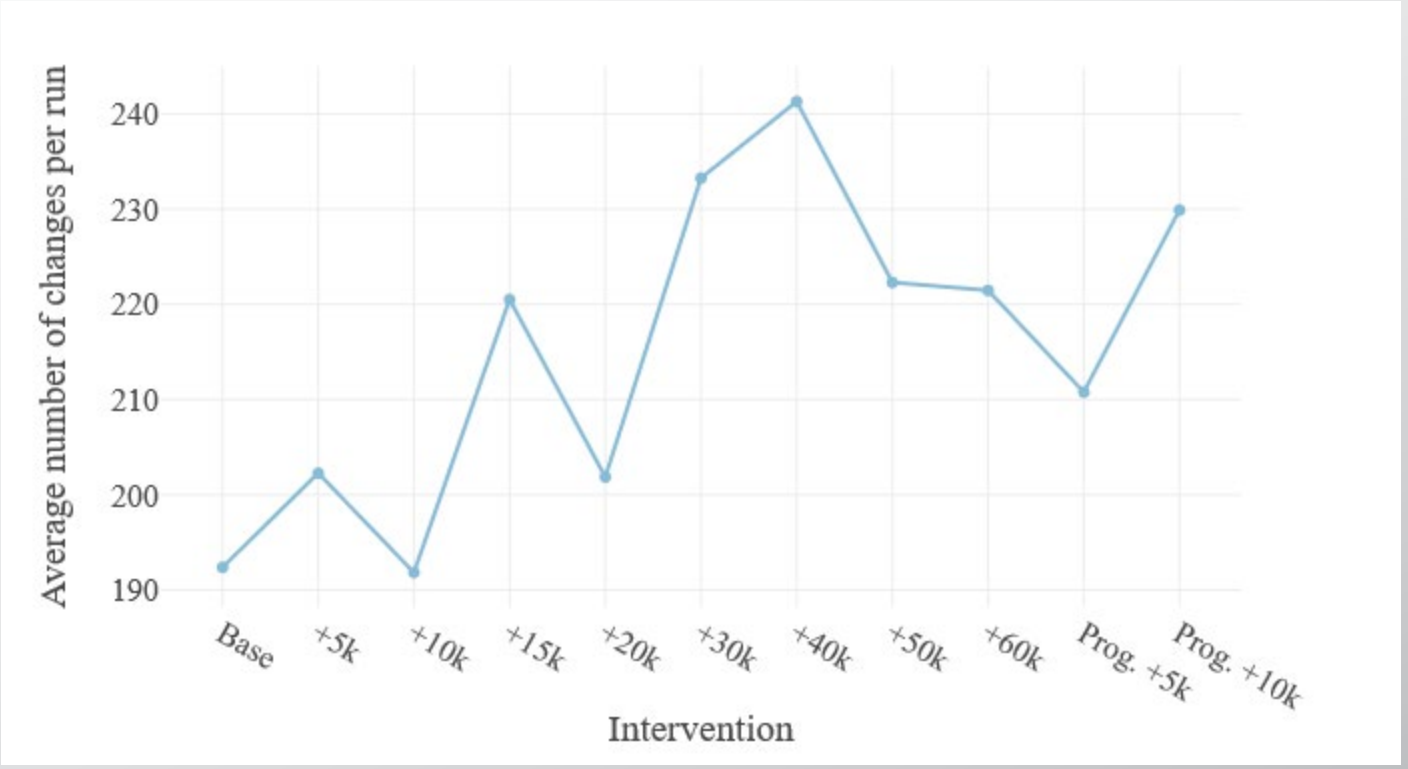
Average result after the simulation

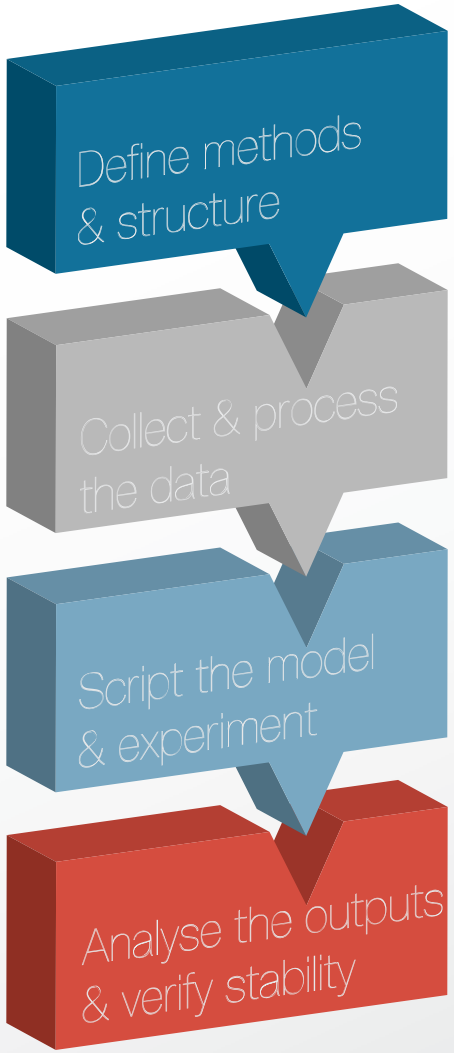




