Mortgage structure, saving rates and the wealth distribution

Luís Teles Morais
Nova School of Business and Economics

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Introduction

How do fixed amortization schedules in mortgages affect homeowners' saving and (the distribution of) wealth?

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- Homeowners: $\sim 60\%$ of saving is mortgage re̲payment in the Euro area (similar in US)
  - → $\rightarrow \sim 40\%$ of the population
- In many countries (Euro area, US), only available structure is a **fully amortizing annuity loan**:
  - → Fixed payment = interest + principal. Balance $\rightarrow 0$ at maturity
- Repayment schedule fixed at origination and costly to deviate from (refinancing, late penalties, …)

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  - → $\rightarrow \sim 40\%$ of the population

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Mandatory amortization schedule $\Rightarrow \uparrow$ saving, $\downarrow$ consumption

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  - → $\to \sim 40\%$ of the population
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This paper. A theory of consumption/saving under different mortgage structures suggests:

- This can be **rationalized** by standard model w/ costly deviation from repayment schedule
- It may have **large, heterogeneous effects** on saving over the life cycle $\to$ wealth distribution

This paper

Life cycle model of homeowners facing uninsurable income risk and a fixed amortization schedule

- Explains large effects on consumption in empirical literature $\rightarrow$ $\uparrow\uparrow$ saving rate
  - → Effects are heterogeneous: younger, poorer homeowners save more; others unaffected

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Matches **novel stylized facts** from household wealth data in Europe

- Younger and lower-income/wealth homeowners with an amortizing mortgage save more
  - → Homeowners 30-40y.o. in Europe save 2x more than renters/free users
- Homeowners with *interest-only* mortgages in **Netherlands** similar to renters
  - → No differences among older, richer groups

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  - $\rightarrow$ No differences among older, richer groups

Large implications of mandatory amortization for wealth accumulation & distribution

- $\uparrow$ Saving rates for young and lower-income homeowners – but leaves them more exposed to shocks:
  - $\rightarrow$ $\uparrow$ Total wealth/income ratios, but $\downarrow$ liquid wealth $\Rightarrow$ higher $\%$ HtM, MPCs, C volatility

Introduction

Contribution to the literature

- Effects of mortgage amortization on household consumption and saving

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- Optimal mortgage payment structure

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- Wealth distribution: housing drives dynamics through return rates

  Saez & Zucman (2016); Jorda et al. (2019), Fagereng et al. (2020), Kuhn, Schularick & Steins (2020); Martinez-Toledano (2022)

  → This paper: role of saving rates channel due to mortgage contract design

Agenda

1. Introduction
2. Model framework and insights
3. Data: stylized facts and calibration
4. Model results
5. Conclusion

Model framework and insights

Model framework

Overview

Standard incomplete markets model + mortgage debt

- First-time homebuyer life-cycle
  - → From origination to maturity of the mortgage
- Basic features:
  - → Two asset types: **liquid safe asset** (risk-free) vs. **mortgage debt**. Housing fixed
  - → Idiosyncratic income risk (permanent + transitory)
- Key addition: mortgage contract transaction costs
  - → Mandatory amortization schedule: cost to delay repayment
  - → How does this wedge affect saving and wealth accumulation?

Model

Household life cycle endowments and decisions

- A home worth P_0 (normalized) and a 30-year fixed-rate mortgage with initial balance M_0
- Some initial financial wealth: A_0 and exogenous risky earnings Y_t over the life cycle
- Decide each period on how much to:
  - → consume c_t and save each period
  - → repay d_t of their mortgage debt

Households in the model maximise utility from non-housing consumption:

$$U(c_t) = \frac{{c_t}^{1-\gamma}}{1-\gamma}$$

- Only non-housing consumption enters utility (housing H fixed)
  - → Assumption: prefs separable, so $\mathbf{argmax} \sum_t u(C_t) = \mathbf{argmax} \sum_t u(C_t, \bar{H})$ (Campbell-Cocco 2015)

Model framework

Assets & mortgage frictions

Liquid saving and mortgage debt

- Savings in the liquid asset (a_t) earn risk-free interest
  - → Borrowing limit $a_t \geq 0$ (no unsecured debt)
  - → Household cannot increase mortgage debt, only repay $d_t \geq 0$
- Outstanding mortgage debt demands interest $r + s$

Mortgage repayment schedule

- Mandatory amortization: $D^*(m_{t-1}, t)$ from standard annuity formula
  - → Deviating from repayment schedule $d_t < d_t^*$, then incurs transaction cost $\tau_t > 0$
- If default, lose house and keep low consumption $\underline{c}$ until end
  - → Repayment usually feasible under calibration $y : y > D^*(m_{t-1}, t) + m_{t-1}(r + s)$

Model insights

Period problem

$$\max_{c_t, d_t} \; u(c_t) \; + \; \beta \mathbb{E}_t \left[V_{t+1}(y_{t+1}, a_{t+1}, m_{t+1}) \right]$$

$$a_{t+1} = (1+r)\left[a_t + y_t - (r+s)m_t - d_t - \tau_t - c_t \right]$$

$$m_{t+1} = m_t - d_t \qquad\qquad m_t \geq 0, \; a_t \geq 0$$

- Key friction: scheduled repayment d_t^*, underpaying costs $\tau_t \equiv \tau \cdot \max\{0, d_t^* - d_t\}$

FOC for amortization trades-off marginal value of liquid asset accumulation vs. mortgage repayment

Model insights

Period problem

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- Key friction: scheduled repayment d_t^*, underpaying costs $\tau_t \equiv \tau \cdot \max\{0, d_t^* - d_t\}$

FOC for amortization trades-off marginal value of liquid asset accumulation vs. mortgage repayment

- For some states (a, y, m), without the cost of delaying ($\tau = 0$), $d_t < d_t^*$ preferable:

$$(1 + r - \tau) \mathbb{E}_t [V_a'] < \mathbb{E}_t [V_m'] < (1 + r) \mathbb{E}_t [V_a']$$

- τ introduces wedge: if liquid assets/income low, but not *too much*, HH sticks to d_t^* and reduces c_t, a_{t+1}
  - → If $\tau = 0$, HH would prefer to delay repayment and increase c_t, a_{t+1}
- Far from liq. constraint, $\mathbb{E}_t [V_a']$ is lower so τ irrelevant (as $s > 0$)

Model insights

Mechanism: how amortization frictions affect saving

Predictions for consumption and saving under mandatory amortization

- Stronger effects for:
  - → Younger: higher expected income growth, lower income, lower wealth (life cycle; down payment)
  - → Lower-income: houses, mortgages indivisible
- Little or no effect for wealthier or higher-income homeowners
- Compared to:
  - → Flexible repayment scheme (e.g. *interest-only mortgages*)
  - → Renters and others
- Consequence: higher saving rates for constrained mortgaged homeowners
  - → Matches stylized facts in Euro area data → life-cycle and income/wealth saving gradients

Data: stylized facts and calibration

Data from euro area countries, focus on NL

The Eurosystem HFCS - Household Finance and Consumption Survey

- Harmonized survey of households in Euro area. Three waves (2013-14; 2016-17; 2020-21)
- Compare avg. of Euro area versus Netherlands (NL): **mostly interest-only mortgages**
- Netherlands policy reform in 2013:
  - → From 2013, MID restricted to **fully amortizing loans** – high cost of deferred payment
  - → New borrowers forced to amortize → sharp rise in repayment flows

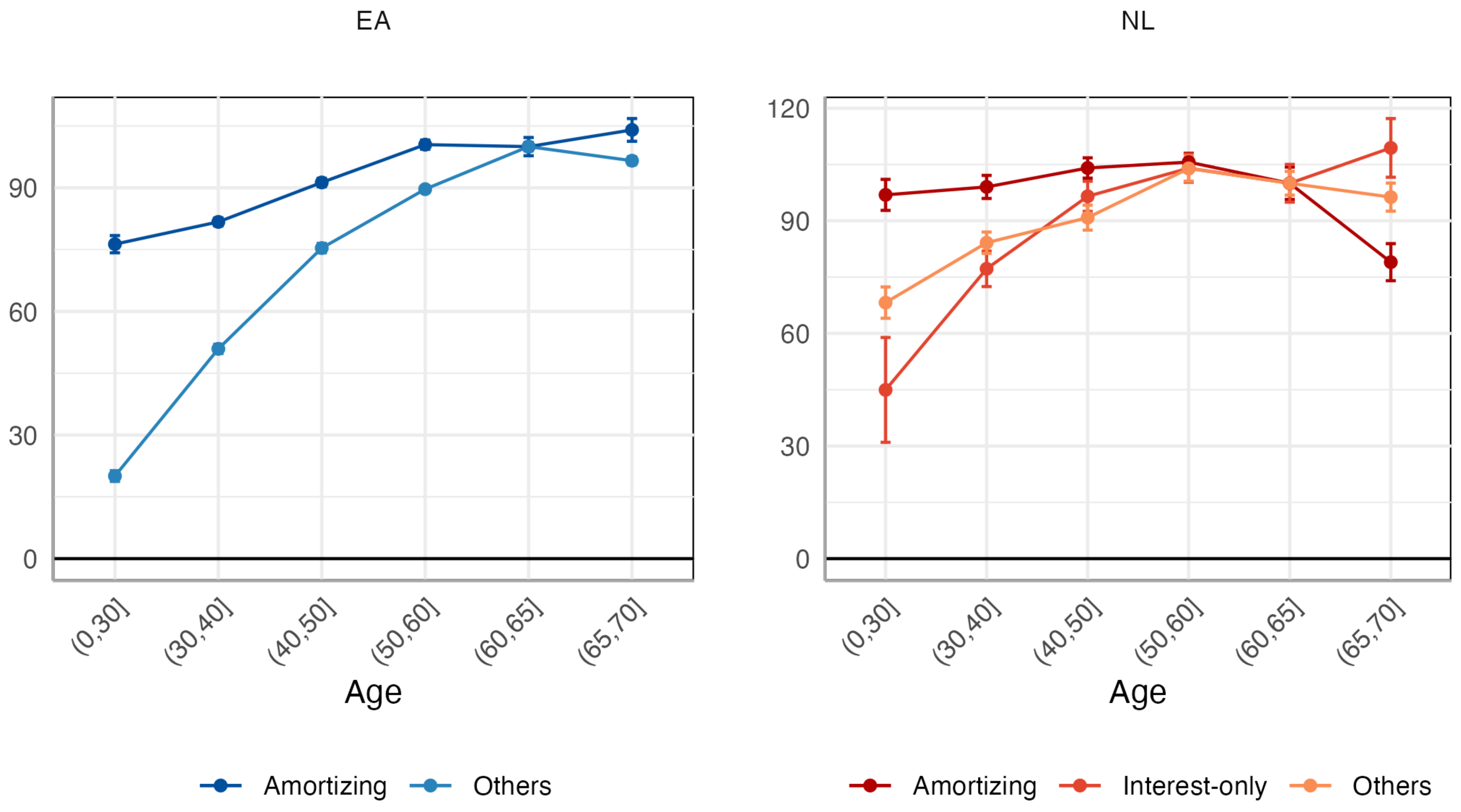
- Data on saving rates from consumption and net income
- **Amortization** backed out from regular payment: $\mathbf{12} \times \textbf{mthly pmt}_i - \boldsymbol{i}_i \times \textbf{debt}_i$, for HH $\boldsymbol{i}$
  - → The median household in EA amortizes ~10% of yearly income; 2.5% in NL Amortization histograms
  - → Various checks on amortization measure Regular payment / income

Histogram by waves | Annuity formula | Interest rates

- Exclude elderly/retired: $\textbf{Age} > \mathbf{70}$

Amortizing mortgages increase saving at the beginning of life cycle

Saving rates over the life cycle (Age 65 = 100)



