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AGENT-BASED MODELLING FOR MACROPRUDENTIAL PURPOSES

MNB-CEMLA-OMFIF | Financial Stability Conference 2024

25-26 March 2024, Budapest

OUTLINE

- **Agent-based modelling**
- **Housing market pilot project**
- **Macroprudential policy application**

The views expressed in this presentation do not necessarily reflect the views of Magyar Nemzeti Bank.

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AGENT-BASED MODELLING

AGENT-BASED MODELLING

Agent-based modelling is simulation in which we simulate the actions and decisions of all the agents in the model one by one with feedbacks.

Main characteristics of agent-based economic models:

- Bottom-up approach: the model is based on economic agents' individual (micro level) decisions
- Heterogeneity: there are many agents of the same type, but each agent has its own parameters and current state of its variables
- Bounded rationality: agents are not perfectly aware of the functioning of the economy
- Direct (endogenous) interactions: usually there is a specific buyer and a specific seller in a market transaction
- Selection-based market mechanism: agents may choose on the basis of market mechanisms who they establish contact with

See Pyka and Fagiolo (2007) and Mérő (2019)

While mainstream models constitute of solving equations systems and everything is determined in a simultaneous manner, agent-based models have a sequence of events within each period.

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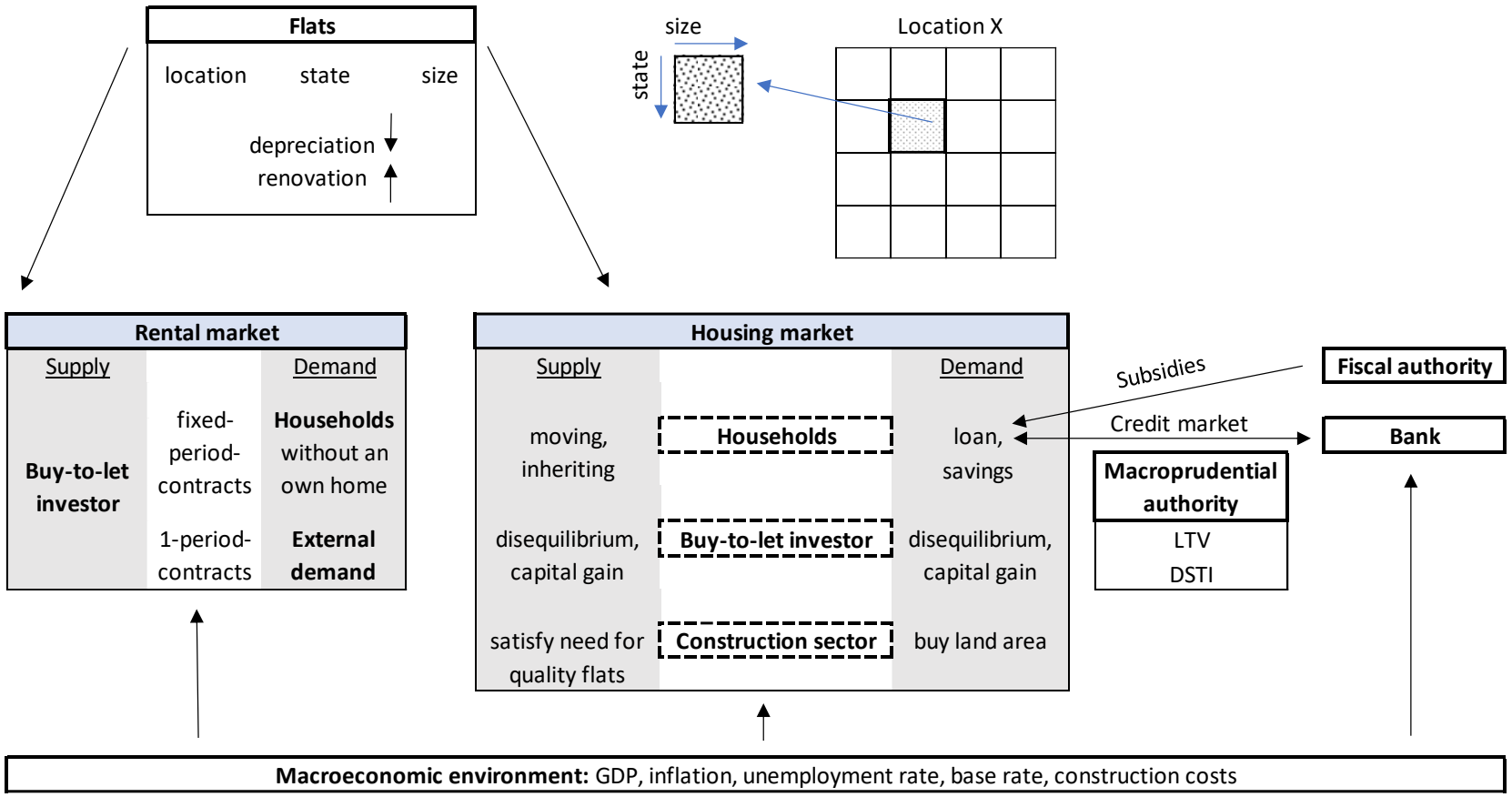
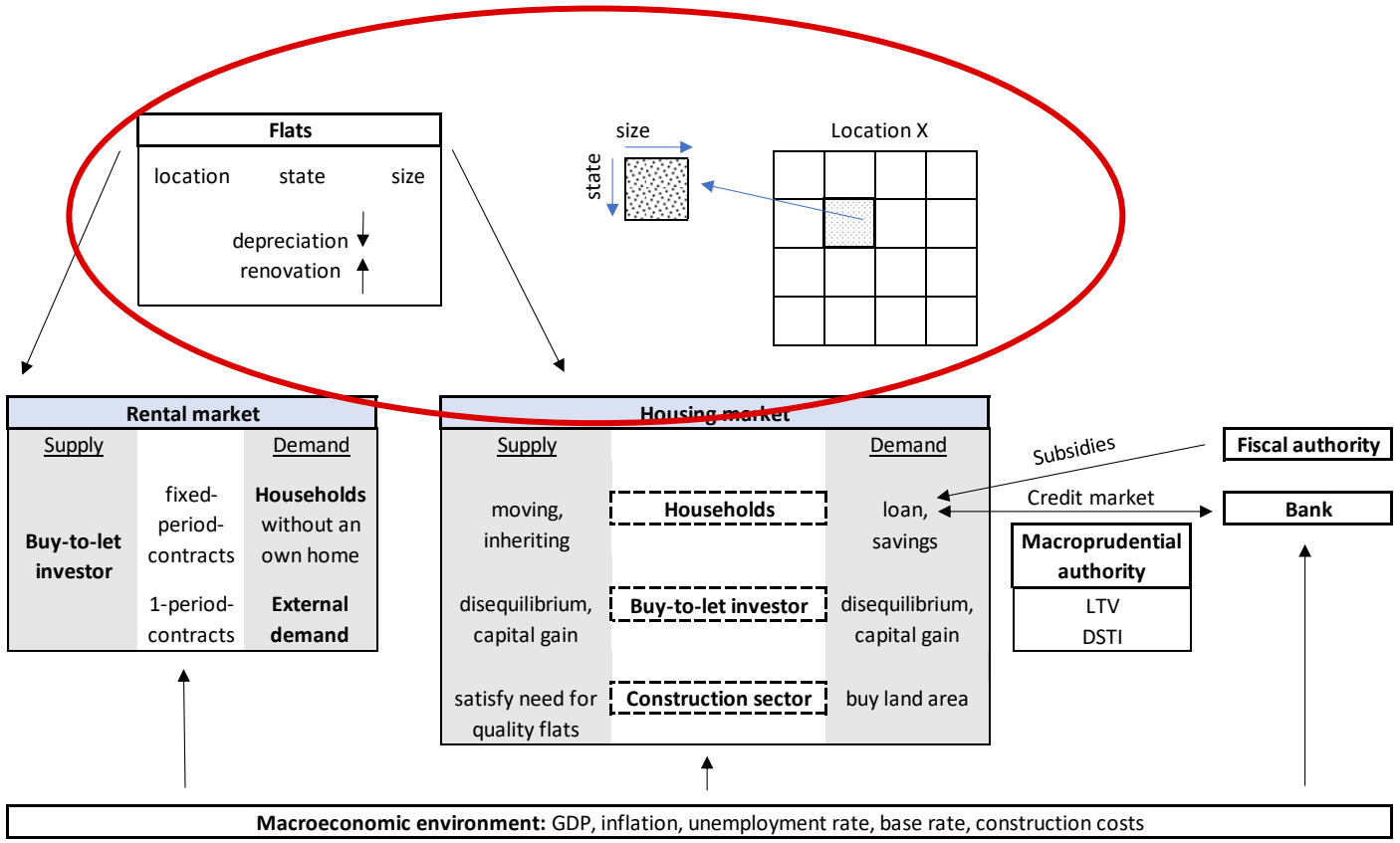
HOUSING MARKET PILOT PROJECT

