Mortgage Prepayment and Path-Dependent Effects of Monetary Policy

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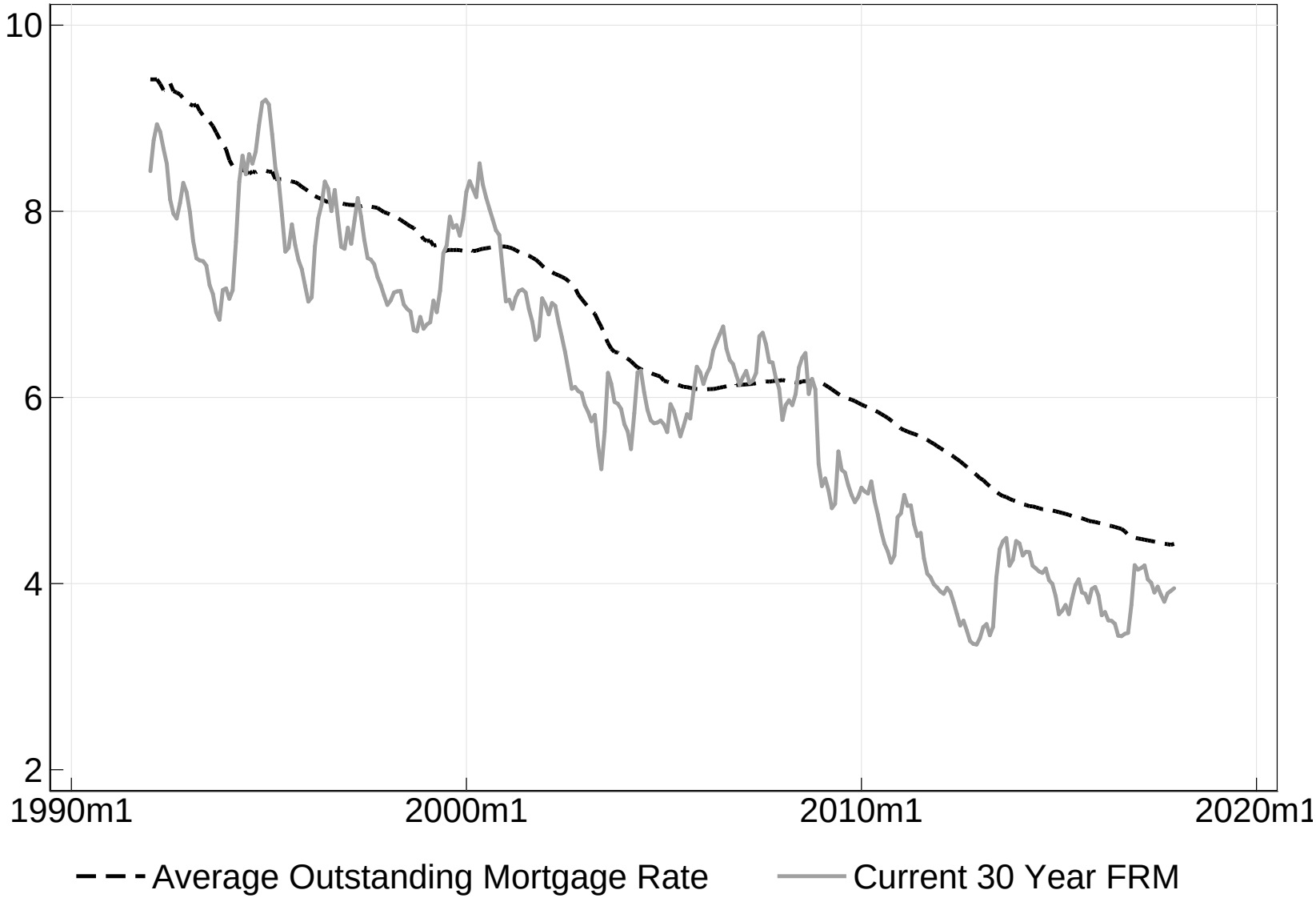
Mortgage Prepayment and Path-Dependent Effects of Monetary Policy

- FOMC forecast for FF rate in 2019: 3.1%
  - Similar to early 2008
- Similar stimulus ability if new crisis emerges?

- This paper: no!
  - Fixed-rate mortgages w/ prepayment option $\Longrightarrow$ *path-dependent* effects of monetary policy
  - Holding current rate constant, past rate history matters
  - Current rate cuts less effective after recent rate hikes

- Why?
  - If rates previously low, people already refinanced
  - "Powder" no longer dry

Outstanding vs. Current Market Mortgage Rates



Paper Overview

- Empirical:
  - Strong time-series and cross-region relationship between fraction of households with positive "rate gap" ($frac > 0$) and prepayment
  - Prepayment and spending respond more to Δr when $frac > 0$ large
- Theory:
  - Calvo-style refinancing model $\implies$ $frac > 0$ sufficient-statistic
  - Simple model but delivers:
    - Good empirical power
    - Straightforward intuition
    - Closed-form endogenous relationship between FFR and mortgage rate
    - Equilibrium borrowing/lending/saving/consumption

Main Theoretical Implications

- Rate cuts have much larger effects when *frac* > 0 large
  - Like Beraja et al (2018): refi incentive affects monetary policy strength
  - But rate gaps more directly under control of Fed than home equity
    - Path-dependence vs. state-dependence

$\Longrightarrow$

1. Refi channel amplified by 30-year downward rate trend
2. Holding current rate constant: Stimulus power greater if past rates were high than if they were low
3. Asymmetric refi incentives mean monetary policy loses effectiveness more quickly than regains it ("powder" dries very slowly)

And won't emphasize today but:

4. Endogenous mortgage pricing: level of rates matters for transmission

Data

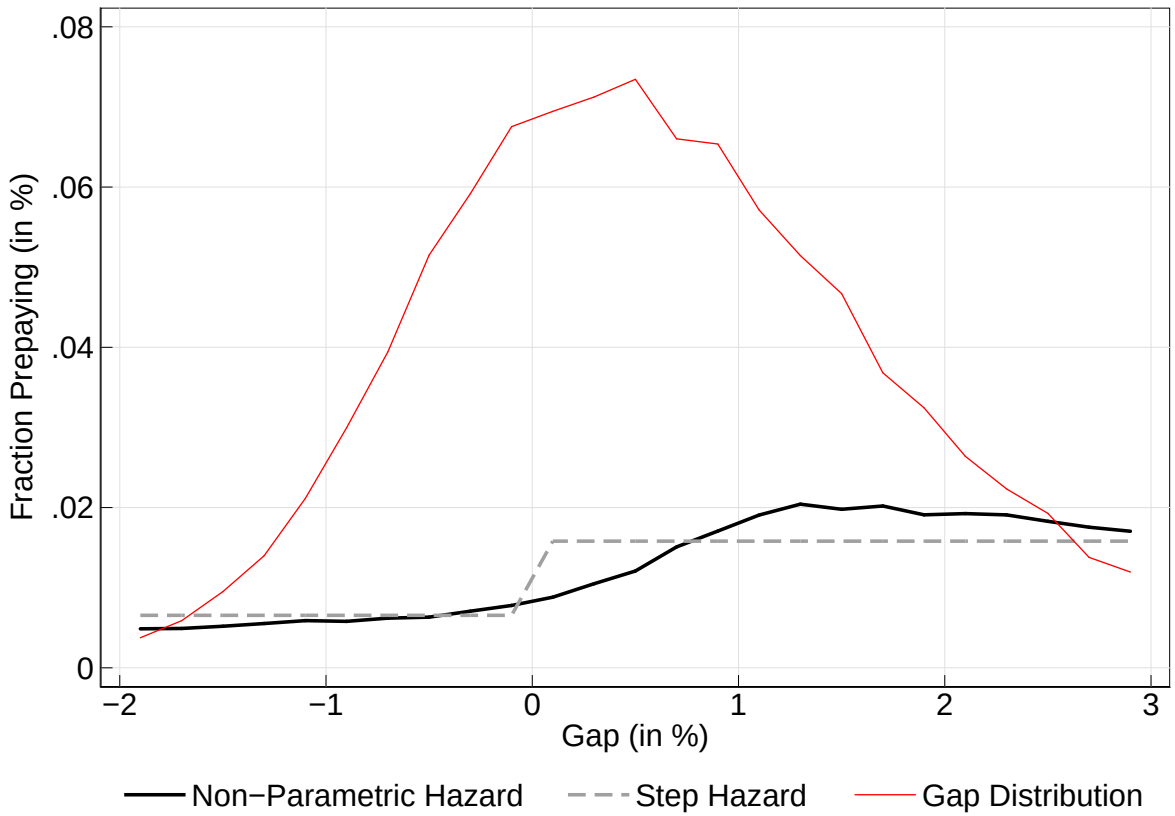
- BKFS McDash loan origination and performance data: 1992-2017
  - With loan-level data, can measure which loans prepay but cannot distinguish rate refi, cashout, moving and early payoff
- Link to Equifax credit records from 2005-2017 ("CRISM" data)
  - Can measure response of each prepayment type to rate incentive
  - Measure individual spend responses as proxied by auto loans
- Supplement w/ CoreLogic LLMA data on origination shares by mortgage type for 1992-2005
  - Note: LLMA better origination info on mortgage type than McDash but no performance data prior to 98, so we use both

