The Long Shadows of the Great Inflation
Evidence from Residential Mortgages

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Mortgage Choice

- Major puzzle in mortgage markets (and financial contracting more broadly): consumers' aversion to adjustable-rate loans.
    - Empirical contract mix in US: 80% fixed-rate.
- Inconsistent with standard life-cycle consumption models (e.g., Campbell and Cocco 2003, 2015).
    - Especially at high price, about 170bp above comparable variable-rate mortgages.
    - Our own calculations (below): far more households choose FRMs than the standard economic model predicts, esp. in the wake of the Great Inflation: Baby Boomers should have taken out 1m fewer FRMs in the late 1980s, and 0.5m fewer in the late 1990s.

Mortgage Choice

- Puzzling because: Cost of these deviations large. Given expected refinancing behavior and mobility, Baby Boomers overpayed >$14 billion on their FRMS in the late 1980s, and almost $9 billion in the late 1990s.

- Puzzling because: Home purchase and financing one of the biggest financial decisions for many households.

- ARM-type contracts have high market shares in other countries (Australia, Belgium, Chile, Estonia, Finland, Greece, Hungary, Ireland, Israel, Korea, Luxembourg, Mexico, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Switzerland, Turkey).

- **Idea here:** Role of "experience effects" in past inflation.

Idea

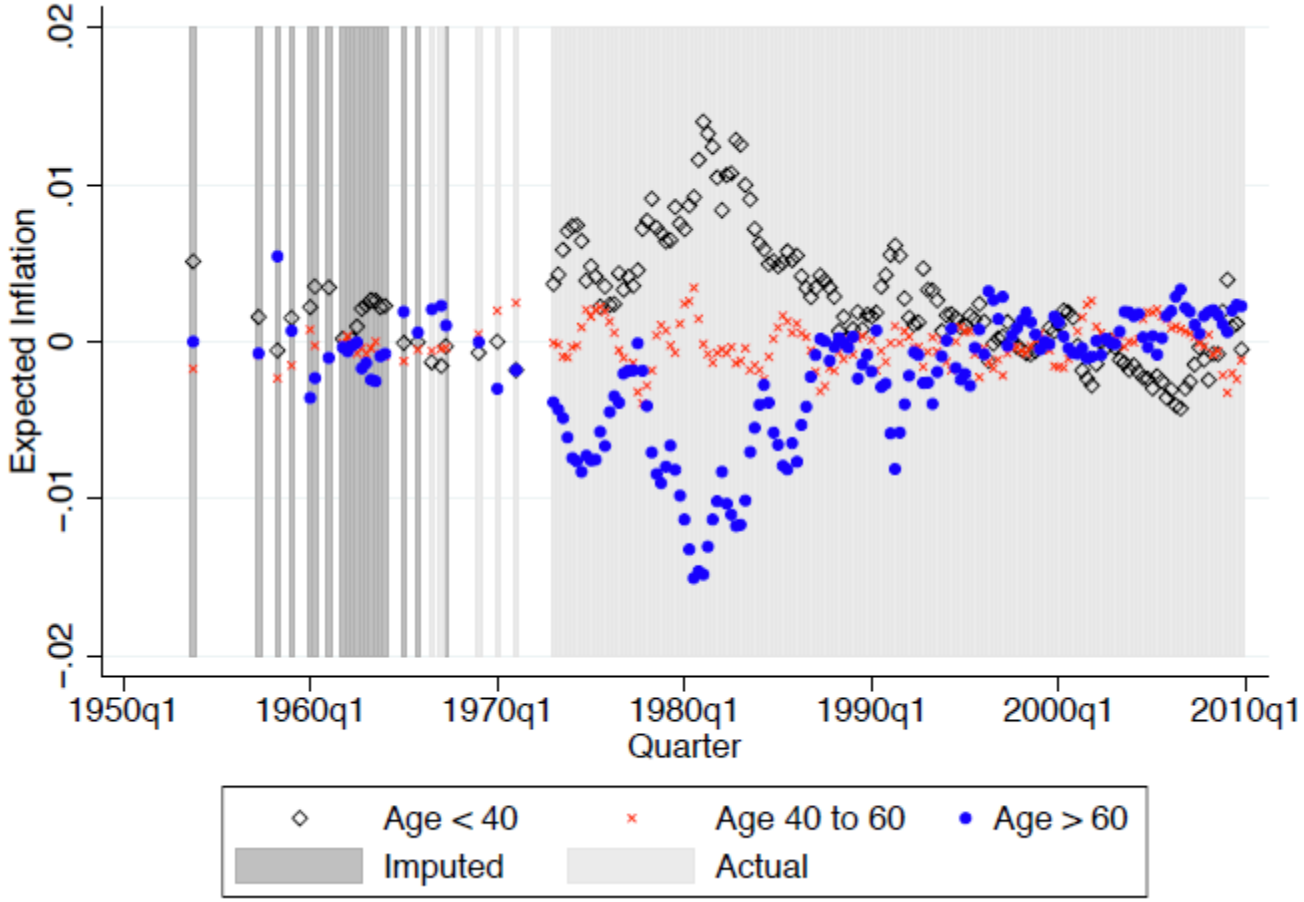
- Individuals overweight **prior lifetime experiences** when forming expectations.
  - Cf. **availability** bias (Tversky and Kahneman 1974): "more memorable events are processed as more likely events" when forming beliefs.
  - Underpinning: **synaptic tagging** (cf. Laudenbach, Niessen-Ruenzi, Malmendier AEA P&P 2018) – personal experiences rewire our "hardware", especially experiences that are anchored more strongly due to emotions.

Many applications

1. Political attitudes: Alesina & Fuchs-Schundeln (2007)
2. Medical diagnoses: Weber et al. (1993); Hertwig et al. (2004)
3. Climate change: Deryugina (2013)
4. Stock-market participation: Malmendier & Nagel (2011)
5. Consumption behavior: Malmendier & Shen (2015)
6. Expected inflation: Malmendier & Nagel (2016)

Inflation experiences & expectations

From Malmendier & Nagel (2016) / Mich. Survey:



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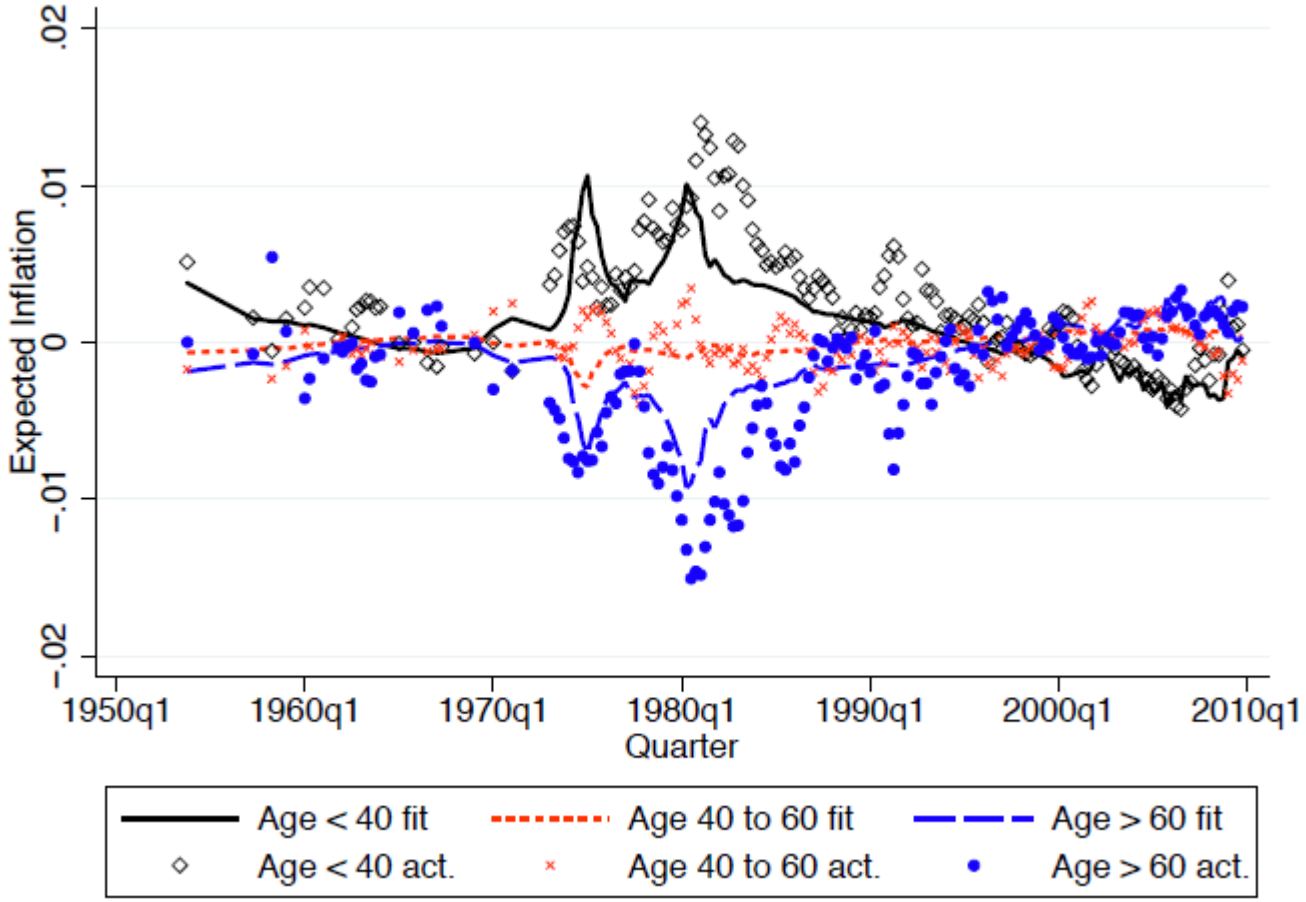