THE MODEL IN A NUTSHELL



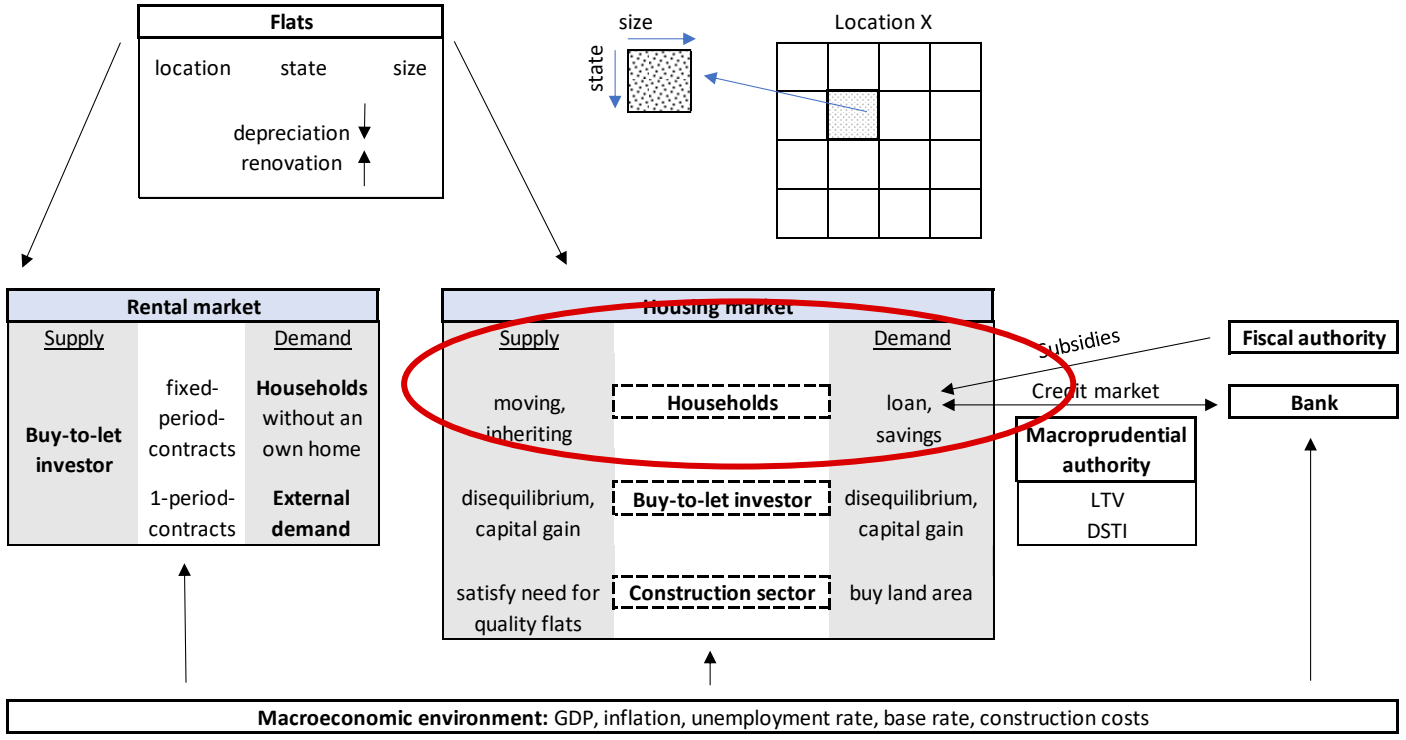
Mérő, B., Borsos, A., Hosszú, Z., Oláh, Z., & Vágó, N. (2023). A high-resolution, data-driven agent-based model of the housing market. Journal of Economic Dynamics and Control, 155, 104738.