External Validity

- Local auto registration data from Polk

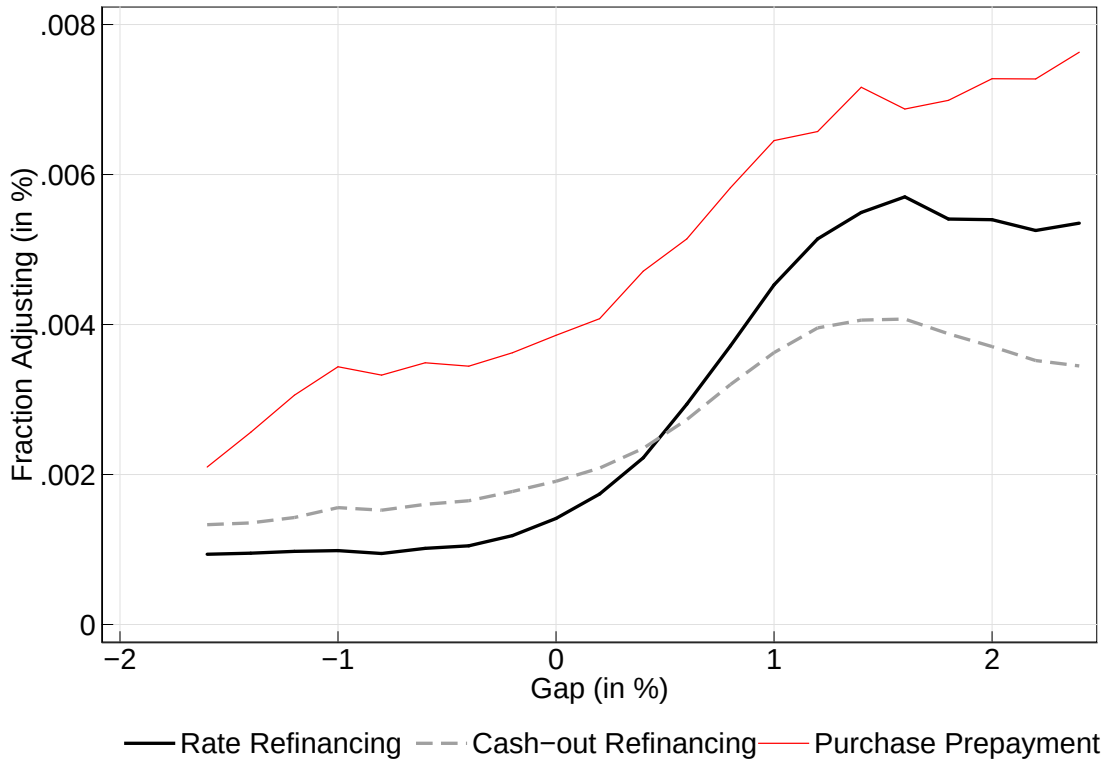
Prepayment vs. Rate Incentive

- Pool all loan-month observations from 1992-2017
- For each loan-month calculate "rate gap" $= m_t^* - m_t$ between outstanding rate (m_t^*) and current 30 year FRM (m_t)
- Bin data by gap and calculate distribution and prepay propensities



Prepayment by Type

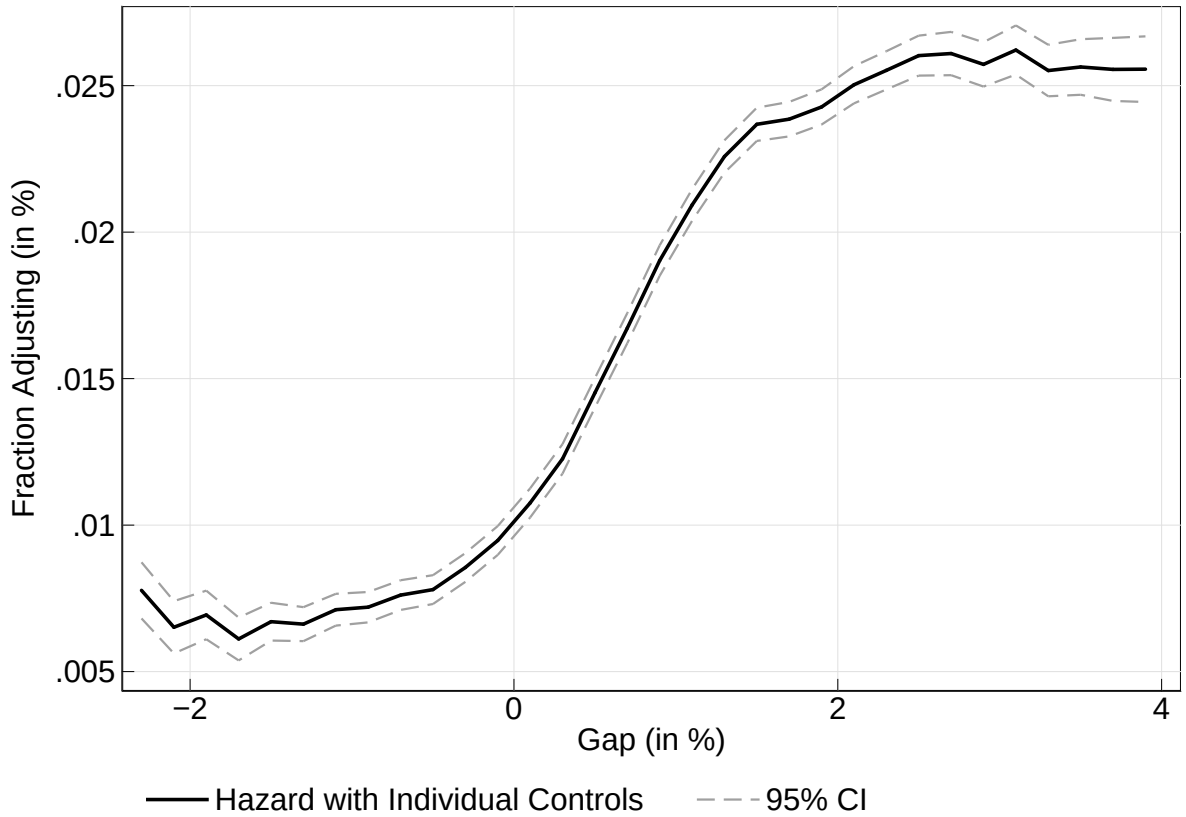
- Focus primarily on total prepayment since all prepayment affects future gap distribution
- But after 2005, use CRISM to compute prepay hazards by type:



- Increasing for all, but sharpest break at 0 for rate-refi

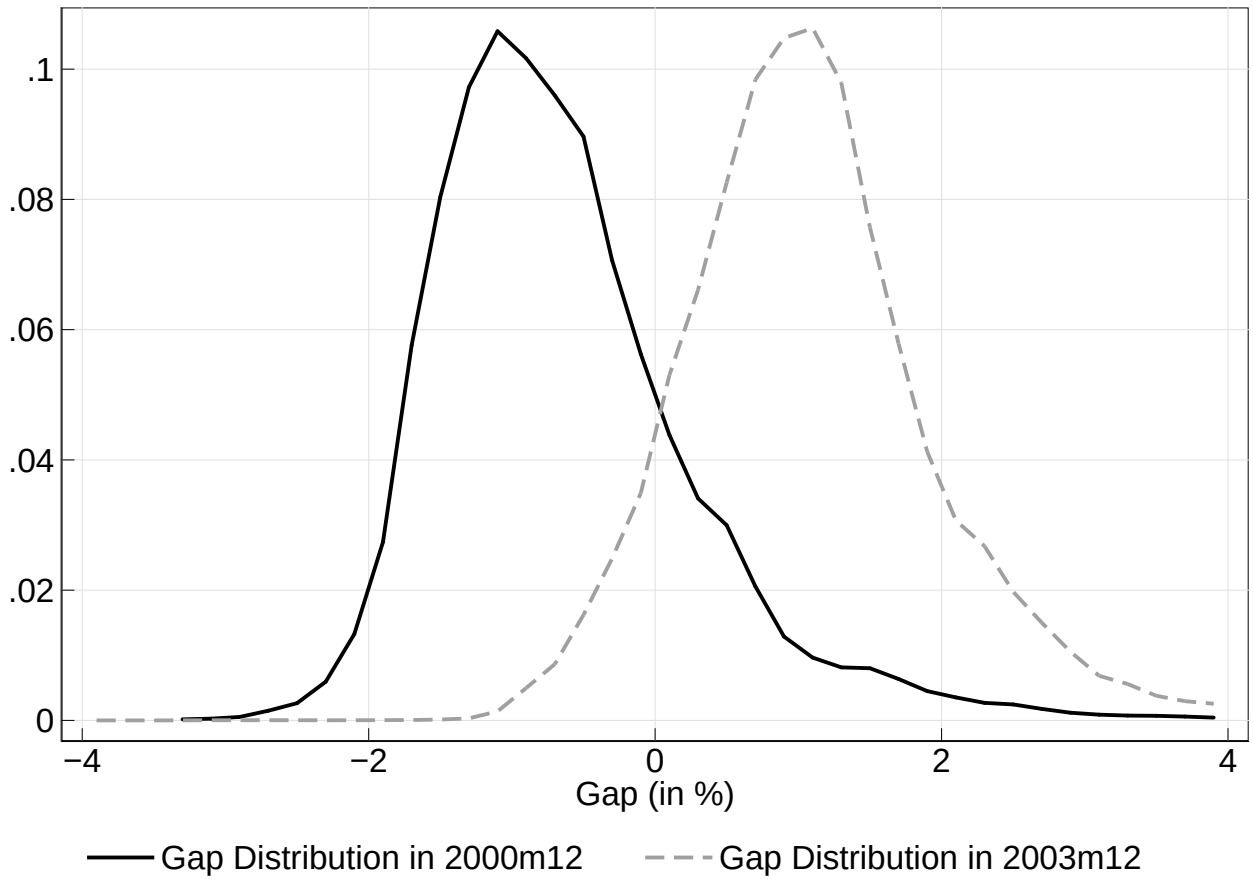
Prepayment Hazards: Individual Regressions

- Previous results calculate average prepay by bins
  - Other confounding characteristics might vary with bins
- Use CRISM linked data to run *individual* prepayment regression with individual FE + other time-varying observables
- Generates even sharper prepayment relationship:



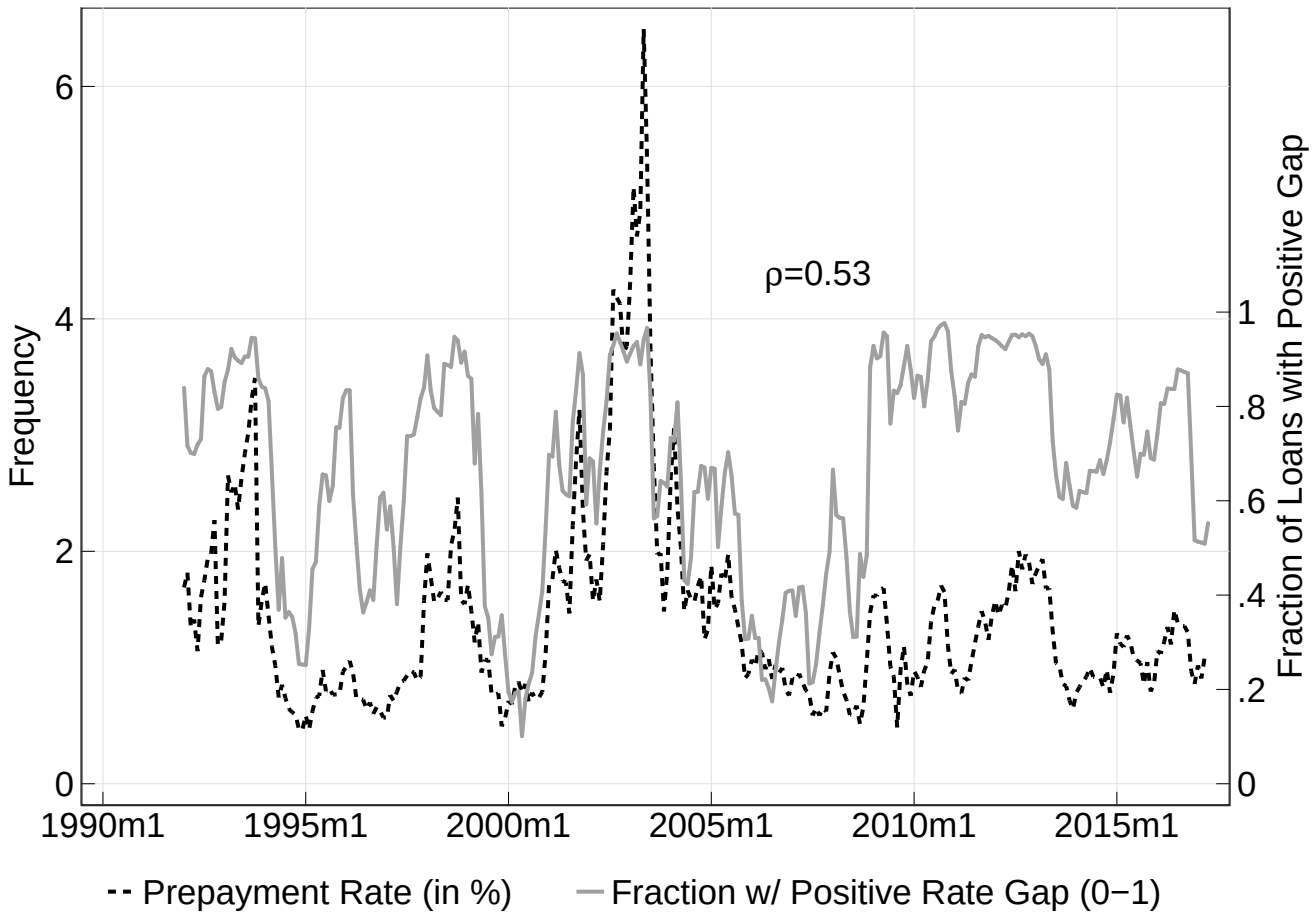
Time-Variation in Rate Gaps

- Just showed individual rate gaps predict prepayment
- Rate gap distribution also moves a lot across time:



What moments of rate gap distribution matter?

