

THE EFFECTS OF MONETARY POLICY THROUGH HOUSING AND MORTGAGE CHOICES ON AGGREGATE DEMAND

Karin Kinnerud

BI Norwegian Business School

December 16, 2021

European Central Bank and Banca d'Italia
7th Conference on Household Finance and Consumption

MOTIVATION

- Since the Great Recession mortgage and housing markets have been a concern for many central banks
 - 40 percent of households in the U.S. have a mortgage, mortgage debt corresponds to 70 percent of GDP
 - Owned housing is the largest asset on most households' balance sheets

MOTIVATION

- Since the Great Recession mortgage and housing markets have been a concern for many central banks
 - 40 percent of households in the U.S. have a mortgage, mortgage debt corresponds to 70 percent of GDP
 - Owned housing is the largest asset on most households' balance sheets
- A large theoretical and empirical literature suggests that liquidity-constrained households often respond strongly to changes in their cash flows

MOTIVATION

- Since the Great Recession mortgage and housing markets have been a concern for many central banks
 - 40 percent of households in the U.S. have a mortgage, mortgage debt corresponds to 70 percent of GDP
 - Owned housing is the largest asset on most households' balance sheets
- A large theoretical and empirical literature suggests that liquidity-constrained households often respond strongly to changes in their cash flows
- Monetary policy can substantially influence households' cash flows by affecting their mortgage and housing choices

RESEARCH QUESTION

- What role do mortgages and housing play in the transmission of monetary policy?
 - To what extent does monetary policy affect aggregate demand by influencing households' housing and mortgage choices?
 - What role does changes in mortgage interest rates and house prices play?
 - Do aggregate responses depend on the type of mortgages that are used?
Fixed-rate vs adjustable-rate mortgages

METHOD

- A heterogeneous-agent life-cycle model to trace out aggregate consumption demand as a function of a real interest rate path
 - Mortgage and housing markets are modeled in detail, and house prices are endogenous
 - Incomplete markets and illiquid housing equity
 - Wealthy hand-to-mouth households
 - Relatively poor households with large exposures to interest-rate shocks

METHOD

- A heterogeneous-agent life-cycle model to trace out aggregate consumption demand as a function of a real interest rate path
 - Mortgage and housing markets are modeled in detail, and house prices are endogenous
 - Incomplete markets and illiquid housing equity
 - Wealthy hand-to-mouth households
 - Relatively poor households with large exposures to interest-rate shocks
- Focus on the mechanisms on the demand side
 - Choices in the mortgage and housing markets
 - Heterogeneous cash-flow effects
 - Mortgage-market specifications

PREVIEW OF RESULTS

- Changes in mortgage interest rates and house prices *amplify* the response in aggregate consumption to an expansionary real interest rate shock

PREVIEW OF RESULTS

- Changes in mortgage interest rates and house prices *amplify* the response in aggregate consumption to an expansionary real interest rate shock
- About half of the increase in aggregate demand is driven by a relatively small share of households who update their discrete mortgage and housing choices
 - Households who adjust their tenure choice and, by doing so, improve their liquidity explain 21 percent of the response in demand
 - Together with households who use cash-out refinancing, they are the main contributors to the aggregate demand response

PREVIEW OF RESULTS

- Changes in mortgage interest rates and house prices *amplify* the response in aggregate consumption to an expansionary real interest rate shock
- About half of the increase in aggregate demand is driven by a relatively small share of households who update their discrete mortgage and housing choices
 - Households who adjust their tenure choice and, by doing so, improve their liquidity explain 21 percent of the response in demand
 - Together with households who use cash-out refinancing, they are the main contributors to the aggregate demand response
- These mechanisms are more pronounced when mortgages have adjustable as opposed to fixed rates: the aggregate consumption response is larger
- The flexibility of both the mortgage *and* the housing market matters for the transmission of monetary policy

LITERATURE REVIEW

- Empirical studies on importance of mortgages for monetary policy
Calza, Monacelli, and Stracca (2013); Di Maggio, Kermani, Keys, Piskorski, Ramcharan, Seru, and Yao (2017); Cloyne, Ferreira, and Surico (2019); Flodén, Kilström, Sigurdsson, and Vestman (2021); Wong (2021)
- Importance of liquid and illiquid wealth for fiscal and monetary policy
Kaplan and Violante (2014); Kaplan, Moll, and Violante (2018); Auclert (2019)
- Mortgages and housing, and monetary policy
Beraja, Fuster, Hurst, Vavra (2019); Berger, Milbradt, Tourre, Vavra (2021); Chen, Michaux, Roussanov (2013); Eichenbaum, Rebelo, Wong (2020); Garriga, Kydland, Sustek (2017); Greenwald (2018); Hedlund, Karahan, Mitman, Ozkan (2019); Wong (2021)

TABLE OF CONTENTS

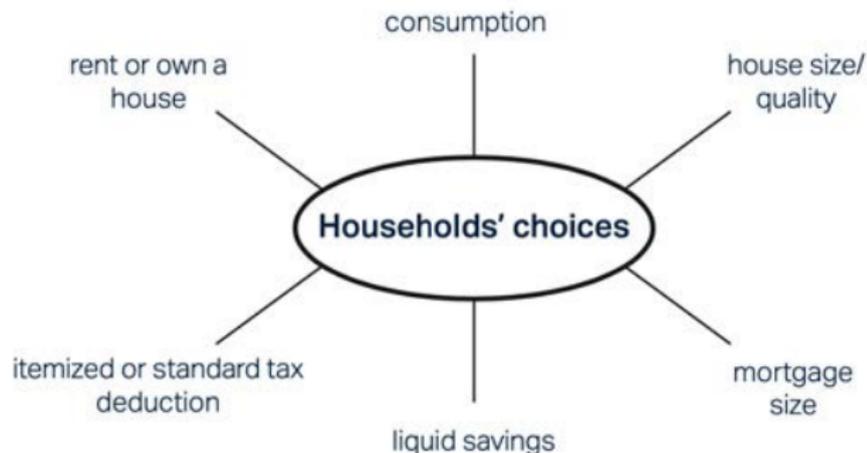
1 MODEL

2 CALIBRATION

3 RESULTS

MODEL OVERVIEW

A heterogeneous-agent incomplete-markets life-cycle model to investigate how consumers respond in the aggregate to a real interest rate shock