This Paper

- **Overweighting** lifetime inflation experiences generates **differences of opinion** about the value of future inflation rates and hence **nominal interest rates** (Fisher equation).
  - Those with **higher lifetime experiences of inflation** will expect **higher nominal interest rates**.
- **Overweighting** lifetime inflation experiences generates **differences of opinion** about the value of **fixed-rate assets** (relative to **variable/real-rate assets**).
  - Those with **higher lifetime experiences of inflation** will overvalue and overpay for **fixed-rate mortgage** contracts, relative to the full-information optimum.
- We assess the **implications** of experience-based beliefs for **mortgage choice**, and we provide **quantitative estimates** of the costs.

Preview of Results

1. Individuals' inflation experiences significantly affect **beliefs about future nominal interests**.
2. Individuals' inflation experiences significantly affect **mortgage choice**.
   - Individuals with high experienced inflation are more likely to choose FRMs (within year).
   - 1 in 6 HHs choose FRMs over ARMs because of π^e
3. **The costs of overweighting are large.**
   - ***Ex ante***: individuals pay 6-14 basis points for every additional pp. of π^e
   - ***Ex post***: switching HHs overpay by \$8,000 - 16,000 (over expected tenure, in after-tax PV)
     - ➢ Concentrated among Baby Boomers: overpaid in aggregate by **\$14 billion** on FRMs in 1980s, **\$9 billion** in 1990s.

Data and Methodology

Learning from Experiences

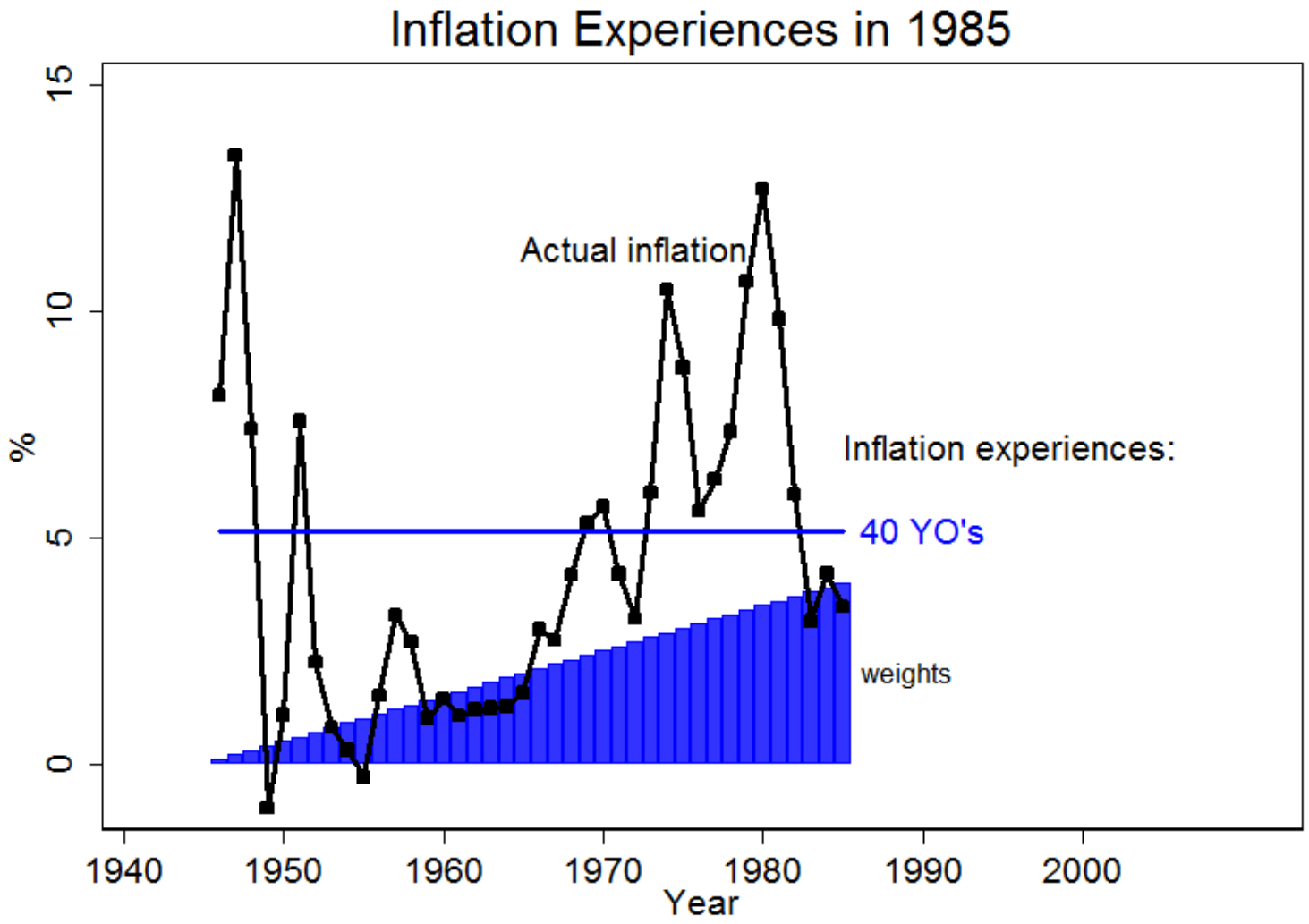
Experience effect hypothesis: individuals learn from **lifetime experiences**

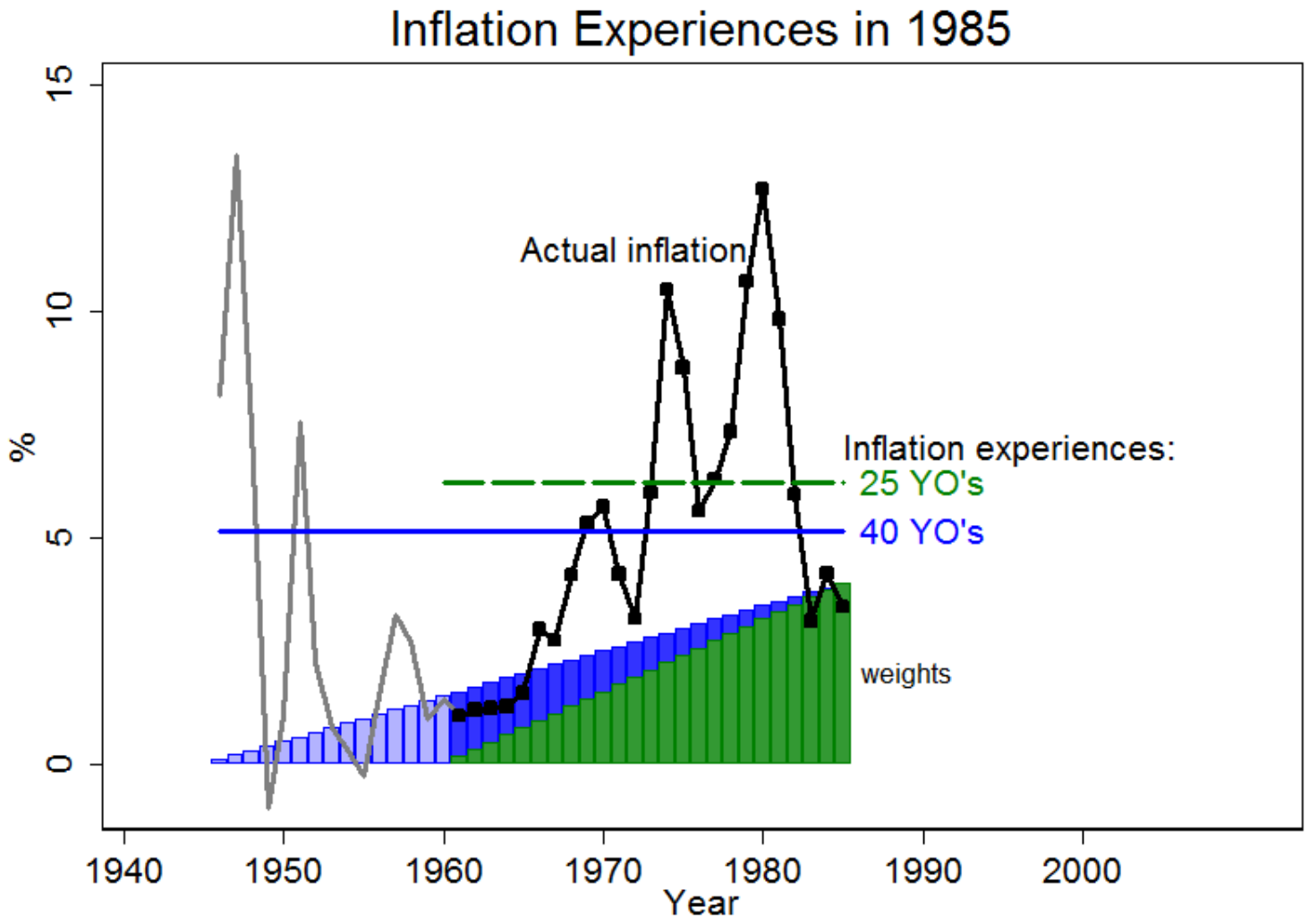
Prior empirical evidence suggests that HH *n*'s experience-based inflation forecast at time *t* is approximately:

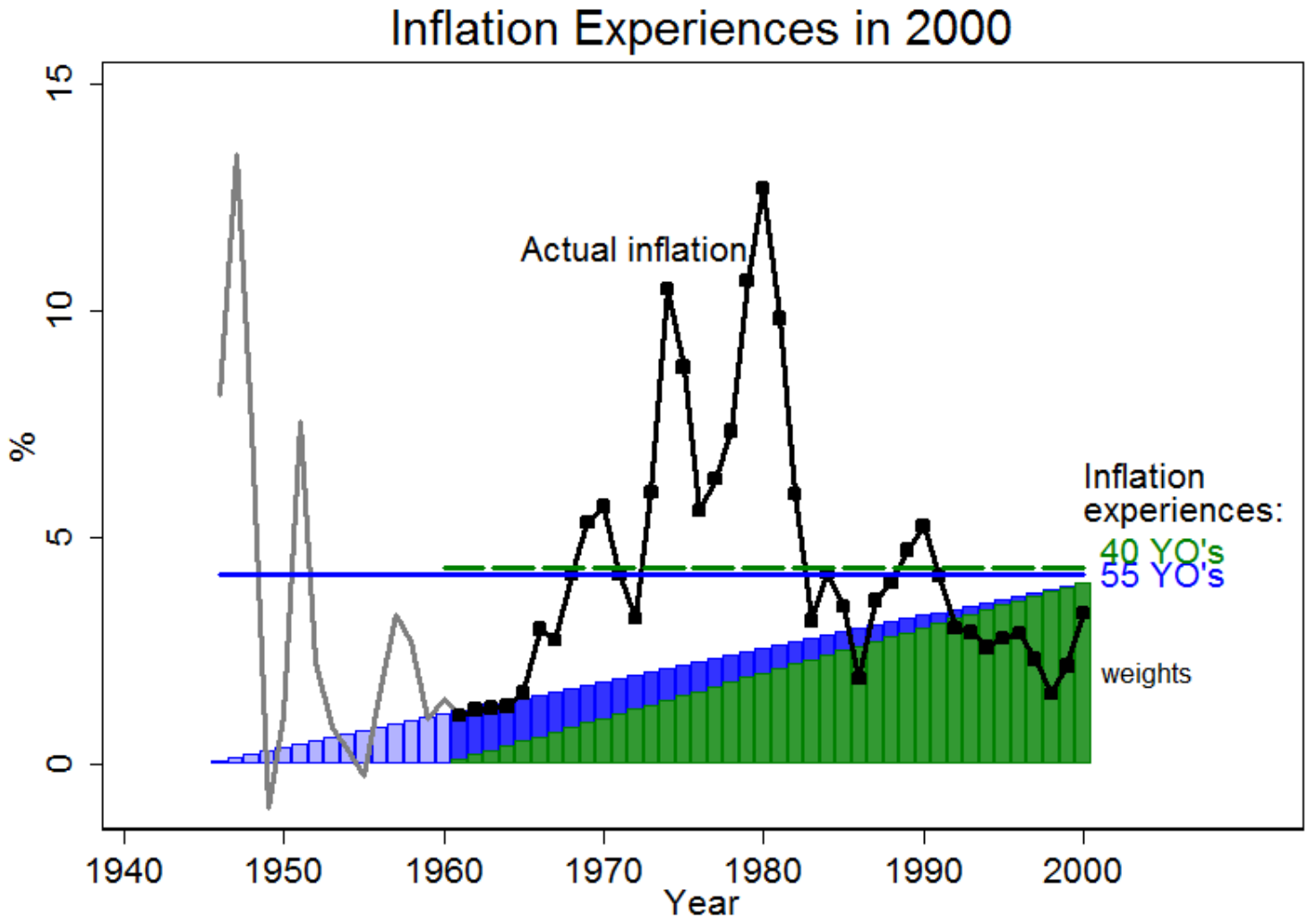
$$\pi_{n,t}^{e} \propto \sum_{j=0}^{\text{age}_n} \left(\frac{\text{age}_n - j}{\text{age}_n} \right) \pi_{t-j}$$

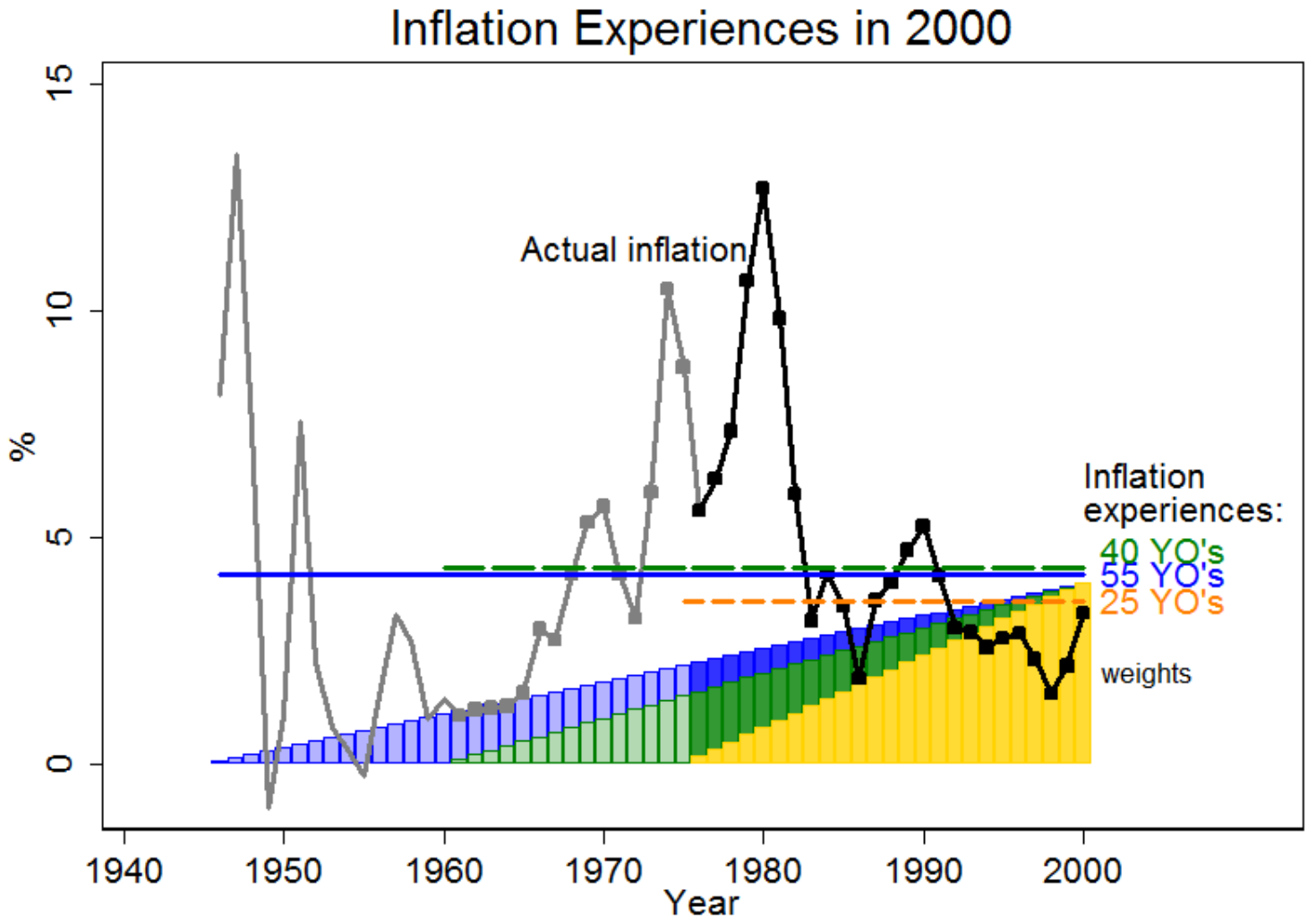
where lag *j* runs from today (*j*=0) to birth (*j*=age$_n$).