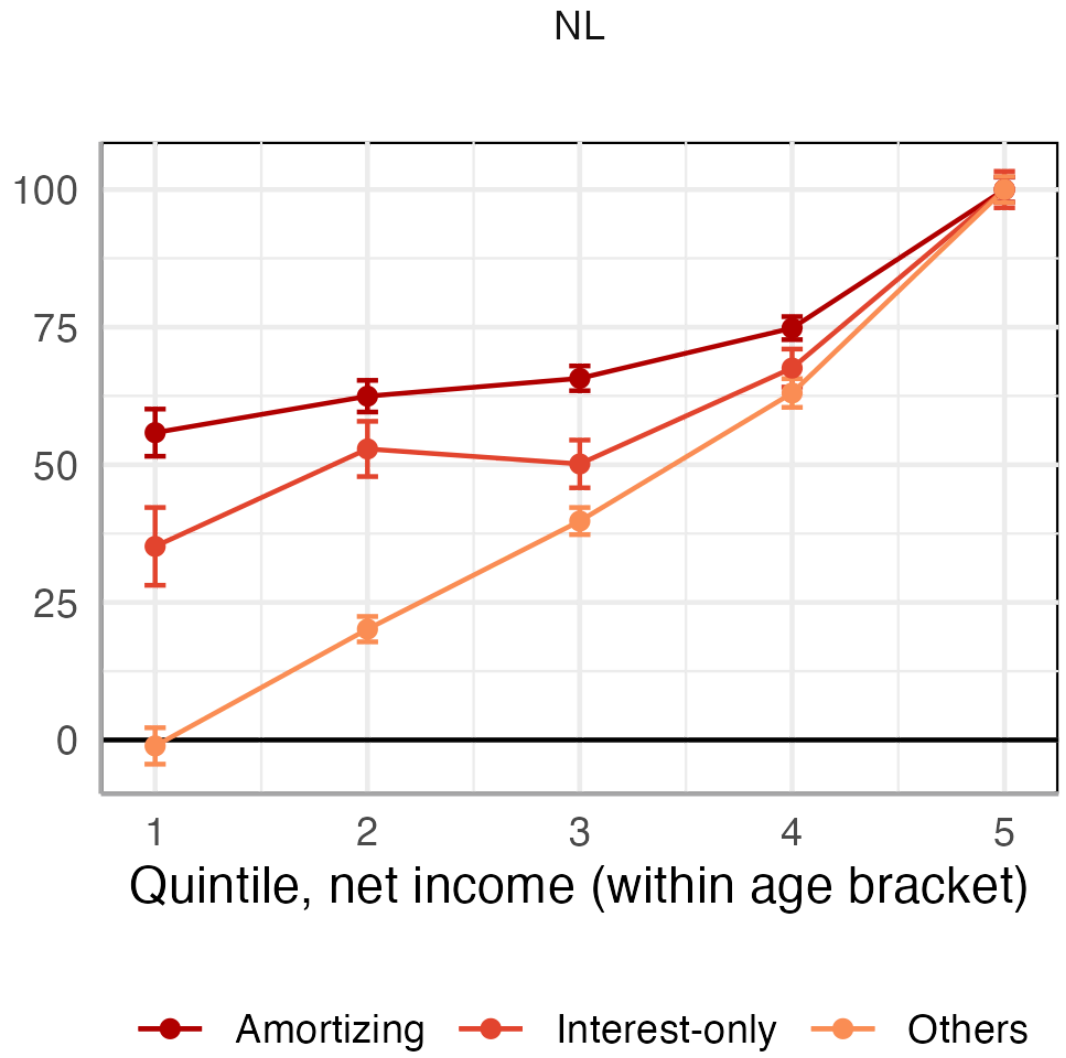
- **Interest-only mortgages** show pattern of renters/outright owners

Post-2013 policy

Life cycle profiles of assets and debt

Amortizing mortgage increase saving only for poorer homeowners

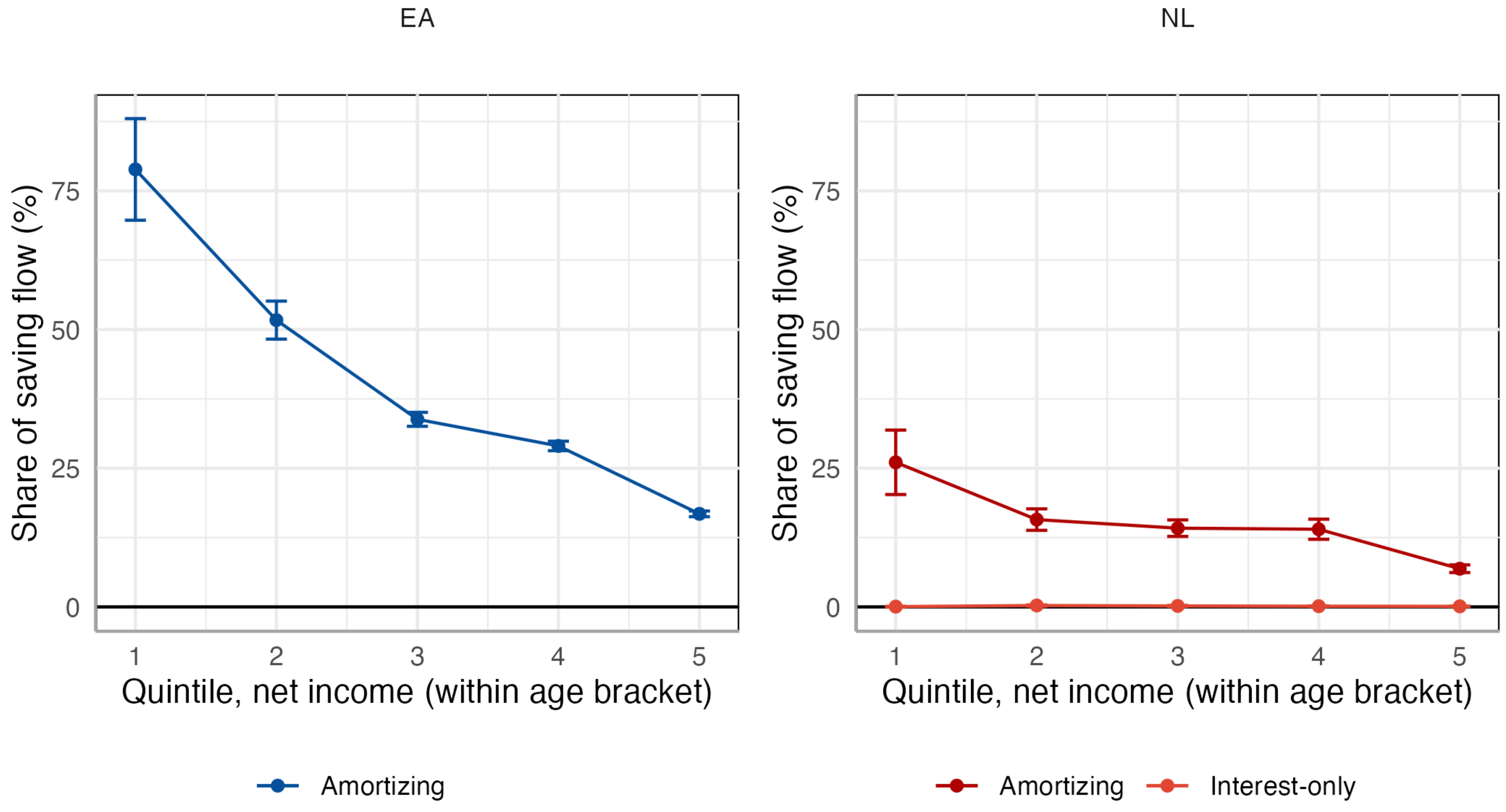
Saving rates over the income distribution (Q5 = 100)



- Again IO mortgages show pattern of renters/outright owners [Post-2013 policy]
- Age + income heterogeneity → same patterns over the wealth dist [Saving rates over wealth dist]

% of saving going to amortization declines with income in EA, less in NL

Amortization as % of saving flow



- In EA without interest-only, % of saving to amortization very high for more constrained homeowners

Calibration

Income process: inelastic labor supply yields earnings $Y_t = \Gamma_t Z_t \, \theta_t$, as standard: (Carroll & Samwick, 1997)

- $\ln Z_t = \ln Z_{t-1} + \ln \psi_t$; $\ln \psi_t \sim N\left(-\frac{1}{2}\sigma_\psi^2,\, \sigma_\psi^2\right)$; $\ln \theta_t \sim N\left(-\frac{1}{2}\sigma_\theta^2,\, \sigma_\theta^2\right)$
- Life-cycle profile Γ and moments of stochastic process from NL micro data (de Nardi et al. 2021)

Initial conditions: loosely matching data moments in Netherlands HFCS

- A home worth $P_0 = 5$ (5x annual permanent income)
- A *small* initial liquid buffer: $A_0 = 2/12$ of annual income
- A 30-year (fixed-rate) mortgage with $M_0 \leq \theta^M P_0$ (LTV = 100 %, ≈ median in NL)

Terminal conditions: *bequest motive at retirement* to match end-of-life wealth and mortgage debt:

$$B(a_T - m_T) = \underline{b}, \frac{\left(a_T - m_T + \bar{b}\right)^{1-\gamma}}{1-\gamma}, \quad \underline{b}, \bar{b} \text{ params}$$

- Mortgage must be fully repaid by retirement ⇔ bequest is net wealth $a_T - m_T$

Model framework

Full dynamic household problem

In practice, solved in terms of consumption c_t and a transformed repayment share ψ_t, where:

$$\psi_t \equiv \frac{d_t}{y_t - (r+s)m_t - \tau_t - c_t} \qquad \text{(share of saving used for mortgage repayment)}$$

The household solves the dynamic problem:

$$V(t, s_t) = \max_{\{c_k, \psi_k\}_{k=t}^{T}} \mathbb{E}_t \left[\sum_{k=t}^{T-1} \beta^{k-t} \frac{c_k^{1-\gamma}}{1-\gamma} + \beta^{T-t} B(a_T - m_T) \right], \text{ s.t.}$$

$$\begin{aligned}
d_t &= \psi_t \cdot (y_t - (r+s)m_t - \tau_t - c_t) \\
a_{t+1} &= (1+r)\left[a_t + y_t - (r+s)m_t - d_t - \tau_t - c_t\right] \\
m_{t+1} &= m_t - d_t \\
\tau_t &= \tau \cdot \max\{0, d_t^* - d_t\}, \quad a_t \geq 0, \quad m_t \geq 0, \quad d_t \geq 0
\end{aligned}$$

- Solution: deep learning algorithm proposed by Duarte et al. (2022), Barrera & Silva (2024)

Model calibrated for the Netherlands data

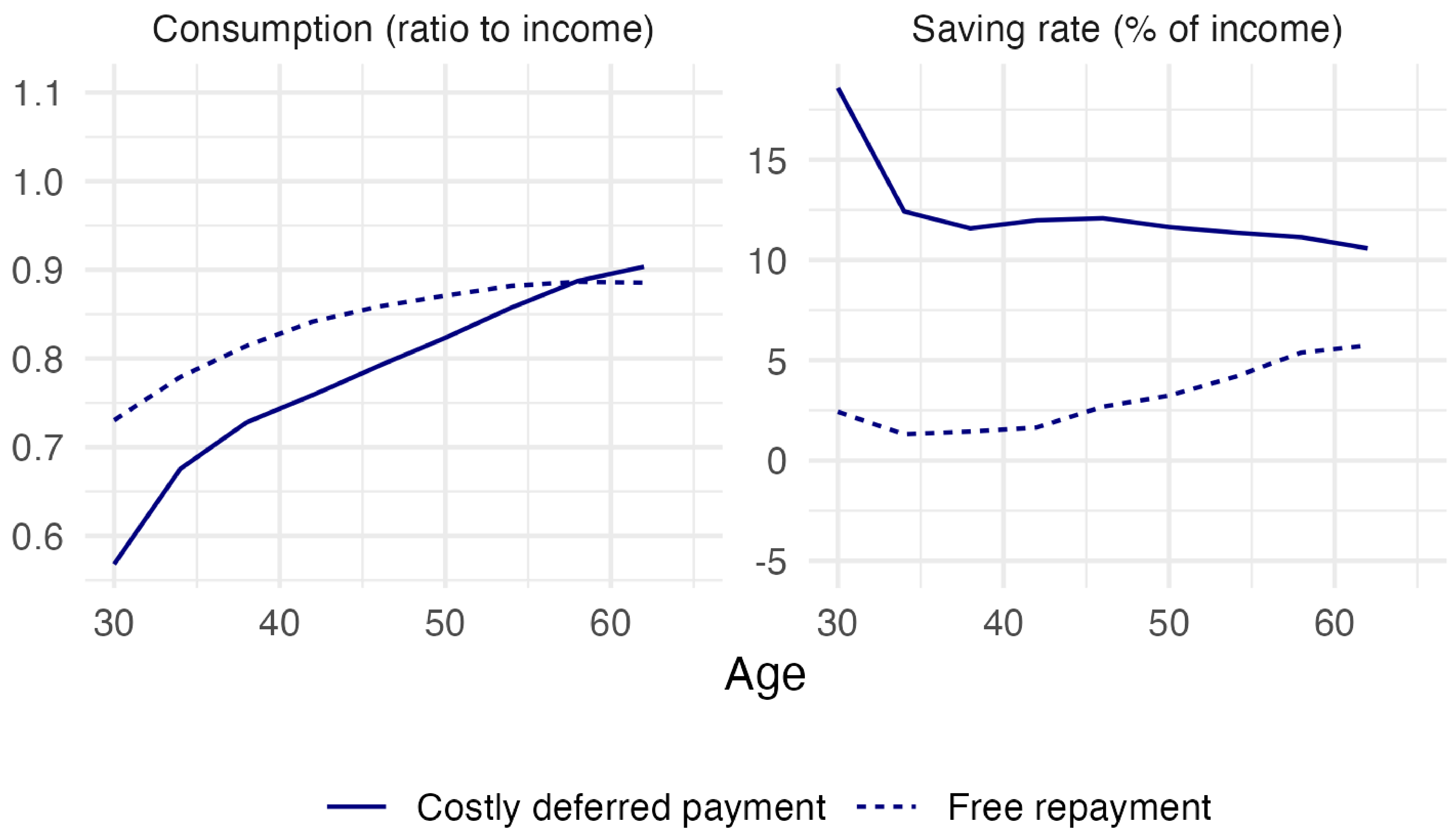
Description	Value	Target moment	Source
Life time in the model (T)	30	Median age purchase + maturity	–
Discount factor (β)	0.96	-	Kovacs et al (2020)
Risk aversion (γ)	5	-	Duarte et al. (2020)
Bequest motive parameters ($\underline{b}$)	1.5	Wealth at retirement	HFCS 2017 micro data
Bequest motive parameters ($\underline{b}$)	0	Normalization	–
Permanent income life cycle path	-	-	HFCS 2017 micro data
Variance of transitory shocks (σ_y^2)	0.025	Earnings shocks (transitory)	Paz-Pardo et al (2020)
Variance of permanent shocks (σ_z^2)	0.01	Earnings shocks (permanent)	Paz-Pardo et al (2020)
Riskless rate (r)	0.03	Long-run real safe rate	Jordà et al. (2019)
Mortgage spread	0.005	NL median fixed-rate spread	HFCS 2017 micro data
Borrowing limit, liquid (θ^A)	0	Normalization	-
Borrowing limit, mortgage LTV (θ^M)	100%	NL median LTV at orig.	Lang et al. (2020)