HOUSEHOLDS

- Households live at most $J = 60$ periods (ages 23-82)
 - Age-dependent death probability

HOUSEHOLDS

- Households live at most $J = 60$ periods (ages 23-82)
 - Age-dependent death probability
- Exogenous earnings (y): deterministic trend, permanent and transitory shocks
 - In retirement, benefits (y) in a fixed proportion of permanent earnings at $j = 42$ (age 64), subject to a cap

HOUSEHOLDS

- Households live at most $J = 60$ periods (ages 23-82)
 - Age-dependent death probability
- Exogenous earnings (y): deterministic trend, permanent and transitory shocks
 - In retirement, benefits (y) in a fixed proportion of permanent earnings at $j = 42$ (age 64), subject to a cap
- $U_j(c, s) = e_j \frac{(c^\alpha s^{1-\alpha})^{1-\sigma}}{1-\sigma}, \quad U^B(q) = v \frac{(q' + \bar{q})^{1-\sigma}}{1-\sigma}$

MARKETS

- The housing market
 - Fixed aggregate housing supply, but divisible owned and rental housing
 - House prices are endogenous
 - Transaction costs when buying and selling a house
 - Rental housing is owned by foreign investors, and the rental rate is given by a user-cost formula `rental market`

MARKETS

- The housing market
 - Fixed aggregate housing supply, but divisible owned and rental housing
 - House prices are endogenous
 - Transaction costs when buying and selling a house
 - Rental housing is owned by foreign investors, and the rental rate is given by a user-cost formula `rental market`
- The mortgage market
 - Possibility to finance owned housing with 30-yr non-defaultable mortgages
 - Amortization plans specify the required minimum mortgage payment
 - Down-payment and payment-to-income requirements (LTV & PTI)
 - Fixed and proportional refinancing costs, ζ^r and ζ_p^r
 - Mortgage interest payments (and property taxes) are deductible, and earnings are taxed progressively `taxes`

HOUSEHOLDS' DYNAMIC PROBLEM

For each $k \in \{R, B, Ref, S\}$, and $\mathbf{z} = \{h, m, ma, n, x\}$:

$$V_j^k(\mathbf{z}) = \max_{c, s, h', m', b'} U_j(c, s) + (1 - \phi_j)U^B(q') + \beta\phi_j\mathbb{E}_j [V_{j+1}(\mathbf{z}')]]$$

HOUSEHOLDS' DYNAMIC PROBLEM

For each $k \in \{R, B, Ref, S\}$, and $\mathbf{z} = \{h, m, ma, n, x\}$:

$$V_j^k(\mathbf{z}) = \max_{c, s, h', m', b'} U_j(c, s) + (1 - \phi_j)U^B(q') + \beta\phi_j\mathbb{E}_j [V_{j+1}(\mathbf{z}')]]$$

s.t.

$$\underbrace{c + b' + \mathbb{I}^R p_r s + \mathbb{I}^B (1 + \zeta^b) p_h h' + \mathbb{I}^{Ref, S} (1 - \zeta^s) p_h h + \mathbb{I}^{Ref} (\zeta^r + \zeta_p^r m')}_{\text{"Expenditures"}} \leq \underbrace{x + m'}_{\text{"Money to spend"}}$$

HOUSEHOLDS' DYNAMIC PROBLEM

For each $k \in \{R, B, Ref, S\}$, and $\mathbf{z} = \{h, m, ma, n, x\}$:

$$V_j^k(\mathbf{z}) = \max_{c, s, h', m', b'} U_j(c, s) + (1 - \phi_j)U^B(q') + \beta\phi_j\mathbb{E}_j [V_{j+1}(\mathbf{z}')]$$

s.t.

$$\underbrace{c + b' + \mathbb{I}^R p_r s + \mathbb{I}^B (1 + \zeta^b) p_h h' + \mathbb{I}^{Ref, S} (1 - \zeta^s) p_h h + \mathbb{I}^{Ref} (\zeta^r + \zeta_p^r m')}_{\text{"Expenditures"}} \leq \underbrace{x + m'}_{\text{"Money to spend"}}$$

$$\mathbb{I}^{B, Ref} m' \leq (1 - \theta) p_h h' \quad \text{LTV constraint}$$

$$\mathbb{I}^{B, Ref} \left(\frac{\chi_{j+1, ma} m' + (\tau^h + \zeta^l) p_h h'}{n} \right) \leq \psi \quad \text{PTI constraint}$$