Interventions – static risk

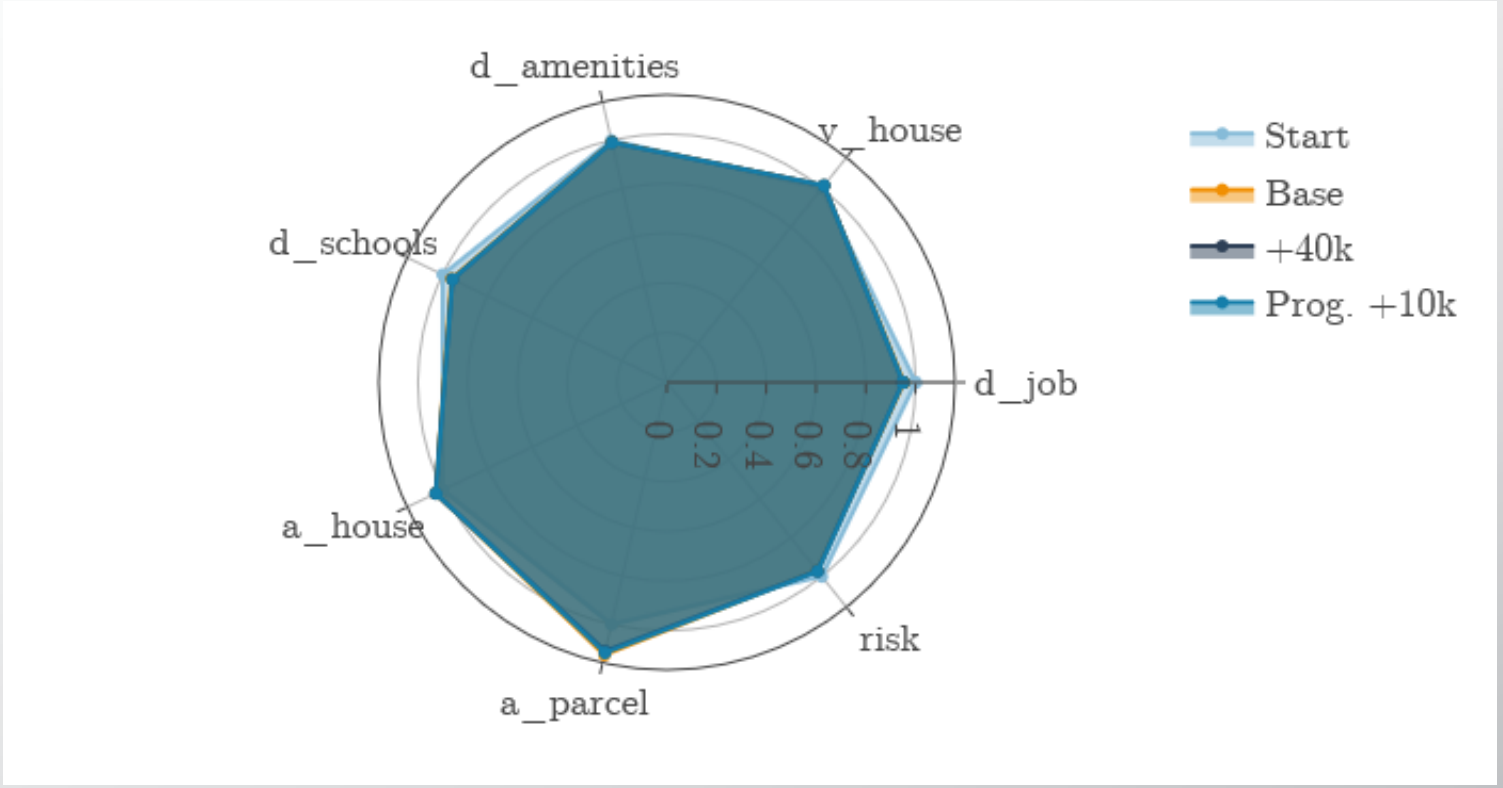
Average number of relocations (changes)





