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INHABIT: building occupancy model

Where and how do people live?

Modelling the occupation of the German building stock by households

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TODAY

- Background/problem
- Model outline
- Historical analysis results [no mod projections yet]



BACKGROUND: LIVING SPACE DEV

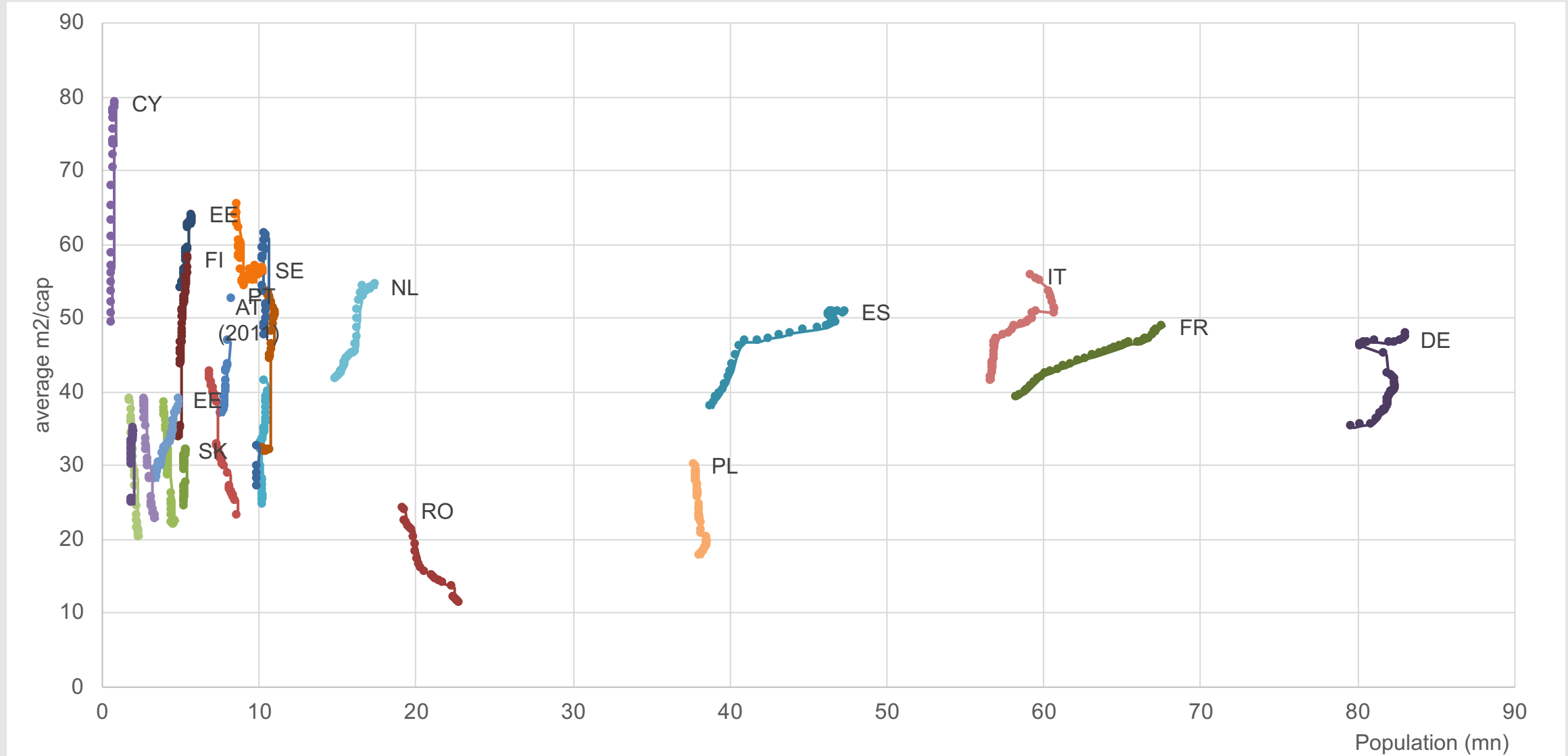


Figure 1. 1991-2021 development of m²/cap by country and population size in EU member states. Country code denotes end of time trajectory (2021). Data source: Eurostat (2024).