- Simple summary statistic:
  - Fraction of hh with positive gap in month t
- In model, this will be sufficient-statistic
- Relationship between frac > 0 and prepay:



What moments of rate gap distribution matter?

- Run time-series regression of $prepay_t$ on $(frac > 0)_t$ (+ alternative gap statistics and covariates):

	(1)	(2)	(3)
frac $>$ 0	2.051***		
	(0.386)		
frac $>$ 50bp		1.989***	
		(0.389)	
frac $>$ 100bp			2.249***
			(0.450)
Constant	0.0416	0.365**	0.673***
	(0.196)	(0.145)	(0.107)
Adj. R^2	0.282	0.277	0.246
Date Range	92-17m4	92-17m4	92-17m4

- $frac > 0$ contains most predictive content: full non-parametric regression increases R^2 from 0.282 to 0.305
  - Also note: rate gap$>$0 $\iff$ \$ gap$>$0

Additional Factors Affecting Prepayment

	(1)	(2)	(3)	(4)	(5)
frac > 0	2.051***	7.861**	5.117*	2.058***	2.066***
	(0.386)	(3.650)	(2.714)	(0.357)	(0.394)
ave CLTV		-0.975	-2.130		
		(2.456)	(1.991)		
(frac > 0) $\times$ ave CLTV		-8.158	-4.259		
		(5.281)	(3.978)		
$\mathbb{1}_{year=2003}$			1.737***		
			(0.621)		
Constant	0.0416	0.228	1.062	-0.0455	-0.398
	(0.196)	(1.646)	(1.304)	(0.194)	(0.298)
Adj. R^2	0.282	0.488	0.623	0.558	0.608
Date Range	92-17m4	92-17m4	92-17m4	92-00	11-17m4

Results by Prepayment Type

	(1) Total	(2) Rate	(3) Cashout	(4) Purchase
frac $>$ 0	2.053*** (0.399)	1.261*** (0.187)	0.296** (0.128)	0.400*** (0.132)
Constant	0.0424 (0.199)	-0.411*** (0.0948)	0.0670 (0.0672)	0.380*** (0.0690)
Date Range	93-17m4	93-17m4	93-17m4	93-17m4

Measuring Prepayment Type

Endogeneity Concerns

- Gap distribution obviously endogenous
- Instrument for frac $>$ 0 using Gertler-Karadi MP shock series

	(1) Total	(2) Rate	(3) Cashout	(4) Purchase
frac $>$ 0	2.762** (1.200)	1.259*** (0.455)	0.874** (0.418)	0.657 (0.484)
Constant	-0.322 (0.769)	-0.393 (0.282)	-0.269 (0.279)	0.235 (0.314)
Date Range	93-12m7	93-12m7	93-12m7	93-12m7

Effects on Average Coupon Changes

- Previous results look at prepayment outcome
- Even more important outcome: change in average coupon rate

Table: Change in Average Coupon

	(1)	(2)	(3)
frac $>$ 0	-0.049***		-0.047***
	(0.006)		(0.005)
Δ FRM		0.019***	-0.029**
		(0.005)	(0.012)
Δ FRM $\times$ (frac $>$ 0)			0.054**
			(0.023)
Constant	0.018***	-0.014***	0.018***
	(0.003)	(0.002)	(0.003)

Regional Evidence

- Think of rate gap primarily as determined by aggregates
- But some regional variation due to different loan ages
- Note: ≈ 0 regional variation in market rates (Keys et al 2016)

Table: Effects of Rate Gaps on Prepayment Propensities by MSA

	(1) Tot Prepay	(2) Rate-Refi	(3) Cashout	(4) Purchase
frac > 0	2.86***	1.67***	-0.068	1.18***
	(0.36)	(0.16)	(0.13)	(0.15)
MSA FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Adj. R^2	0.85	0.85	0.67	0.63

Standard errors two-way clustered by MSA and month

Local Spending

- Mostly care about region results to measure local spending
- Auto sales growth from Polk:

Table: Auto Sales Growth Responses to Refinancing and Mortgage Rate Changes

	(1) IV	(2) IV	(3) IV	(4) IV
Δ freq	0.081***	0.081***		
	(0.028)	(0.028)		
freq $\times\Delta$ FRM			-0.20***	-0.20***
			(0.066)	(0.068)
freq			0.0036	-0.023
			(0.015)	(0.015)
MSA FE	No	Yes	No	Yes
Time FE	Yes	Yes	Yes	Yes

Standard errors two-way clustered by MSA and month

Summarizing Empirical Evidence

- Substantial time-variation in rate gap distribution
- frac > 0 important summary stat for entire gap distribution:
  - Correlated w/ prepayment (particularly strong for rate refi)
  - Correlated w/ greater response of prepay and m^* to m
  - Correlated w/ local auto spending

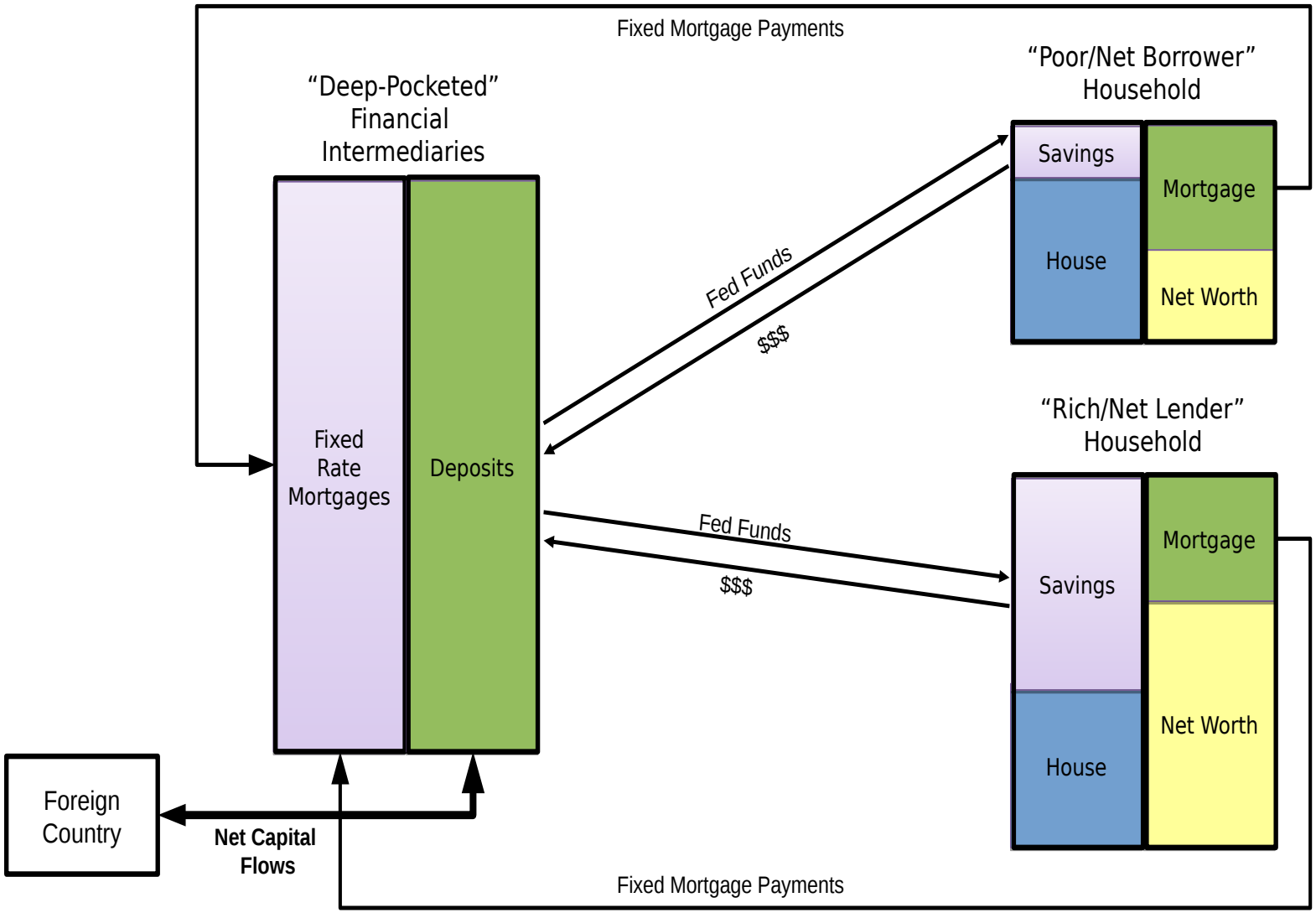
Theoretical Implications

- What are implications of this empirical evidence for monetary policy?
- Build simple model w/ frac > 0 as key statistic
  - Just showed this statistic has strong predictive power
- This model delivers:
  - Straightforward intuition
  - Closed-form endogenous relationship between FFR and mortgage rate
  - Equilibrium borrowing/lending/saving/consumption through financial intermediaries