Interventions – static risk

Relative criteria optimization



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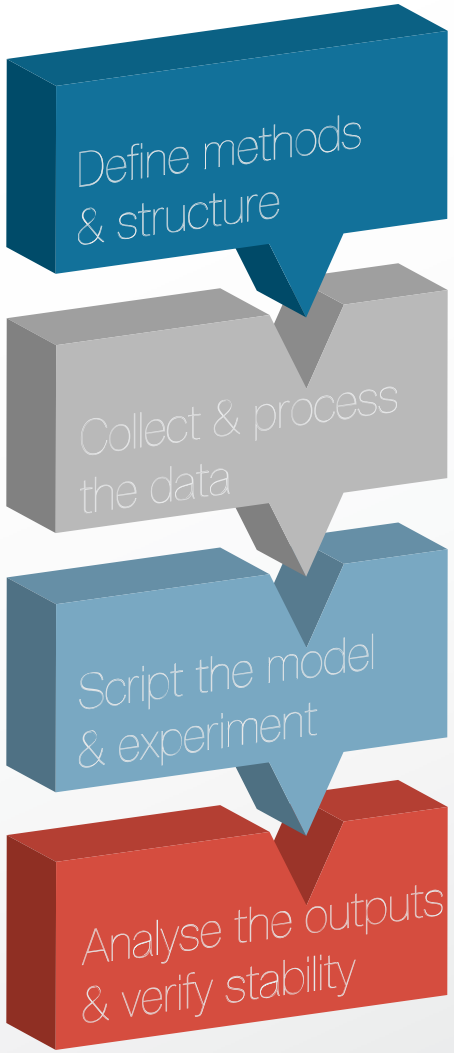
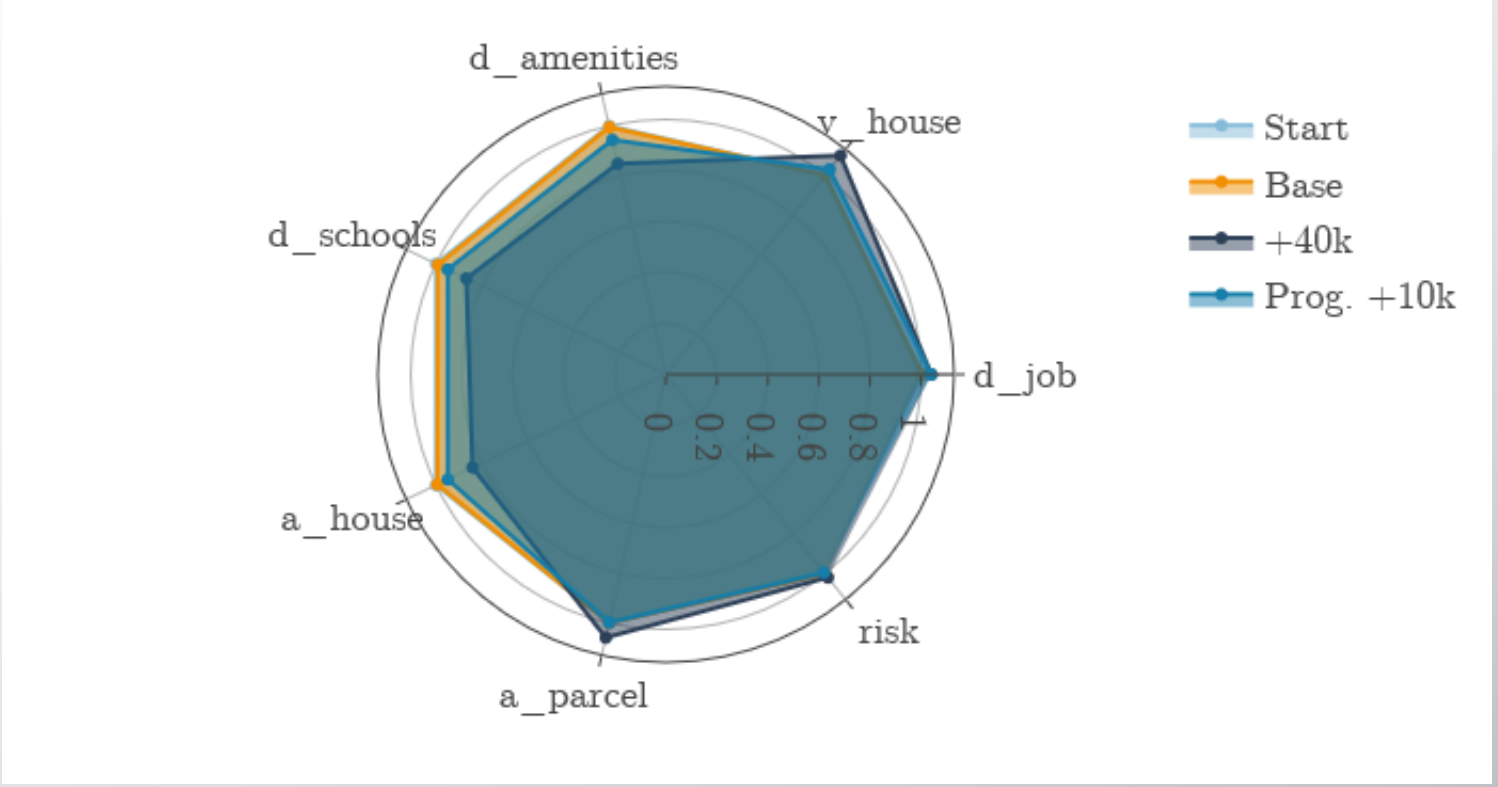