BACKGROUND: THE PROBLEM

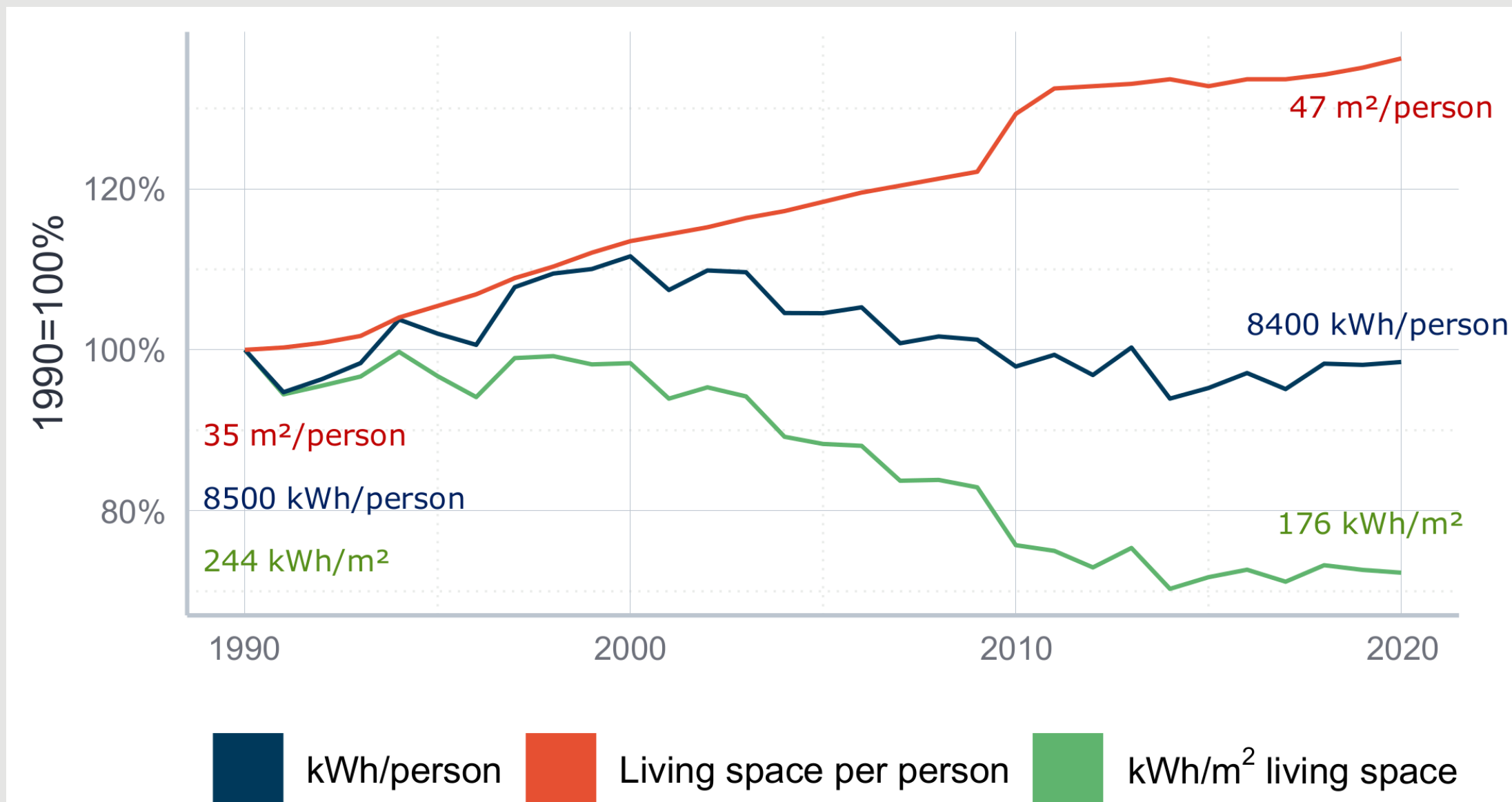


Figure 2. Development of per-capita living space, building energy efficiency and per capita energy consumption. Published in Gräßner-Radkowsch et al. (2022). Data sources: (AGEB, 2021; DESTATIS, 2000, 2021)



WE ALREADY HAVE BUILDING MODELS...

Activity levels
- population
- m2, m2/cap

How do people
distribute across the
stock?

Historical stock
data t=0

Stock change
rates (new
build, decom.,
renovation/deep
ness)

Tech.
Deployment/
market rates

Usage: HDD,
temperature
levels

Complex building typologies

- By country
- SFH/MFH/AB
- Renovation status



Country	Region	Construction Year Class	Additional Classification	SFH Single Family House	TH Terraced House	MFH Multi Family House	AB Apartment Block
DE	national (Gesamt-Österr...	... 1919	generic (Standard / allgemein typisch)				
				AT.N.SFH.01.Gen	AT.N.TH.01.Gen	AT.N.MFH.01.Gen	AT.N.AB.01.Gen
		1919 ... 1944	generic (Standard / allgemein typisch)				
				AT.N.SFH.02.Gen	AT.N.TH.02.Gen	AT.N.MFH.02.Gen	AT.N.AB.02.Gen
		1945 ... 1960	generic (Standard / allgemein typisch)				
				AT.N.SFH.03.Gen	AT.N.TH.03.Gen	AT.N.MFH.03.Gen	AT.N.AB.03.Gen
DE	national (Gesamt-Österr...	1961 ... 1980	generic (Standard / allgemein typisch)				
				AT.N.SFH.04.Gen	AT.N.TH.04.Gen	AT.N.MFH.04.Gen	AT.N.AB.04.Gen
DE	national (Gesamt-Österr...	1981 ... 1990	generic (Standard / allgemein typisch)				
				AT.N.SFH.05.Gen	AT.N.TH.05.Gen	AT.N.MFH.05.Gen	AT.N.AB.05.Gen

TABULA

Supply-side models (heat tech)
e.g. stock models/building-attached

Energy
consumption
GHG emissions



OCCUPANCY IDEA

t=-1

		Non-renovated		renovated	
		SFH	MFH	SFH	MFH
Quintile 1	<40				
	>40				
Quintile 2	<40				
	>40				
Quintile 3	<40				
	>40				

Read-out:

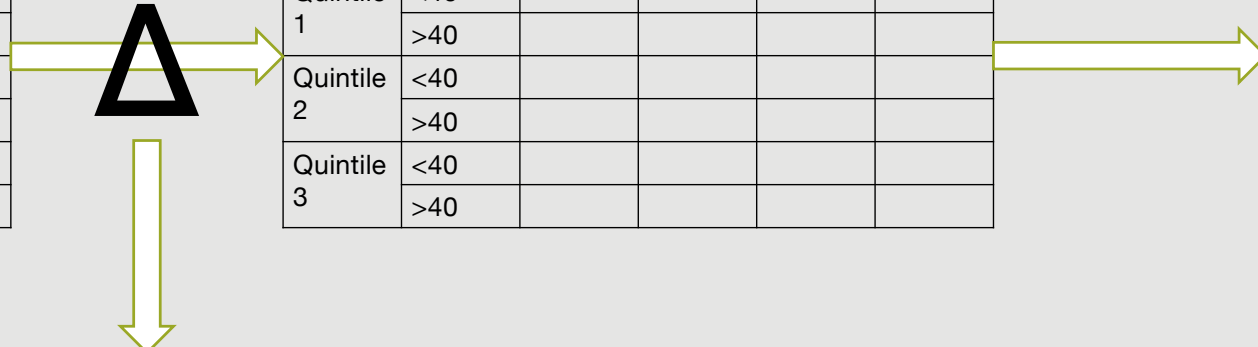
- who lives where
- distribution of living space

t=0

		Non-renovated		renovated	
		SFH	MFH	SFH	MFH
Quintile 1	<40				
	>40				
Quintile 2	<40				
	>40				
Quintile 3	<40				
	>40				

- Change in
- dwelling structure
 - population
 - move out/in, where?

t=1...n





INHABIT – DATA BASE

- Empirical basis:
German Socio-Economic Panel (SOEP).
- one of the largest and longest-running multidisciplinary panel studies worldwide
- 30k people in 15k households, starting 1986.
- conducted by Leibniz Association / DIW (German Institute for Economic Research).



INHABIT – OPEN SOURCE DEV

• GitLab Repository

- <https://gitlab.com/energy-sufficiency-model/inhabit>


• ReadTheDocs

- <https://inhabit.readthedocs.io/en/latest/>

• Python based



Energy sufficiency model / Inhabit

Inhabit  Unstar 2 Fork 0

main inhabit +

History Find file Edit Code

Issue #64: added percentile loop
Georg authored 1 week ago 4fb005f4

Name	Last commit	Last update
data	issue #18: added growing_shrinking...	9 months ago
docs	updated model outline figure - bugf...	2 months ago
scripts	Issue #64: added percentile loop	1 week ago
.gitignore	merged regions changes to main	8 months ago
.readthedocs.yaml	documentation	9 months ago
LICENSE	added description of move out ratio...	3 months ago
README.md	added Parameter Issue #80	1 month ago

Project information

- 330 Commits
- 8 Branches
- 0 Tags
- 18.7 MiB Project Storage

README

- MIT License
- + Add CHANGELOG
- + Add CONTRIBUTING
- + Enable Auto DevOps
- + Add Kubernetes cluster
- + Set up CI/CD
- + Add Wiki

https://inhabit.readthedocs.io/en/latest/

Inhabit
latest

Search docs

Structure of Inhabit project
Usage
Understanding the code
API

Welcome to Inhabit's documentation! [Edit on GitLab](#)

Welcome to Inhabit's documentation!