- Replicate regime change
  1. **Pre-2013: Interest-only free** $(\tau = 0)$
  2. **Post-2013: High cost of deferred payment** $(\tau = 0.5)$

Model results

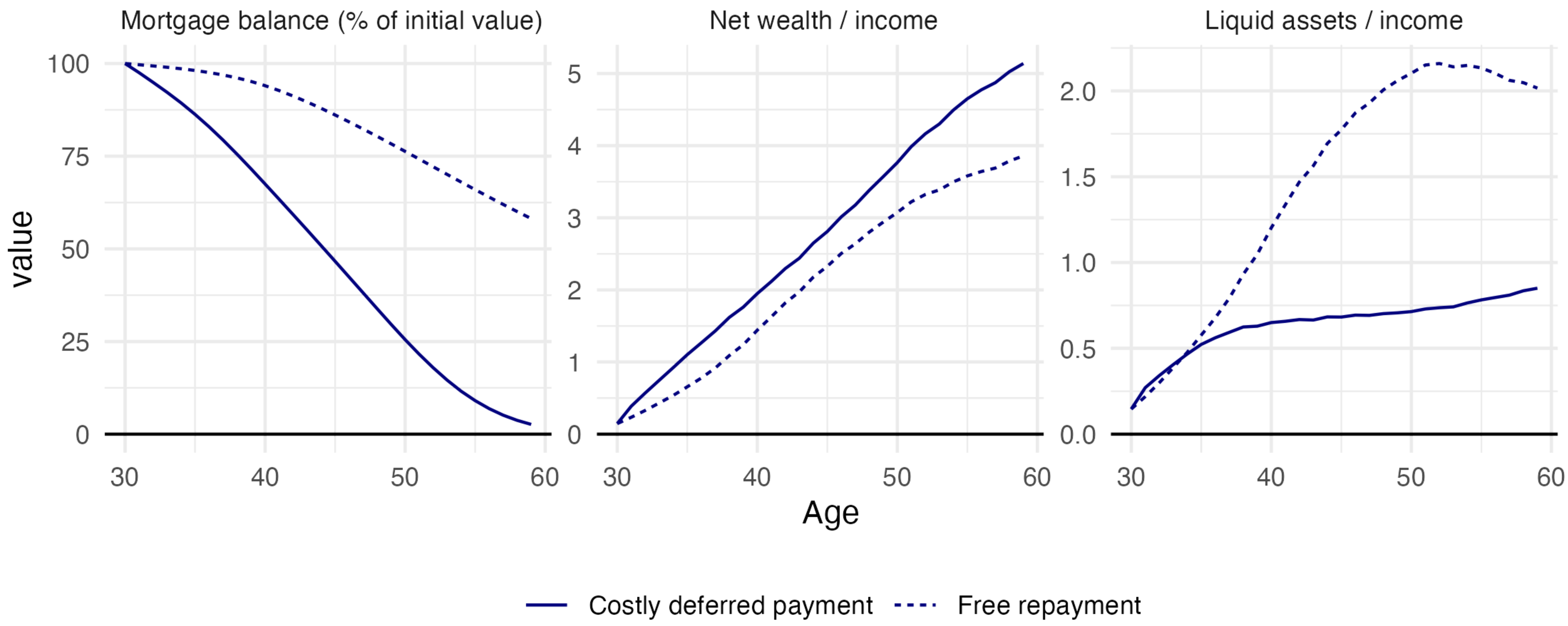
Model HHs forced to amortize cut consumption until mortgage is repaid

Average age profiles of consumption and saving



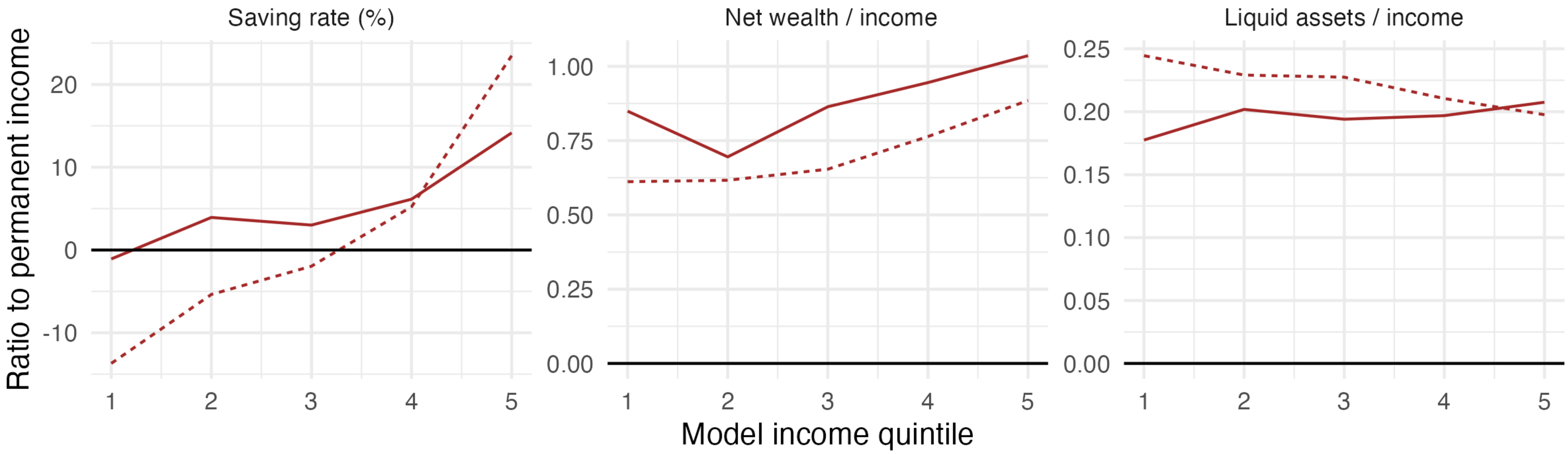
Model HHs allowed to optimize backload repayment

Average age profiles of mortgage balance and wealth



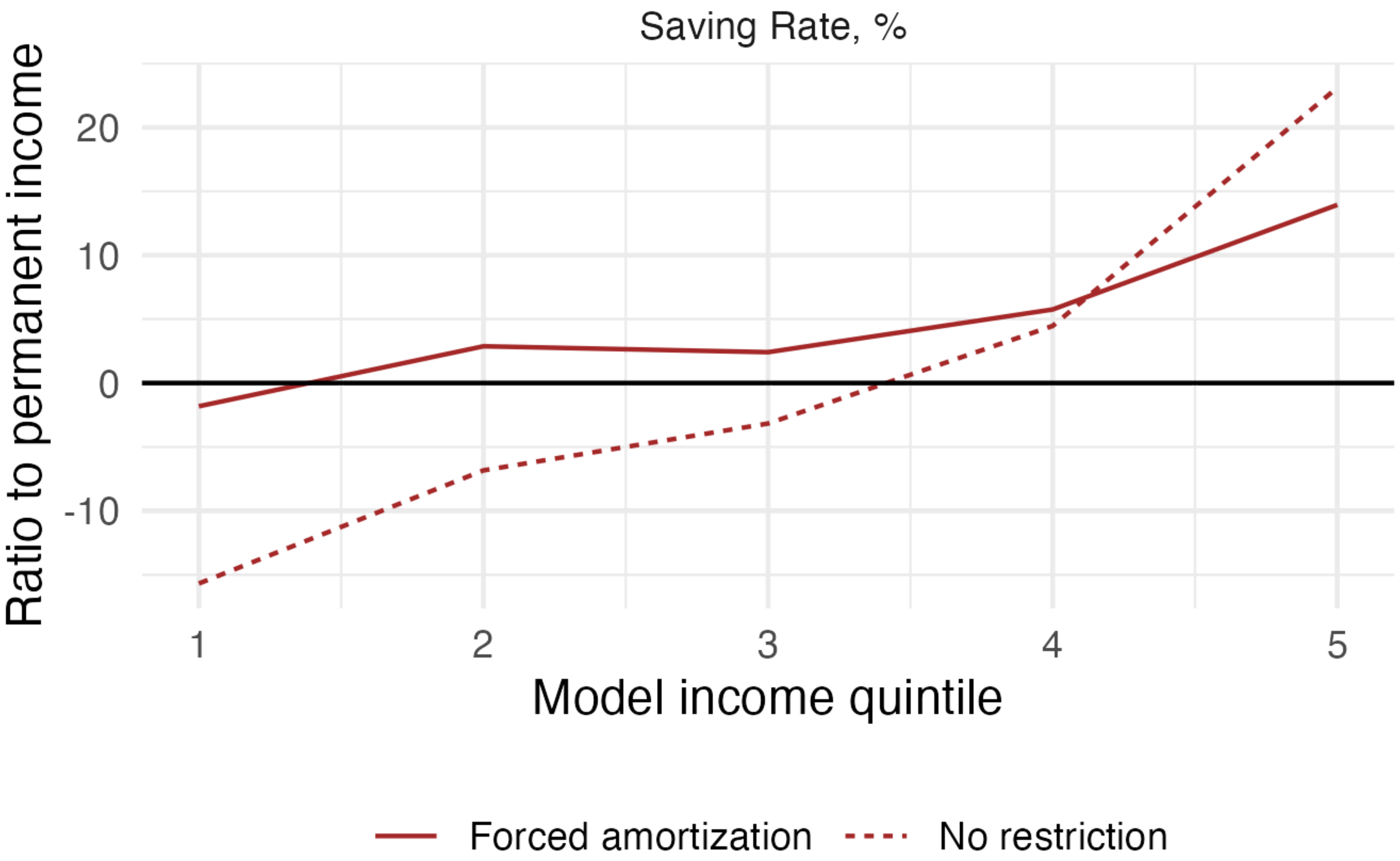
Income-poorer model HHs save more in total, but less into liquid wealth

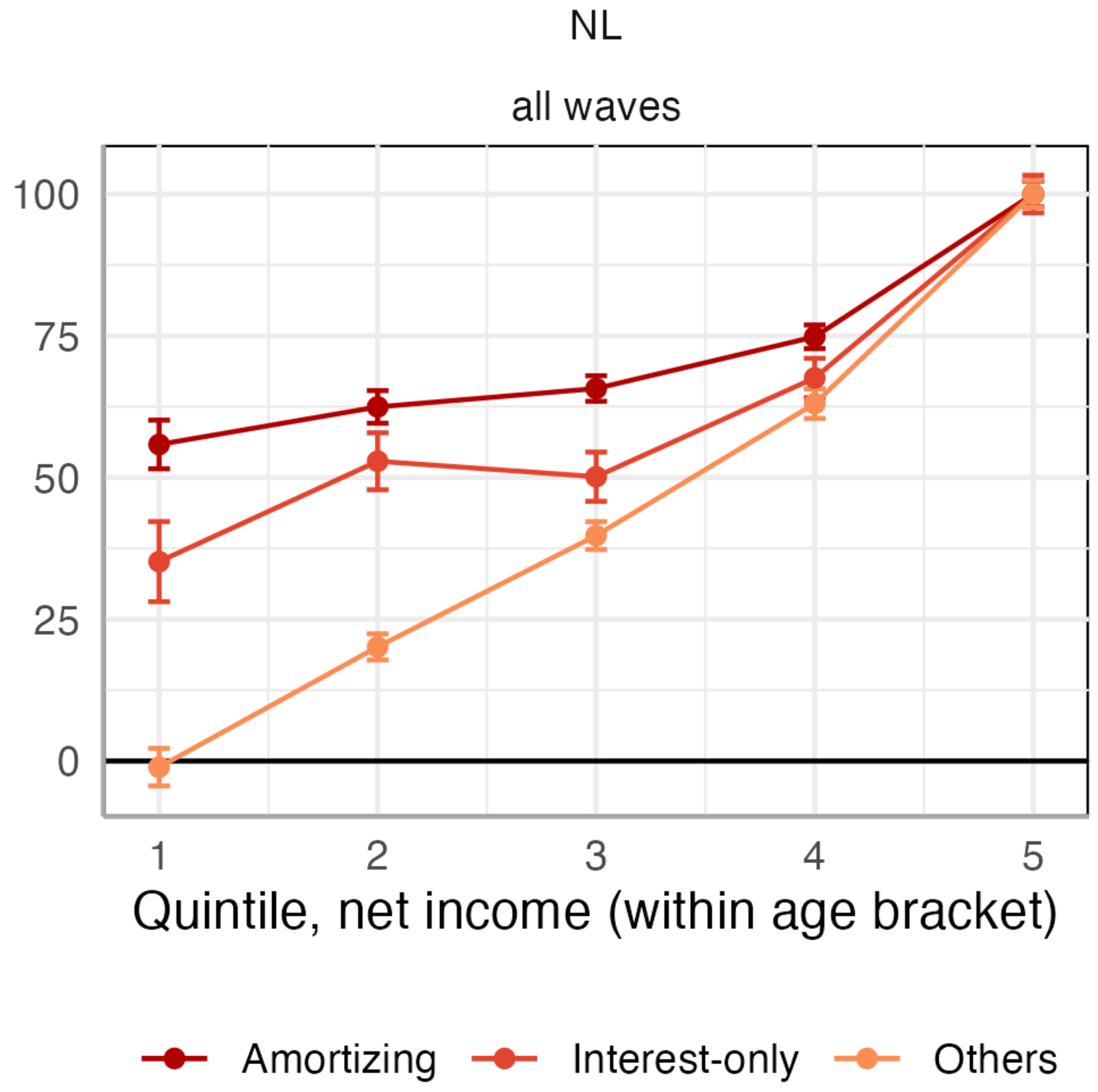
Means of model population across income quintiles (conditional on age)