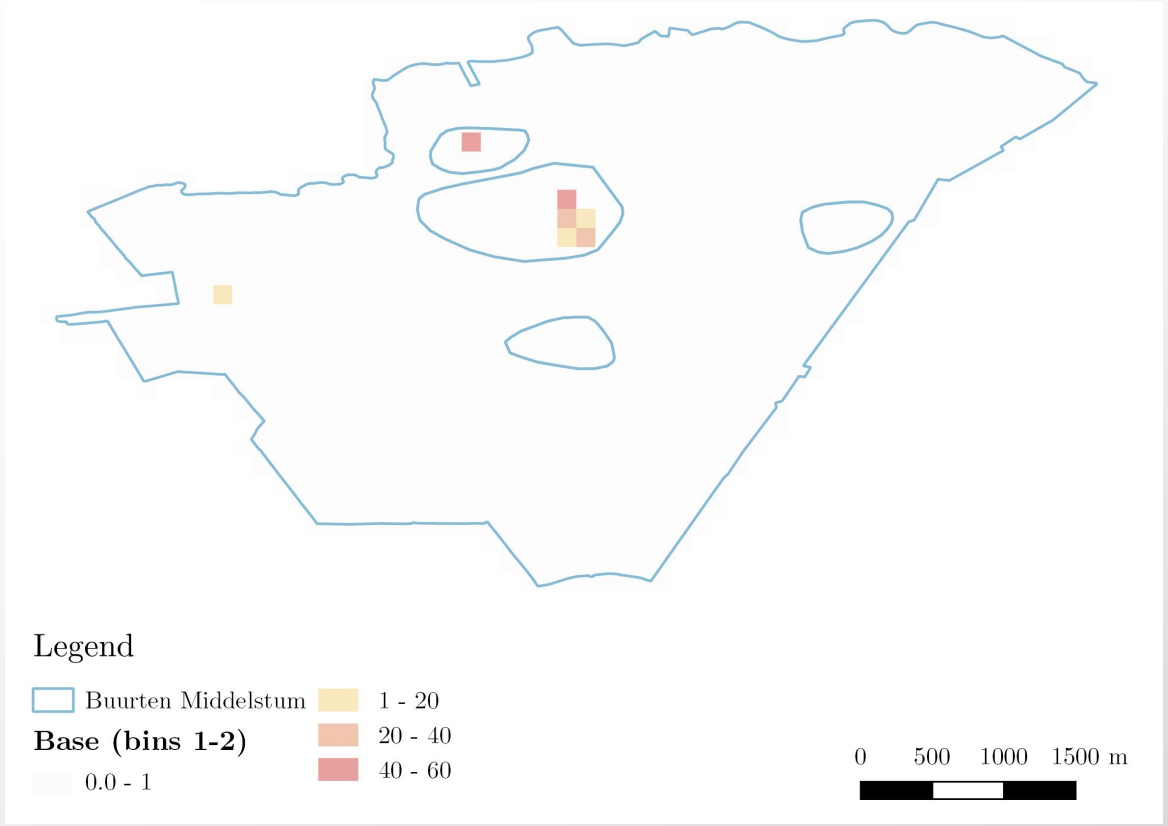
Interventions – static risk

Relative criteria optimization – lowest income bins

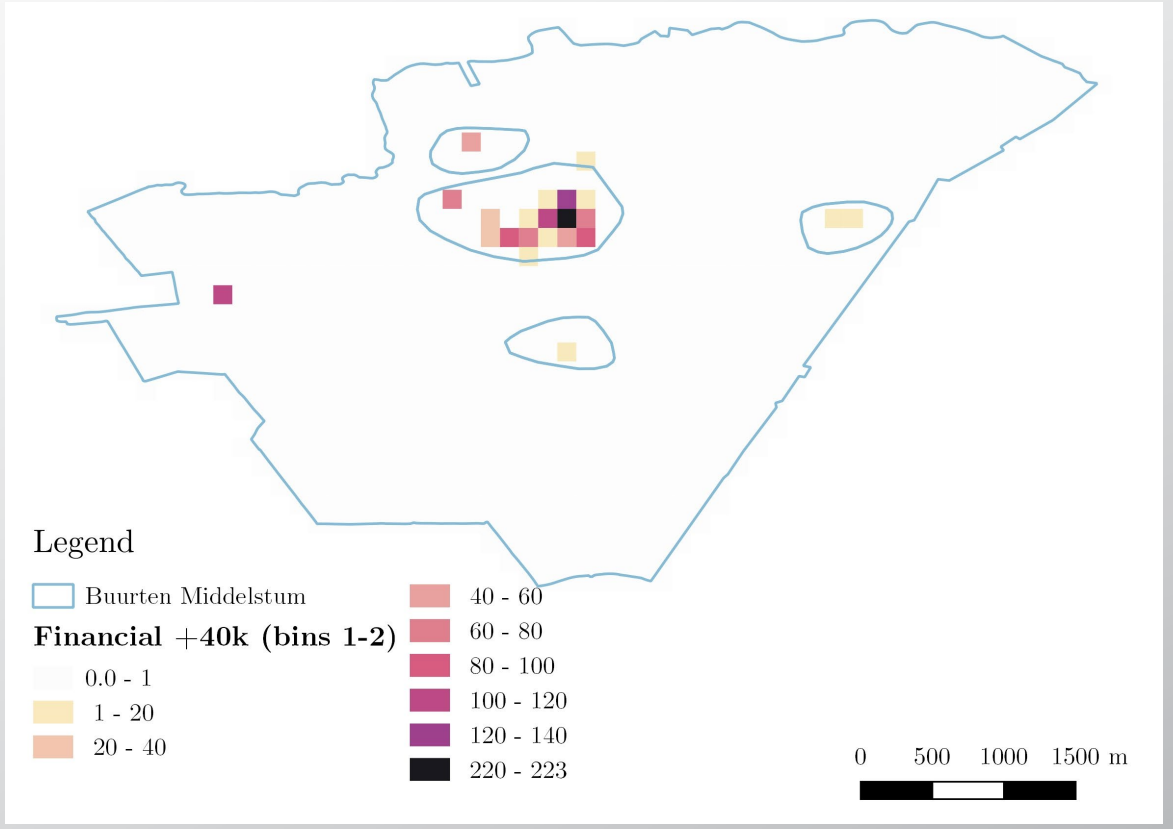