- Structure of Inhabit project
- Usage
 - Installation
 - Data
 - Running the model
- Understanding the code
 - Code from inhabit_table.py
 - Code from household.py
 - Code from dwelling.py
 - Code from misc.py
 - Code from check_values_label.py



INHABIT-MATRIX

- Mother of our model calculations
- Generated from SOEP microdata
- Dimensions:
 - 250 household categories
 - 64 dwelling categories
 - Future: +growing/shrinking; urban/rural

$$I_{hd} = \begin{pmatrix} i_{1,1} & \cdots & i_{1,d} \\ \vdots & \ddots & \vdots \\ i_{h,1} & \cdots & i_{h,d} \end{pmatrix}$$

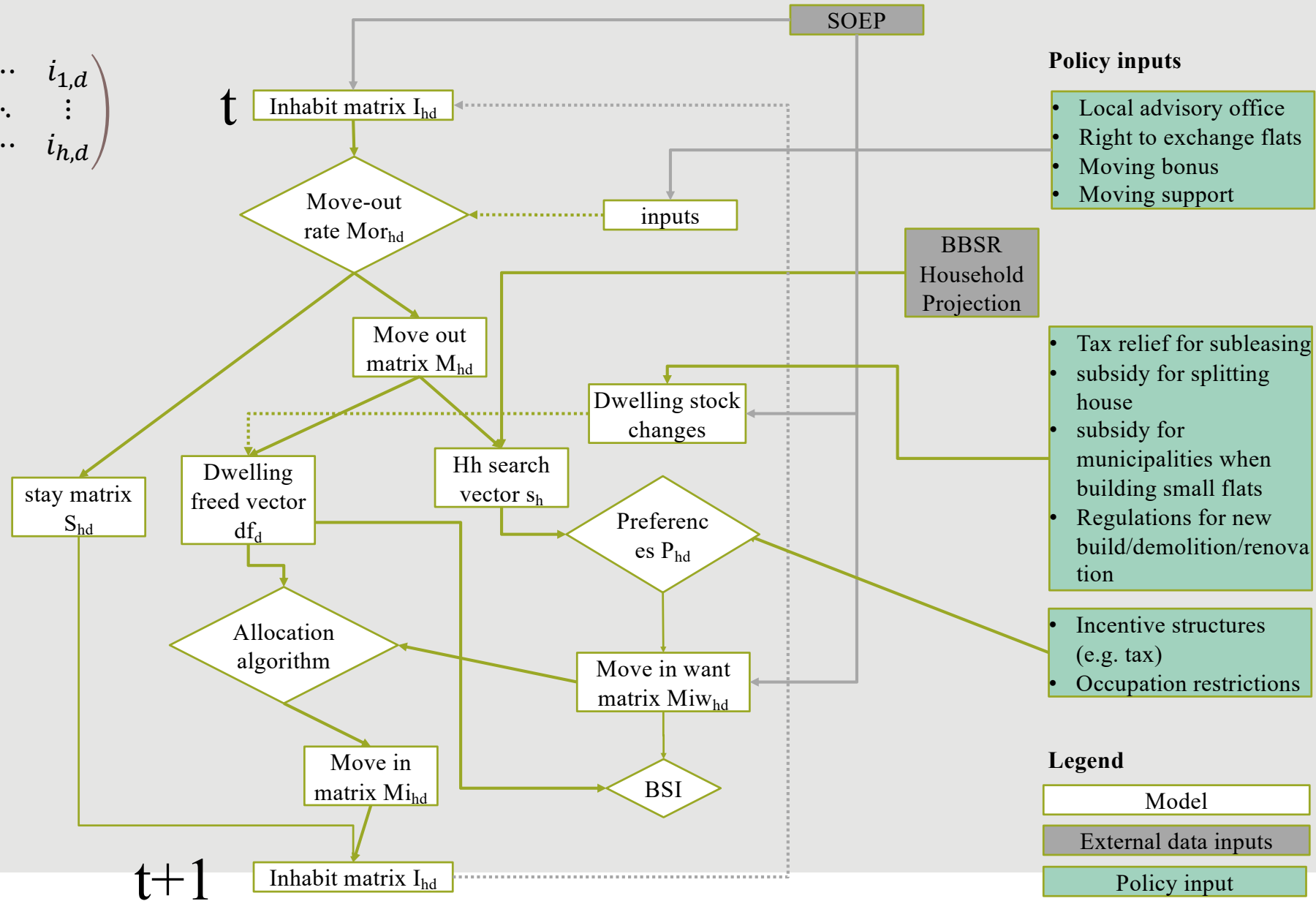
Household (h)	
Income quintile	5 Categories
Household type	Single, single parent, couple without children, couple parent, other
Household Size	1, 2, 3, 4, 5+
Age	<40, >=40
Region	growing, neutral, shrinking + urban, suburban, rural

Dwelling (d)	
Building type	Single Family Houses (SFH), Multi Family Houses (MFH)
Ownership	non profit dwelling, private owner, private tenant
Condition	Renovated, not renovated
Number of rooms	1, 2, 3, 4+



INHABIT – MODEL STRUCTURE

$$I_{hd} = \begin{pmatrix} i_{1,1} & \cdots & i_{1,d} \\ \vdots & \ddots & \vdots \\ i_{h,1} & \cdots & i_{h,d} \end{pmatrix}$$