THE MODEL IN A NUTSHELL 1/6 – FLATS



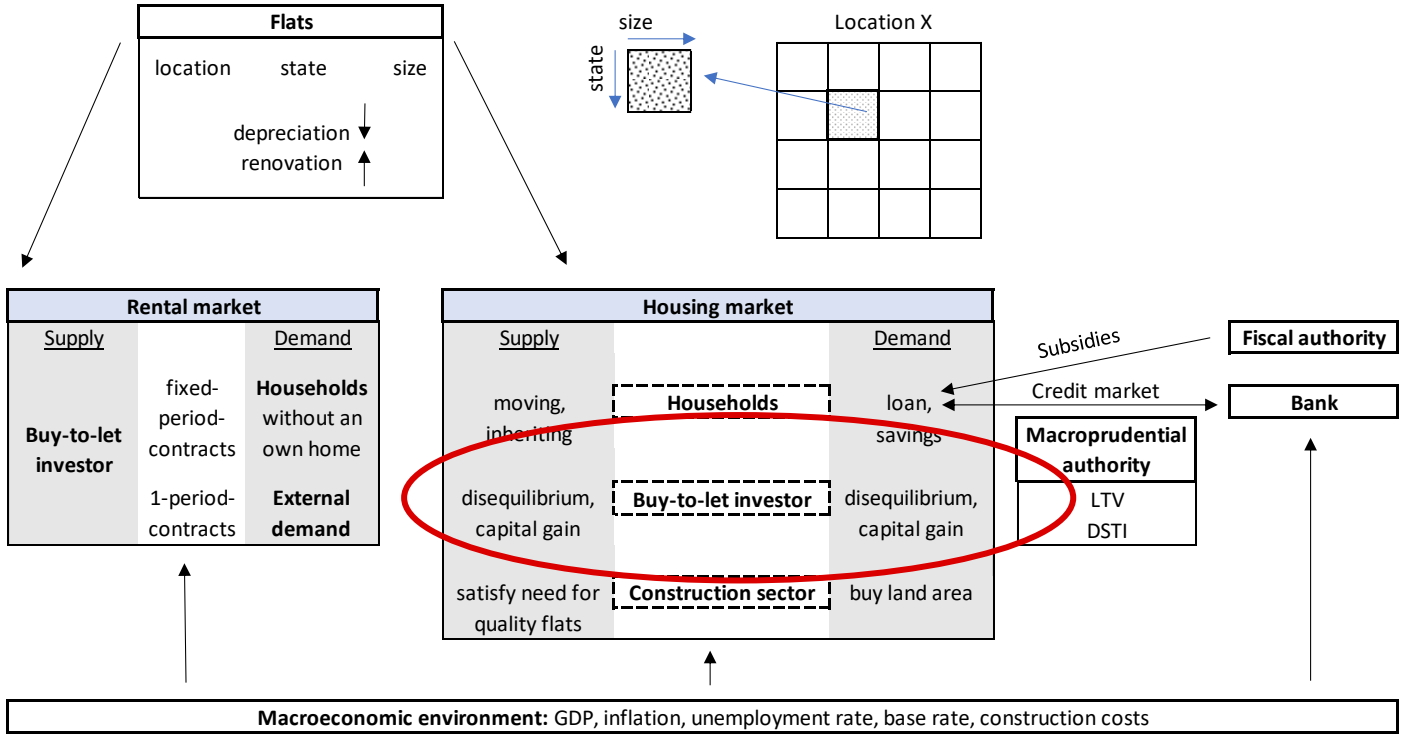
- Flats have three characteristics:
  - Size
  - Location (neighbourhood quality);
  - State (which is a composition of several measures which can change);
- Regarding the location of flats, we have divided the country into 124 actual, interpretable neighbourhoods, and estimated a cardinal quality value to each neighbourhood.
- Each month a flat's state depreciates, (but renovation can increase it).
- Within each location, flats are grouped into buckets: flats within a specific size and state interval constitute a bucket.

THE MODEL IN A NUTSHELL 2/6 – HOUSEHOLDS



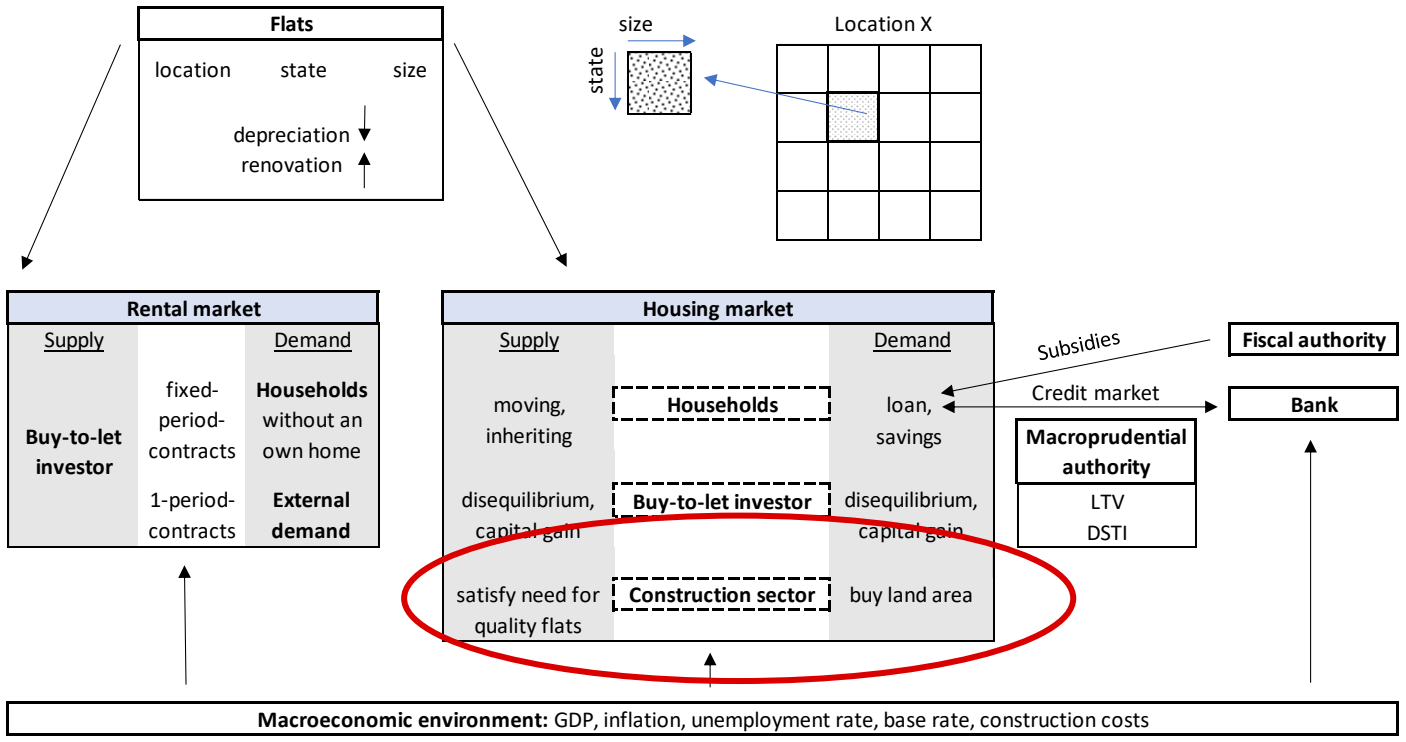
- We implemented demography in the model, including birth and death, according to empirical data.
- Households' income is determined in the model not only by their educational level and stochastic labour market shocks, but also by macroeconomic processes.
- Households can consume, accumulate savings, or buy a flat.
- They can take out a loan, but they have to meet regulatory requirements.
- Regular households may appear on the supply side when they inherit a flat and take it to the market.
- Each period, some households may decide to move if they find that they can achieve a significant increase in their consumer surplus by selling their home and moving to a new one.