Model: Main Elements

- Small open economy incomplete markets' model ("Bewley"-style)
- Households subject to idiosyncratic income risk decide:
  - How much to consume,
  - How much to save,
  - Whether to refinance their mortgage ("Calvo"-style)
- (Deep-pocketed, risk-neutral, foreign-owned) financial intermediaries engaged in "maturity transformation":
  - Lend long term via fixed rate prepayable mortgages
  - Borrow short term in floating rate form
  - Solve risk-neutral mortgage pricing problem
- Aggregate states
  - Short term interest rates (driving process)
  - Fixed mortgage rates (pinned down in equilibrium)

Model: Balance-Sheets



Model: Mortgage Prepayment Process

- Mortgage contract
  - Fixed balance (no amortization for now)
  - Fixed rate perpetuity, prepay option
  - No credit risk
  - Mortgage market rate m_t

- Refinancing decision by households (mortgage coupon m_t^*)
  - Move from one house to another (hazard rate ν) $\Rightarrow$ forced refi
  - Pay attention to market rates (hazard rate χ) $\Rightarrow$ refi if $m_t < m_t^*$

- Key simplifying assumptions
  - No margin of adjustment of mortgage balance (for now)
  - No adjustment of house size
  - Calvo-style rate refi:
    - Reduced form for various pecuniary and non-pecuniary refi costs

$\Rightarrow$

  - Only source of state dependence for refi is rate incentive: $\mathbb{1}_{(m_t^* - m_t > 0)}$

Model: Mortgage Pricing

- Aggregate state of the economy
  - $a_t \in \{1, ..., n_a\}$ as continuous-time Markov chain
  - Short term rates $r(a_t)$
  - Market mortgage rates $m(a_t)$ determined endogenously
- Financial intermediaries
  - Funding via short term floating rate debt
  - Issue fixed-rate prepayable mortgage contract
  - Competitive mortgage pricing, with m_t solution of:

$$1 = \mathbb{E}_t \left[\int_t^{t+\tau} e^{-\int_0^s r_{t+u} du} m_t ds + e^{-\int_0^\tau r_{t+u} du} \right]$$

  - Closed form expression for $m(a_t)$
- Key simplifying assumptions
  - Intermediaries owned by foreigners $\Rightarrow$ change in firm value not affecting households' consumption/savings decisions
  - "Calvo"-style rate refi $\Rightarrow$ simple pass-through between short term rates and mortgage rates, independent of the household cross-sectional distribution

Household Consumption/Savings Problem

- Household with mortgage balance F and state vector
  - Aggregate state a_t (continuous time Markov chain)
  - Idiosyncratic income state s_t (continuous time Markov chain)
  - Liquid savings W_t
  - Current morgage coupon $m(a_t^*)$ (a_t^*: state at last refi)

- Household solves standard incomplete market "Bewley" problem

$$\sup_C \quad \mathbb{E}\left[\int_0^\infty e^{-\delta t} u(C_t) dt\right]$$
$$\text{s.t. } dW_t = \left(Y(s_t) - C_t + r(a_t)W_t - m(a_t^*)F\right) dt$$
$$da_t^* = (a_t - a_{t-}^*)\left(dN_t^\nu + 1_{\{m(a_t) < m(a_{t-}^*)\}} dN_t^\chi\right)$$

- Resulting policies:
  - consumption rate $C(W, a, a^*, s)$
  - savings rate $S(W, a, a^*, s)$

Calibration

- Refi parameters
  - $\nu = 2\%$ p.a. (refi hazard rate conditional on negative gap)
  - $\nu + \chi = 22\%$ p.a. (refi hazard rate conditional on positive gap)
- Preference parameters
  - $\gamma = 2$ (risk-aversion, isoelastic time-separable preferences)
  - $\delta = 12\%$ (rate of time preference; results in ergodic agg. savings = agg. mortgage debt)
- Income and mortgage parameters
  - 2 income states: employed ($60k/year) and unemployed ($15k/year)
  - transition intensities matching U-E and E-U hazard rates
  - mortgage face value: $175k (avg. US household debt)
- Short term rates
  - r_t: 10 discrete states, 1% intervals
  - transition intensities calibrated to approximate CIR model with:
    - ergodic mean short rate: 3.42%
    - ergodic standard deviation: 2.2%
    - half-life: 5.3 years
  - resulting mortgage rate process with average "pass-through" of 0.53

First Implications and Intuition for Mortgage Outcomes

- Given gap x, with distribution $f(x)$ and hazard $h(x)$ with k jumps

$$\text{Define: } D_k \equiv x_k[h(x_k^+)f(x_k^+) - h(x_k^-)f(\bar{}_k)]$$

- Accounting relationship for IRF on impact of m^* to m (application of Caballero-Engel 2007):

$$\frac{d\bar{m}^*}{dm} = \int h(x)f(x)dx + \int xh'(x)f(x)dx + \sum_k D_k$$

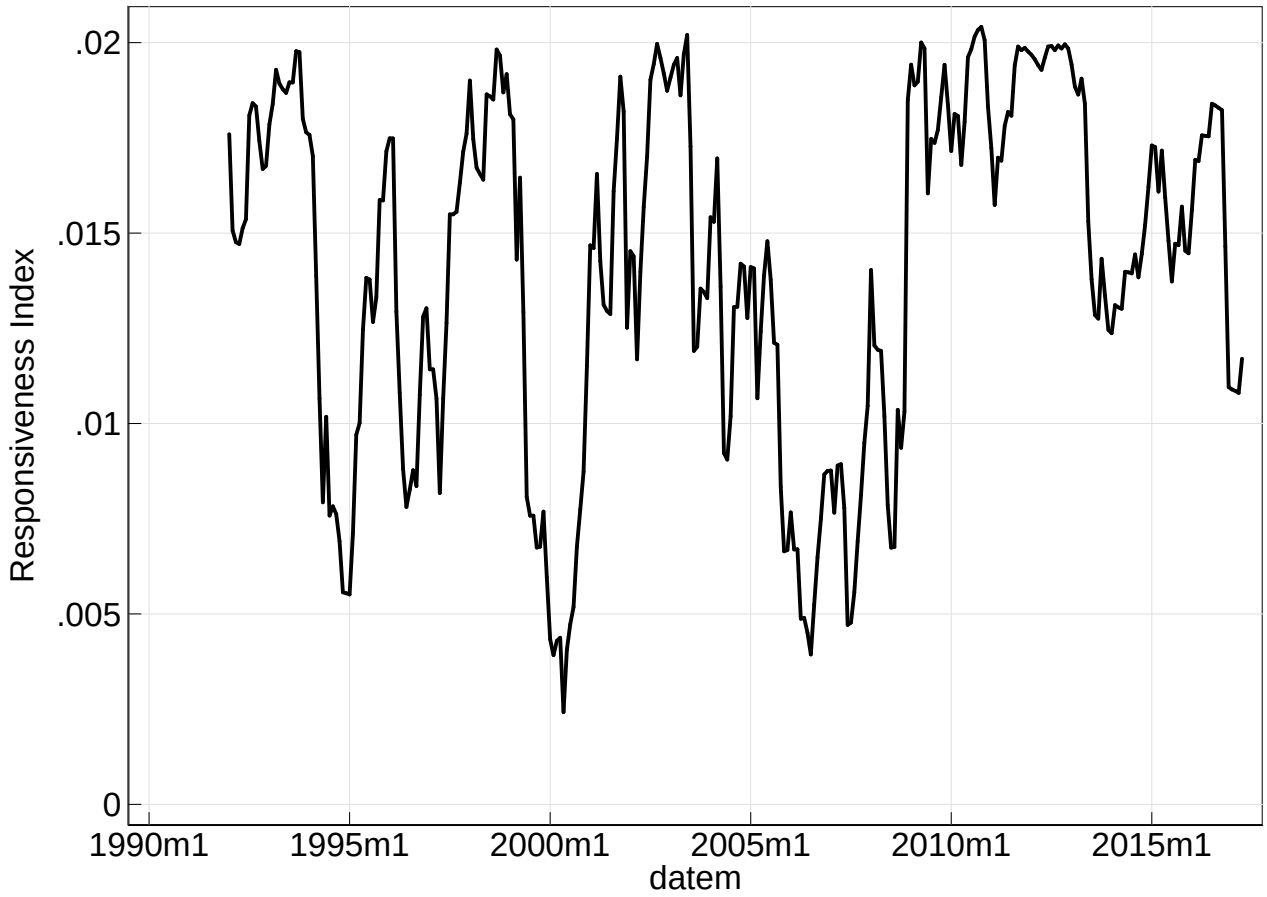
- In our model, only change in hazard is jump at $x = 0 \implies$