Interventions – static risk

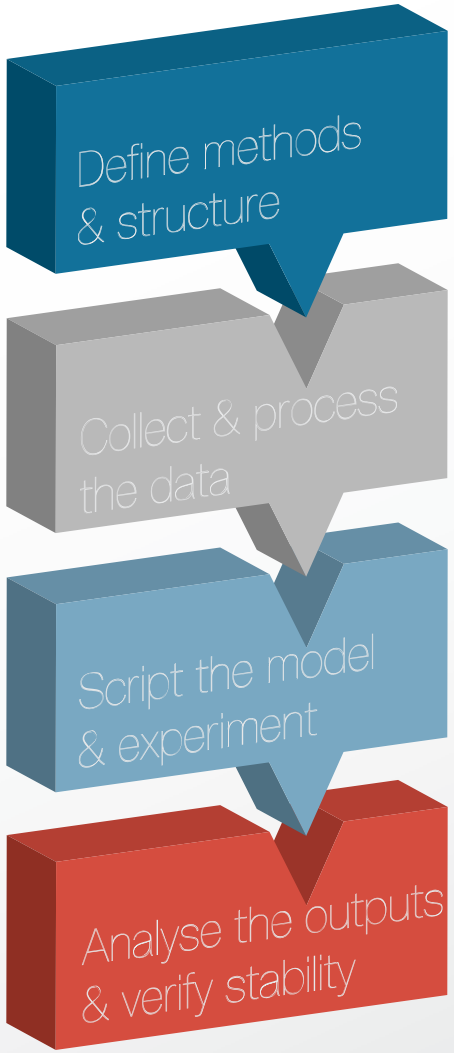
Movement patterns of lowest income bins



Origins base