$$\mathbb{I}^S m' \leq (1 + r_m) m - \chi_{j, ma} m \quad \text{Min payment}$$

$$s = h' \quad \text{if } h' > 0$$

$$m' \geq 0 \quad \text{if } h' > 0$$

$$m' = 0 \quad \text{if } h' = 0$$

$$c > 0, s \in S, h' \in H, b' \geq 0.$$

TABLE OF CONTENTS

1 MODEL

2 CALIBRATION

3 RESULTS

CALIBRATION

- Parameters that can be directly calibrated from data are set in that way

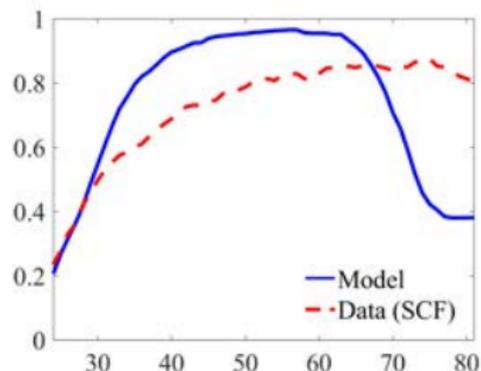
Independently calibrated parameters

- That leaves 10 parameters that are calibrated internally to match cross-sectional and life-cycle moments, e.g.,
 - The homeownership rate
 - Housing wealth relative to earnings
 - Leverage
 - Prevalence of refinancing

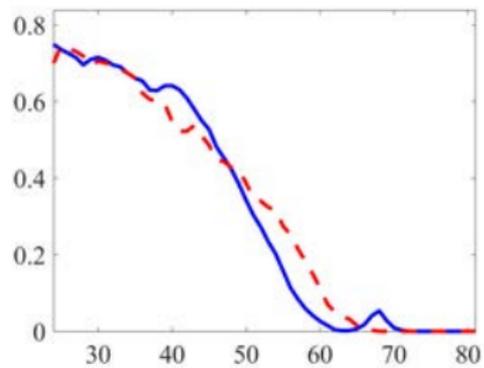
Internally calibrated parameters

LIFE-CYCLE PROFILES

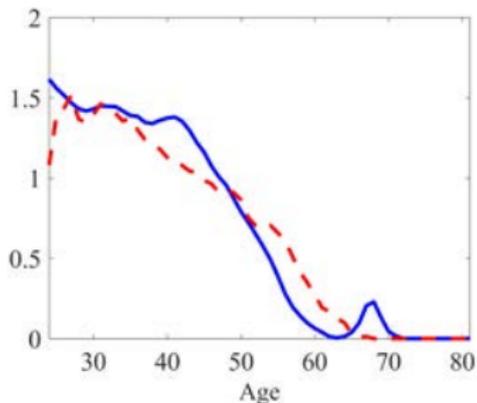
Homeownership rate



Median LTV



Median mortgage-to-earnings



Median house-to-earnings

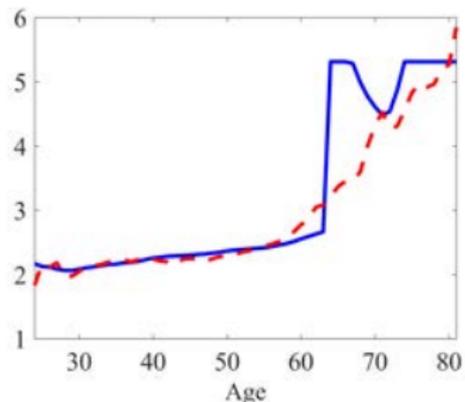


TABLE OF CONTENTS

1 MODEL

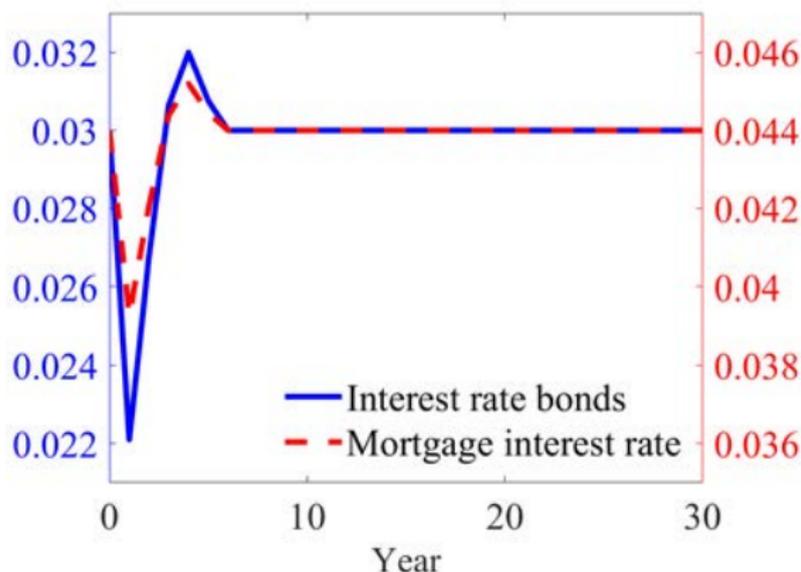
2 CALIBRATION

3 RESULTS

THE EXPERIMENT

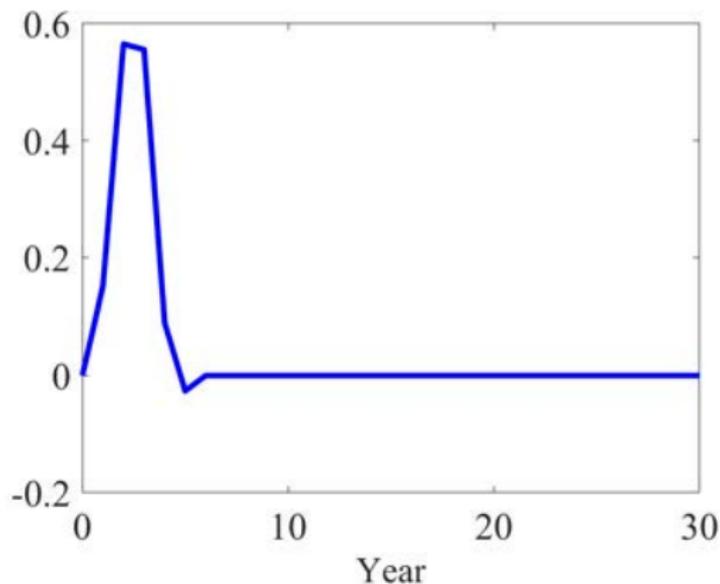
- Start from steady state with an invariant distribution over households
- Study non-linear impulse response functions to a probability zero shock to the real interest rate
- Following Boppart, Krusell, and Mitman (2018) can use IRFs to provide a linearized solution to the model with aggregate risk (i.e. only first-order effects of aggregate shock, as with standard first-order perturbation)