$$\frac{d\bar{m}^*}{dm} = \int h(x)f(x)dx = \nu + (1 - F(0))\chi$$
$$\implies$$
$$frac > 0 \text{ sufficient-statistic for coupon response}$$

- Only need fraction w/ positive gaps not whole distribution!

Application to Historical Time-Series

- Model hazard + observed *frac* > 0 sufficient for impact effect of Δm:



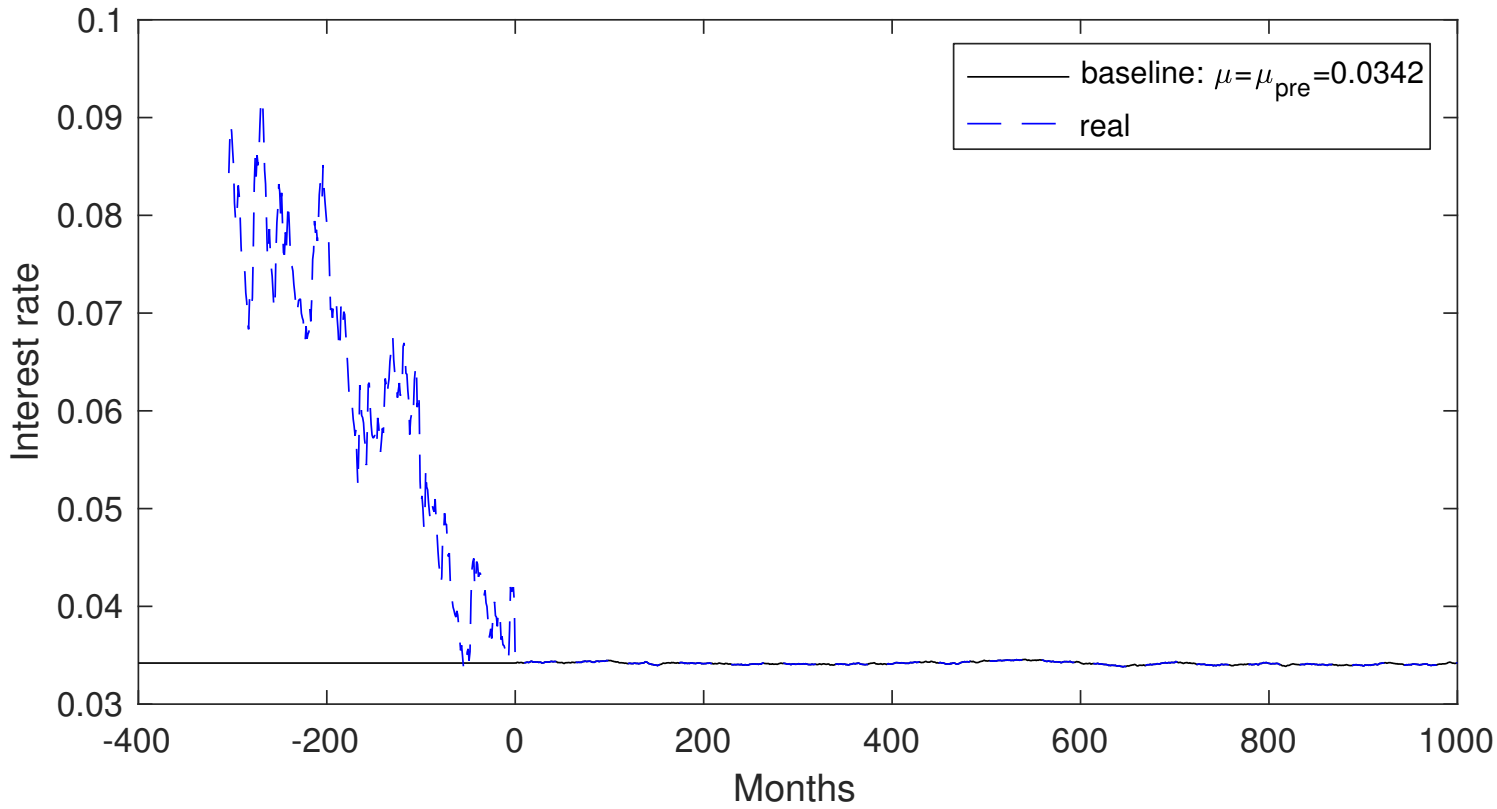
- Consistent with earlier empirical regression that average coupon more responsive to rate changes when fracpos large