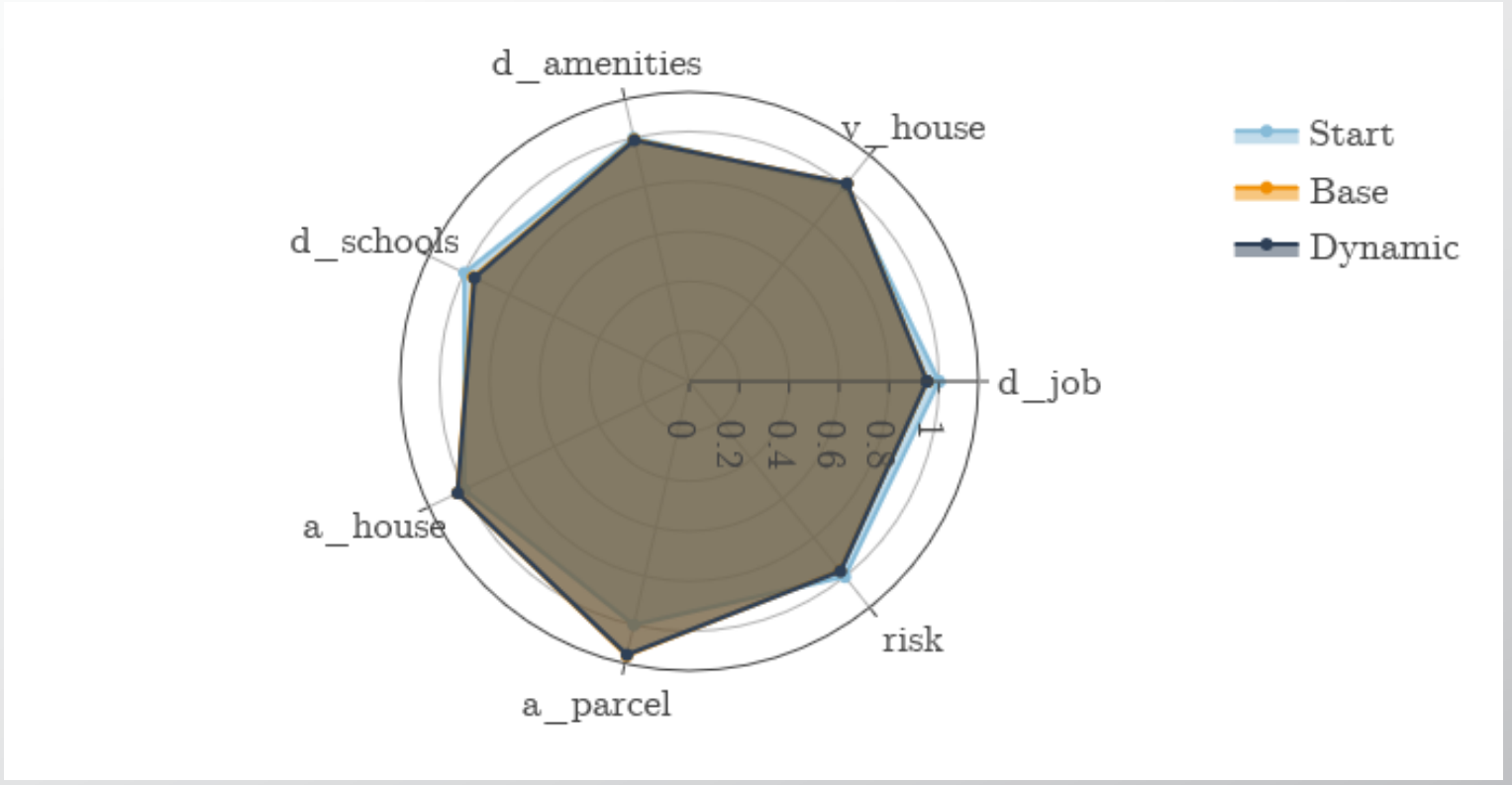


Origins intervention



Interventions – dynamic risk

Relative criteria optimization