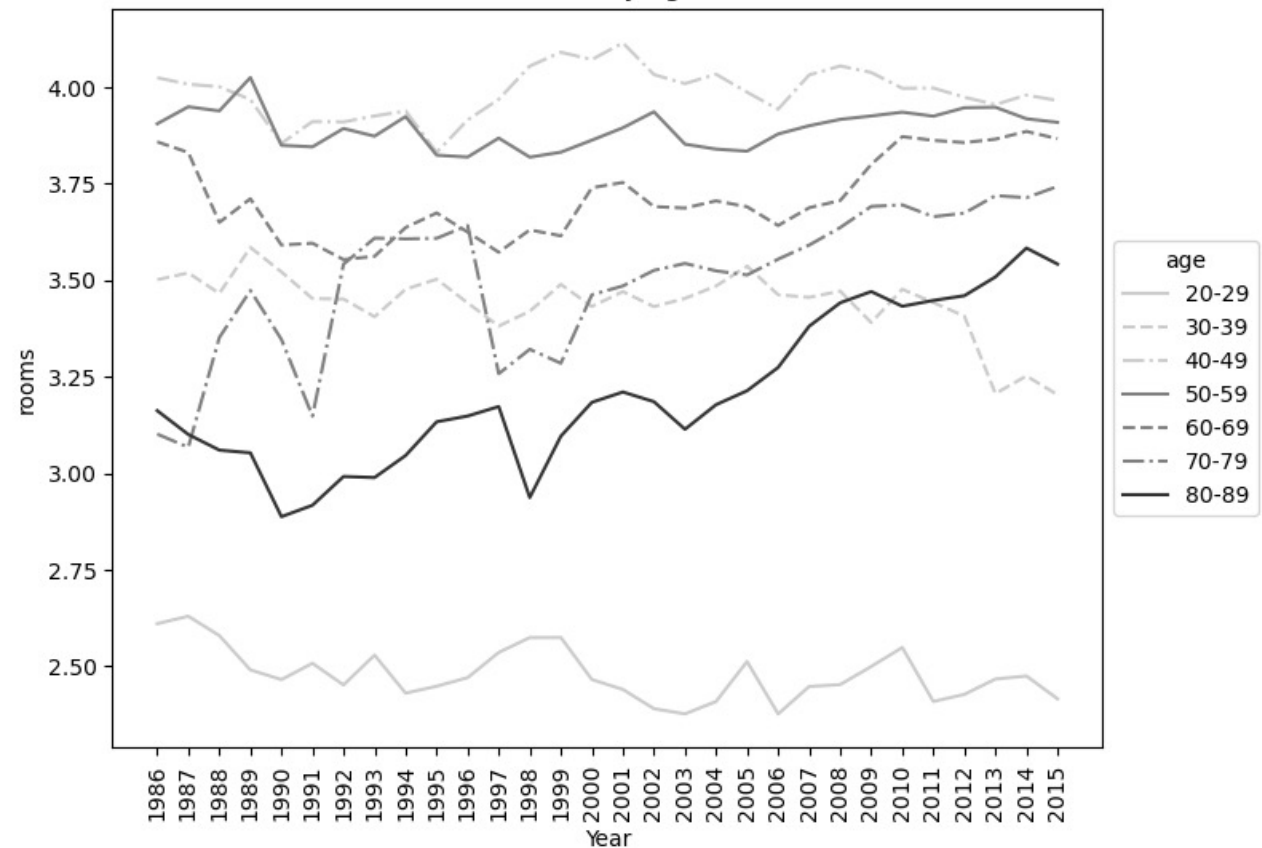
SOME HISTORICAL ANALYSIS RESULTS

[as model projections still under dev]