THE REAL INTEREST RATE SHOCK



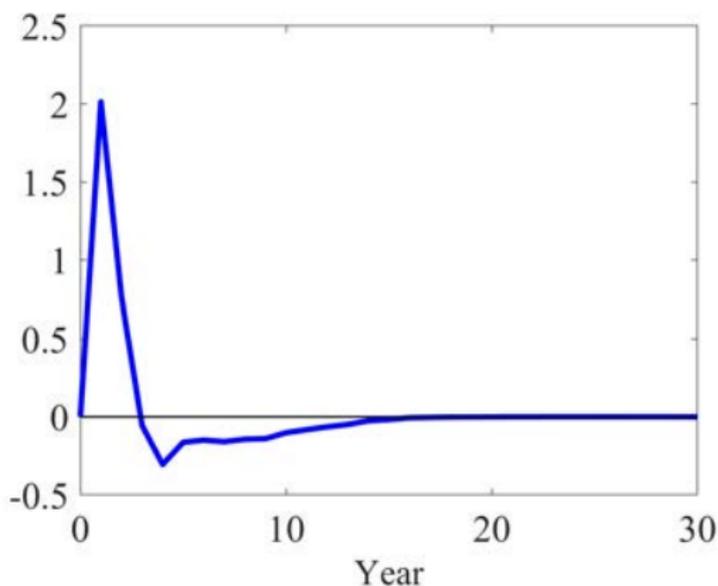
- -100bp monetary policy shock
- Empirically estimated path of the real interest rate, from Auclert, Rognlie, and Straub (2020)
- 60% pass-through to 30-yr rate of fixed-rate mortgages (FRM)

THE PATH OF INCOME



- Empirically estimated path of output, also from Auclert et al. (2020)

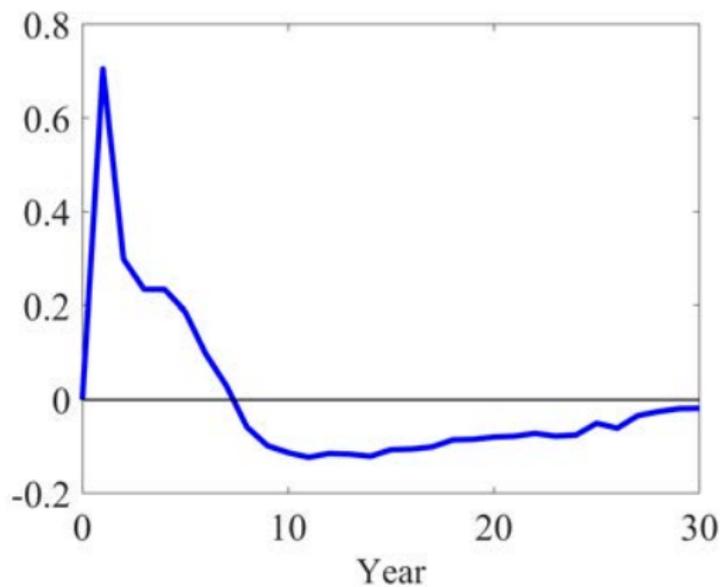
EQUILIBRIUM HOUSE PRICES



- House prices increase in response to expansionary monetary policy
- In line with empirical findings

Rental rate

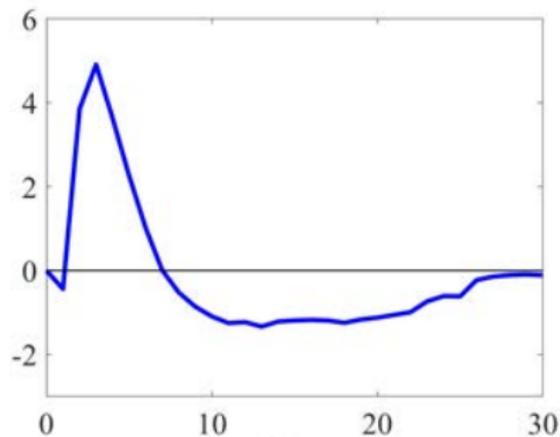
RESPONSE OF CONSUMPTION



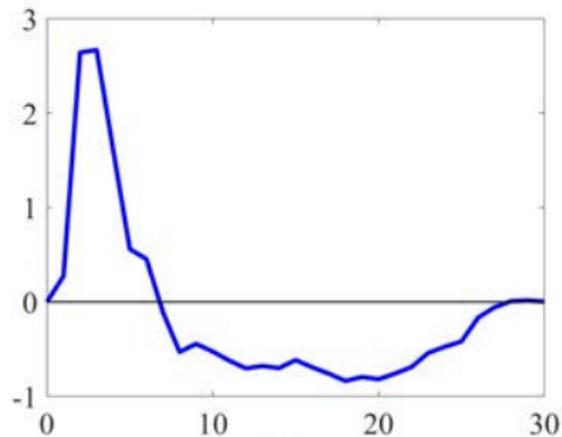
Changes in discrete choices over time

SAVINGS BEHAVIOR

Liquid savings



Mortgages



- Savings in liquid bonds actually increase...
- ... While the aggregate mortgage balance also increases