Empirical content: cross-sectional heterogeneity of forecasts (by householder age).


Inflation Experiences in 1985
%
0
5
10
15
1940
1950
1960
1970
1980
1990
2000
Year
Actual inflation
Inflation experiences:
40 YO's
weights


Inflation Experiences in 1985
%
0
5
10
15
1940
1950
1960
1970
1980
1990
2000
Year
Actual inflation
Inflation experiences:
25 YO's
40 YO's
weights

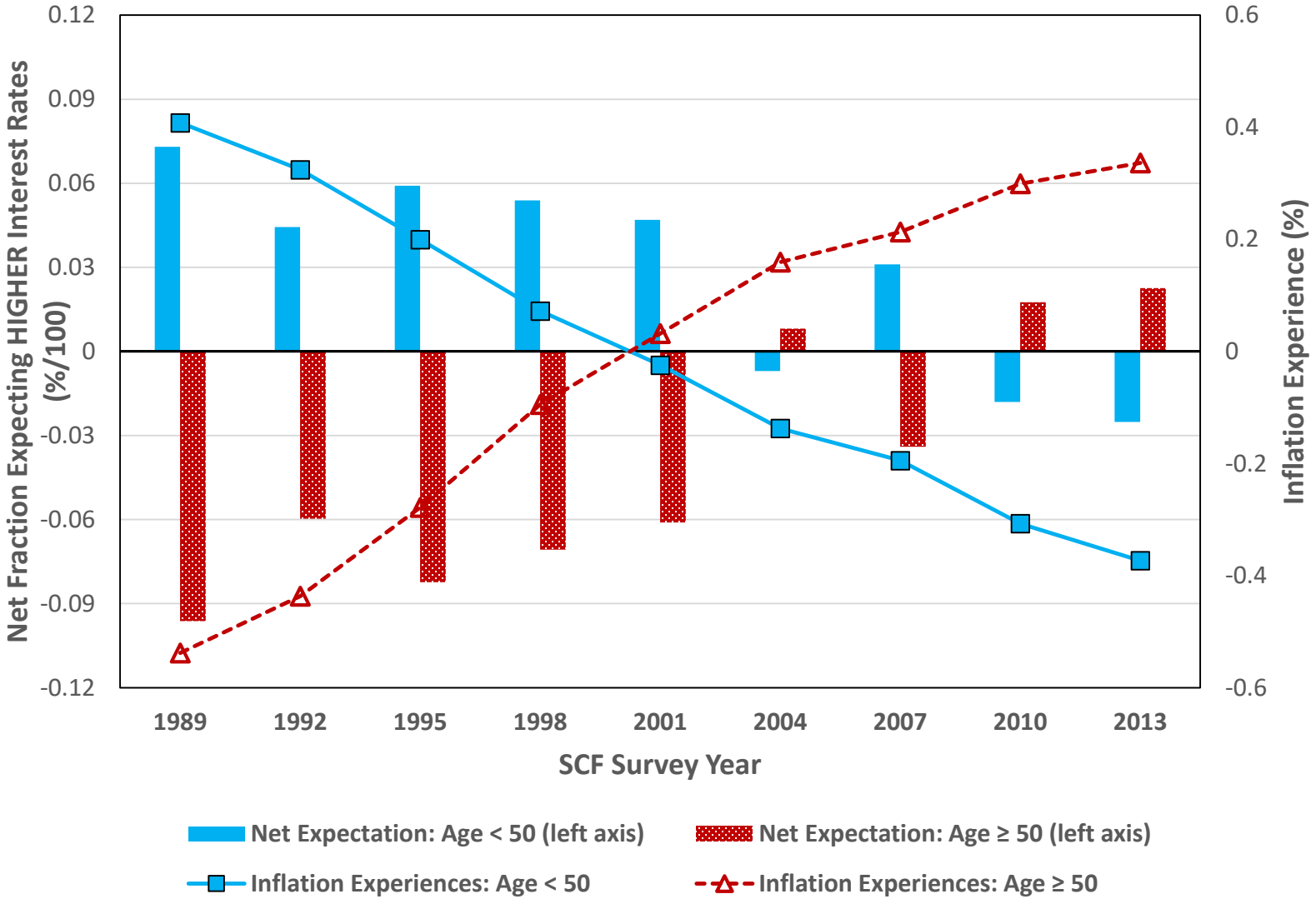



Inflation Experiences in 2000
Actual inflation
Inflation experiences:
40 YO's
55 YO's
25 YO's
weights
%
0
5
10
15
1940
1950
1960
1970
1980
1990
2000
Year

Three Steps

1. **Overweighting** lifetime inflation experiences and **nominal interest rates**.
   - Those with **higher lifetime experiences of inflation** will expect **higher nominal interest rates**.
   - SCF data
2. **Overweighting** lifetime inflation experiences choice of **fixed-rate mortgages**.
   - Those with **higher lifetime experiences of inflation** will overvalue and overpay for **fixed-rate mortgage** contracts, relative to the full-information optimum.
   - RFS data (and BLS, PMMS)
3. **Quantitative estimates** of the costs.

Inflation experiences & **Interest Rate** expectations



Mortgage Data

Residential Finance Survey: decennial Census Bureau survey of households, cross-referenced with servicers, in 1991 and 2001.

- Microdata on outstanding mortgages linked to 1-4 unit, owner-occupied properties:
  - ❑ FRM/ARM status
  - ❑ Loan terms & property value
  - ❑ HH income & demographics
  - ❑ Census region
- Missing recent movers
- We subset on mortgages originated ≤ 6 years prior.

Table 1: Summary Statistics

	FRM	ARM	FRM - ARM
N =	12,416	2,245	
Contract Characteristics			
Current rate (bps)	972.7	924.5	48.2*
Initial rate (bps)	"	876.2	96.4*
Margin (bps)	n.a.	282.7	n.a.
Term (years)	23.2	26.1	-2.9*
Loan Amount (2000 $k)	102.0	140.3	-38.3*
Borrower Characteristics			
Primary owner age	41.4	41.8	-0.4
Non-white	0.136	0.099	0.037*
First-time owner	0.413	0.348	0.065*
Total income (2000 $)	75,177	84,165	-8,989*
Other Loan Characteristics			
Junior mortgage	0.129	0.086	0.043*
Non-conventional	0.211	0.061	0.150*
Refi	0.256	0.244	0.012
Loan / income	1.73	2.04	-0.31*
Loan / value × 100	81.7	90.0	-8.3*
Jumbo loan?	0.043	0.127	-0.084*

Notes. Sample of mortgages <= 6 years old at time of 1991 and 2001 Residential Finance Surveys of homeowner properties. Statistics are based on available cases. * $p<0.05$.