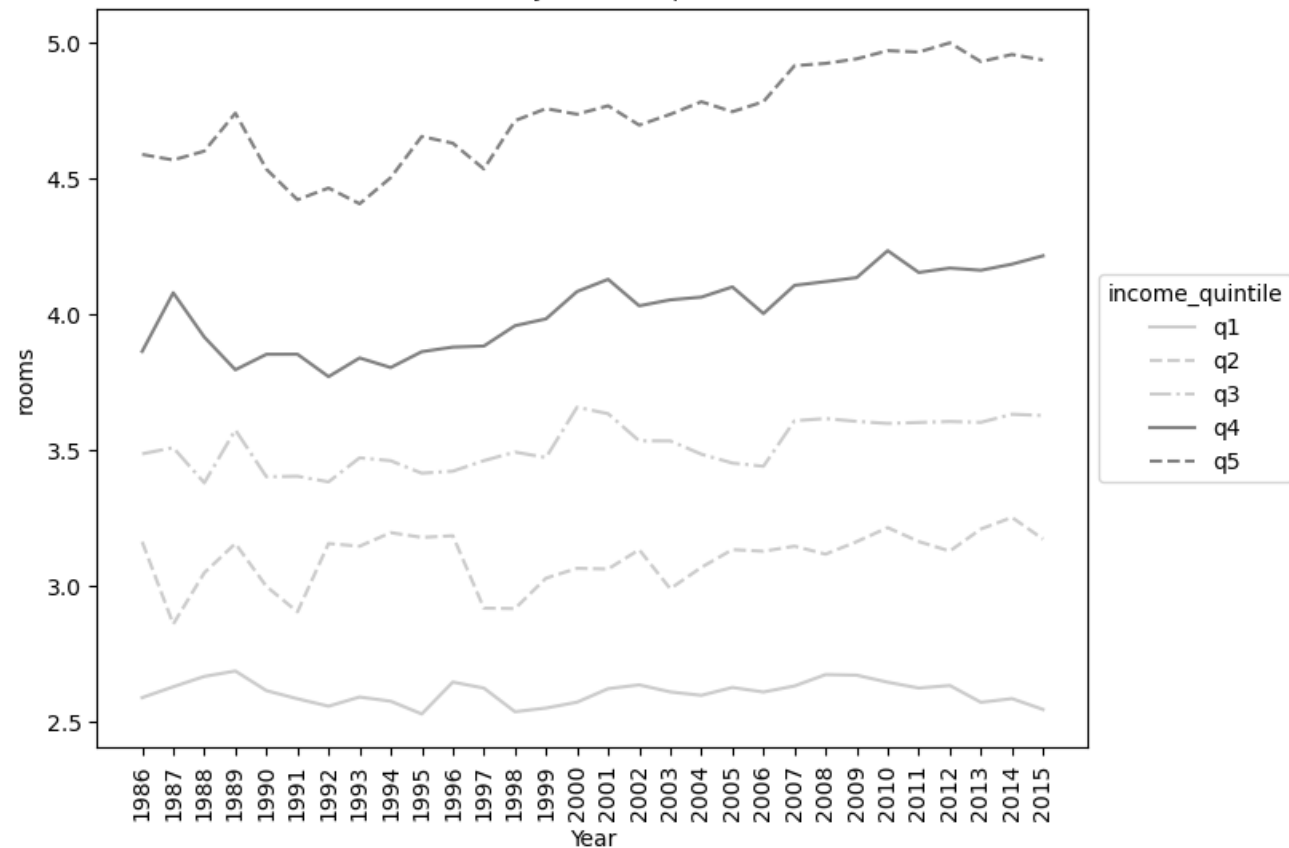


AVG NR OF ROOMS BY AGE AND INCOME

rooms by age

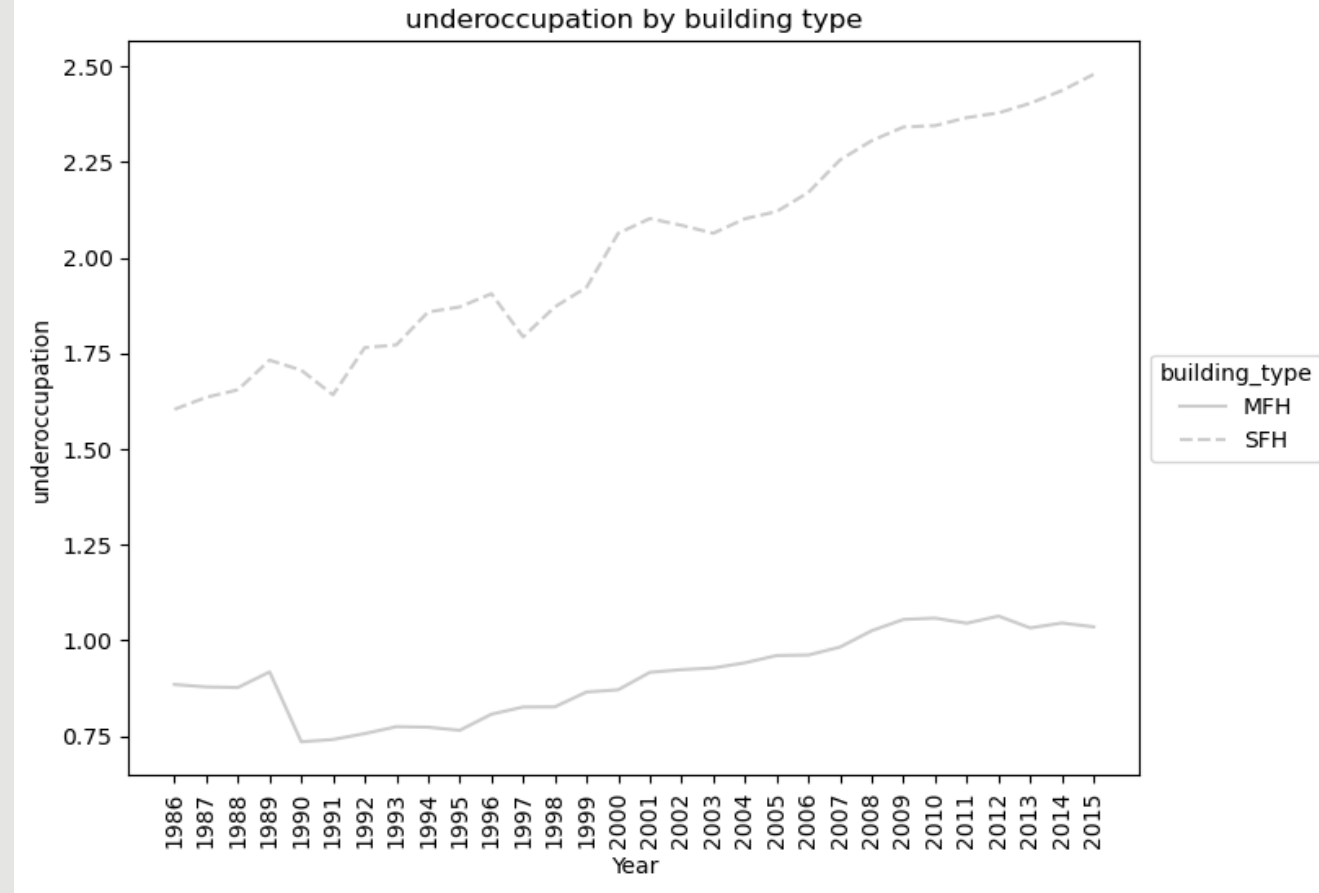
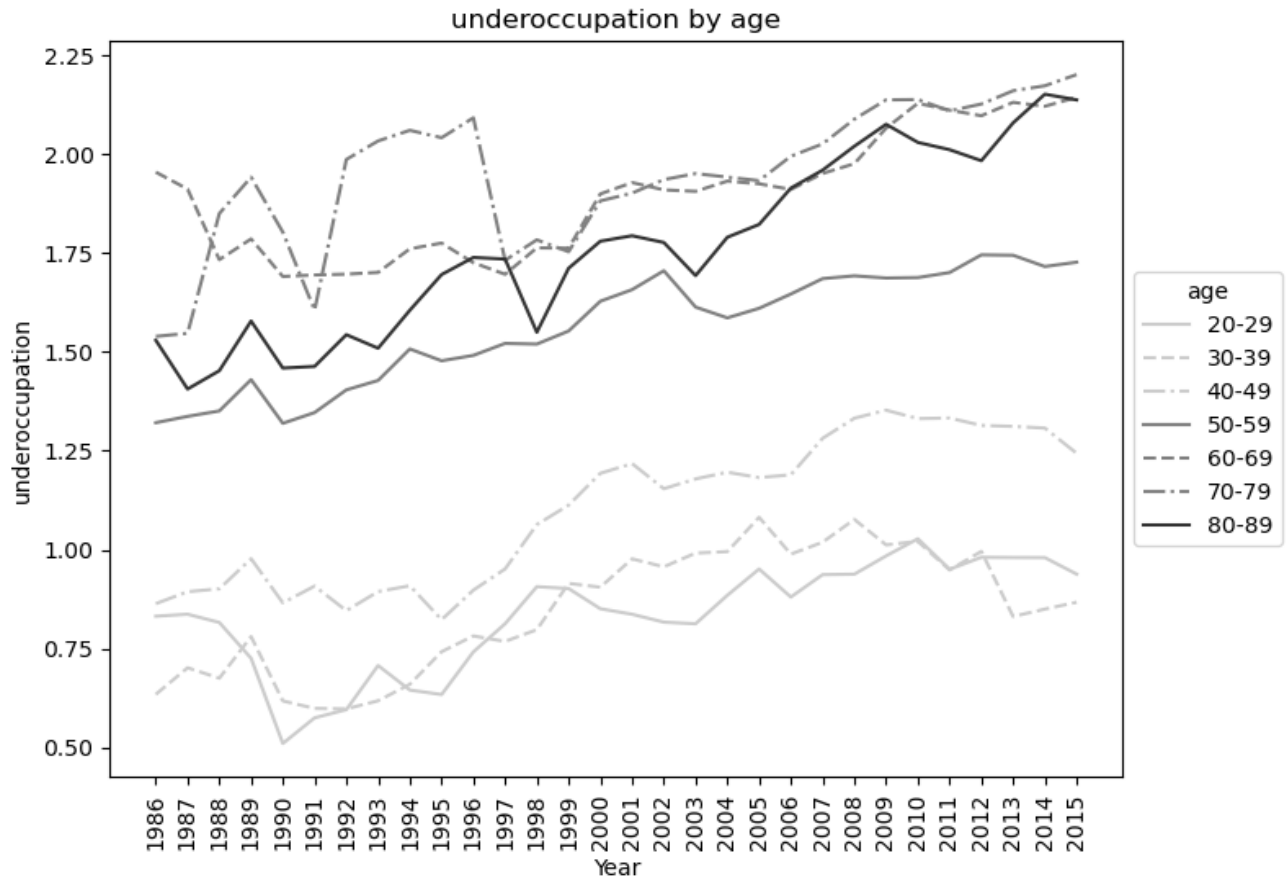