- Saving rate increases, but $\downarrow C$, liquid savings
- More exposed to shocks $\Rightarrow$ higher MPCs, C volatility

Flattening of saving rate differences reproduces pattern in the data

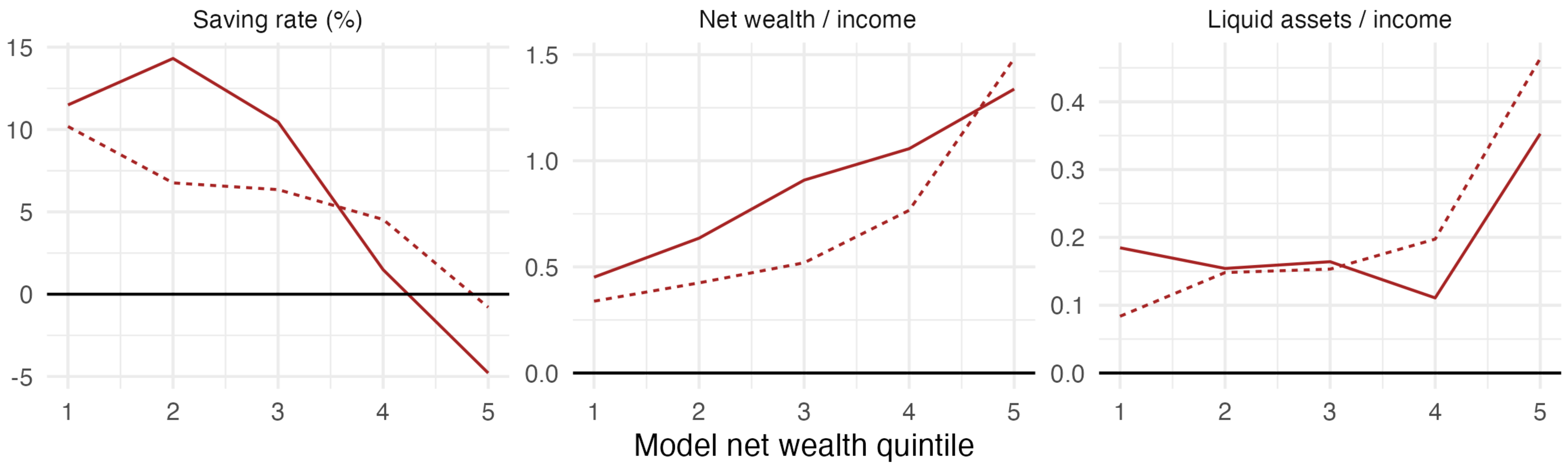




- Saving rates increase for lower income (and younger ages)

Forced amortization increases saving rates at the bottom of wealth dist.

Suggesting effects on distribution of total and financial wealth



- Saving rates increase for groups at the bottom wealth groups
- Implications for wealth distribution: ↓ total wealth inequality but ↑ financial w. ineq., $\%HtM$

Conclusion

Conclusion

- Mortgage debt repayment is an important part of household saving flows
- **Precautionary saving response of homeowners** in standard model rationalizes:
  - → Reduced-form lit: large effects of mandatory amortization on C
  - → Stylized facts in Europe: young, low-income homeowners save more; richer unaffected
- Important implications for consumption and wealth distribution:
  - → $\uparrow$ Total wealth/income ratios, but $\downarrow$ liquid wealth $\Rightarrow$ higher % HtM, MPCs, C volatility
  - → Financial stability benefits must be weighed against costs for households
  - → Younger, lower-income households seem to be unduly penalized

Thank you!

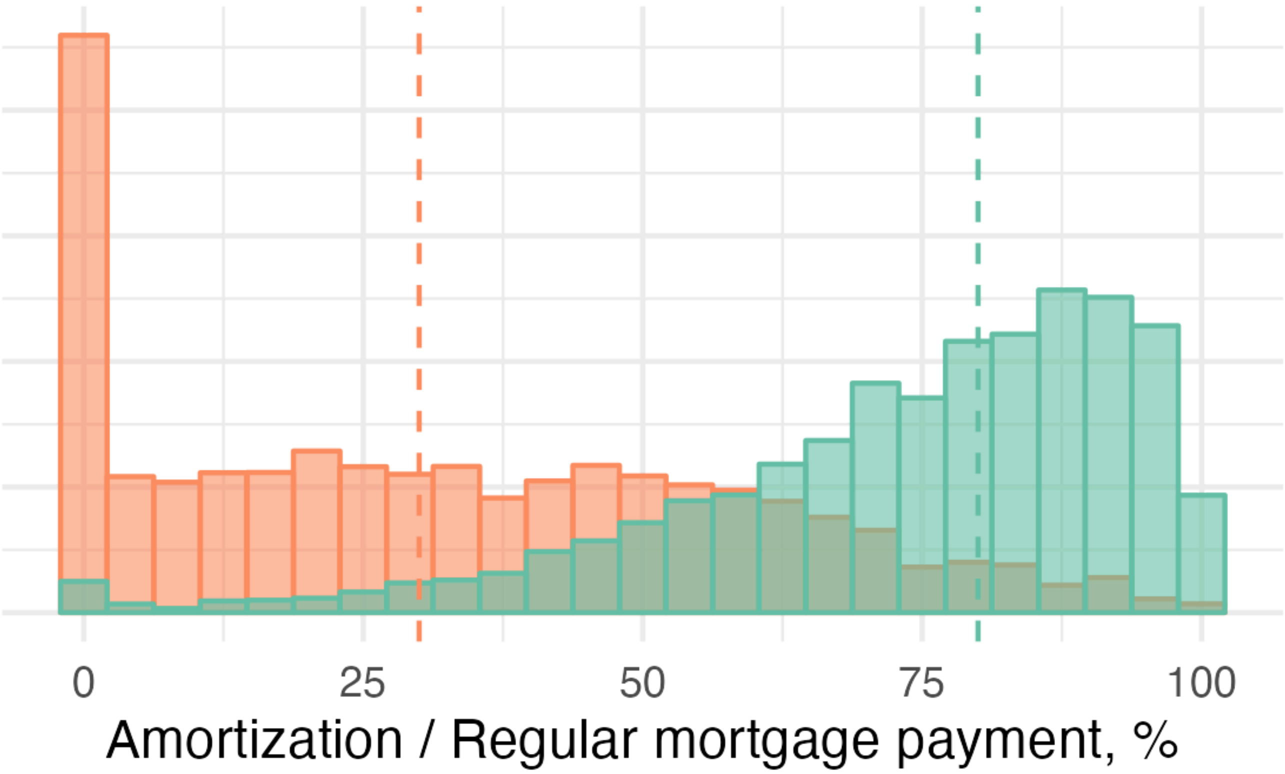
Reach out: **luistelesm.github.io** | **luis.teles.m@novasbe.pt**

Appendix

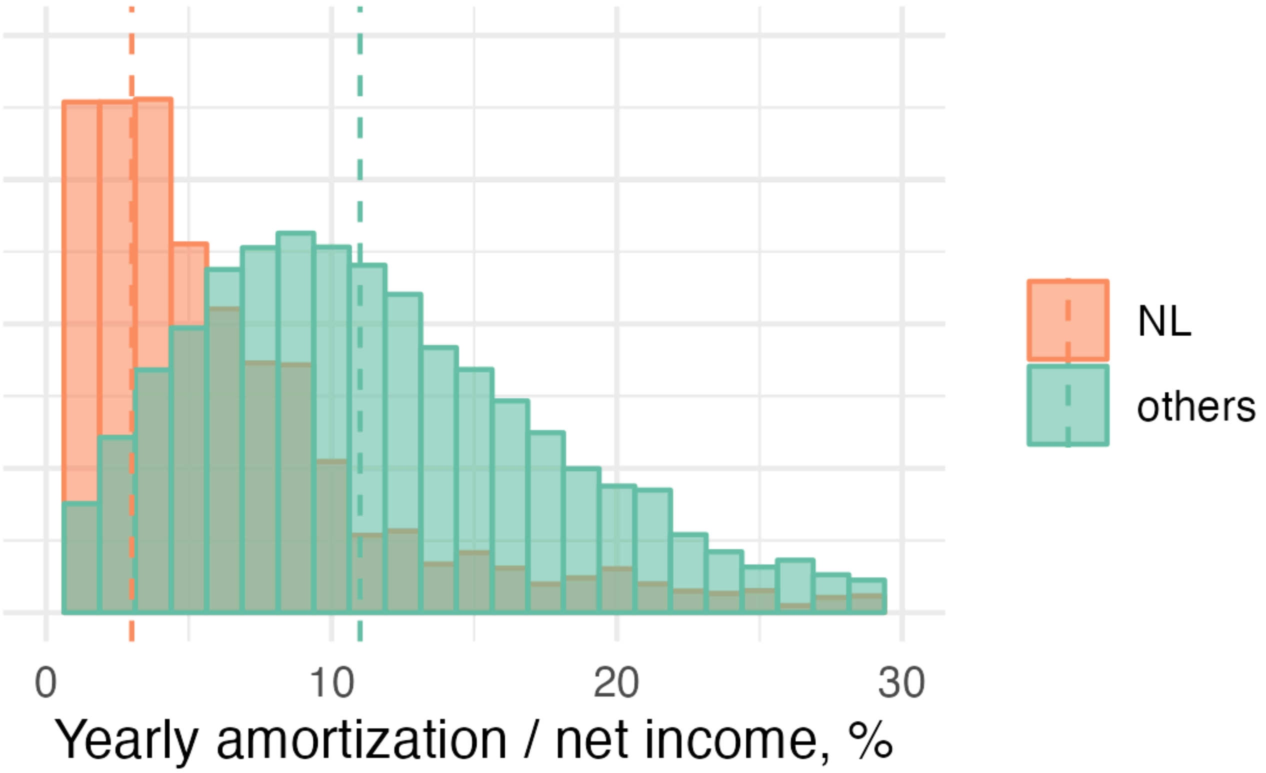
Appendix

Data: mortgage amortization in the HFCS

% of regular payment going to amortization



% of household income going to amortization



Dashed lines indicate medians.

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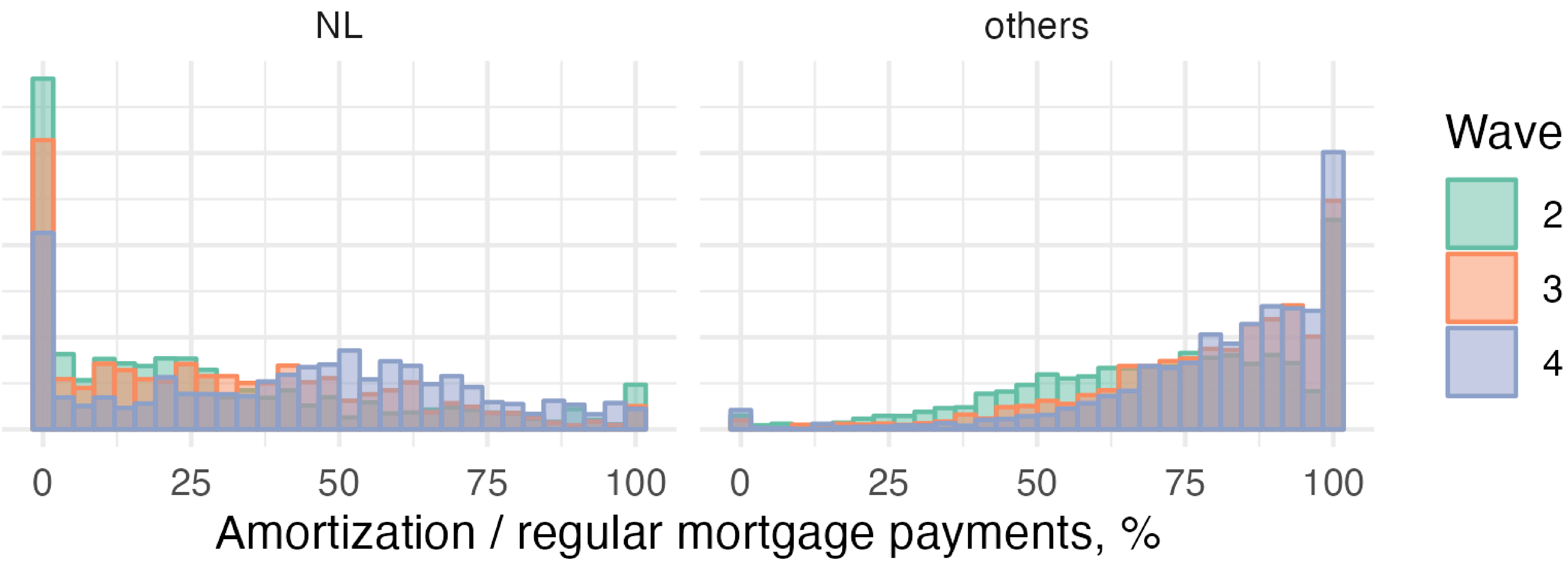
Appendix