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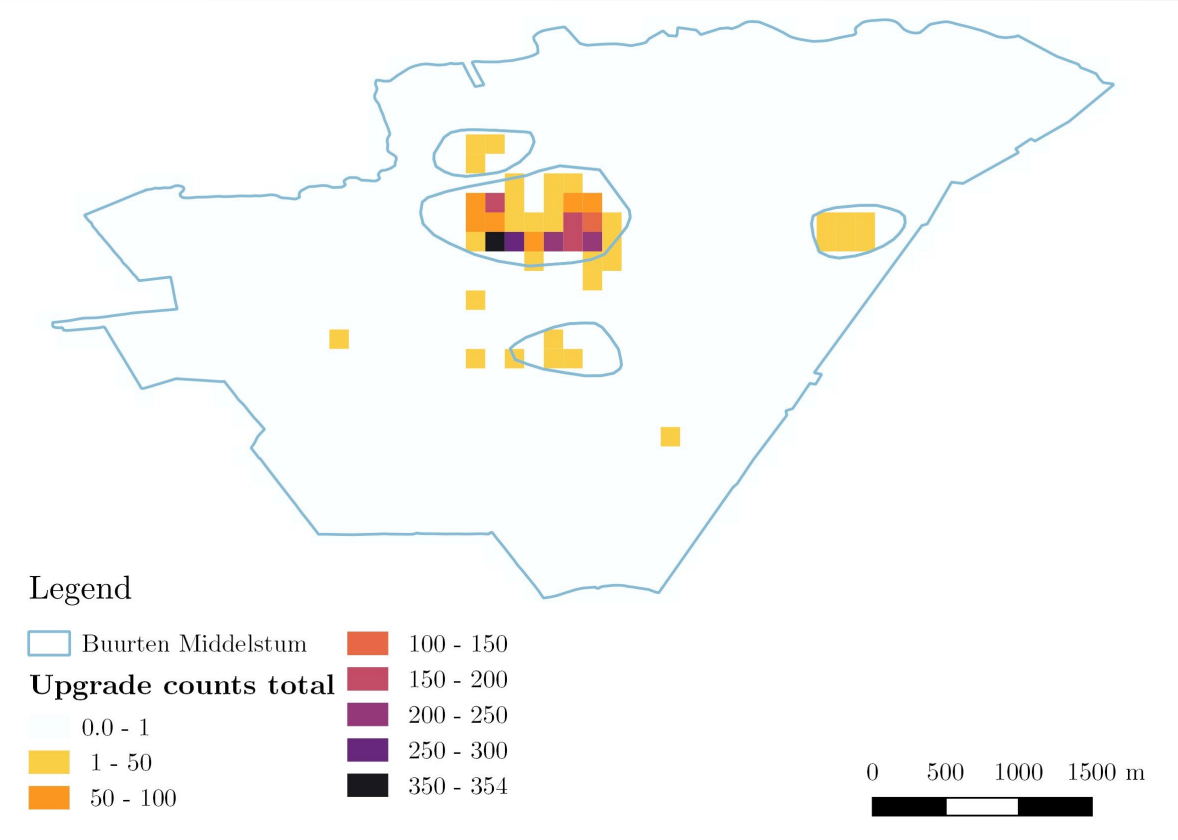
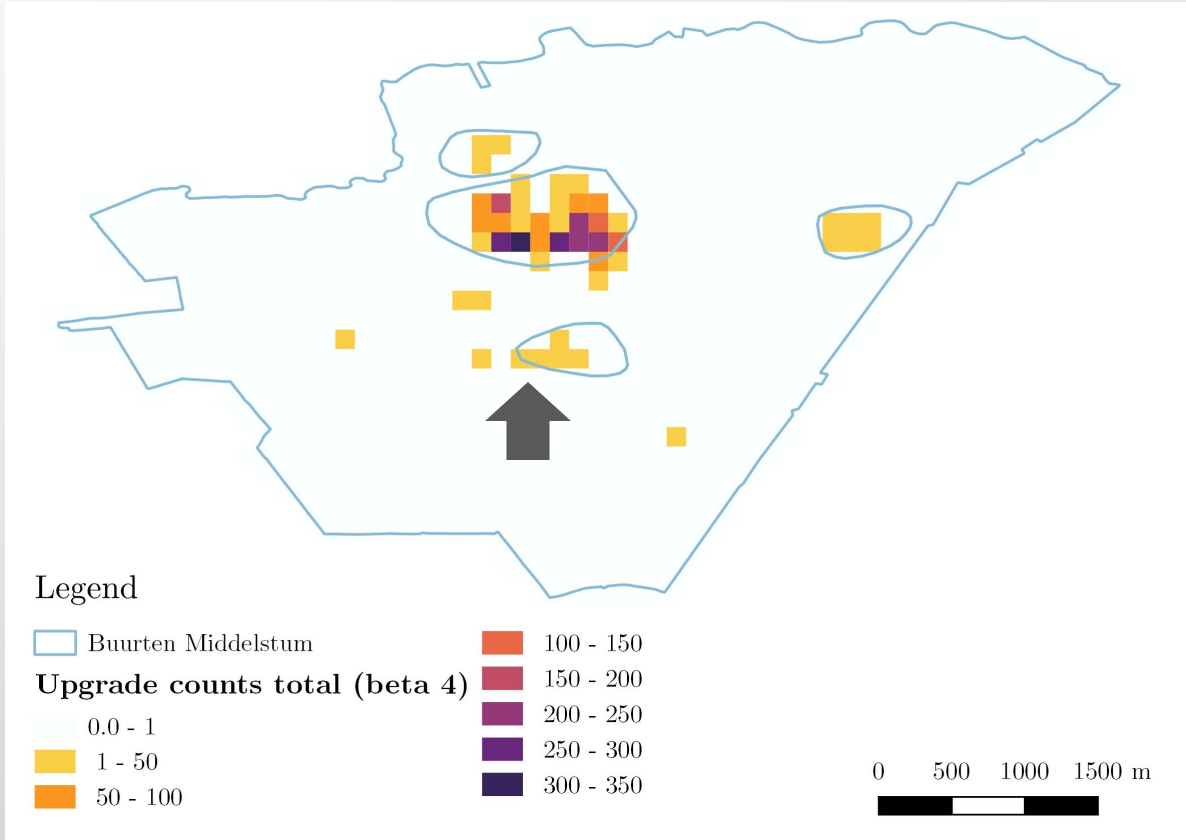
Interventions – dynamic risk