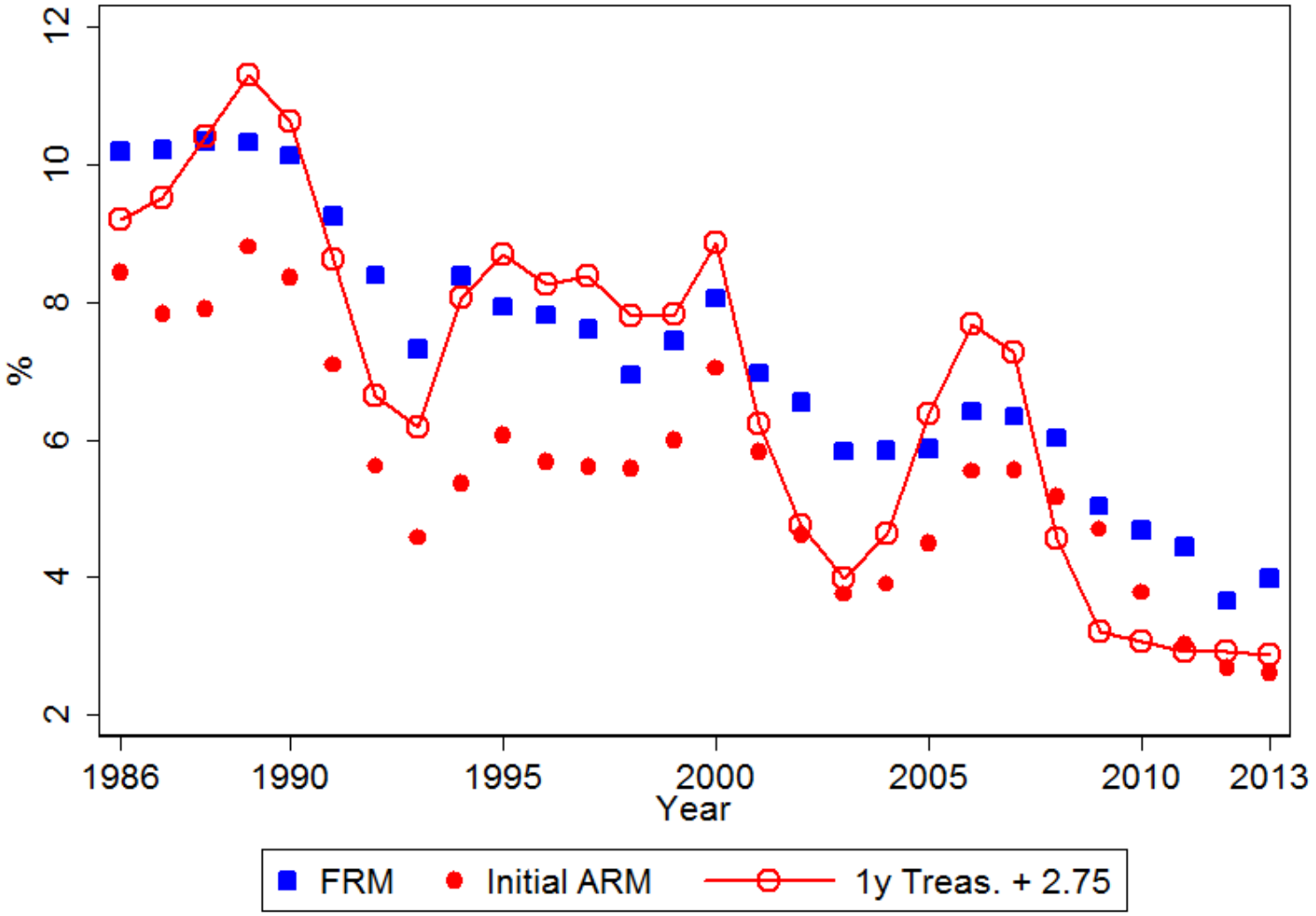
Other Data

Inflation: log changes in CPI-U (from BLS)

Primary Mortgage Market Survey index rates for FRM and ARM (from Freddie Mac)

- Representative, nationwide survey of mortgage originators
- Quotes interest rates on first-lien, prime, conventional, conforming, 30-year loans with LTV = 0.8
  - FRM and 1/1 ARM
- Reweight from 5 Freddie Mac regions to 4 Census regions using 1990 Census state housing counts.
- Annual average of weekly data

Path of PMMS Interest Rates



Identification

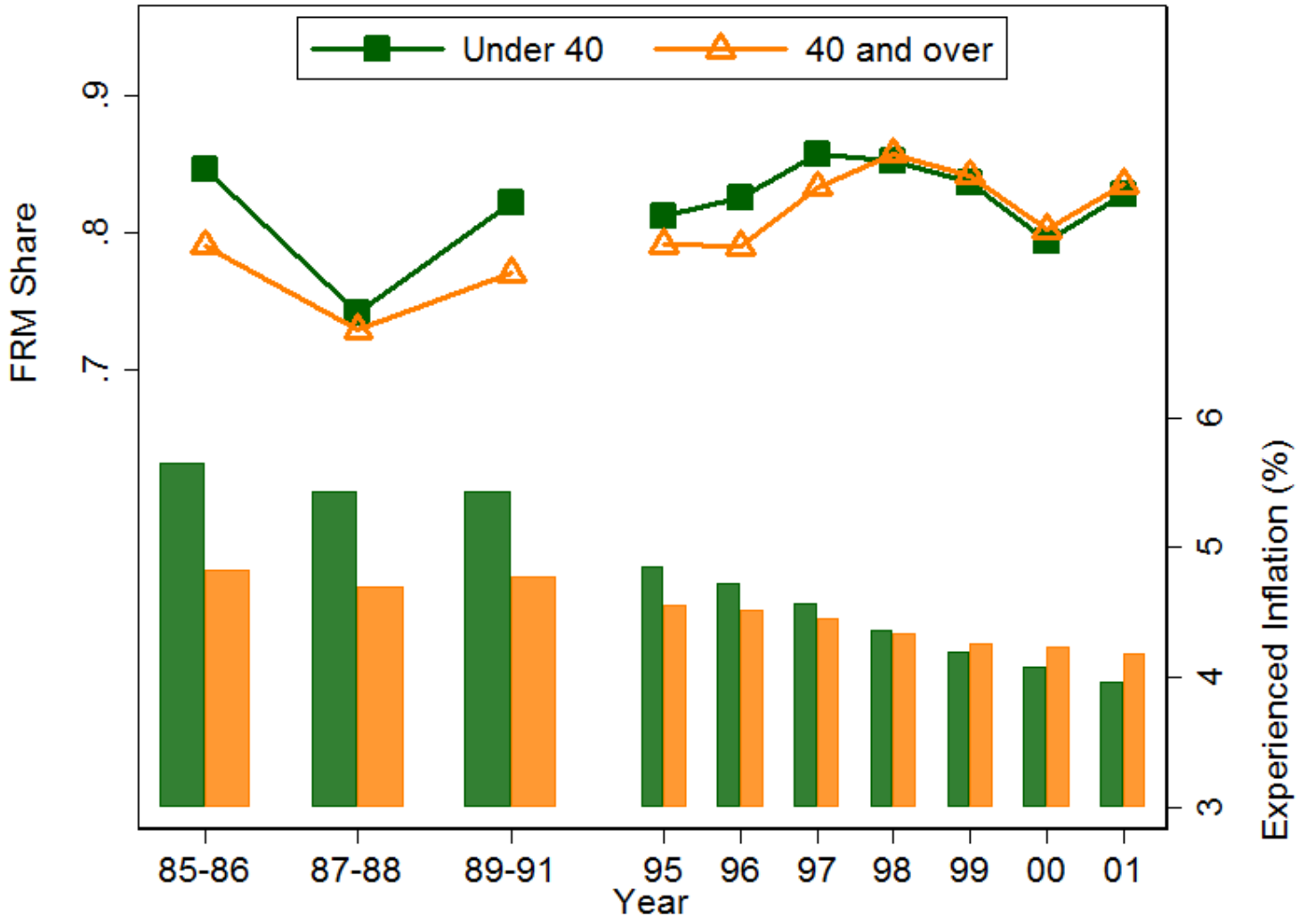
Identification from cross-sectional differences in inflation experiences + their evolution over time (time series). This rules out:

1. **Time-specific effects** unrelated to learning from experiences.
   - **Time dummies** capture the effect of all individuals learning from the full historical inflation data, including current inflation.
2. **Life-cycle effects**
   - **Age** is separately identified in repeated XS data

$\beta_{\pi,FRM}$ picks up influence of remaining, individual heterogeneity in **inflation experiences** on **expectations**.

- If experiences don't matter, coefficient should be **zero**.

FRM Share and Experienced Inflation by Age Group



Econometric Model

McFadden (1974): Indirect utility of HH n considering alternative i (FRM or ARM):

$$U_{ni} = \alpha_{it} + \beta_R Rate_{ni} + \beta_{\pi,i}\pi_n^e + x_n'\delta_i + \varepsilon_{ni}$$

Alternative i is chosen iff $U_{ni} > U_{nj} \forall j \neq i$.

Predictions:

1. $\beta_R < 0$ – price elasticity of demand is negative
2. $\beta_{\pi,FRM} > 0$ – inflation histories raise the FRM share (learning-from-experiences effect)

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Missing Data Problem:

We only observe the rate of the chosen alternative:

$$Rate_n = D_n Rate_{n,FRM} + (1 - D_n) Rate_{n,ARM}$$

Three-Step Estimation Procedure

1. **Reduced-form mortgage choice model** using Freddie Mac FRM & ARM index rates (by year-region)

$$U_{ni} = \alpha_{it} + \tilde{\beta}_R PMMSRate_{ni} + \beta_{\pi,i}\pi_n^e + x_n'\delta_i + \tilde{\varepsilon}_{ni}$$

2. **Mortgage pricing equations**, correcting for any selection bias using choice probabilities from Step 1 – Heckman (1979), Powell (1984), Newey (2009)

$$Rate_{ni} = \gamma_R PMMSRate_{ni} + x_n'\gamma_i + \nu_{ni}$$

3. **Structural mortgage choice model** using individual-level predicted interest rates for each alternative from Step 2

$$U_{ni} = \alpha_{it} + \beta_R \widehat{Rate_{ni}} + \beta_{\pi,i}\pi_n^e + x_n'\delta_i + \varepsilon_{ni}$$

n: household; *i*: FRM or ARM.