THE MODEL IN A NUTSHELL 3/6 – INVESTORS



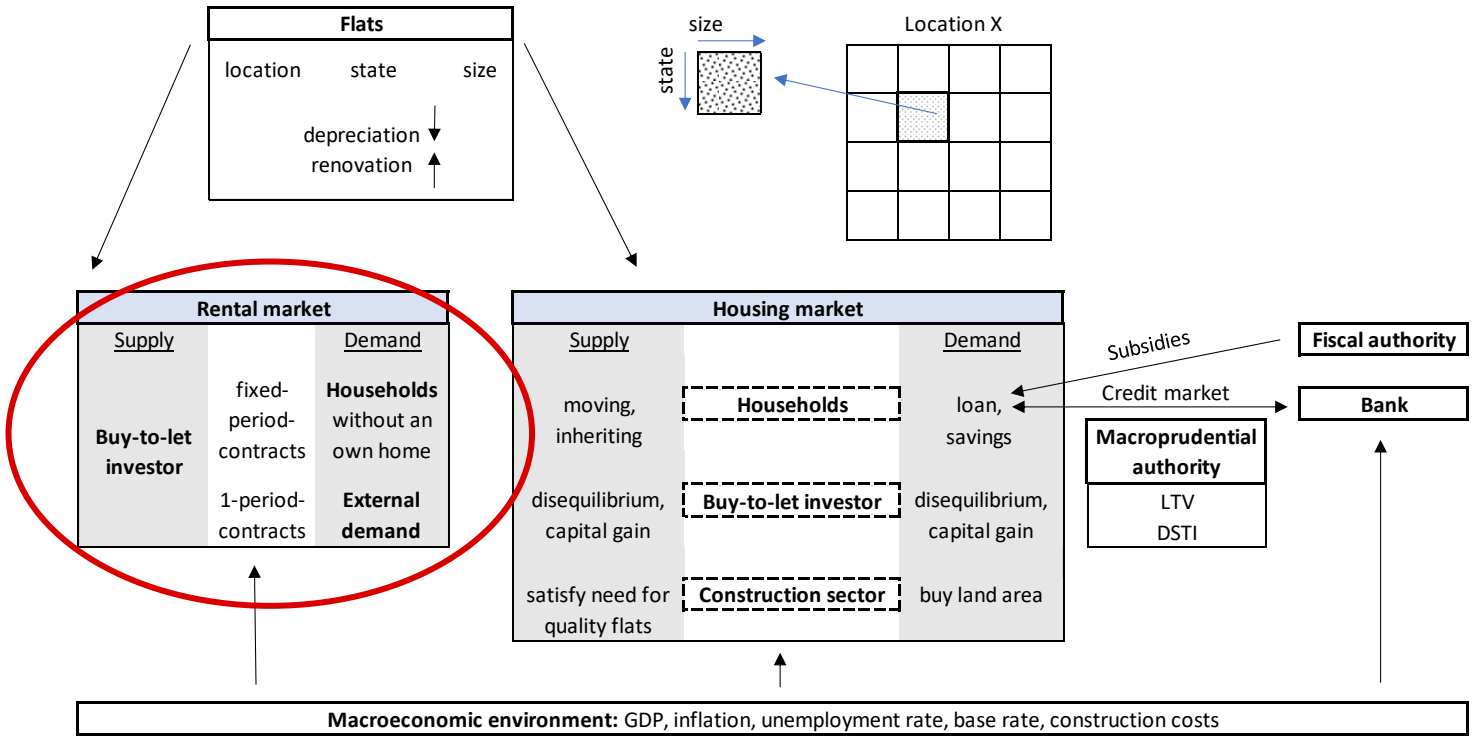
- **Representative professional investor + HHs**
- Demand is influenced by the obtainable **capital gain**, so their decisions are determined by
  - price changes and
  - vacancy rates.
- The supply and demand sides can be temporarily detached → **disequilibrium**
- The **endogenous change** in the **prices** and in the **rental markups** ensures the long term convergence to equilibrium

THE MODEL IN A NUTSHELL 4/6 – CONSTRUCTION



- The construction sector
  - is represented by a representative firm,
  - which estimates demand for newly built flats heterogeneously for neighborhoods and flat categories.
- Construction process:
  - The construction sector **builds high quality** flats.
  - It needs **land site** to build, so it buys the flats with the lowest unit price for sale in the neighborhood where it wants to build.
  - Construction takes **18 months**, but the construction firm can sell the flats even before they are finished.
  - Construction costs are proportional to the regional average salary (and higher than the renovation cost).

THE MODEL IN A NUTSHELL 5/6 – RENTAL MARKET



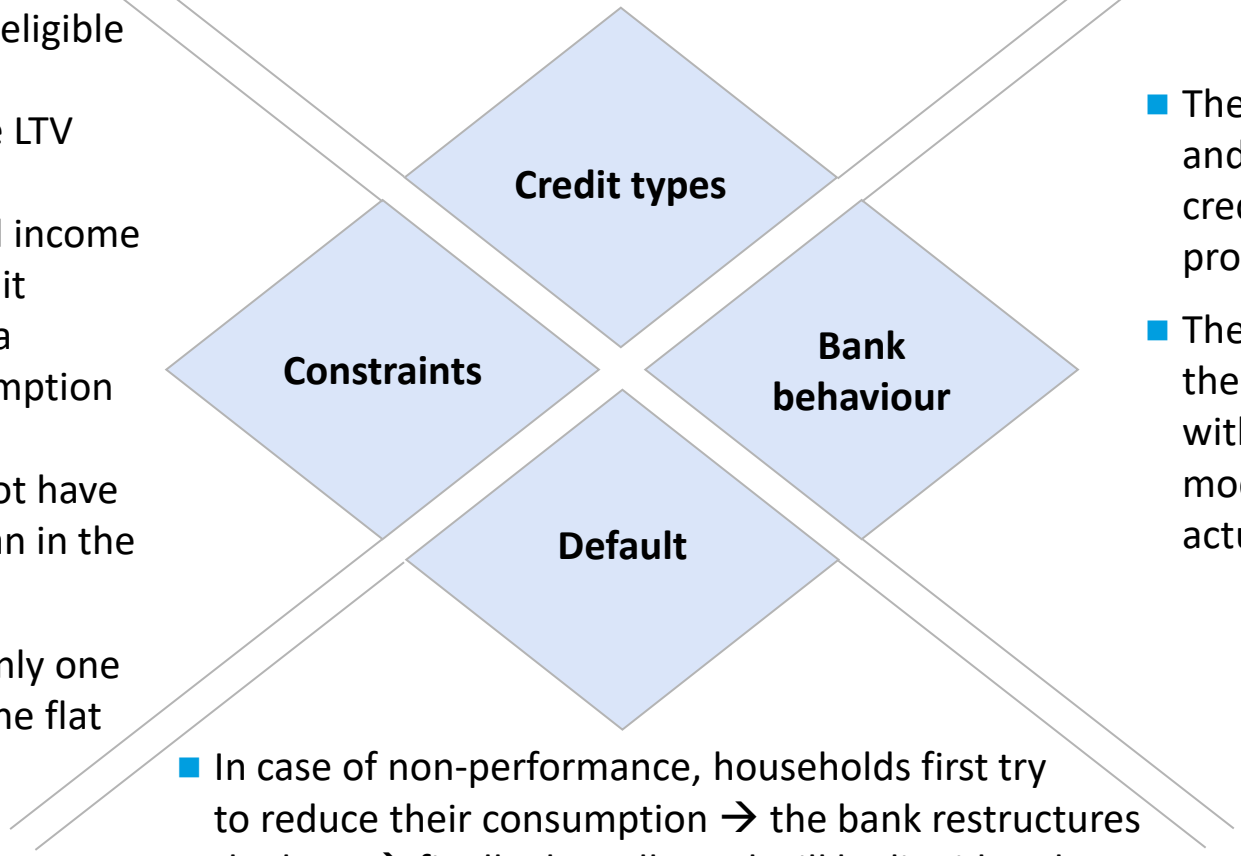
We distinguish between short-term (maximum one month) and long-term renting.

- Short-term
  - represents online market place platforms (e.g. Airbnb), which mostly serve the demand coming from tourism.
  - → time-dependent, exogenously given external demand for every for neighborhoods and flat categories based on empirical data
- Long term
  - If a household does not have an own home, it can go to the rental market.

THE MODEL IN A NUTSHELL 6/6 – CREDIT MARKET

- There are housing mortgage loans, bridge loans and also consumer loans for renovation.
- There are fix and variable rate loans as well.