Movement patterns of lowest income bins



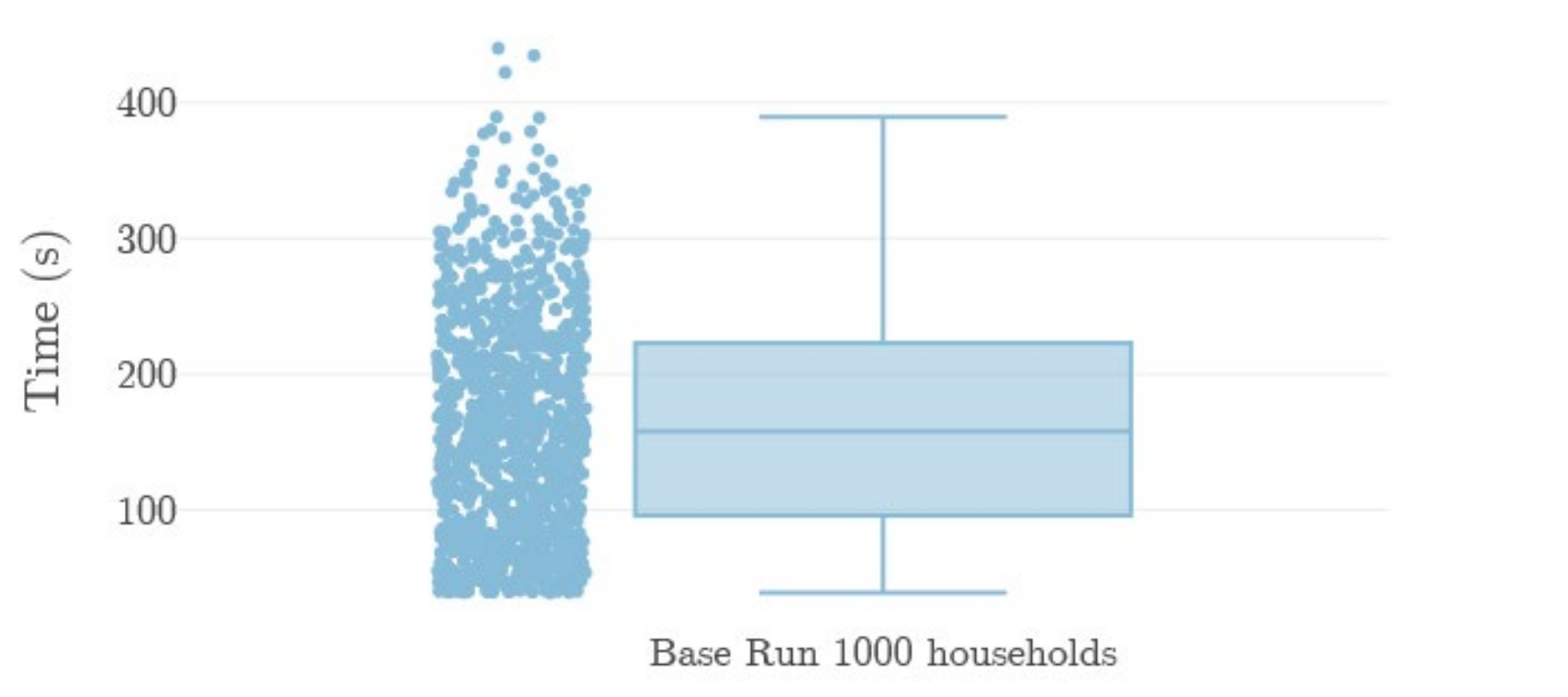
Upgrading counts with β_{risk} =1



Upgrading counts with β_{risk} =4

Discussion & conclusions

Performance



Discussion & future work

- Part of input data is stochastic:
  - Further restrictions can be brought in by new datasets
  - E.g. incorporating key register of persons and businesses (private data)
- The model is still deterministic:
  - Regret should include the unobserved regret
  - Replace ranking by multinomial or nested logit
- The model is **not yet** predictive:
  - For that we need to collect more data:
    - Stated preferences for start
    - Identify heterogeneous population sets & calibrate
    - Collect observed preferences, recalibrate...

Discussion & future work

- Model realism:
  - Would need to incorporate land market representation
  - Life-cycle events
  - Transaction costs
  - Agent heterogeneity
- Usability validation needs more extensive testing:
  - User requirement analysis
  - Interface testing

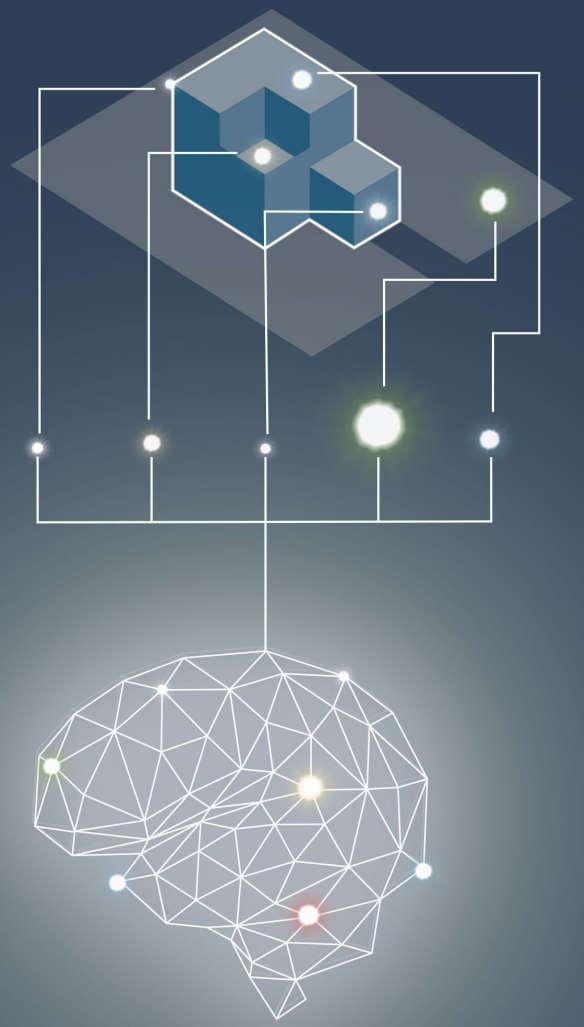
Research Question

How to **build a computational framework** examining the **residential location choice behavior** of households within a regional, **disaster** situation, given public sector agency-defined policy scenarios?

Conclusion

Outcomes and contribution

- Result is a residential location choice model, explicitly incorporating disaster risk as a variable:
  - Represents agent heterogeneity as their personal points of interest (jobs, education) and capital
  - Also integrates various data types,
- First this type of incorporating random regret minimization model



Thank you!

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