Amortization by wave



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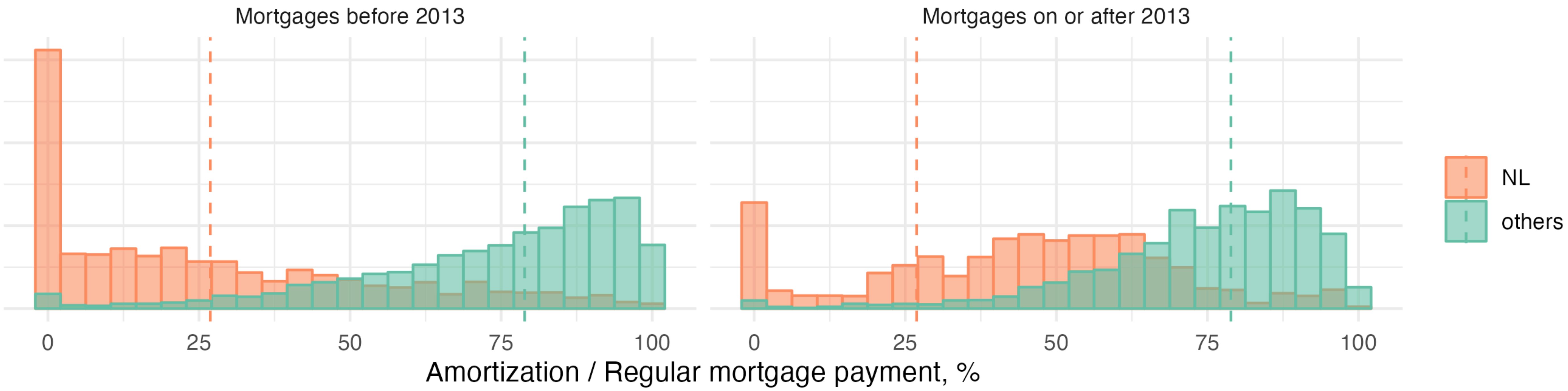
Appendix

Amortization for mortgages before and after 2013



Dashed lines indicate medians.

Percentage of obs. where amortization is less than 5% of the regular payment:

	NL	others
Mortgages before 2013	30.1	1.7
Mortgages on or after 2013	11.8	1.0

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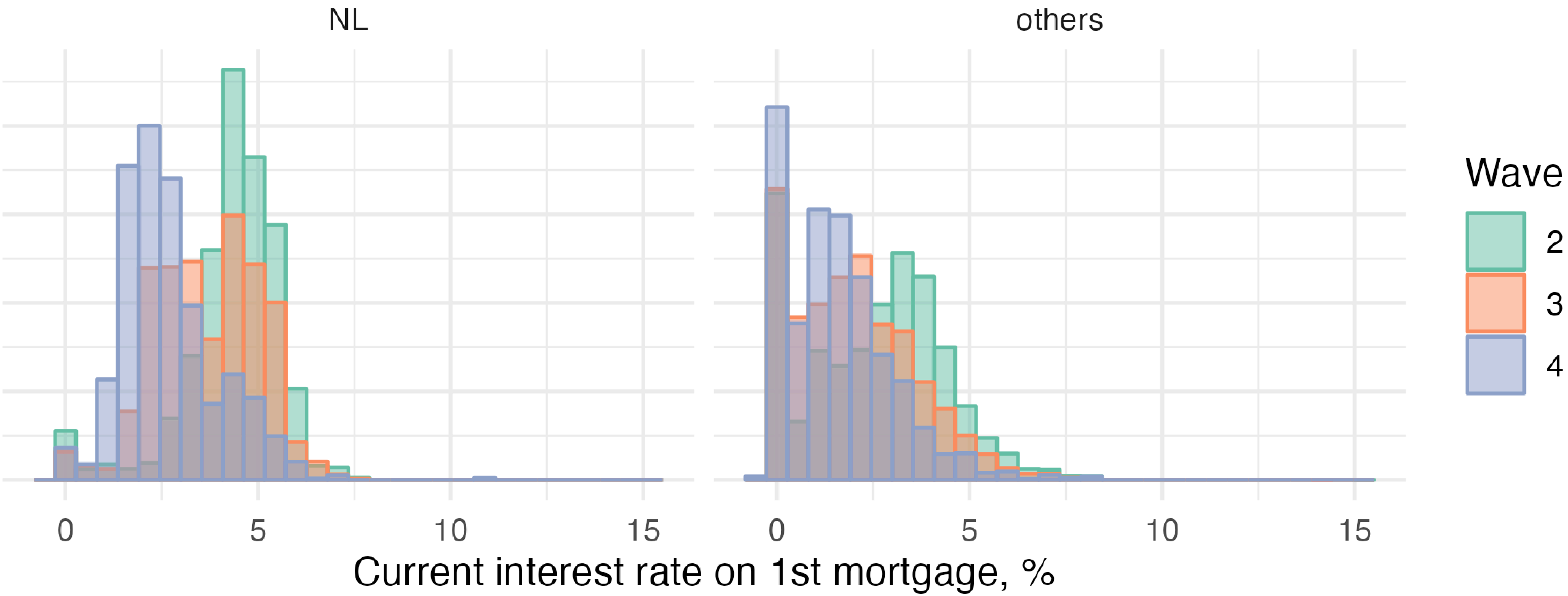
Interest rates



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Appendix

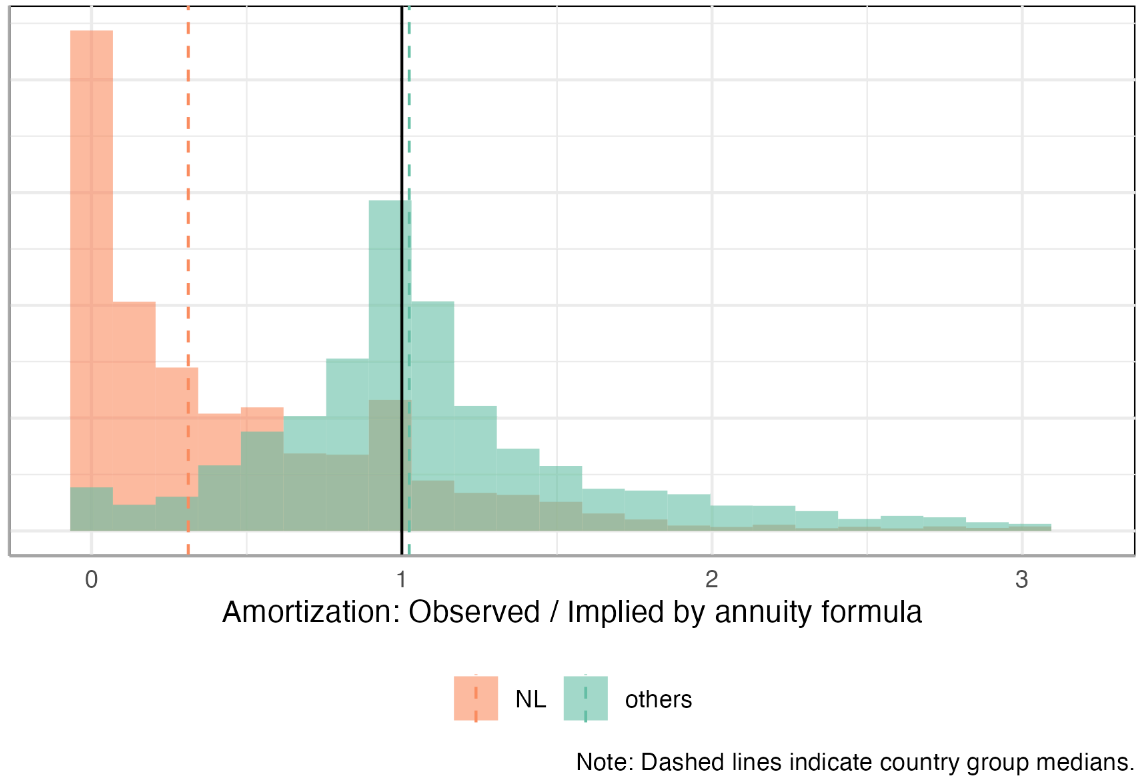
Amortization implied by annuity formula

- If mortgage is an annuitized loan, the amortization paid as part of the installment in period t is:

$$L \times r \times \left(\frac{1}{1 - \frac{1}{(1+r)^{T-t}}} - 1 \right)$$

→ where L is the outstanding amount, r the loan rate and T the residual maturity.

- This is what we observe for the median HH in the overall sample but not in NL:



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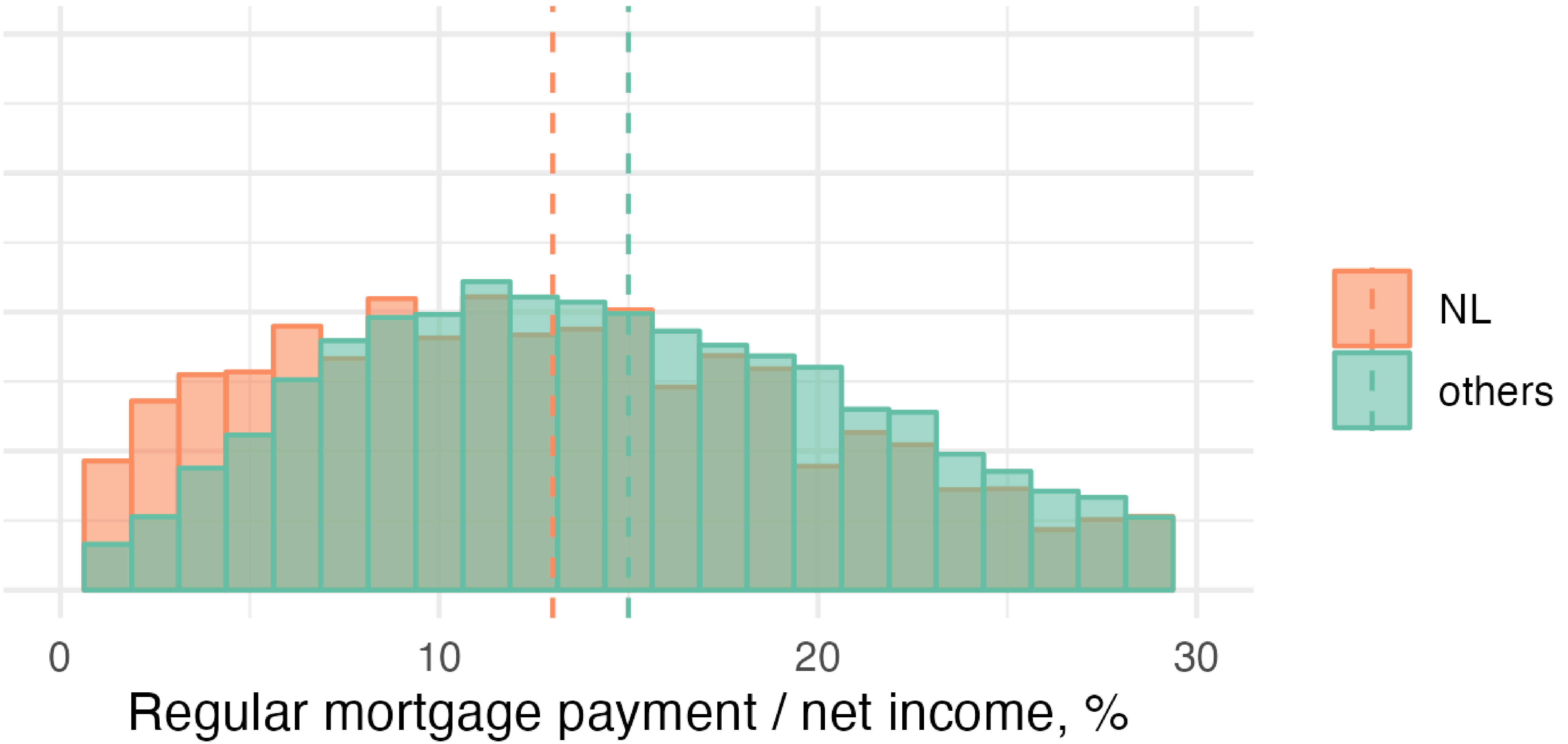
Weight of regular mortgage payments on income



Note: Dashed lines indicate medians.