Moving to Full Model Results

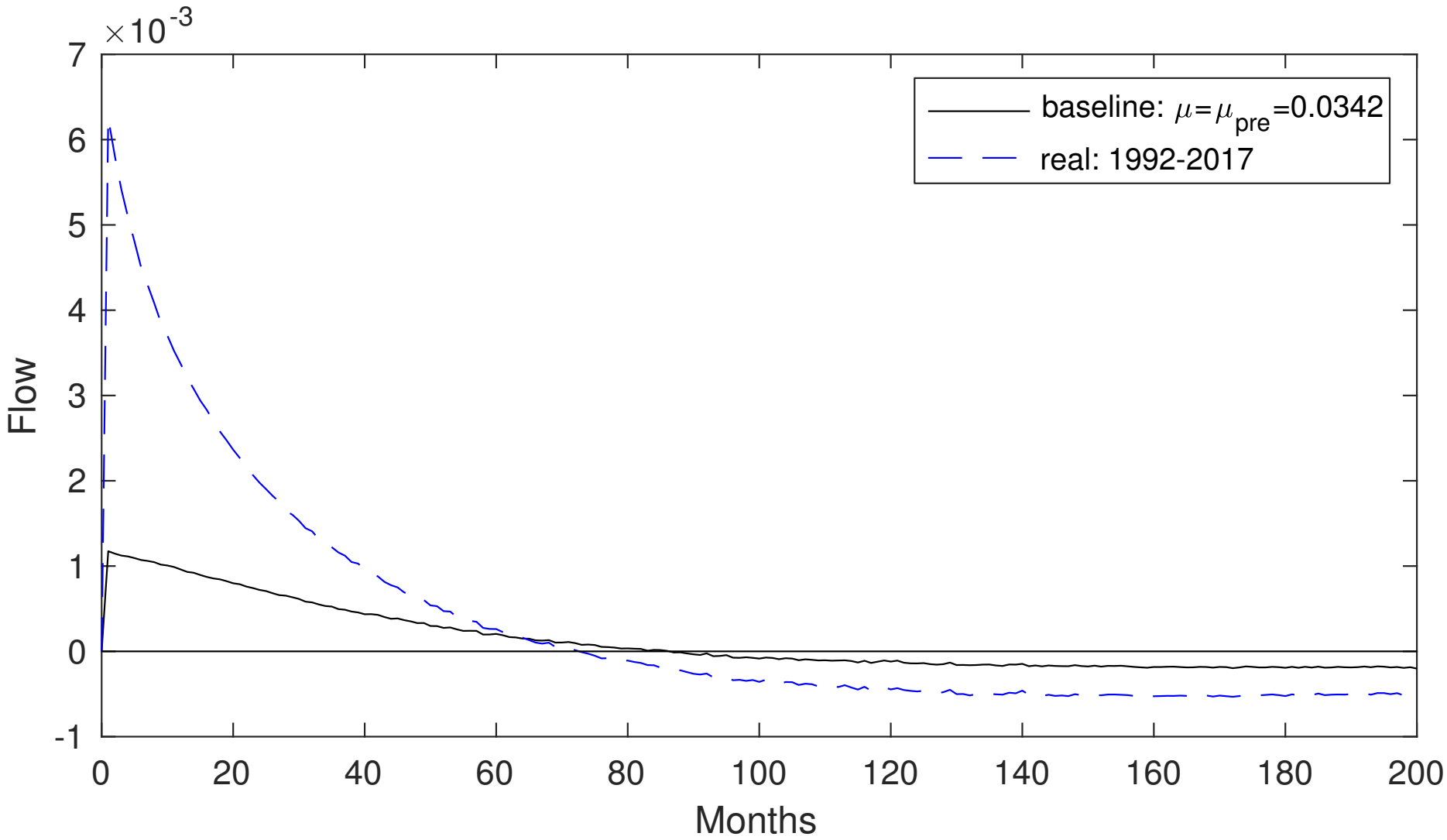
- Accounting relationship useful given historical coupon distribution and requires only observable inputs
- But can't tell us more ambitious counterfactuals
  - Effects of trends
  - How quickly does $frac > 0$ and stimulus power change?
- Effects of conventional monetary policy (short rather than long rates)
- IRFs beyond impact
- Consumption effects

Full Model Result 1: Amplification from Downward Trend

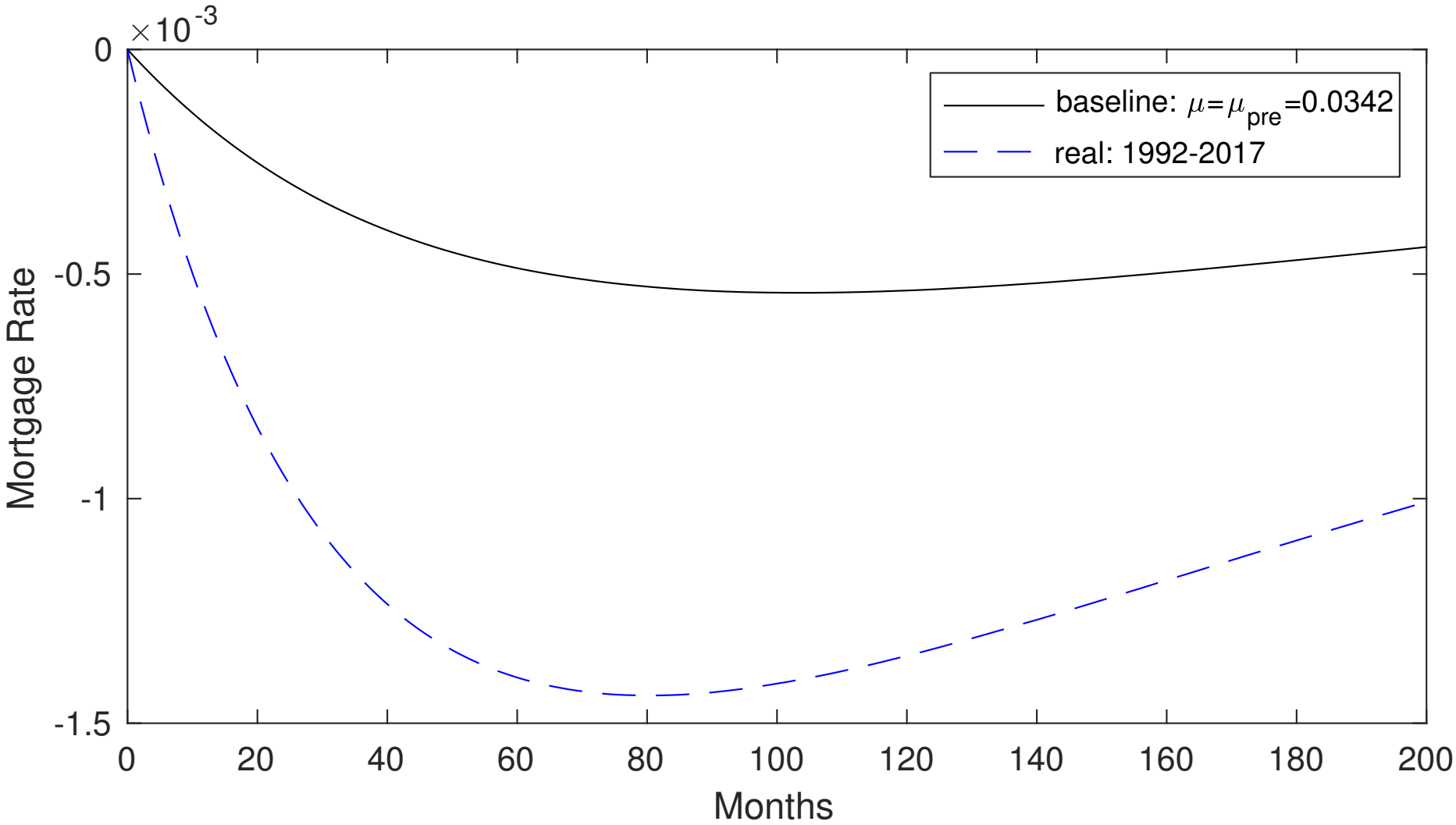
- Compute model response to 100bp decline in r in period 0 under two different scenarios for *past* rates:
  1. Ergodic distribution with short-rate to match 2017
  2. 1992-2017 actual mortgage rate series
- *Current* r in both scenarios set identical in period 0