- A household is eligible for a loan if:
  (1) it meets the LTV and DSTI rules;
  (2) its expected income covers the credit payments and a minimal consumption level;
  (3) and it did not have a defaulting loan in the past five years.
- There can be only one mortgage on one flat

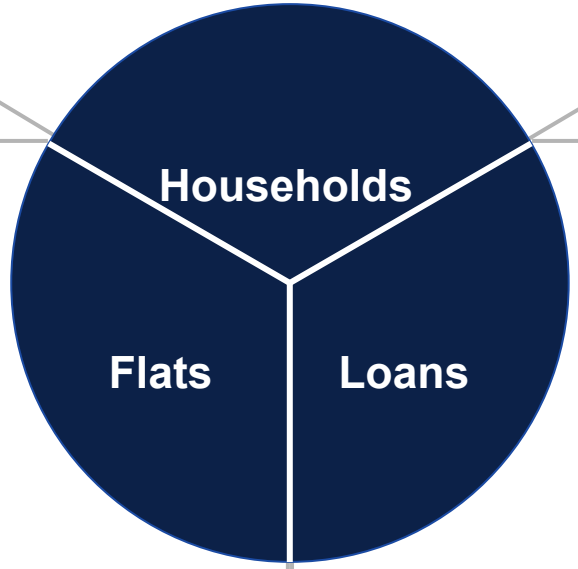


- The bank increases and reduces the credit supply procyclically.
- The bank determines the credit margins with a regression model estimated on actual empirical data.

- In case of non-performance, households first try to reduce their consumption → the bank restructures the loan → finally the collateral will be liquidated.

1:1 SCALE MAPPING

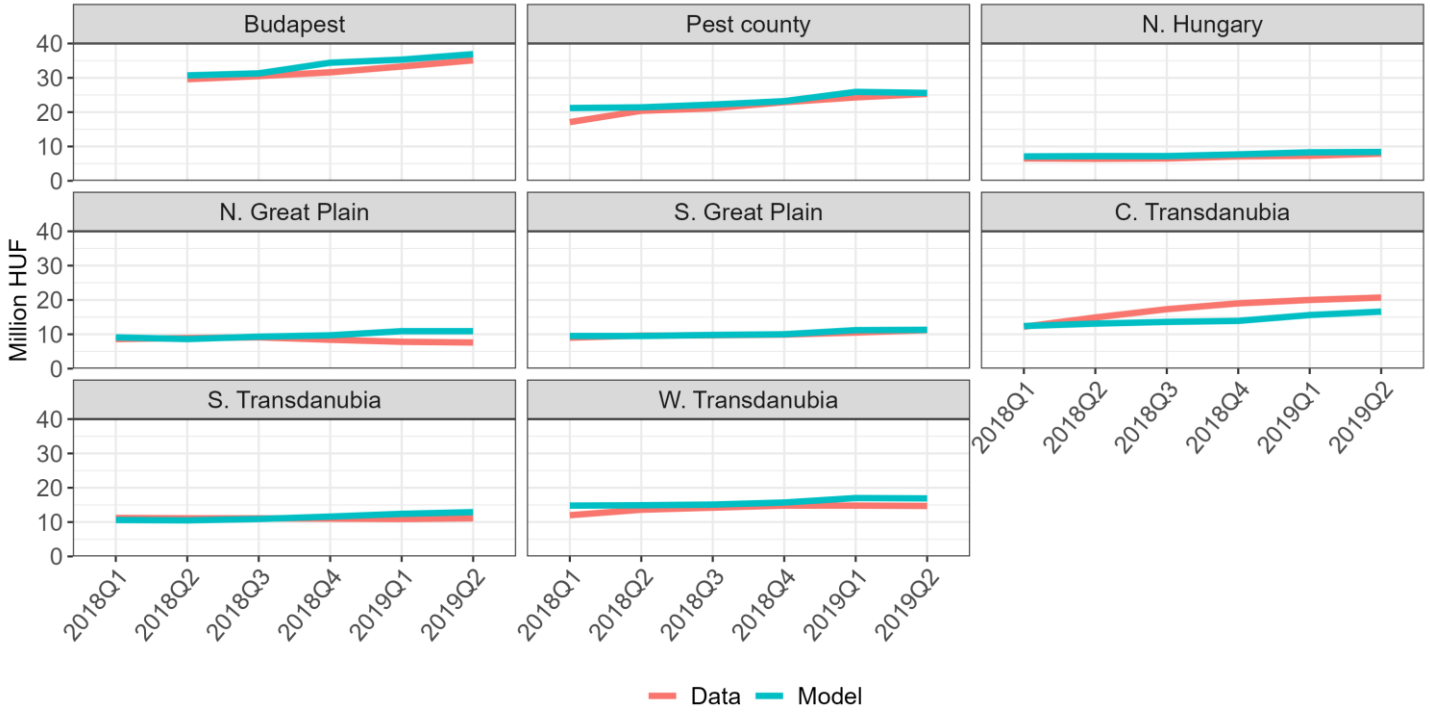
- **All of the 4 million Hungarian households**
- Every household is assigned a flat to live in (rent/own status is decided at the beginning of the simulation)
- We assign also the observed loan contracts to the households.
- Attributes of households: number of members, number of children; educational level, age and initial income of individuals.



- **cc. 200K flats (realtors)**
  + all transactions (NTA)
  + aggregated statistics of
  HCSO micro census → 4M flats
- Reconstructing the housing stock such that it mimics the agg. statistics
- 3 characteristics: neighborhood, size, quality attributes.

- **All 700K housing loan contracts**
- Central Credit Registry
- Start date, contracting value, maturity, principal outstanding, payment, interest rate, non-performing status, non-performing start date

CALIBRATION



Average house prices

Monthly averages	2018Q1-2019Q2	
	Actual	Model
Number of transactions on the housing market	15 148	14 752
Number of transactions of newly built flats	1 966	1 897

- Parameters are calibrated such that the dynamics of the observable variables match the empirical data:
  - average regional prices,
  - the number of transactions
  - newly built housing stock
- We used data from 2018/19.