THE MECHANISMS: PRICES AND DISCRETE CHOICES

First period of the transition, Δ consumption (%):

	Δr	$+\Delta r_m$	$+\Delta p_h$	$+\Delta y$
ΔC	0.06	0.18	0.29	0.70

Changes in mortgage interest rates and house prices *amplify* the response in aggregate consumption

THE MECHANISMS: PRICES AND DISCRETE CHOICES

First period of the transition, Δ consumption (%):

	Δr	$+ \Delta r_m$	$+ \Delta p_h$	$+ \Delta y$
ΔC	0.06	0.18	0.29	0.70

Changes in mortgage interest rates and house prices *amplify* the response in aggregate consumption

ΔC , optimal portfolio choices	0.70
ΔC , steady-state discrete choices	0.34

Half of the aggregate demand response is driven by households' discrete portfolio updates

DISCRETE CHOICES & CONSUMPTION

Mean Δ consumption (%)

	Buyers	Refinancers	Movers	Stayers	Renters
Buyers	0.2	-	-	-	7.8
Refinancers	-	1.8	14.4	-10.9	14.1
Movers	-	7.6	1.5	-12.2	0.2
Stayers	-	14.3	6.9	0.1	27.7
Renters	-4.2	-11.9	-3.6	-18.3	0.6

DISCRETE CHOICES & CONSUMPTION

Mean Δ consumption and shares of households (%)

	Buyers	Refinancers	Movers	Stayers	Renters
Buyers	0.2 (2.4)	-	-	-	7.8 (0.5)
Refinancers	-	1.8 (4.7)	14.4(0.2)	-10.9 (0.4)	14.1 (0.0)
Movers	-	7.6 (0.1)	1.5 (2.3)	-12.2 (0.3)	0.2 (0.2)
Stayers	-	14.3 (2.0)	6.9 (0.8)	0.1 (59.5)	27.7 (0.4)
Renters	-4.2 (0.3)	-11.9 (0.1)	-3.6 (0.1)	-18.3 (0.3)	0.6 (25.9)

5.7 percent of households make an extensive-margin portfolio adjustment, due to the shock

THE ROLE OF CHANGES IN LIQUID SAVINGS

Mean Δ consumption (%), red indicates that liquid savings increase on average

	Buyers	Refinancers	Movers	Stayers	Renters
Buyers	0.2	-	-	-	7.8
Refinancers	-	1.8	14.4	-10.9	14.1
Movers	-	7.6	1.5	-12.2	0.2
Stayers	-	14.3	6.9	0.1	27.7
Renters	-4.2	-11.9	-3.6	-18.3	0.6

Changes in liquid savings

THE ROLE OF CHANGES IN LIQUID SAVINGS

Cash-out refinance, due to the shock

	Buyers	Refinancers	Movers	Stayers	Renters
Buyers	0.2	-	-	-	7.8
Refinancers	-	1.8	14.4	-10.9	14.1
Movers	-	7.6	1.5	-12.2	0.2
Stayers	-	14.3	6.9	0.1	27.7
Renters	-4.2	-11.9	-3.6	-18.3	0.6

THE ROLE OF CHANGES IN LIQUID SAVINGS

Update tenure choice and increase liquid savings, due to the shock

- move to a new house
- choose to rent instead of own

	Buyers	Refinancers	Movers	Stayers	Renters
Buyers	0.2	-	-	-	7.8
Refinancers	-	1.8	14.4	-10.9	14.1
Movers	-	7.6	1.5	-12.2	0.2
Stayers	-	14.3	6.9	0.1	27.7
Renters	-4.2	-11.9	-3.6	-18.3	0.6

CONTRIBUTIONS TO OVERALL Δ CONSUMPTION

	Buyers	Refinancers	Movers	Stayers	Renters
Buyers	0.01	-	-	-	0.04
Refinancers	-	0.16	0.03	-0.05	0.00
Movers	-	0.01	0.04	-0.03	0.00
Stayers	-	0.45	0.06	0.13	0.08
Renters	-0.01	-0.01	-0.00	-0.04	0.15

CONTRIBUTIONS TO OVERALL Δ CONSUMPTION

Cash-out refinance, due to the shock

	Buyers	Refinancers	Movers	Stayers	Renters
Buyers	0.01	-	-	-	0.04
Refinancers	-	0.16	0.03	-0.05	0.00
Movers	-	0.01	0.04	-0.03	0.00
Stayers	-	0.45	0.06	0.13	0.08
Renters	-0.01	-0.01	-0.00	-0.04	0.15

CONTRIBUTIONS TO OVERALL Δ CONSUMPTION

Those who update tenure choice and increase liquid savings, due to the shock, account for 21% of the increase in aggregate demand

	Buyers	Refinancers	Movers	Stayers	Renters
Buyers	0.01	-	-	-	0.04
Refinancers	-	0.16	0.03	-0.05	0.00
Movers	-	0.01	0.04	-0.03	0.00
Stayers	-	0.45	0.06	0.13	0.08
Renters	-0.01	-0.01	-0.00	-0.04	0.15

CONTRIBUTIONS TO OVERALL Δ CONSUMPTION

Those whose updated discrete choice leads to less liquid savings contribute with negative 14% to the increase in aggregate demand

	Buyers	Refinancers	Movers	Stayers	Renters
Buyers	0.01	-	-	-	0.04
Refinancers	-	0.16	0.03	-0.05	0.00
Movers	-	0.01	0.04	-0.03	0.00
Stayers	-	0.45	0.06	0.13	0.08
Renters	-0.01	-0.01	-0.00	-0.04	0.15