rooms by income quintile





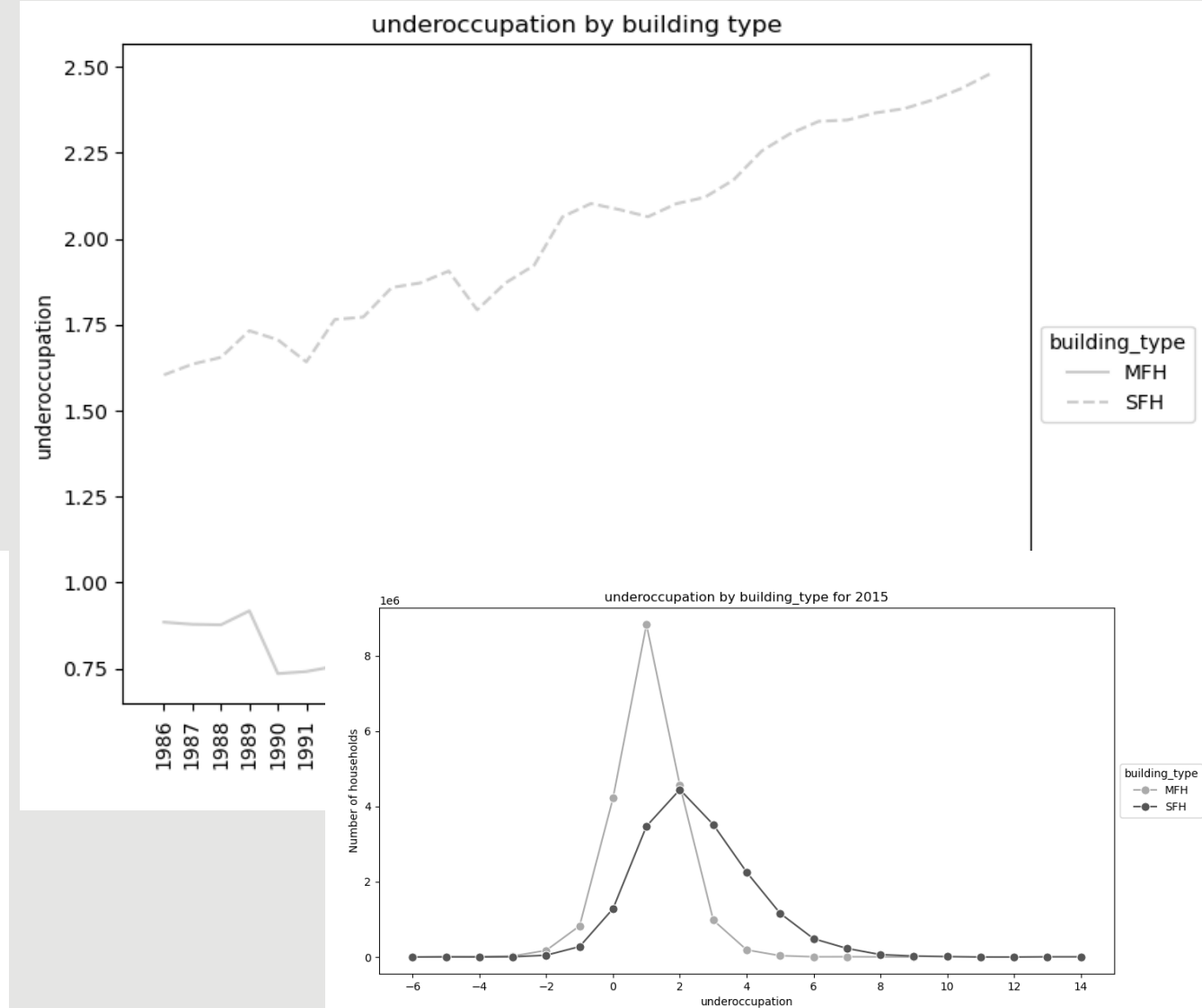
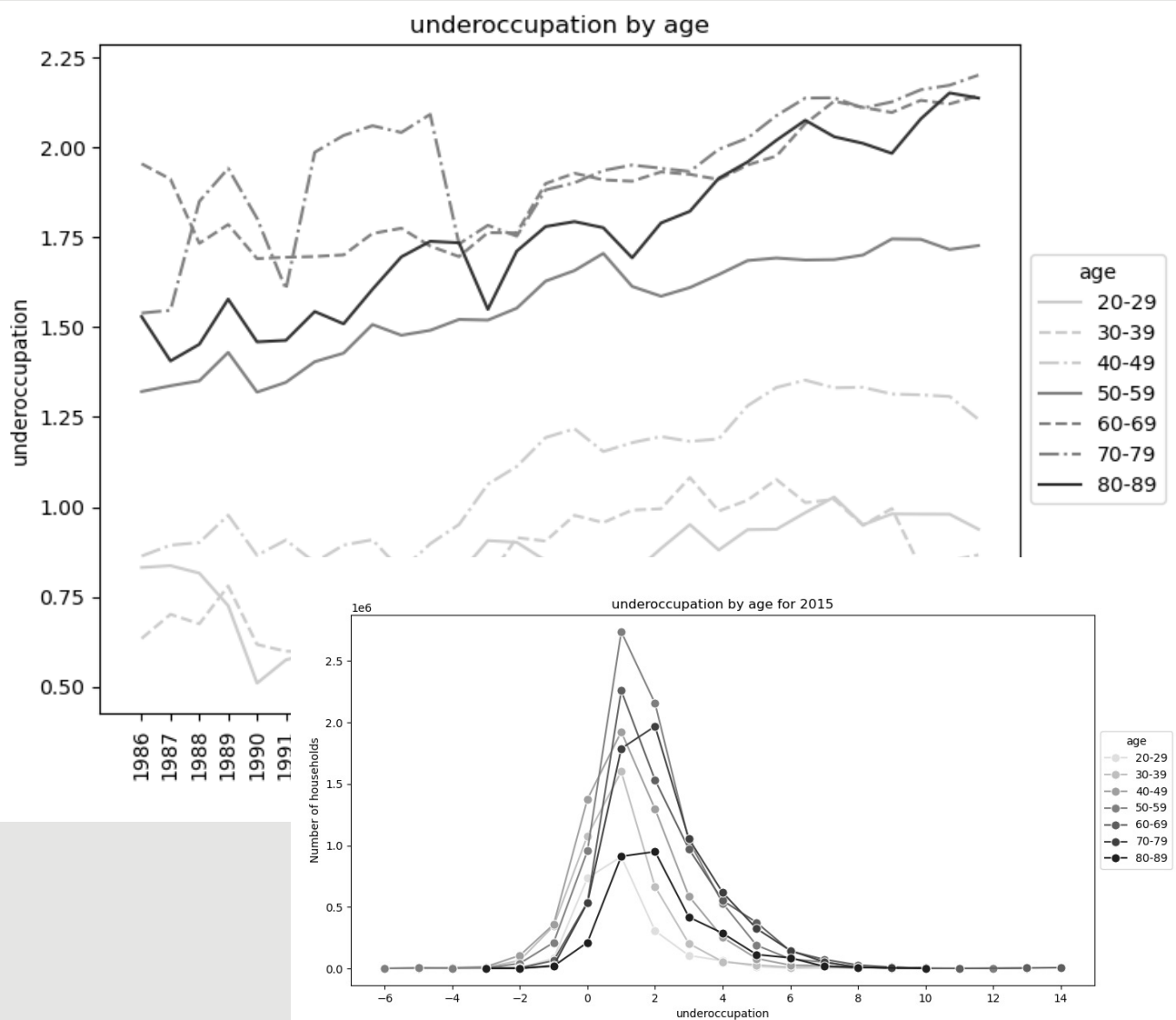
OVER/UNDER-OCCUPANCY 1



Average underoccupation (number rooms – hh size) by age, building type, hh size, income. Values >1 = underoccupation