Results

Table 2: Reduced-Form Mortgage Choice Model

	(4)	(5)
FRM Alternative-Specific Characteristics		
Freddie Mac PMMS FRM index rate (%)	-3.33***	-3.59***
	(0.575)	(0.816)
Experienced inflation (%)	0.254***	0.187*
	(0.086)	(0.098)
Log(Income)	0.0276**	0.0278**
	(0.012)	(0.012)
ARM Alternative-Specific Characteristics		
Freddie Mac PMMS ARM initial rate index (%)	-0.768***	-0.844***
	(0.250)	(0.314)
Alternative-specific constants	YES	YES
Origination year FE	YES	YES
Other controls	YES	YES
Number of Choice Situations	15,051	14,337
Number of Alternatives	3	2

Notes. Multinomial logit coefficients shown (robust SEs).
*** p<0.01, ** p<0.05, * p<0.1

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WTP calculation:

$$\beta_{\pi^e} = 0.254$$

$$\beta_{Rate,FRM} = -3.33$$

$$\Rightarrow WTP = -\frac{\beta_{\pi^e}}{\beta_{Rate,FRM}}$$

$$= 7.6 \text{ bps}$$

$$(SE = 2.9 \text{ bps})$$

Actual and Counterfactual FRM Shares

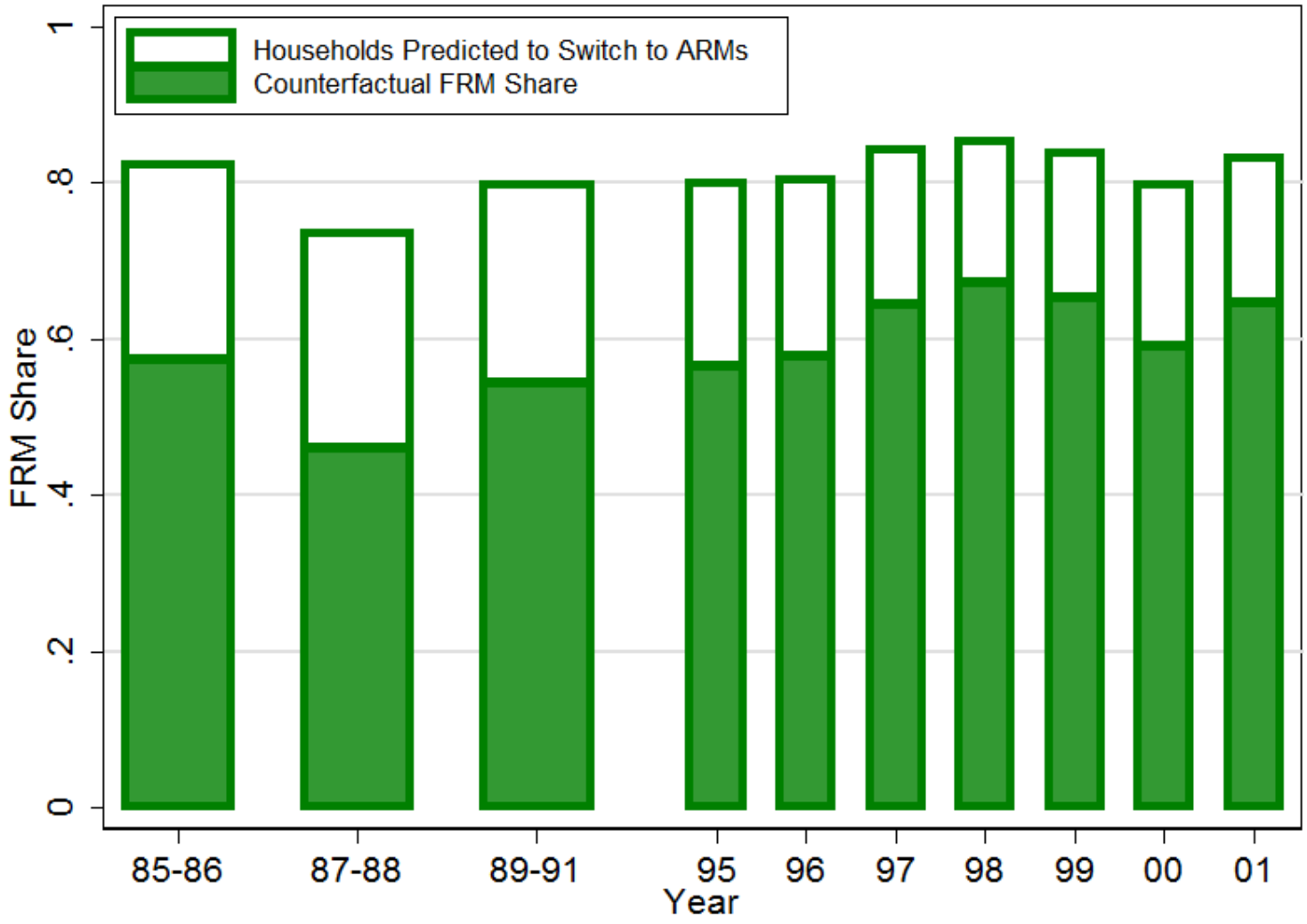

Table 4: Structural Logit Model of Mortgage Choice

	(1)	(2)	(3)	(4)	(5)	(6)
Step 2 Selection Correction?	No	Yes	No	Yes	No	Yes
FRM Rate Offered	0.764	-1.474**				
	(0.74)	(0.58)				
Initial ARM Rate Offered	-0.368	1.280**				
	(0.62)	(0.54)				
ARM Margin Offered						
Experienced inflation (%)	0.237**	0.181*				
	(0.09)	(0.10)				
Log(Income)	0.00221	-0.00875				
	(0.02)	(0.03)				
Age	-0.015	0.004				
	(0.02)	(0.02)				
Age^2 / 100	0.018	-0.005				
	(0.02)	(0.02)				
Joint owners	0.144	-0.074				
	(0.12)	(0.13)				
Rural county	-0.053	-0.776**				
	(0.32)	(0.35)				
Non-conventional						
Origination year FE	YES	YES	YES	YES	YES	YES
Number of Choice Situations	14,337	14,337	14,337	14,337	14,337	14,337

Notes. Binomial logit coefficient estimates. Dependent variable is 1=FRM, 0=ARM. Bootstrapped standard errors in parentheses, adjusting for 1st- and 2nd-step estimation, from 200 repetitions. *** p<0.01, ** p<0.05, * p<0.1.

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Non-conventional						
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$$WTP = \frac{0.181}{1.474} = 12\text{bps}$$

Notes. Binomial logit coefficient estimates. Dependent variable is 1=FRM, 0=ARM. Bootstrapped standard errors in parentheses, adjusting for 1st- and 2nd-step estimation, from 200 repetitions. *** p<0.01, ** p<0.05, * p<0.1

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Step 2 Selection Correction?	No	Yes	No	Yes	No	Yes
FRM Rate Offered	0.764	-1.474**	-0.127	-1.272***		
	(0.74)	(0.58)	(0.60)	(0.45)		
Initial ARM Rate Offered	-0.368	1.280**	0.838	1.196***		
	(0.62)	(0.54)	(0.55)	(0.38)		
ARM Margin Offered			-2.364***	-0.302		
			(0.55)	(0.47)		
Experienced inflation (%)	0.237**	0.181*	0.222**	0.180*		
	(0.09)	(0.10)	(0.10)	(0.10)		
Log(Income)	0.00221	-0.00875	-0.0572	-0.0171		
	(0.02)	(0.03)	(0.04)	(0.04)		
Age	-0.015	0.004	-0.007	0.004		
	(0.02)	(0.02)	(0.02)	(0.02)		
Age^2 / 100	0.018	-0.005	0.010	-0.004		
	(0.02)	(0.02)	(0.02)	(0.02)		
Joint owners	0.144	-0.074	0.035	-0.062		
	(0.12)	(0.13)	(0.15)	(0.12)		
Rural county	-0.053	-0.776**	-0.860**	-0.761***		
	(0.32)	(0.35)	(0.36)	(0.28)		
Non-conventional						
Origination year FE	YES	YES	YES	YES	YES	YES
Number of Choice Situations	14,337	14,337	14,337	14,337	14,337	14,337

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Step 2 Selection Correction?	No	Yes	No	Yes	No	Yes
FRM Rate Offered	0.764	-1.474**	-0.127	-1.272***	-0.575	-0.692*
	(0.74)	(0.58)	(0.60)	(0.45)	(0.45)	(0.41)
Initial ARM Rate Offered	-0.368	1.280**	0.838	1.196***	0.184	0.593
	(0.62)	(0.54)	(0.55)	(0.38)	(0.35)	(0.39)
ARM Margin Offered			-2.364***	-0.302	3.738***	2.600**
			(0.55)	(0.47)	(1.03)	(1.22)
Experienced inflation (%)	0.237**	0.181*	0.222**	0.180*	0.181*	0.192**
	(0.09)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)
Log(Income)	0.00221	-0.00875	-0.0572	-0.0171	0.0798*	0.0916
	(0.02)	(0.03)	(0.04)	(0.04)	(0.05)	(0.06)
Age	-0.015	0.004	-0.007	0.004	0.007	0.015
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Age^2 / 100	0.018	-0.005	0.010	-0.004	-0.006	-0.014
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Joint owners	0.144	-0.074	0.035	-0.062	0.101	0.183
	(0.12)	(0.13)	(0.15)	(0.12)	(0.16)	(0.20)
Rural county	-0.053	-0.776**	-0.860**	-0.761***	0.106	-0.375
	(0.32)	(0.35)	(0.36)	(0.28)	(0.33)	(0.40)
Non-conventional					3.744***	4.736**
					(0.59)	(2.16)
Origination year FE	YES	YES	YES	YES	YES	YES
Number of Choice Situations	14,337	14,337	14,337	14,337	14,337	14,337

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SIMULATION OF *EX POST* COSTS

Simulation Details

We simulate the *ex post* payments each household would make.