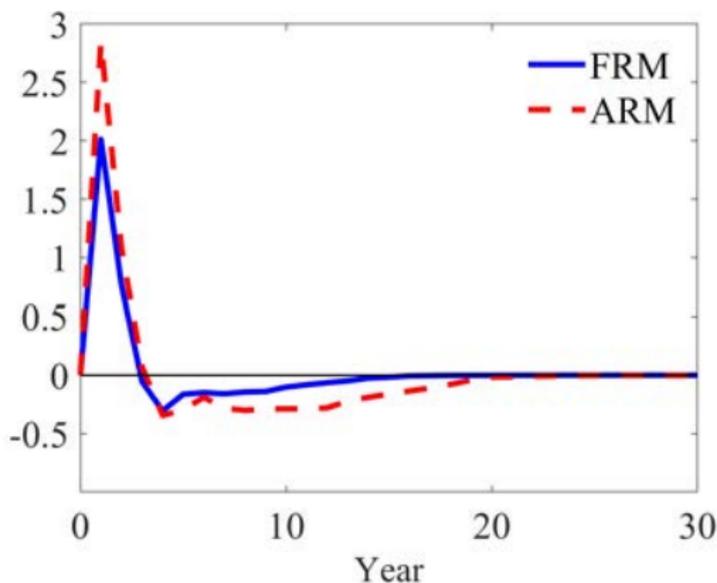
Summary discrete choices

FRM vs ARM

THE REAL INTEREST RATE SHOCK

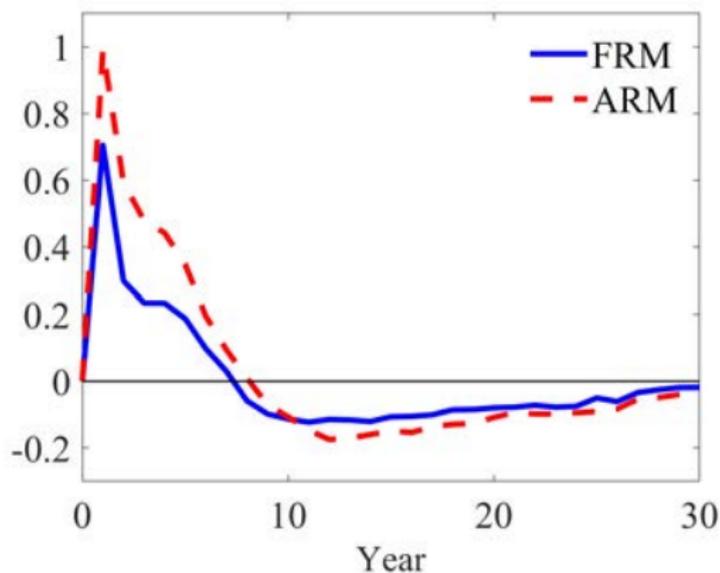


EQUILIBRIUM HOUSE PRICES



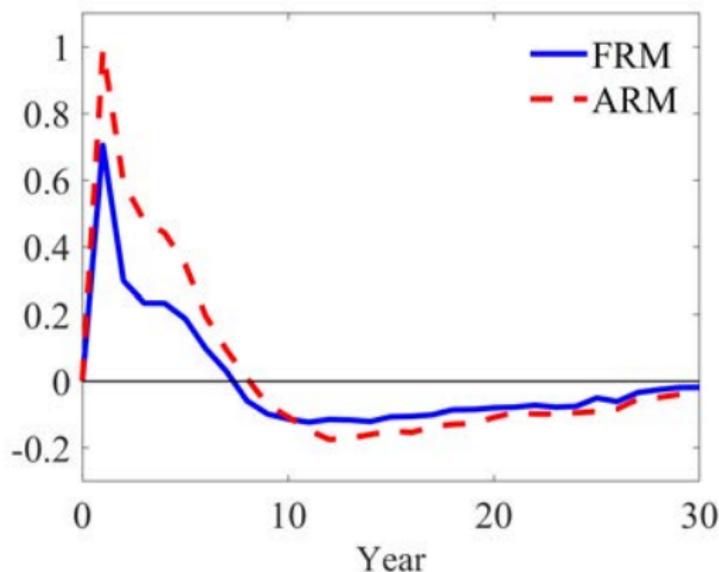
- Consistent with empirical findings (see, e.g., Calza et al. (2013)), house prices respond stronger in economies with more variable-rate contracts

RESPONSE OF CONSUMPTION



- The initial response of consumption is significantly larger under ARMs

RESPONSE OF CONSUMPTION



- The initial response of consumption is significantly larger under ARMs
- The response in mortgage rates is the key difference between the contracts

	FRM geo avg	FRM 60% pass-through	FRM 100% pass-through	ARM
ΔC	0.48	0.70	1.02	0.99

CONCLUSIONS

- Changes in mortgage interest rates and house prices amplify the response in aggregate demand to an expansionary monetary policy shock
- Households who update their discrete mortgage and housing choices account for approximately half of the increase in consumption
 - Households whose liquidity endogenously improves, through adjusted tenure choices or cash-out refinancing, increase consumption the most

CONCLUSIONS

- Changes in mortgage interest rates and house prices amplify the response in aggregate demand to an expansionary monetary policy shock
- Households who update their discrete mortgage and housing choices account for approximately half of the increase in consumption
 - Households whose liquidity endogenously improves, through adjusted tenure choices or cash-out refinancing, increase consumption the most
- These mechanisms are stronger when mortgage rates respond more
 - Larger response in aggregate demand with adjustable-rate mortgages as compared to fixed-rate contracts
- The flexibility of both the mortgage and the housing market matters for the transmission of monetary policy

Thank You!