VALIDATION

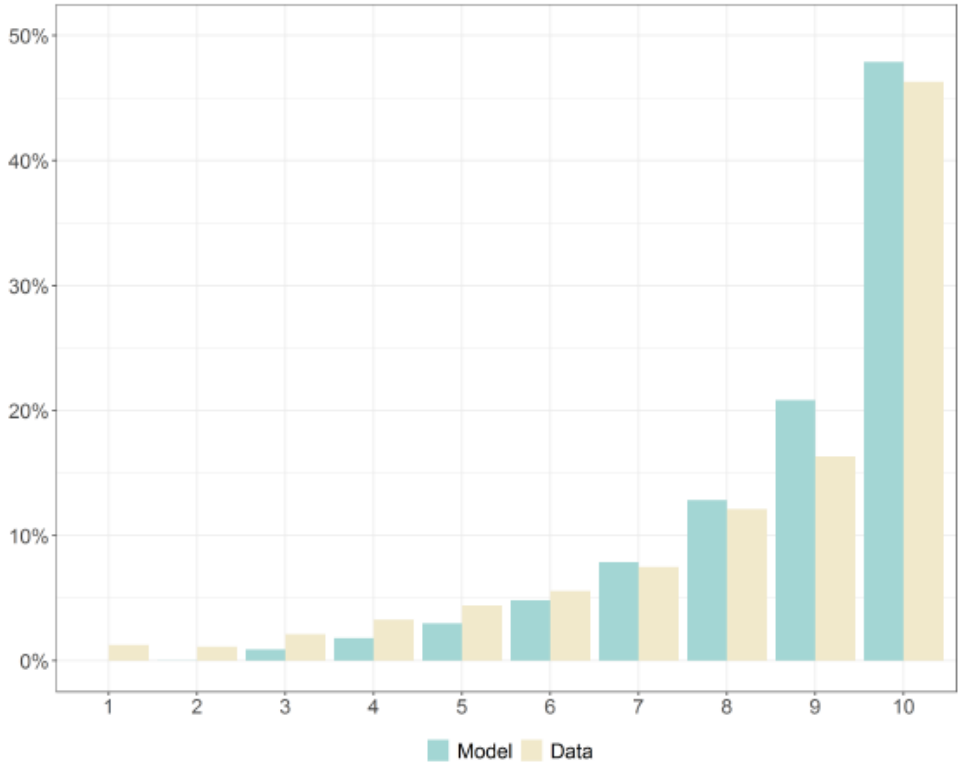


Figure 4: Distribution of the volume of newly issued housing loans in 2018 and 2019 based on the income deciles of the households. (Source: MNB.)

Yearly averages	New credit flow (billion HUF)		Number of contracts	
	Actual	Model	Actual	Model
2018-2020	895	1136	79744	75967

- We tested whether the variables of the model which were not calibrated follow the empirical data.
- We used mainly lending market variables:
  - Number of loan contracts,
  - New credit flow,
  - Distribution of loans based on income deciles, LTV and DSTI categories.
- But also some disaggregated housing market statistics:
  - # of transactions at the regional level
  - Average neighborhood quality of flats in transactions

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MACROPRUDENTIAL POLICY APPLICATION

MOTIVATION

Policy challenges

- Preventing the emergence of excessive financial risks in the economy
- In the context of the housing market:
  - Inhibiting the build up of vulnerable loan portfolios
  - Restraining the volatility of the prices on the housing market
- **BUT:** Finding an optimal trade-off between stability and the costs of the regulation

Contributions

1) Multiple objectives beyond the „stability-economic growth trade-off”:
   - Social, welfare and inequality consequences
   - Housing stock quality, housing standards, energy efficiency

2) Heterogeneity of the housing market → Disaggregated policy impact assessment along:
   - Geographic (neighborhoods, counties, regions),
   - Social (income, FTB vs HO vs. BTL)
   - Economic (LTV, DSTI)

   dimensions.

Policy scenarios

3-3 versions of LTV and DSTI:

- Either unchanged, or +/- 10 percentage point change (3x3)

+1 „No limit” scenario:

- No regulatory rules, only credit history and consumption constraints

The results are always relative to the current official regulatory framework in Hungary:

- LTV: 80%
- DSTI: 50%

ASYMMETRIC DEVIATIONS FROM BASELINE, LTV SEEMS MORE EFFECTIVE

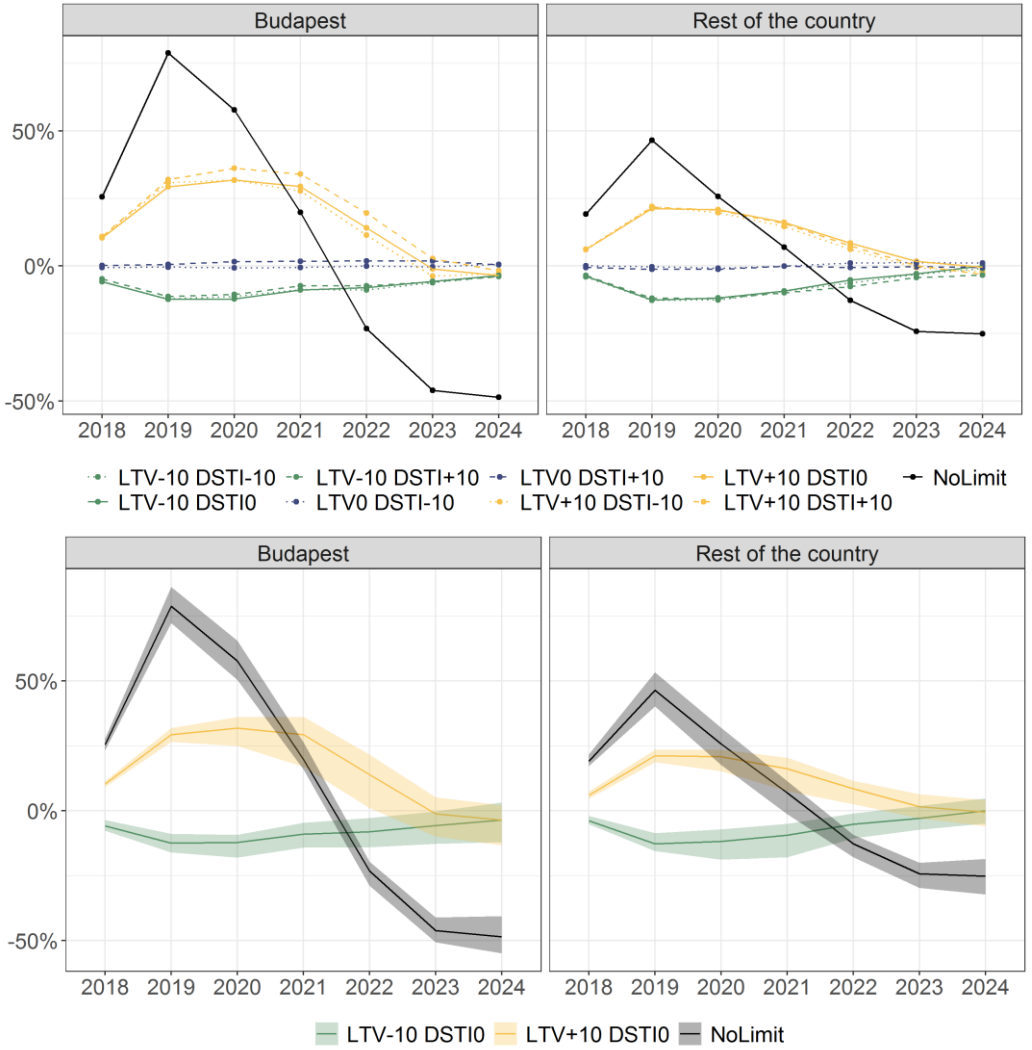


Figure 1: *Changes in the house price index relative to the baseline scenario decomposed based* ***on regions of the country***

- **Looser (or no) LTV →** house price boom (especially in Budapest)
  - „no limit" → bubble bursts endogenously
  - Loose LTV → bubble bursts only in the crises
- **Stricter LTV →**
  - Does not decrease considerably the volatility of the house prices
  - Effect is similar in the whole country
- **DSTI**
  - only relevant when the LTV is looser