<u>Standard contract types:</u>

- 30-year term
- Self-amortizing, level payment FRM
- 1/1 ARM indexed to 1-year Treasury
- No early payments or defaults
- **Predicted interest rates** $\left(\widehat{Rate}_{n,FRM}, \widehat{Rate}_{n,ARM}\right)$

<u>Time horizon:</u>

- Survey year
- If held to 5, 10, 15 years

Simulation Details

How to model refinancing behavior?

1. **No Refinancing**: borrower holds FRM until maturity

2. **Expected Refinancing**: empirical model from Andersen, Campbell, Meisner-Nielsen, Ramadorai (2014):
$$P(\text{refi}|i_0) = \Phi\left\{-1.921 + \exp\left(-1.033 \times \left(OT - (i - i_0)\right)\right)\right\}$$

3. **Optimal Refinancing**: follow Agarwal, Driscoll, Laibson (2013) square-root rule for Optimal Threshold:
$$\text{Refinance iff } i - i_0 < OT,$$
$$OT \approx -\sqrt{\frac{\sigma\kappa}{M(1-\tau)}}\sqrt{2(\rho+\lambda)}$$

FRM Rate for Mortgage ID 500

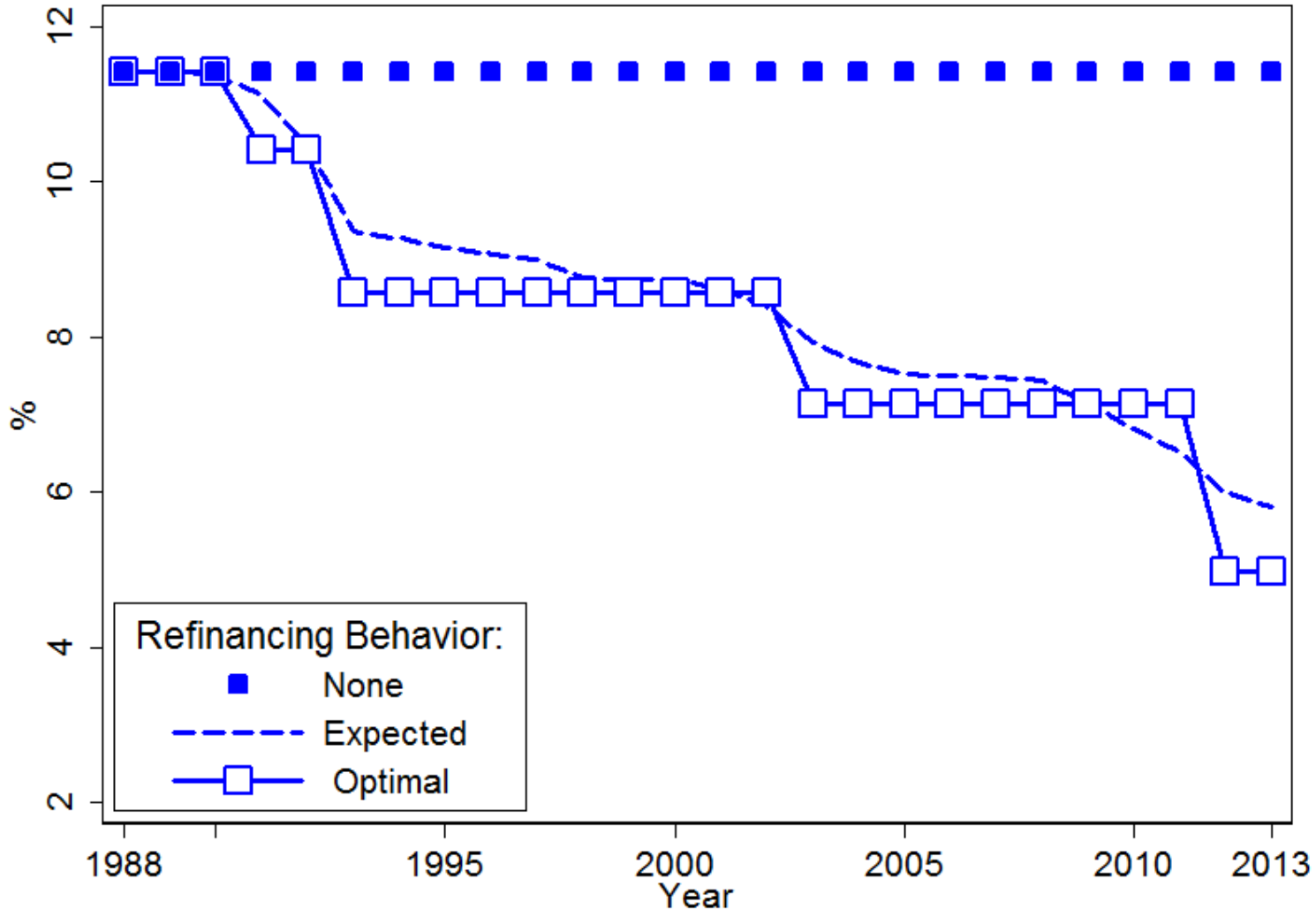

Table 6: Interest Payments for a Sample Household

PV of interest payments, discounted at 8% per year. The loan was for $204,844 in constant year 2000 $. Marginal tax rate = 0.25; T = 25 years.

	FRM ($)			ARM ($)
	No Refi	Expected Refi	Optimal Refi	
PDV	**235,498**	**199,637**	**193,659**	**163,074**
- Int. Deduct.	-58,874	-49,909	-48,415	-40,768
+ Refi Cost	0	4,633	3,895	0
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Simulated dollar cost of choosing an FRM:

- **No Refi:** $176K - $122K = $54,000
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Welfare-Relevant TE: weighted average over all households (using switching probabilities)

Aggregate Cost Calculations

What is the *ex post* cost of choosing an FRM for marginal households?

- We calculate a "welfare-relevant treatment effect":

$$\mathbb{E}[\underbrace{Y_{n,FRM} - Y_{n,ARM}}_{\text{potential outcomes}} \mid \underbrace{D_n(\beta_\pi) = 1, D_n(0) = 0}_{\text{potential treatments}}]$$

- **Intuition**: difference in actual and counterfactual mortgage payments for the subpopulation of nearly-indifferent HHs

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$$=$$

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can be estimated by

$$\propto \frac{1}{N} \sum_{n=1}^{N} \left(\hat{Y}_{n,FRM} - \hat{Y}_{n,ARM}\right) \cdot \left(\hat{P}\left(D_n\left(\hat{\beta}_\pi\right) = 1\right) - \hat{P}(D_n(0) = 0)\right)$$

Table 7: Additional Interest Paid Due to Inflation Experiences

Scenario 2: Risk-adjusted rates, seniority-adjusted ARM margins

Time Horizon:	Survey Year	5 years	10 years	15 years
After-tax PDV: (all in $)				
No Refi	5,674	10,124	19,126	27,345
Expected Refi	-	10,056	15,886	20,505
Optimal Refi	-	9,455	14,460	18,639
% switching households	13.5	13.5	13.5	13.5

Scenario 3: Risk-adjusted rates and ARM margins

Time Horizon:	Survey Year	5 years	10 years	15 years
After-tax PDV: (all in $)				
No Refi	5,355	9,635	18,193	26,176
Expected Refi	-	9,556	14,915	19,261
Optimal Refi	-	8,947	13,474	17,374
% switching households	14.3	14.3	14.3	14.3

Notes. Table reports WRTEs, measured as the extra interest (after taxes) + refinancing costs paid by a household choosing an FRM instead of an ARM due to experienced inflation. Original loan amounts are in constant 2000 $.