RENTAL FIRMS

The rental firms are owned by foreign investors with a long-term investment horizon. The rental rate in steady state

$$p_r^{ss} = [1 - \beta_f + \beta_f (\delta^r + \tau^h)] p_h,$$

is such that the rental firms earn their required rate of return, after paying maintenance costs ($\delta^r p_h$) and property taxes ($\tau^h p_h$).

RENTAL FIRMS

The rental firms are owned by foreign investors with a long-term investment horizon. The rental rate in steady state

$$p_r^{ss} = [1 - \beta_f + \beta_f (\delta^r + \tau^h)] p_h,$$

is such that the rental firms earn their required rate of return, after paying maintenance costs ($\delta^r p_h$) and property taxes ($\tau^h p_h$).

The rental rate in general

$$p_r = (1 - \beta_f) p_h + \beta_f (\delta^r + \tau^h) p'_h + \beta_f \Delta p'_h \frac{S - S^{ss}}{S},$$

where $\Delta p'_h \equiv p_h - p'_h$, and $S - S^{ss}$ is the deviation in the rental stock from the steady state level, which is transacted in the market.

Back to [model](#)

CASH-ON-HAND AND TAXES

Define cash-on-hand x as

$$x \equiv \begin{cases} y + (1+r)b - (1+r^m)m + (1-\zeta^s)p_h h - \delta^h p_h h - \Gamma & \text{if } j > 1 \\ y - \Gamma + a & \text{if } j = 1, \end{cases}$$

where total taxes are

$$\Gamma = \tau^l y + I^w \tau^{ss} y + \tau^c r b + \tau^h p_h h + T(\tilde{y}).$$

Progressive earnings taxes

$$T(\tilde{y}) = \tilde{y} - \lambda \tilde{y}^{1-\tau^p}$$

where mortgage interest and property taxes are deductible.

Back to [model](#)

INDEPENDENTLY CALIBRATED PARAMETERS

Parameter	Description	Value
σ	Coefficient of relative risk aversion	2
r	Interest rate	0.03
κ	Yearly spread, mortgages	0.014
τ^l	Local labor income tax	0.05
τ^c	Capital income tax	0.15
τ^{ss}	Payroll tax	0.153
τ^h	Property tax	0.01
θ	Down-payment requirement	0.20
ψ	Payment-to-income requirement	0.28
δ^h	Depreciation, owner-occupied housing	0.03
ζ^I	Home insurance	0.005
ζ^b	Transaction cost if buying house	0.025
ζ^s	Transaction cost if selling house	0.07
ζ_p^r	Proportional refinancing cost	0.01
R	Replacement rate for retirees	0.50
B^{max}	Maximum benefit during retirement	0.61

Back to [Calibration](#)

INTERNALLY CALIBRATED PARAMETERS

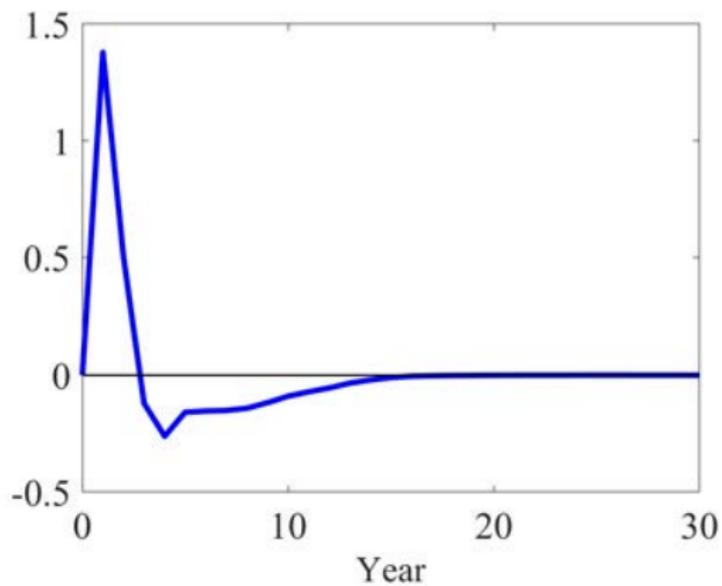
Using simulated method of moments

Parameter	Description	Value	Target moment	Data	Model
α	Consumption weight	0.75	Median house value-to-earnings	2.30	2.30
β	Discount factor	0.92	Median LTV	0.35	0.35
δ^r	Depreciation rate, rentals	0.055	Homeownership rate, age < 35	0.44	0.40
\underline{h}	Min. owned house value	0.35	Homeownership rate	0.70	0.73
ζ^r	Fixed refinancing cost	0.12	Refinance rate	0.08	0.08
\bar{q}	Luxury of bequests	6.8	Net worth p75/p25, age 68-76	5.37	5.26
v	Utility shifter of bequests	190	Mean net worth/mean earnings	1.38	1.40
SD	Standard deduction	0.081	Itemization rate	0.53	0.53
λ	Level, tax function	0.975	Average marginal tax rates	0.13	0.13
τ^p	Progressivity, tax function	0.17	Distr. of marginal tax rates	N.A.	N.A.