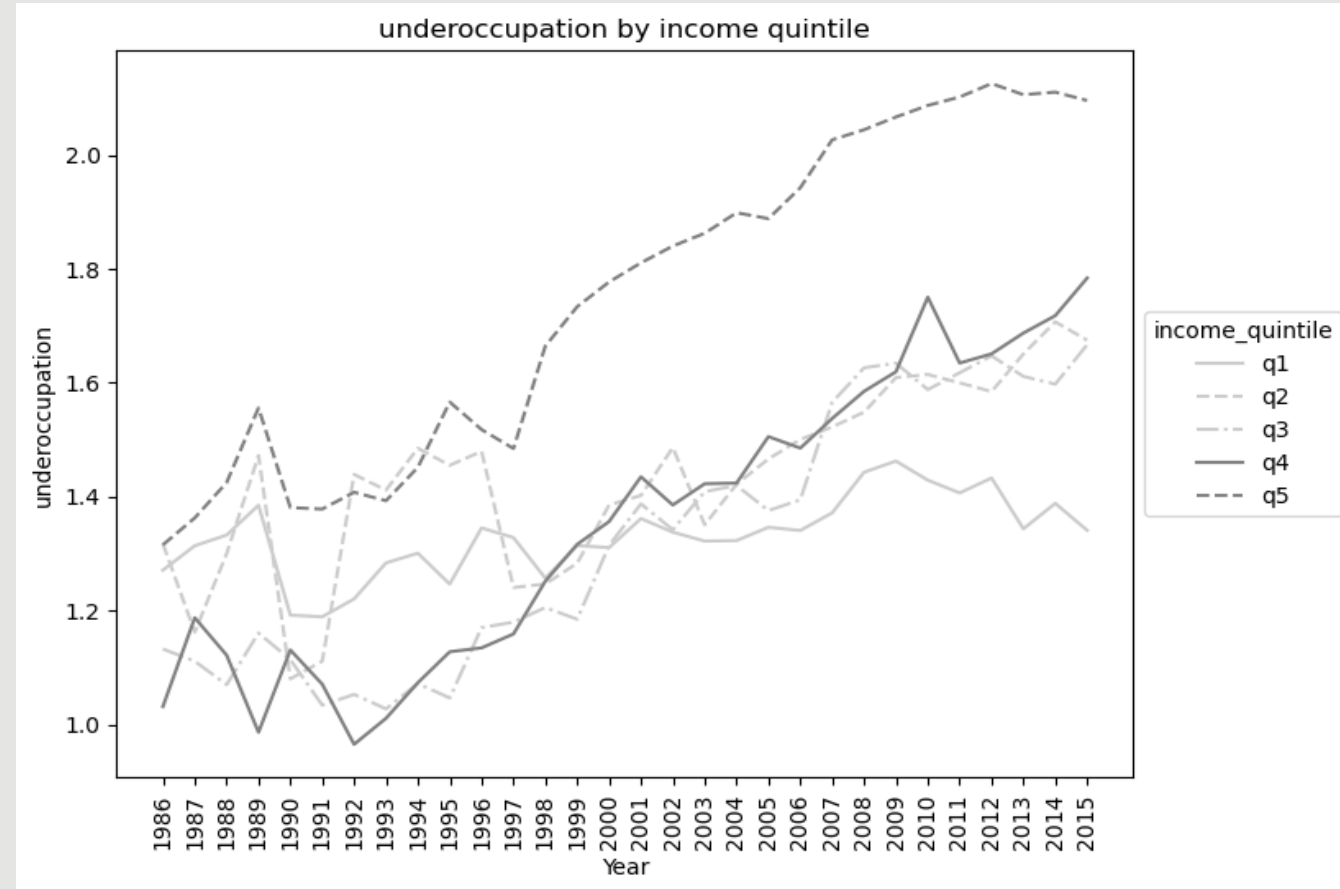
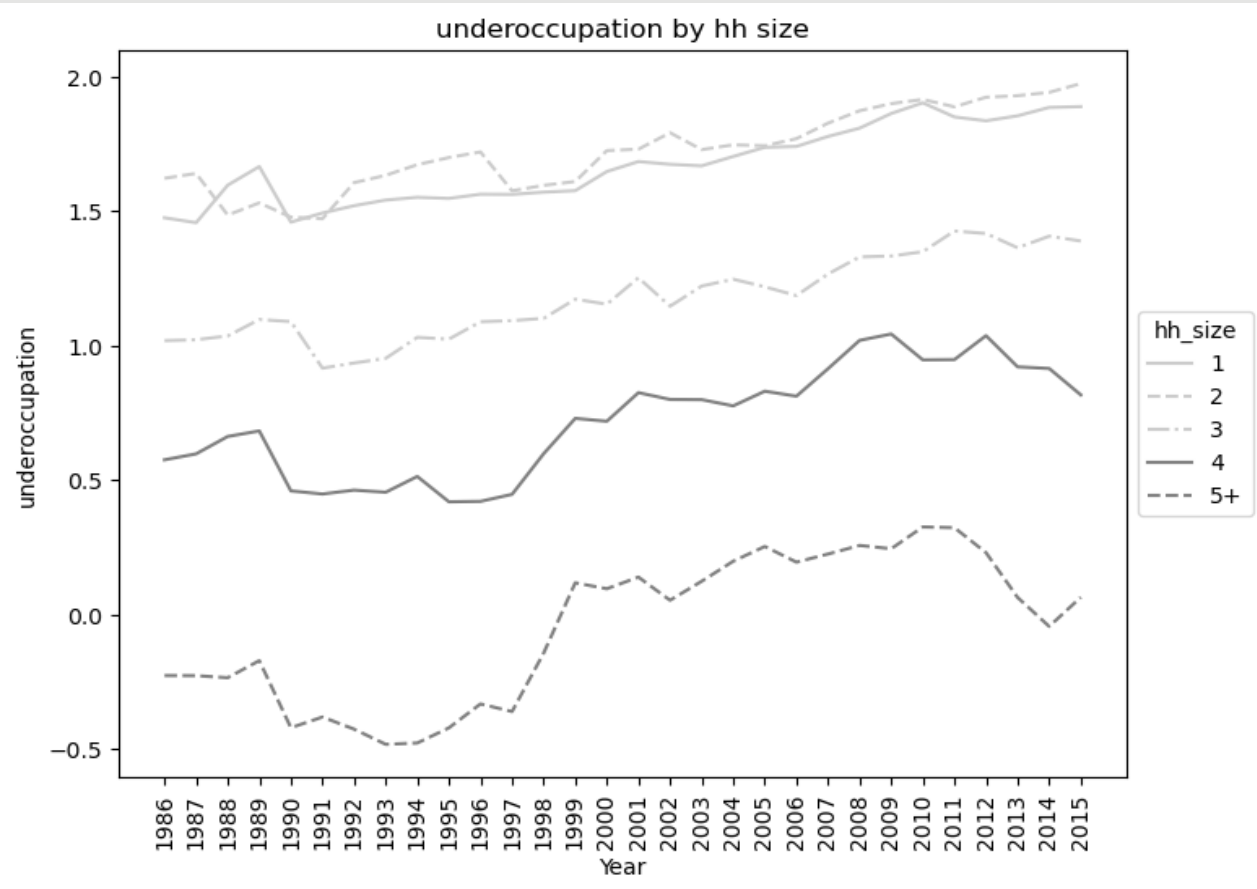
OVER/UNDER-OCCUPANCY 1