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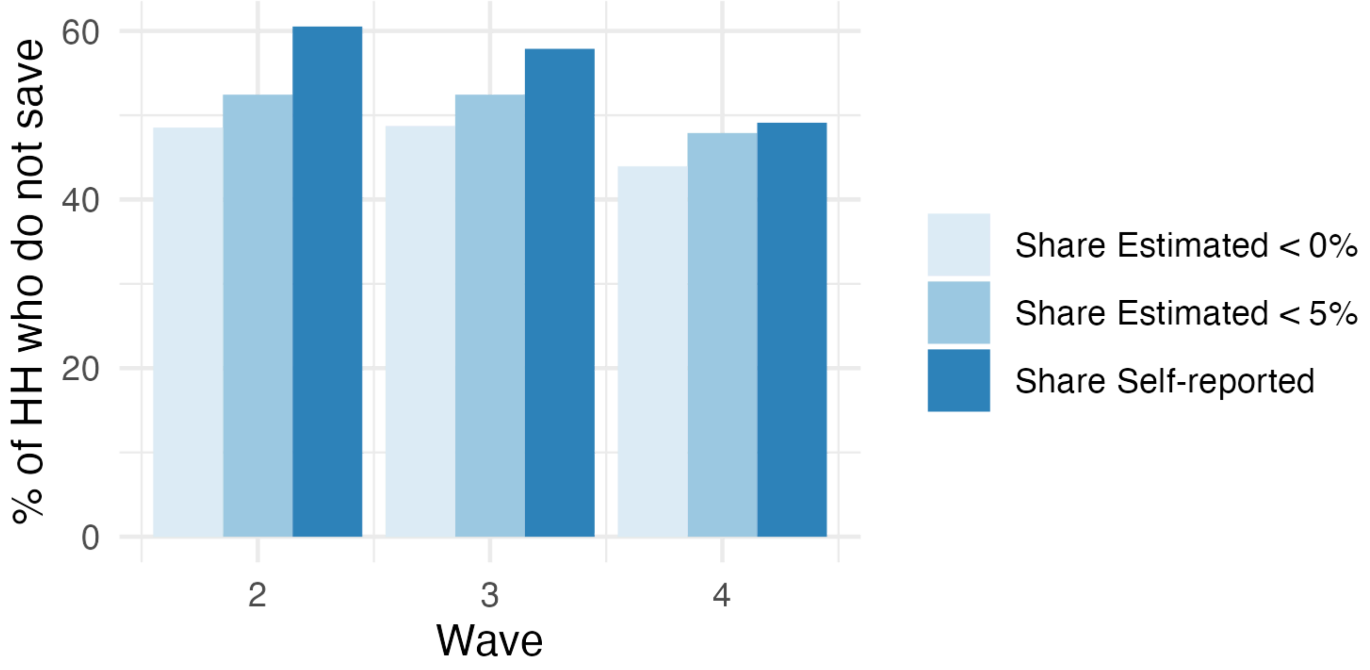
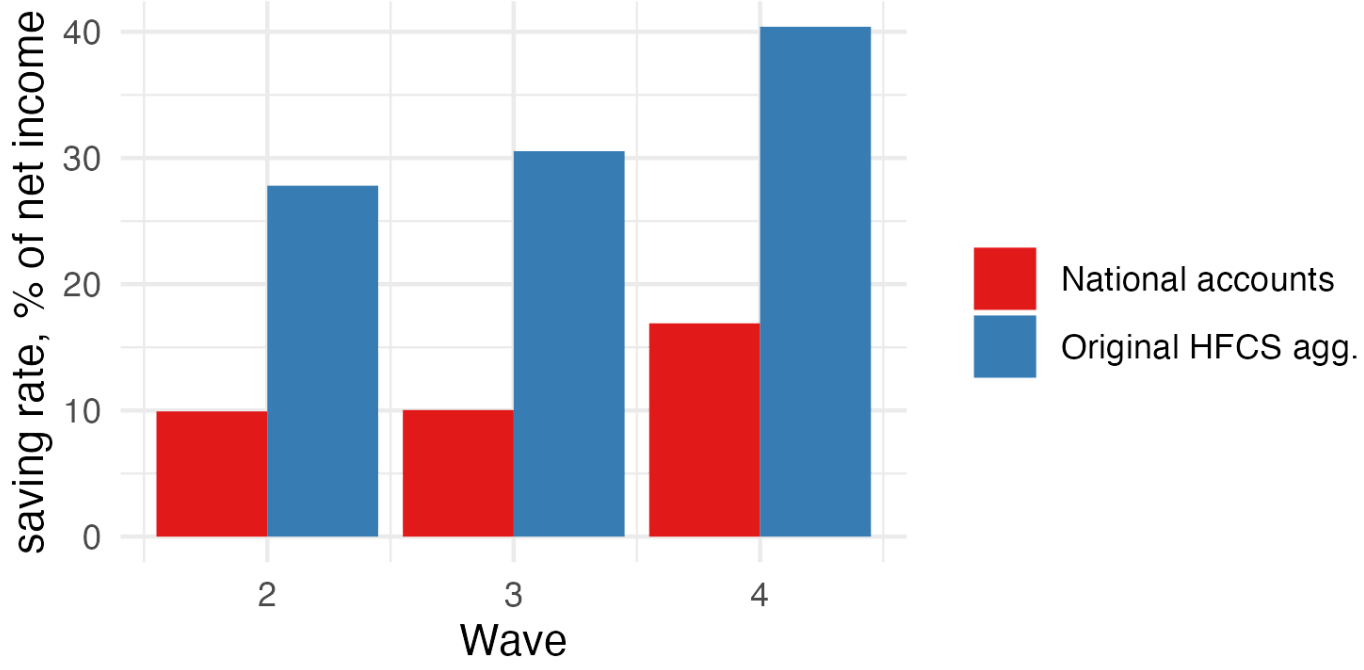
Appendix

Saving rate measure checks

- Match with self-reported ability to save:



- HFCS aggregates vs. national accounts (QSA)



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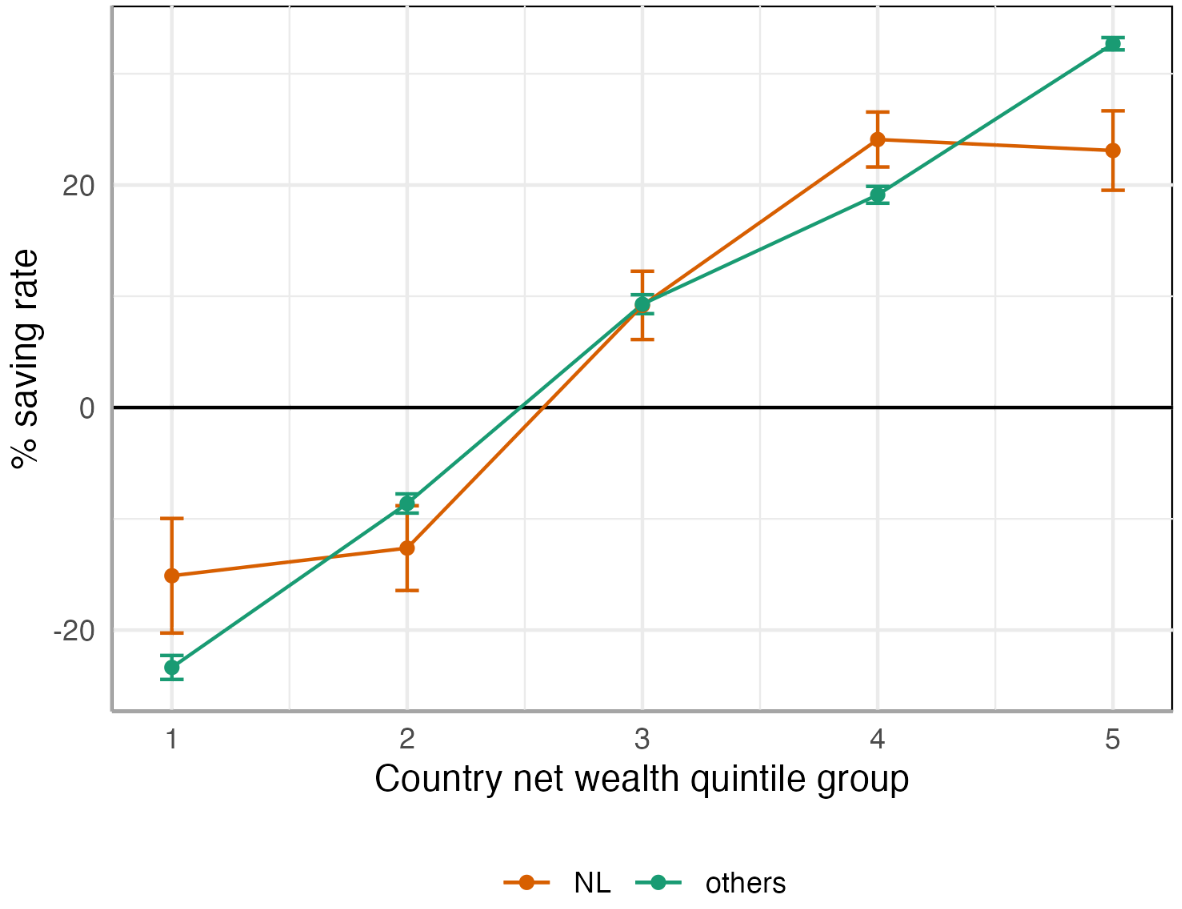
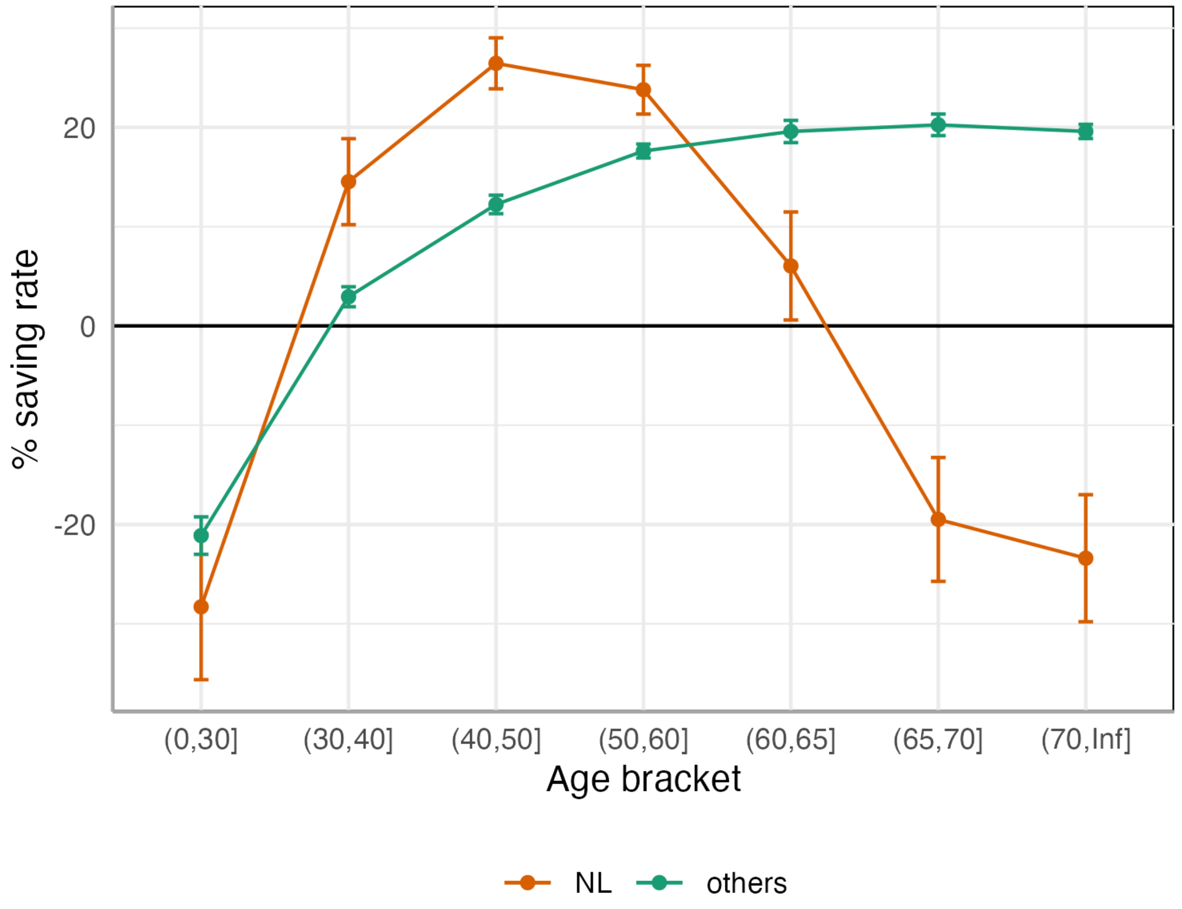
Data: saving rates in the HFCS