Sources: Survey of Consumer Finances (SCF), Gorea and Midrigan (2017), Congressional Budget Office, The Tax Foundation, 2013

Back to [Calibration](#)

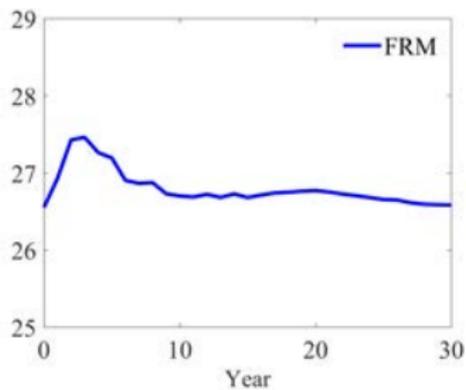
RENTAL RATE



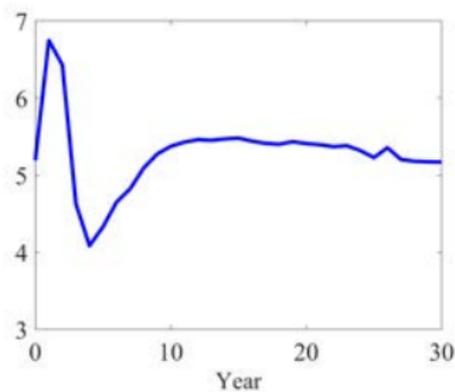
Back to [main](#)

SHARES

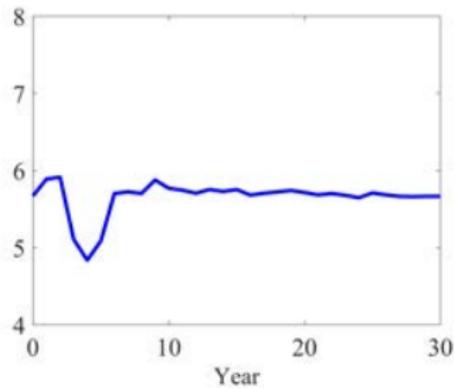
Renters



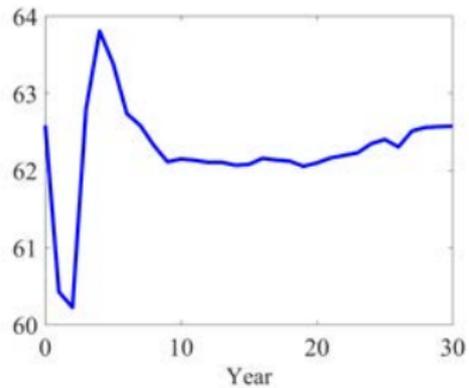
Refinancers



Buyers

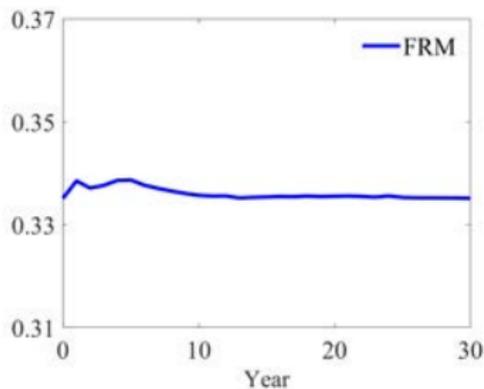


Stayers

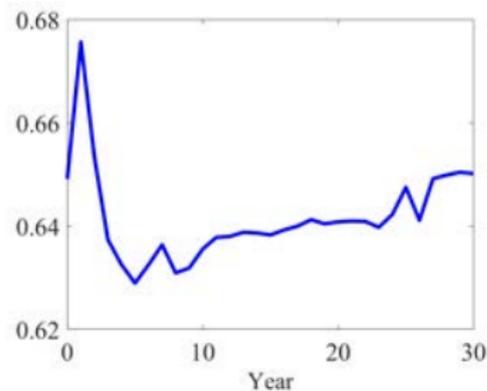


MEAN CONSUMPTION

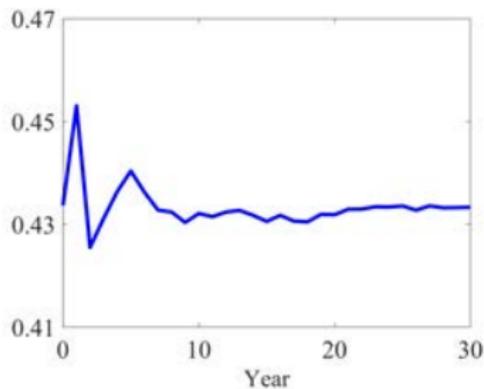
Renters



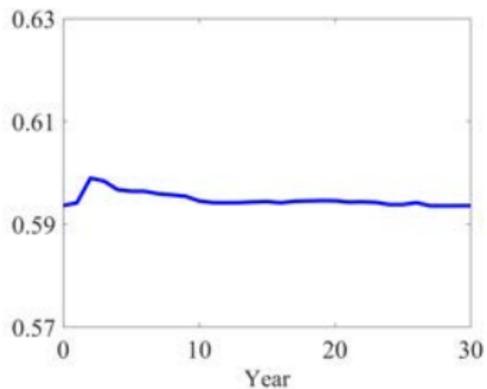
Refinancers



Buyers



Stayers



Back to

[main](#)

DISCRETE CHOICES & LIQUID SAVINGS

Mean Δ liquid savings (%)

	Buyers	Refinancers	Movers	Stayers	Renters
Buyers	13	-	-	-	347
Refinancers	-	96	14	-95	1585
Movers	-	63	2	-93	223
Stayers	-	2172	7	-6	3838
Renters	-62	-74	-4	-99	-1

Back to [main](#)

SUMMARY - DISCRETE CHOICES

When mortgage interest rates are low and house prices are high:

- Liquidity-constrained homeowners increase consumption
 - use cash-out refinancing to smooth consumption
 - sell when house prices are high and become renters
 - move to a new house to access their housing equity
- Some renters increase consumption
 - postpone buying a house when house prices are high
- Whereas others endogenously become more liquidity constrained
 - some owners choose to no longer sell or refinance
 - some renters advance their house purchases

Back to [main](#)