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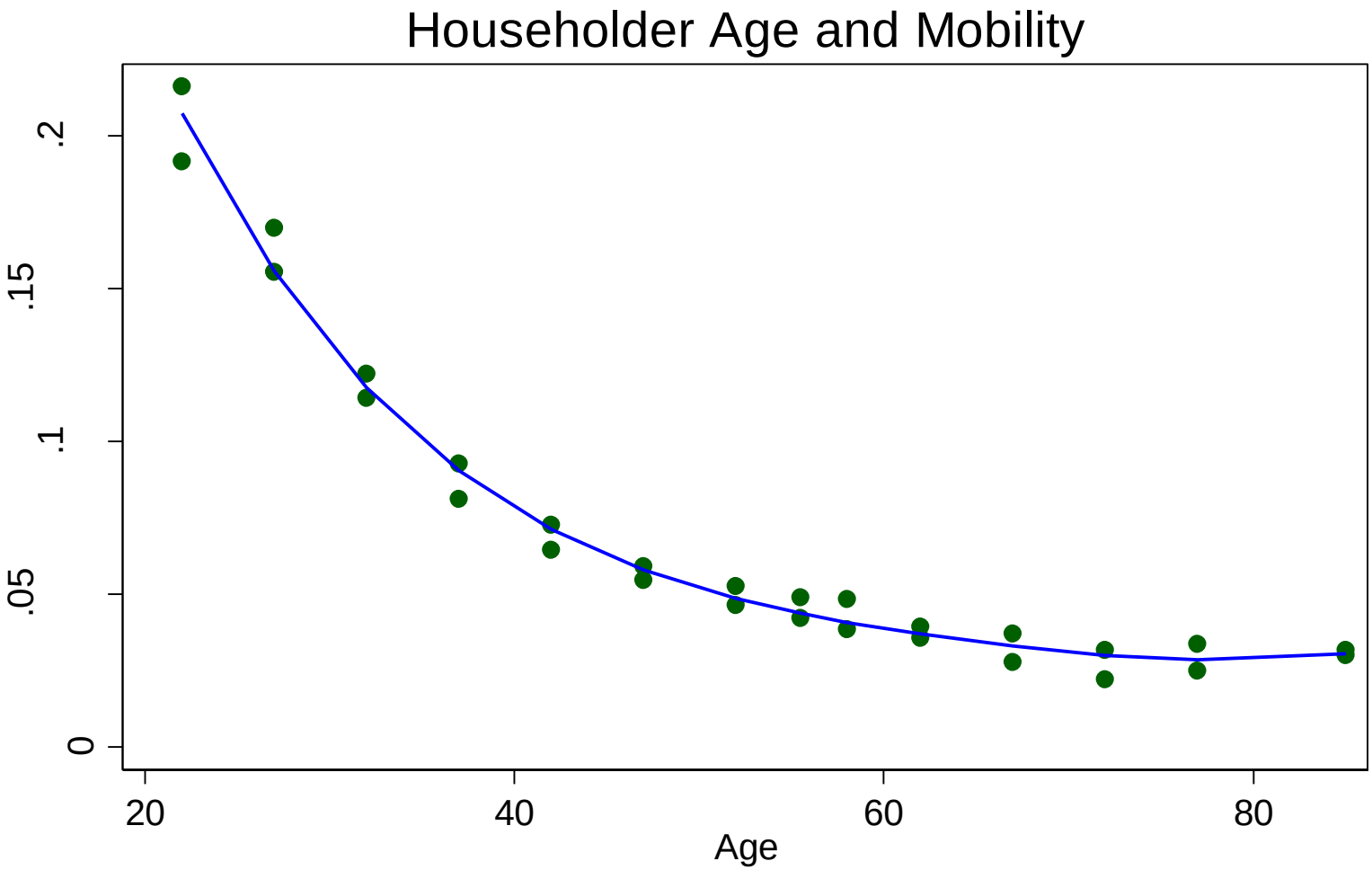


Source: CPS ASEC 2005 & 2010 / authors' calculations.

Fitted values calculated using fourth-order polynomial.

Table 7: Additional Interest Paid Due to Inflation Experiences

Scenario 2: Risk-adjusted rates, seniority-adjusted ARM margins

Time Horizon:	E[tenure | age]
After-tax PDV: (all in $)	
No Refi	20,819
Expected Refi	15,769
Optimal Refi	14,475
% switching households	13.5

Scenario 3: Risk-adjusted rates and ARM margins

Time Horizon:	E[tenure | age]
After-tax PDV: (all in $)	
No Refi	19,964
Expected Refi	14,854
Optimal Refi	13,543
% switching households	14.3

Notes. Table reports WRTEs, measured as the extra interest (after taxes) + refinancing costs paid by a household choosing an FRM instead of an ARM due to experienced inflation. Original loan amounts are in constant 2000 $.

Different Inflation Environments

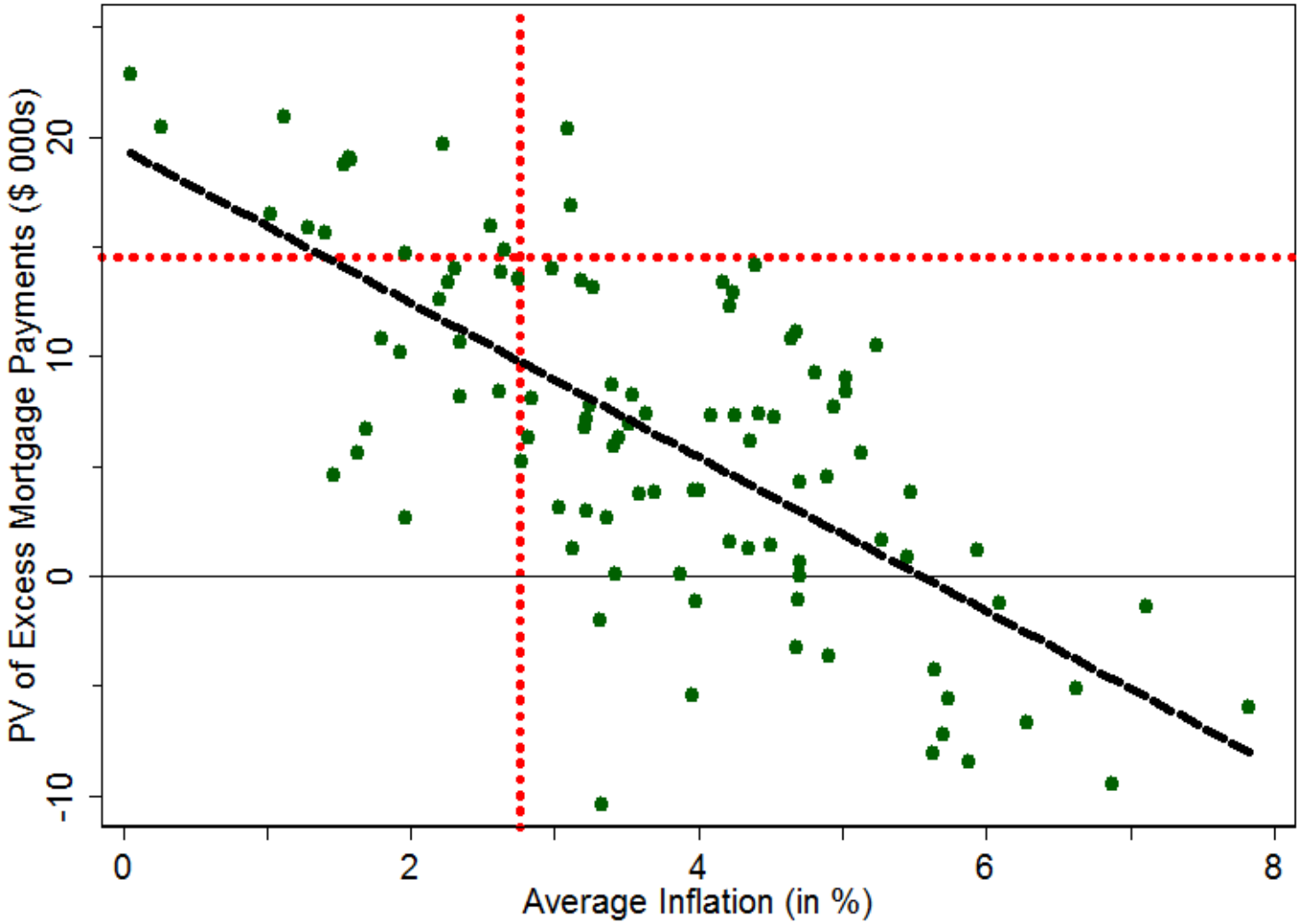
Our *ex post* estimates reflect the actual realization of inflation over 1985-2013.

- Are results driven by the Great Moderation?
- Other realizations were possible **given initial conditions.**

Simulation parameters

Variable	Process	μ	σ	Source
$\boldsymbol{\pi}$	AR(1), $\phi = 0.811$	0.038	0.027	CPI-U, 1960-2013
$\boldsymbol{r_1}$	Indep. WN	0.02	0.022	Campbell-Cocco (2003)
Nominal rates	ST given by Fisher equation LT given by EH + TP	$\theta_{10} = 0.01$		Campbell-Cocco (2003)
Mortgage rates	$y_{FRM} = y_{10} + \theta_{FRM}$ $y_{ARM,1} = y_1 + \theta_{ARM,1}$ $y_{ARM,2+} = y_1 + \theta_{ARM,2+}$	$\theta_{FRM} = 0.017$ $\theta_{ARM,1} = 0.015$ $\theta_{ARM,2+} = 0.0275$		PMMS, 1971-2013 PMMS, 1984-2013 PMMS, 1987-2013

Average Inflation and E[WRTE] in 100 Simulations



Aggregate Implications

Lifetime experiences of macroeconomic outcomes influence HH decision-making in an economically-significant manner.

- Most effected cohorts: young in the 1980s – Boomers.
- **Overweighting** lifetime experiences significantly **distorted** mortgage decisions. Using structural choice estimates and accounting for E[tenure] and E[refi]:
  - In late 1980s: **1 million** additional FRMs ⇒ *ex post* overpayment of **$14 billion**.
  - **Long shadows**: in late 1990s, Boomers took out **½ million** additional FRMs ⇒ *ex post* overpayment of **$9 billion**.

Welfare implications of overweighting are potentially large.