BANKS: WITH A LENIENT POLICY, LENDING & DEFAULT RATES CATCH UP

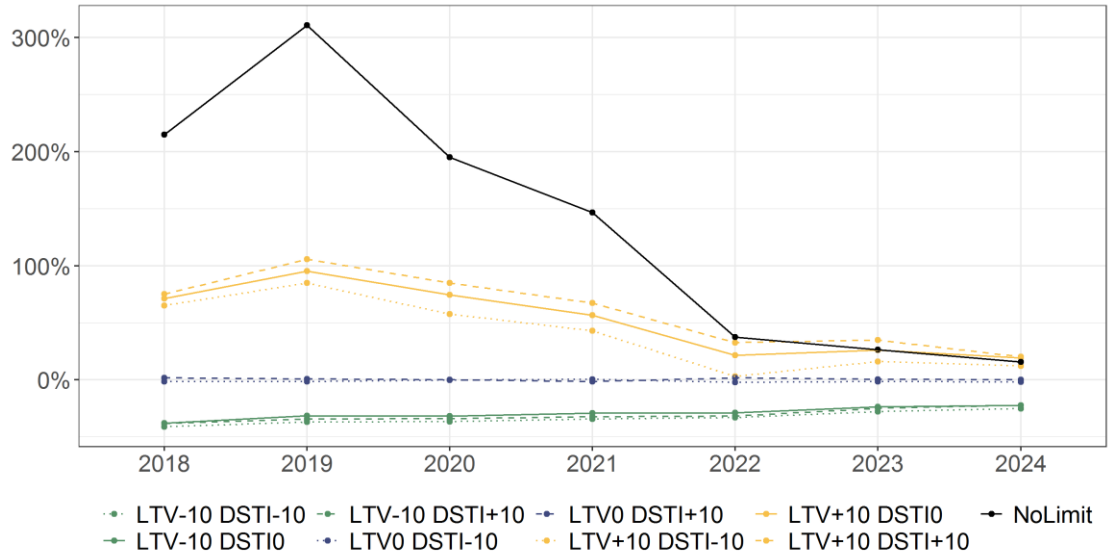
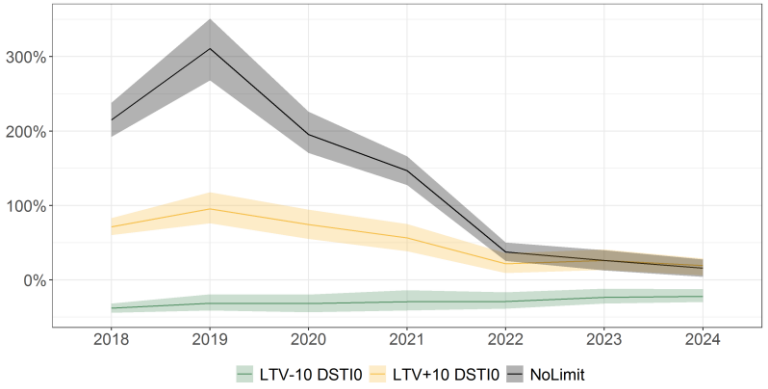
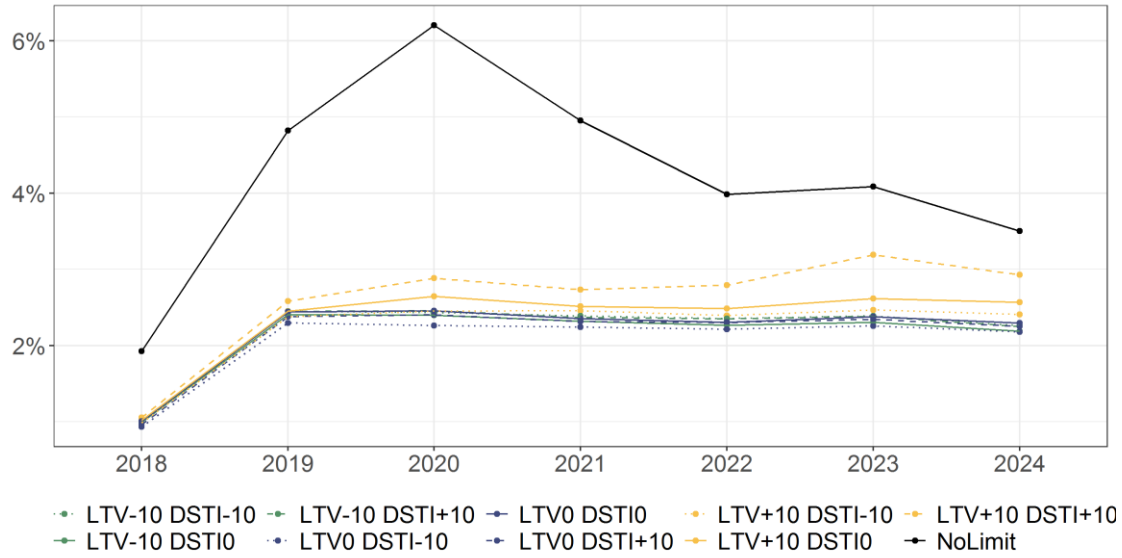


Figure 3: *The volume of newly issued housing loans relative to the baseline scenario.*





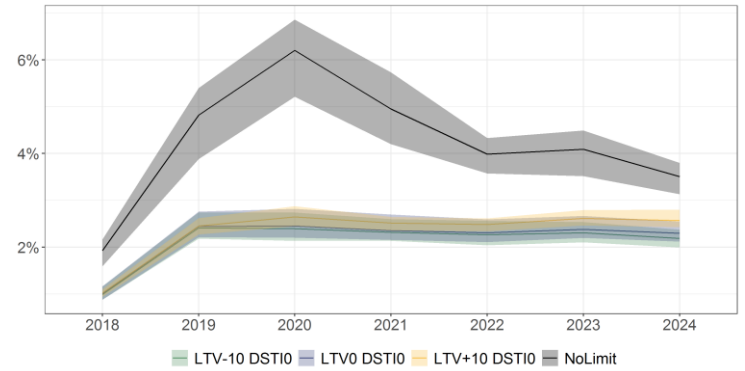


Figure 4: *Yearly average default rates of mortgage loans in the 10 different scenarios.*