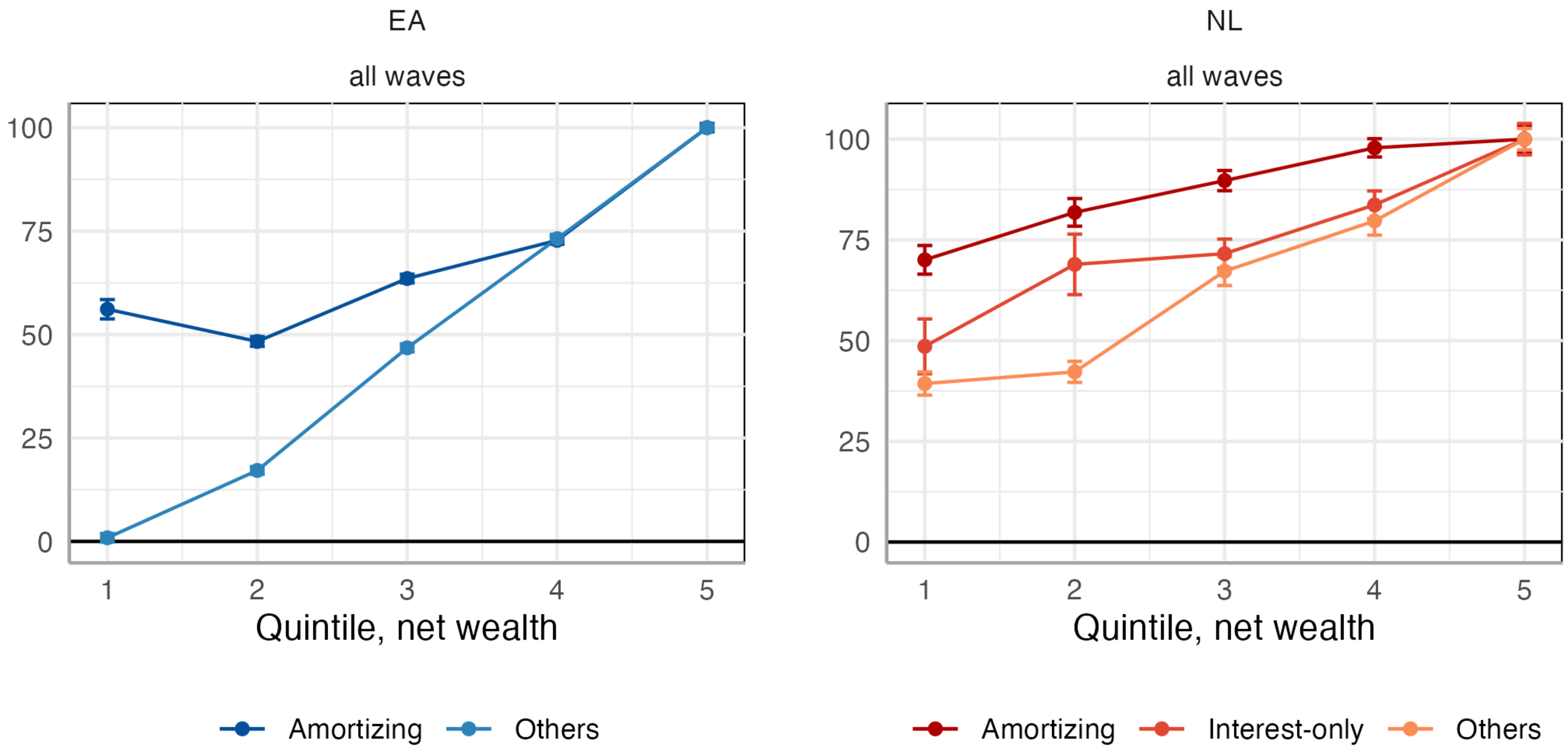
- Saving rates increase with wealth for both

- Decline in old age in NL
- Interesting, as illiquidity of housing possible reason for plateau of saving (eg Yang 2009)

Appendix

Data from Euro area countries

Saving rates over the wealth distribution (Q5 = 100)



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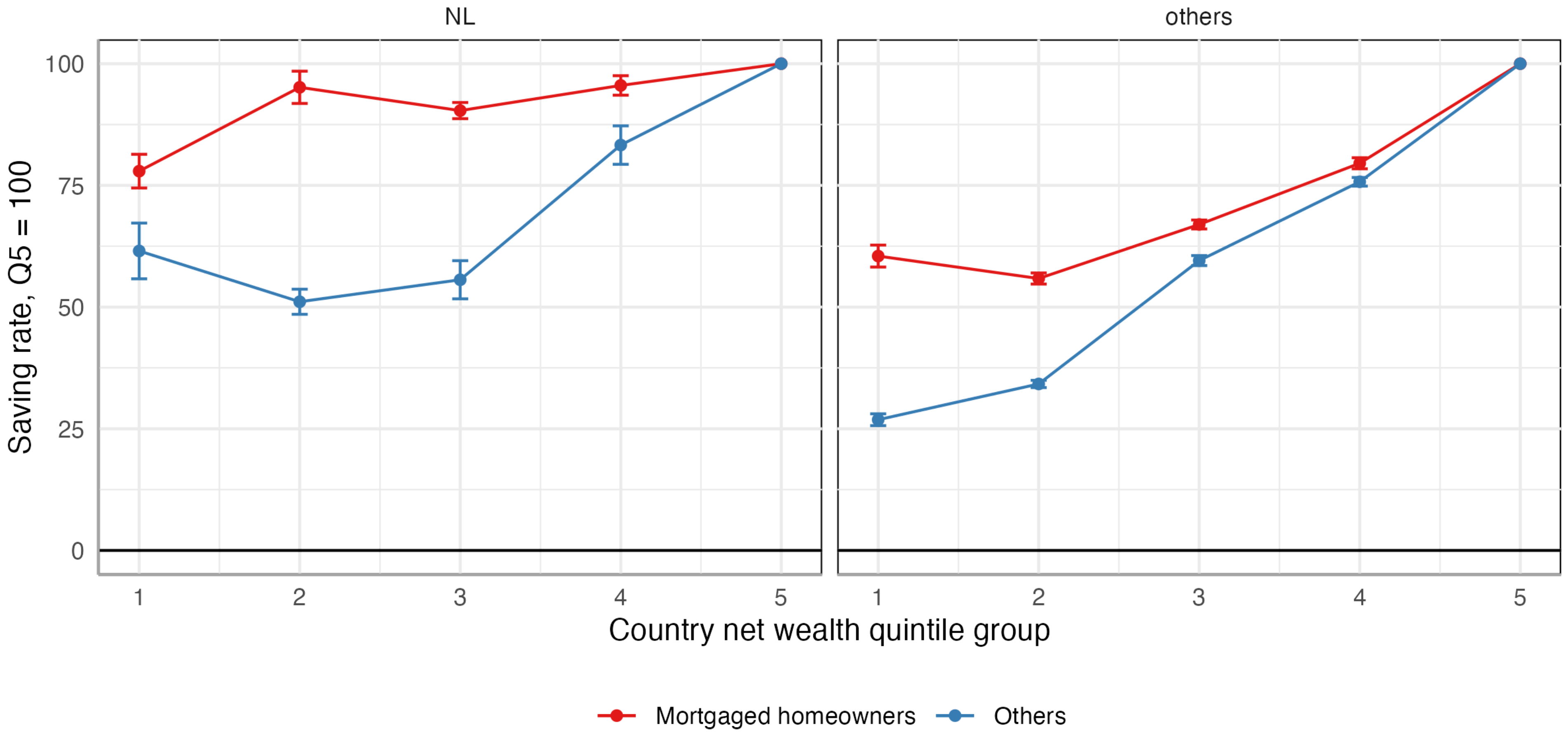
Appendix

Saving rates over the wealth distribution

Mortgaged homeowners vs. others

- Waves 3 and 4:



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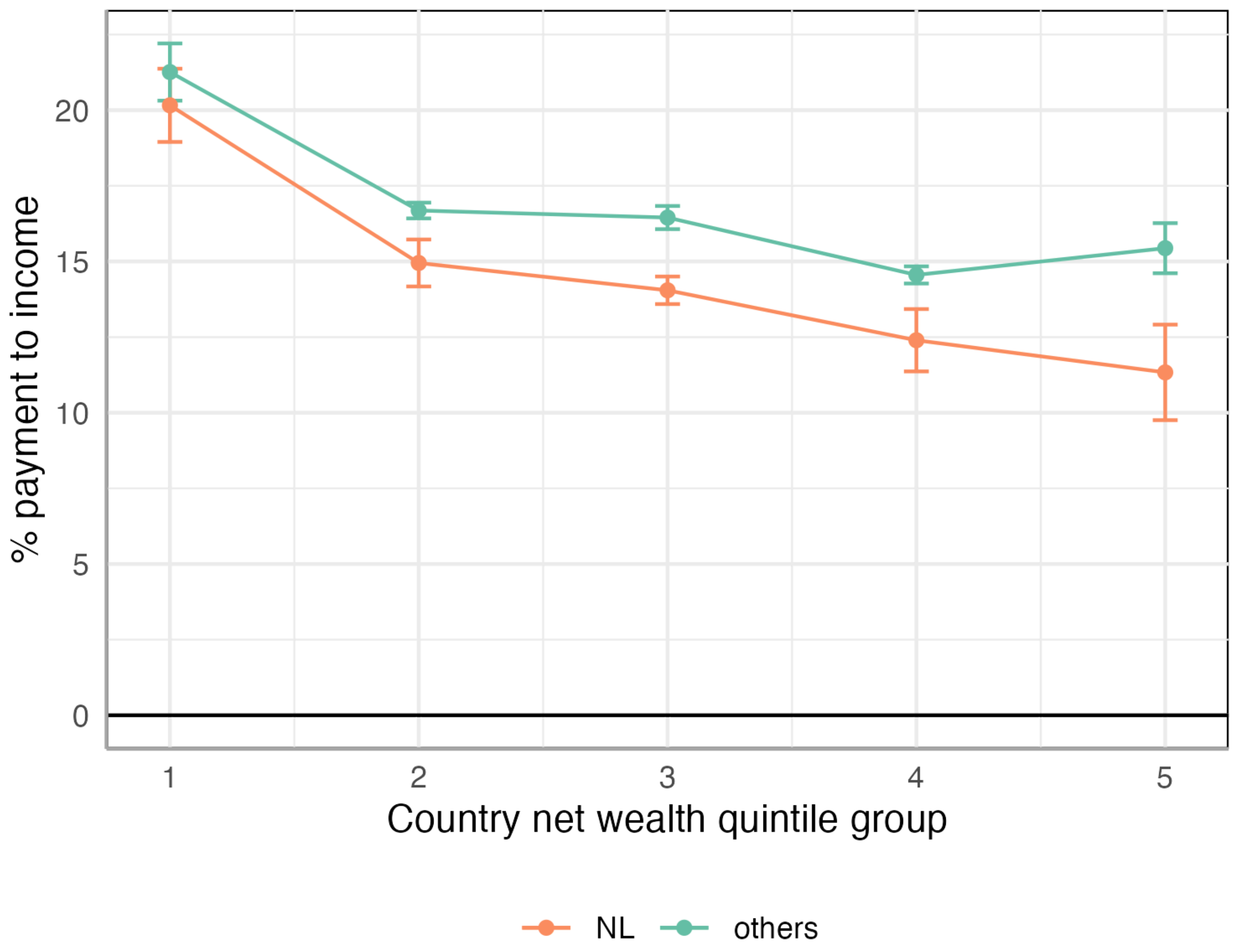
Saving rates over the wealth distribution

Mortgaged homeowners vs. others



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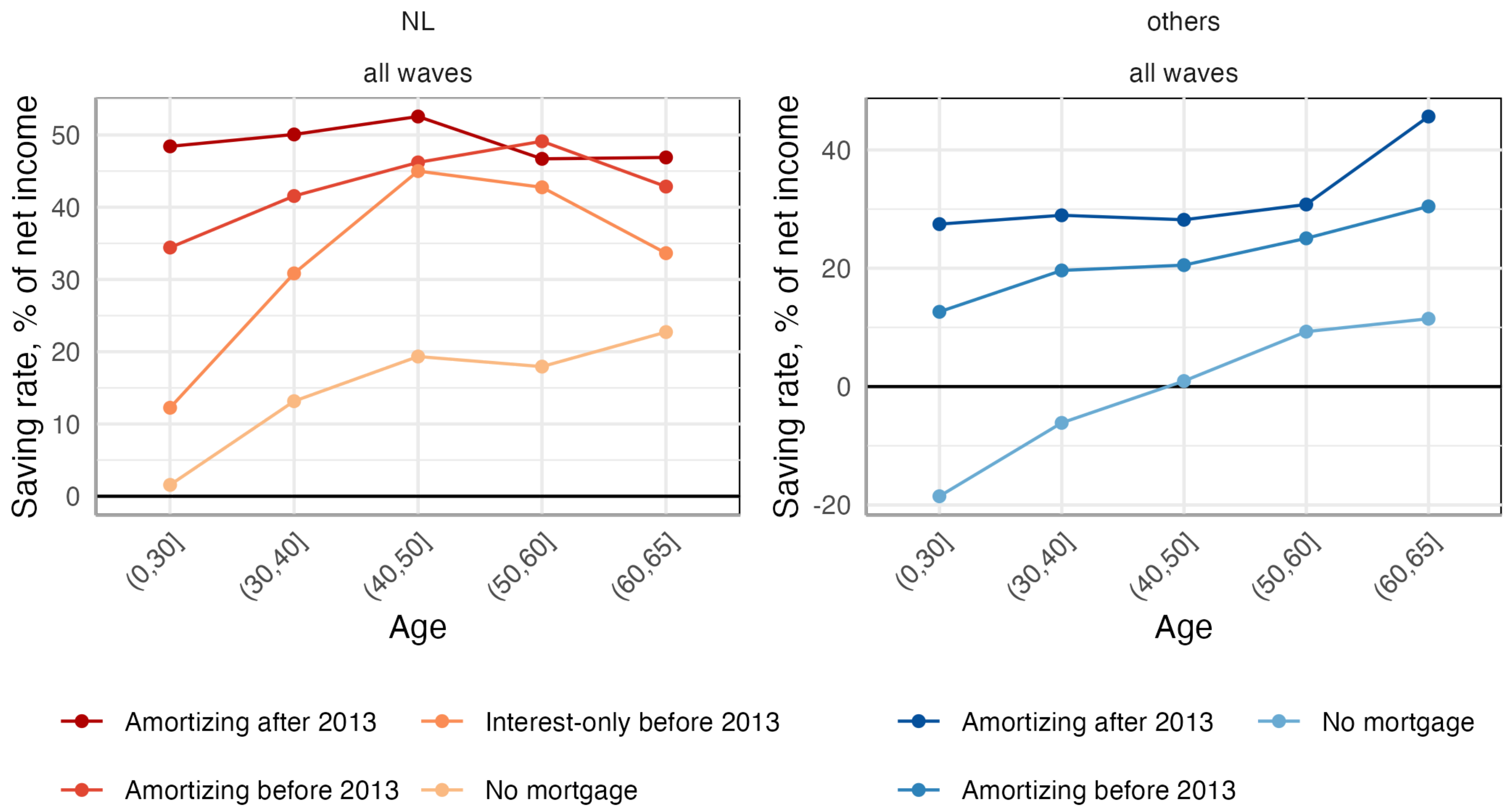
Appendix