Average underoccupation (number rooms – hh size) by age, building type, hh size, income. Values >1 = underoccupation



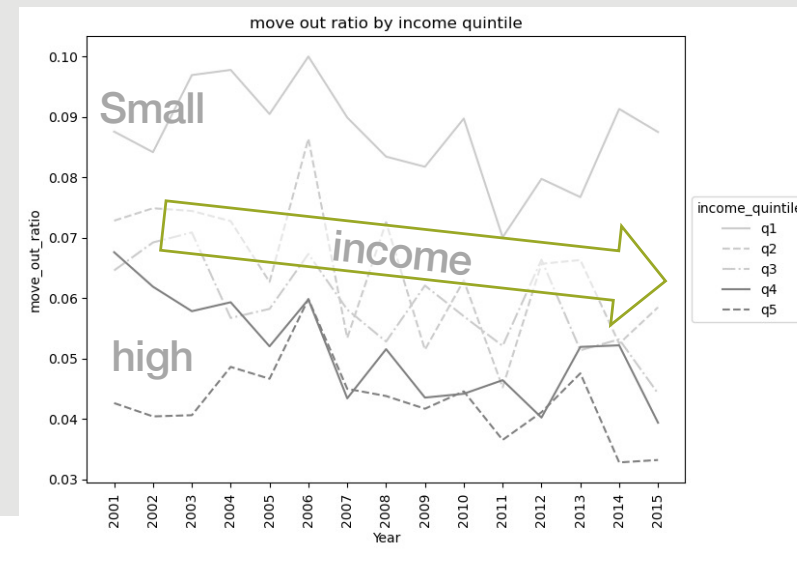
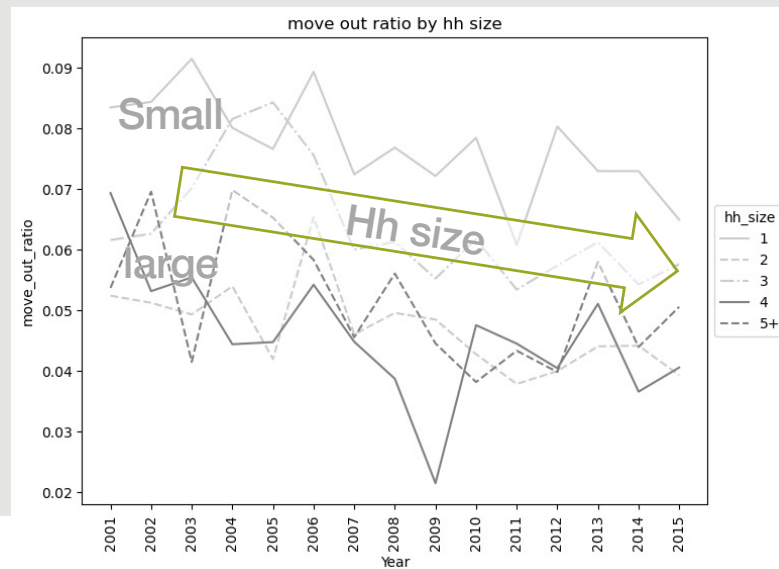
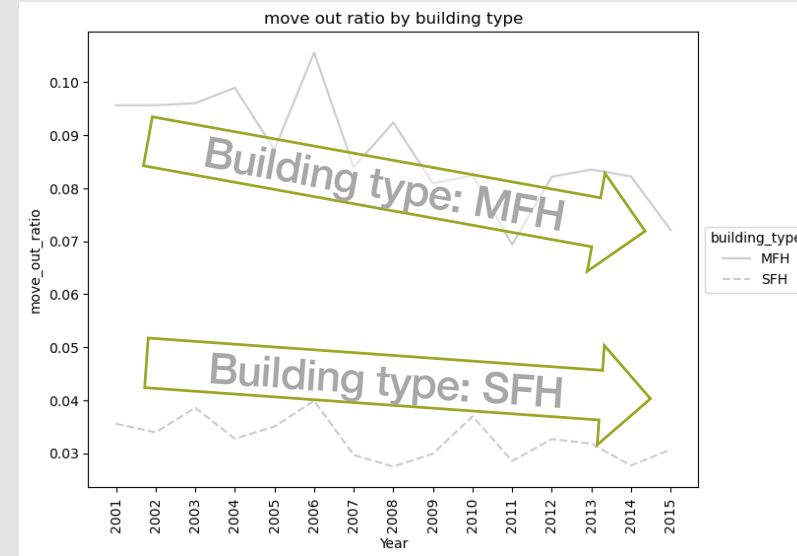
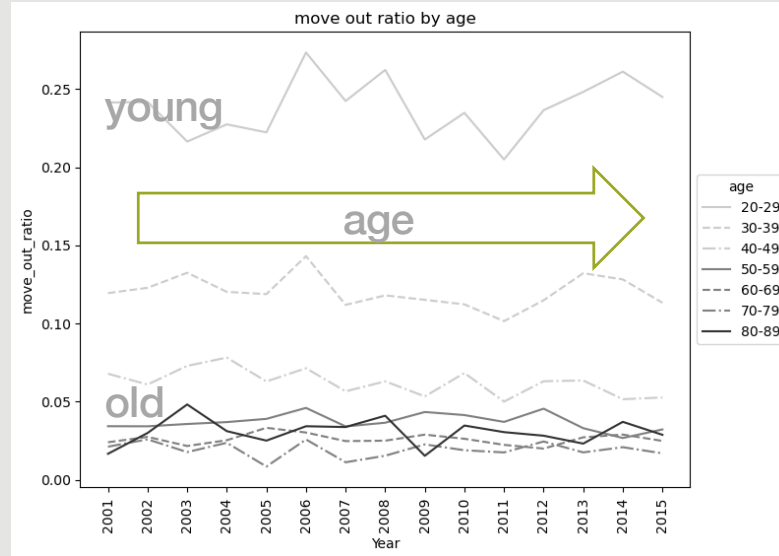
OVER/UNDER-OCCUPANCY 2



Average underoccupancy (number rooms – hh size) by age, building type, hh size, income. Values >1 = underoccupancy



SNAPSHOT OF MOVING PATTERNS





... MORE TO COME SOON

PROJECTIONS TO THE FUTURE FOR...

- MOVE-OUT RATES
- CHANGES IN BUILDING STOCK & POPULATION
- ALLOCATION OF MOVERS TO FREED DWELLINGS
- OCCUPATION PROJECTIONS

VIELEN DANK!



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