CREDIT AVAILABILITY

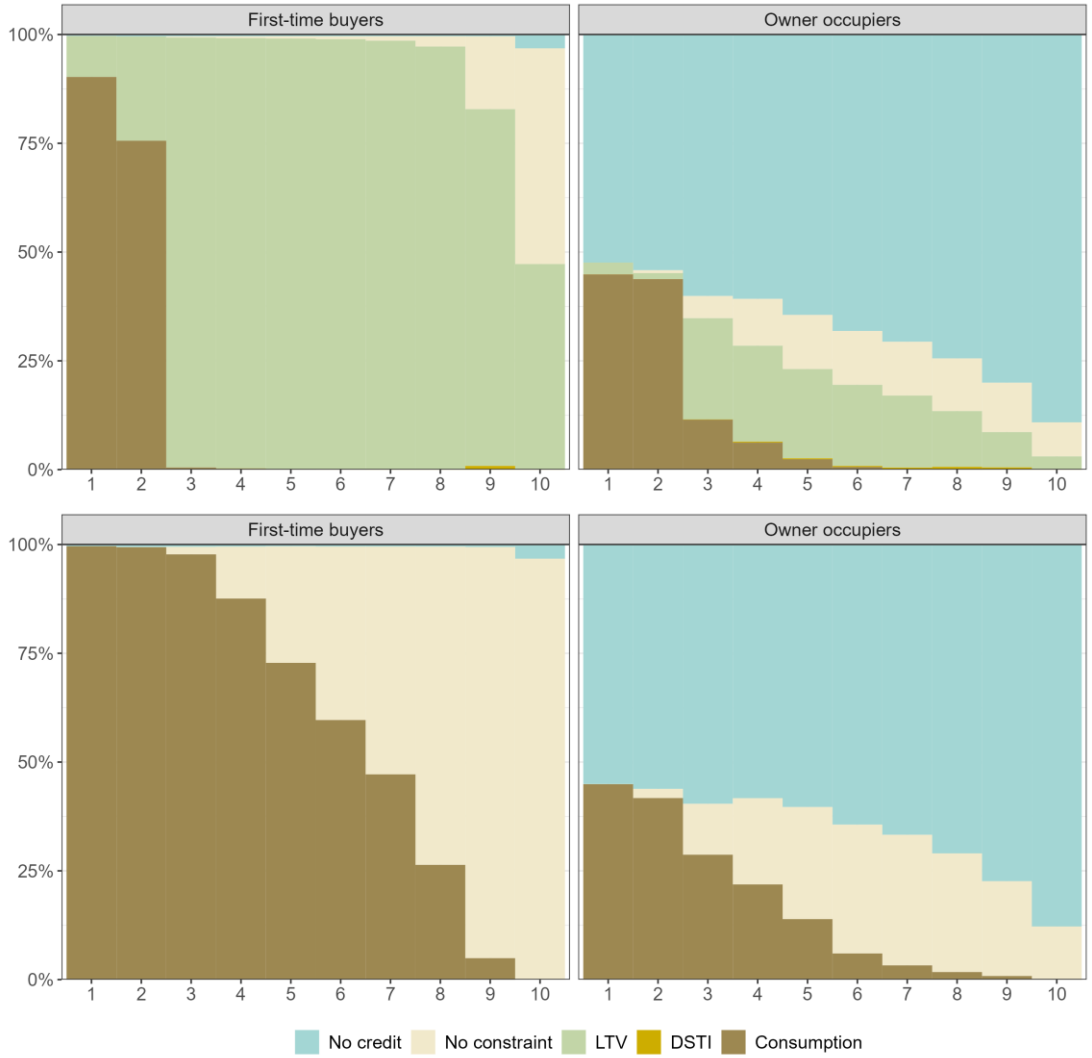


Figure 5-6: *Credit availability in the baseline (upper) and in the no limit scenario disaggregated based on income deciles and on FTB-OO categories, aggregated between 2018-2024.*

Credit availability (Kelly et al. 2018)

- What is the most restrictive constraint for a household to buy a fair, „justifiable" flat?
- „Justifiable": average flat in the region and income decile for a given household

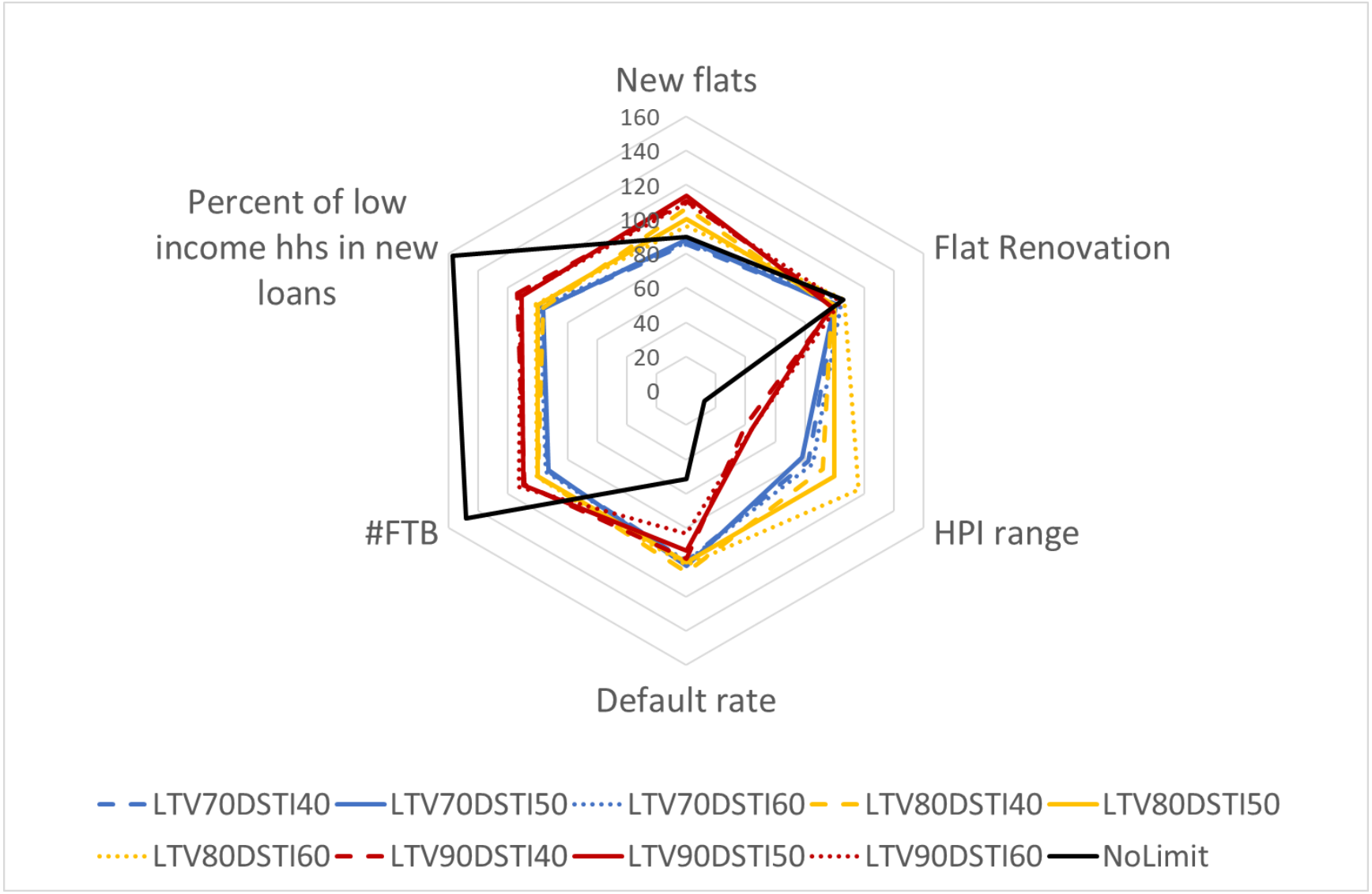
Owner occupiers

- They can mostly buy their „fair" flat.
- LTV/consumption constraints mainly below median income.

First-time buyers

- **Without LTV/DSTI** → First 3 deciles: not eligible for credit. Even in the 7th decile only 50% eligible.
- **With LTV/DSTI** → Barely anyone is eligible for credit. (Even in the 10th decile 50% is not eligible.)

OPTIMAL POLICY MIX



STATUS OF MNB'S ABM RESEARCH PROJECT

„Pilot": Housing market ABM development

- 1:1 empirical mapping
- High realism in agents' behavior

Housing ABM Applications

- Construction cost shocks
- Family support policy
- Macroprudential policies
- Targeted FTB subsidies
- Optimal scaling
- ABM – SVAR hybrid model for macroeconomic feedback

Macroeconomic ABM development

- Reference model: CANVAS
- 1:1 mapping with empirical data
- 6 stages of development
- Special focus on the financial system

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