Saving rates over the life cycle

Saving by homeowners in NL and others



- No substantial difference between post-policy reform mortgages

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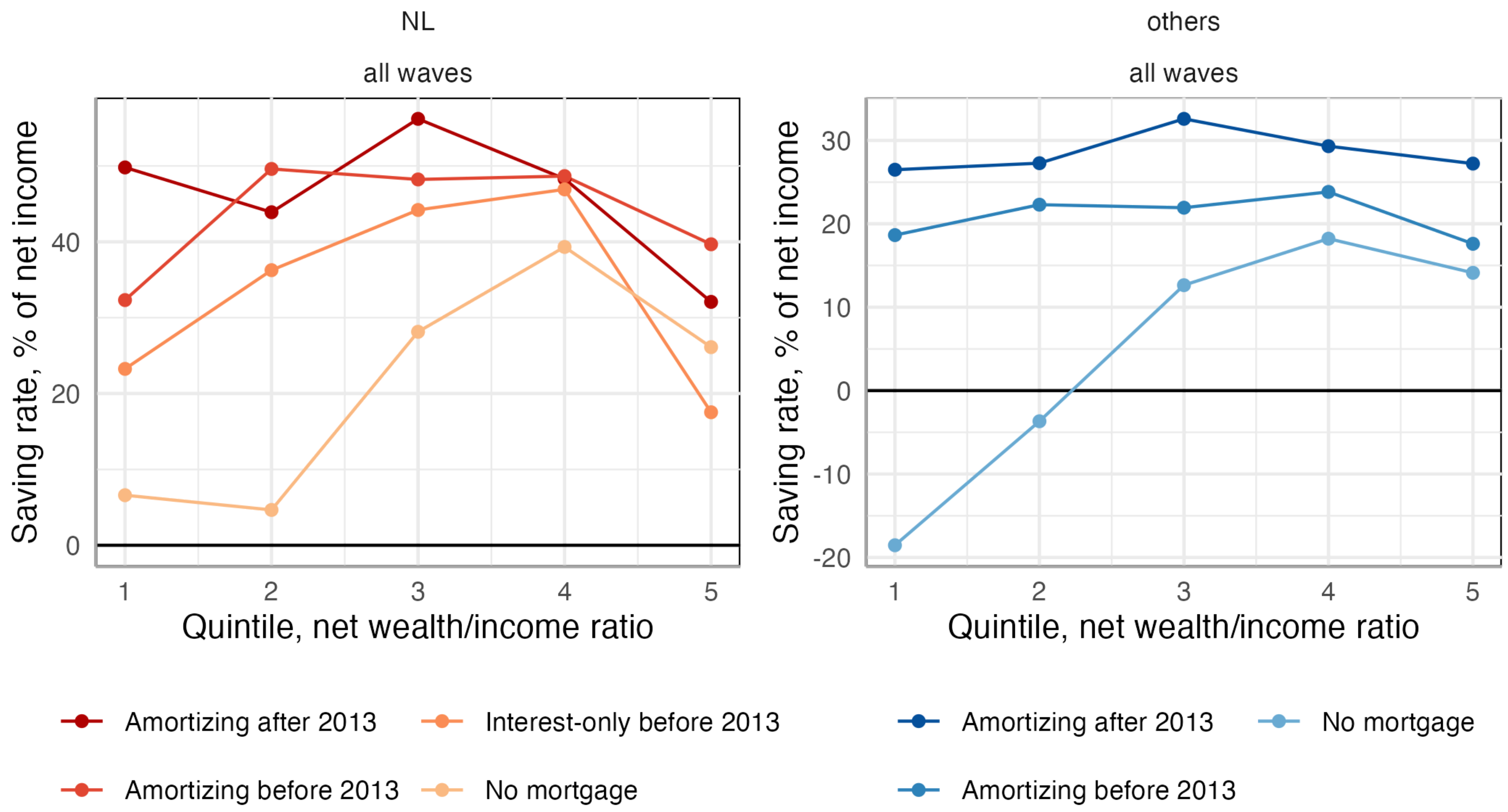
Appendix

Saving rates over the wealth distribution

Saving by homeowners in NL and others



- No substantial difference between post-policy reform mortgages

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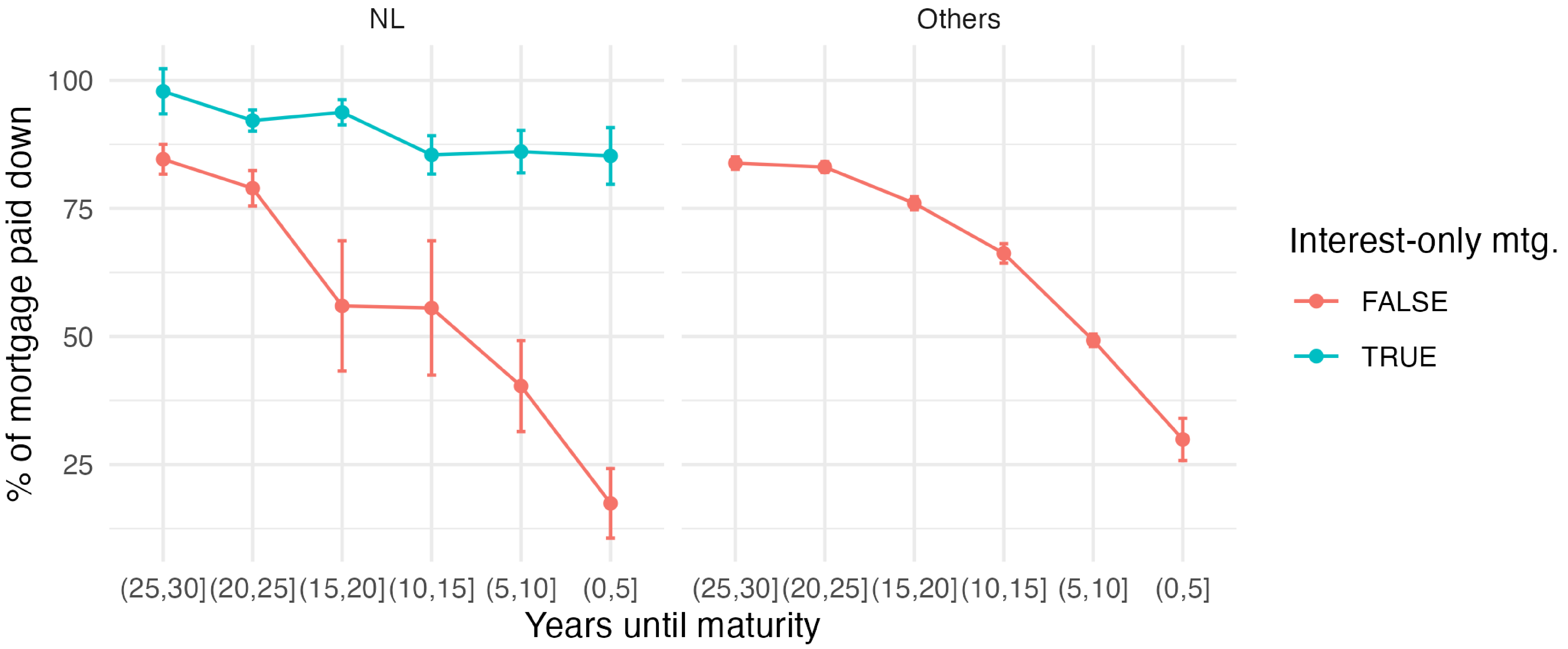
Appendix

Age profiles of debt in the data

- Life cycle profile of savings and mortgage debt
- Strict subsample of households who:
  - → Have never refinanced
  - → Live in their first home
    - ↪ Roughly identified by age at purchase ≤ 35
- Interest-only mortgages: those for which amortization is $<$ 80% implied by annuity formula

Appendix

Age profiles of debt in the data

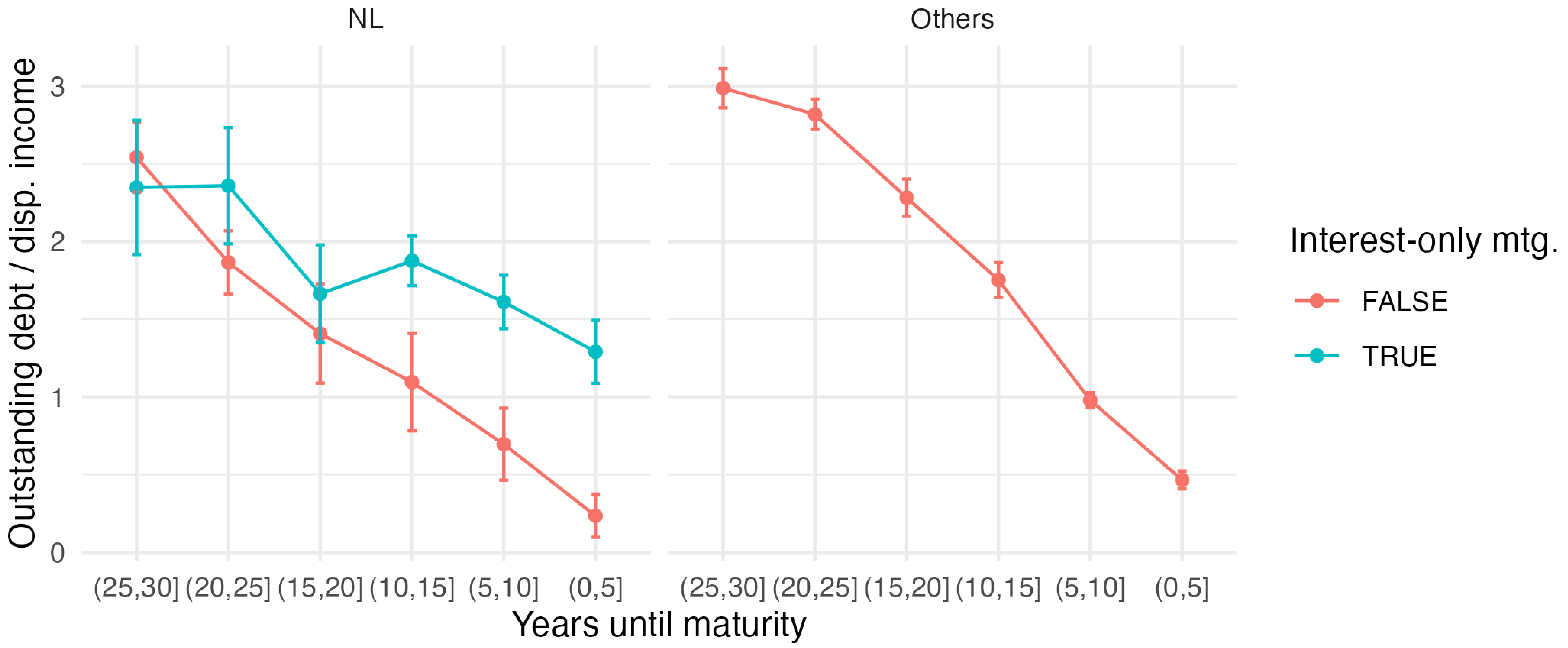


Appendix

Age profiles of debt in the data

Appendix

Age profiles of debt in the data



Appendix

Model solution details

HH problem and solution

Basic principle uses stochastic gradient descent to find parameters of neural network that solve for the optimal policy function.

- Machine learning techniques allow to compute the gradient $\nabla_\theta \tilde{V}\left(s_0, \theta; \hat{\pi}\right)$
  - → Computationally feasible with ML infrastructure, as neural networks are designed to work with problems with many dimension
  - → JAX-based solution (implemented by Barrera & Silva, 2024, **nndp**)
  - → Solved using Google Cloud TPU
- Adjust θ according to:

$$\Delta\theta = -\alpha \nabla_\theta \tilde{V}\left(s_0, \theta; \hat{\pi}\right)$$

  - → i.e., move in the direction that reduces the loss function ($-V$) the fastest
  - → α is the learning rate