IRF of Prepayment Flows

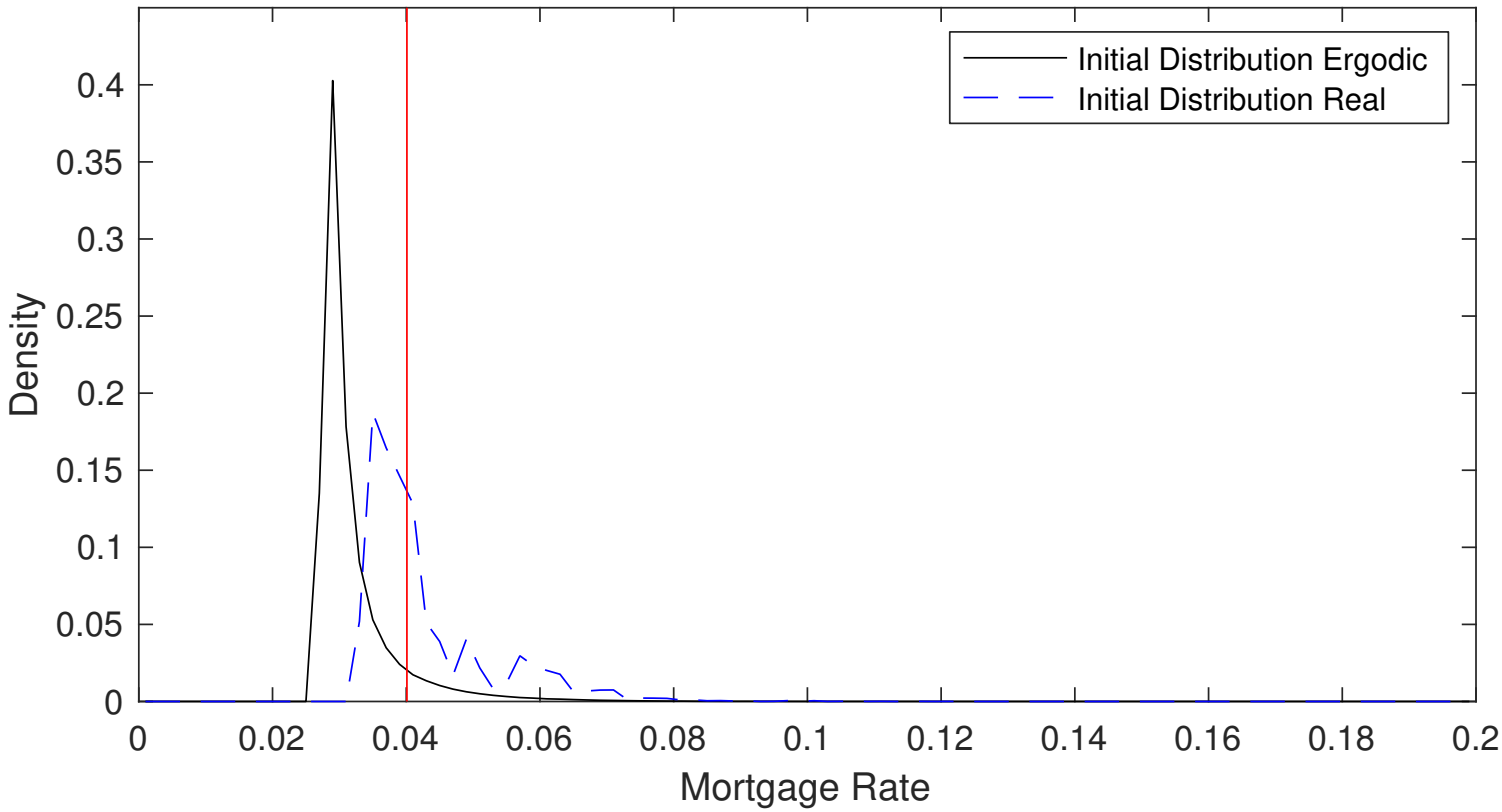


IRF of Average Coupon



Intuition

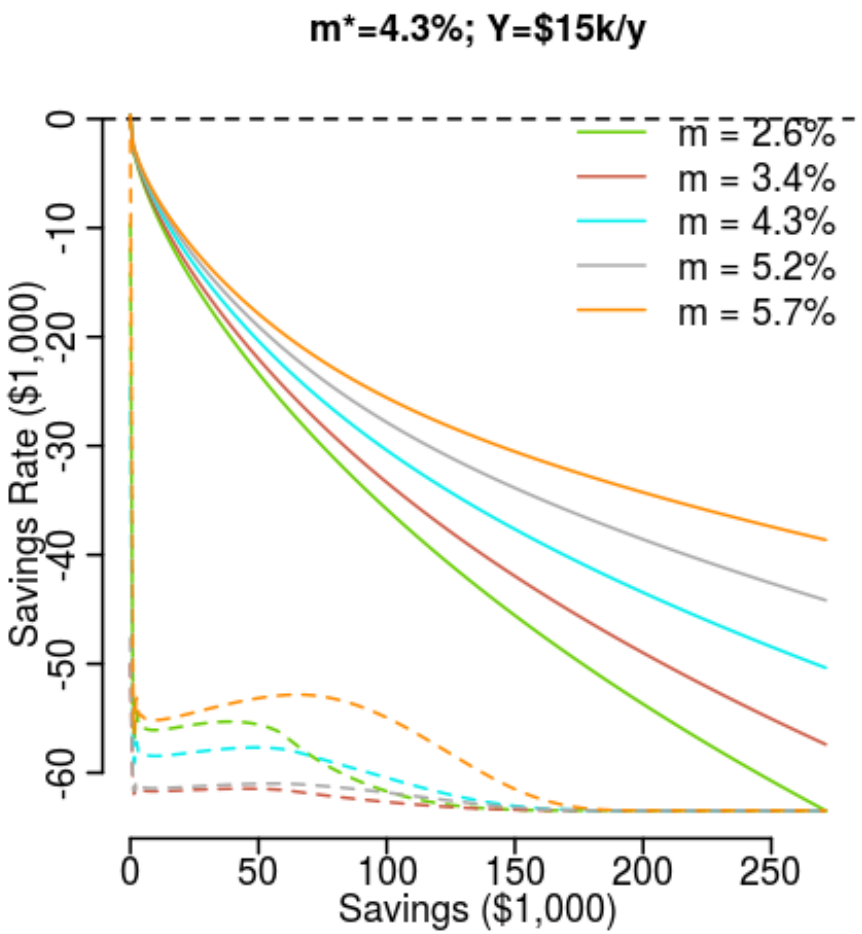
- Driven by effects on $frac > 0$
- Many more households with positive gaps with 30 year downward trend than in stable rate environment

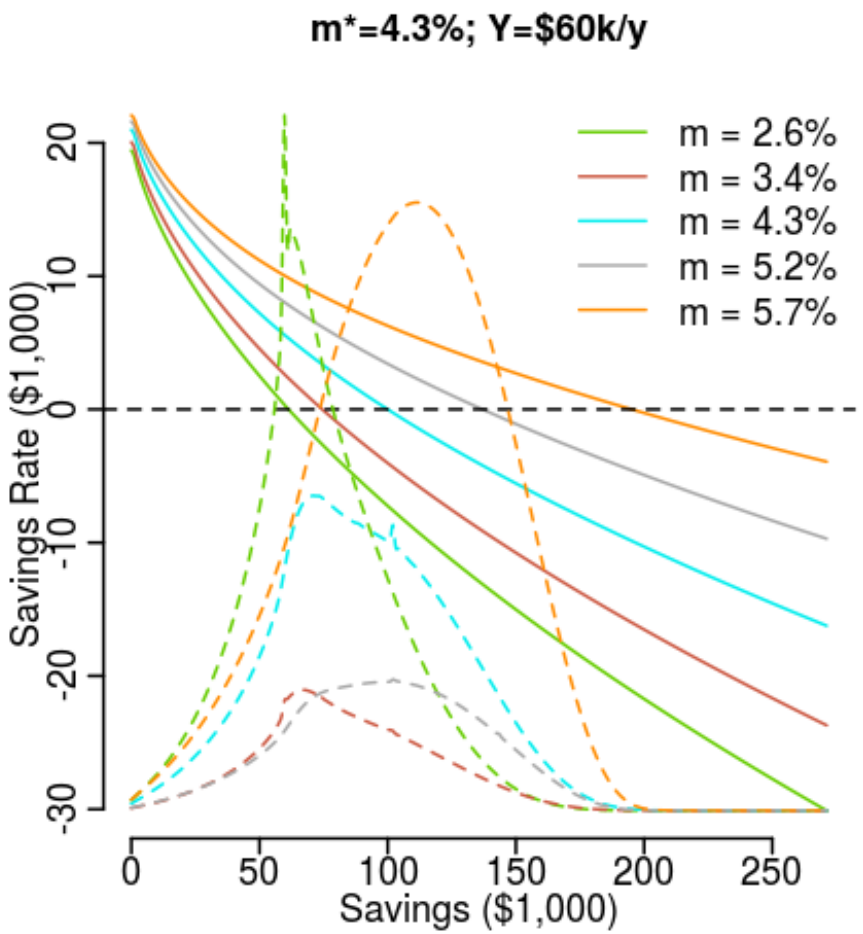


Aggregate Consumption Effects

IRF

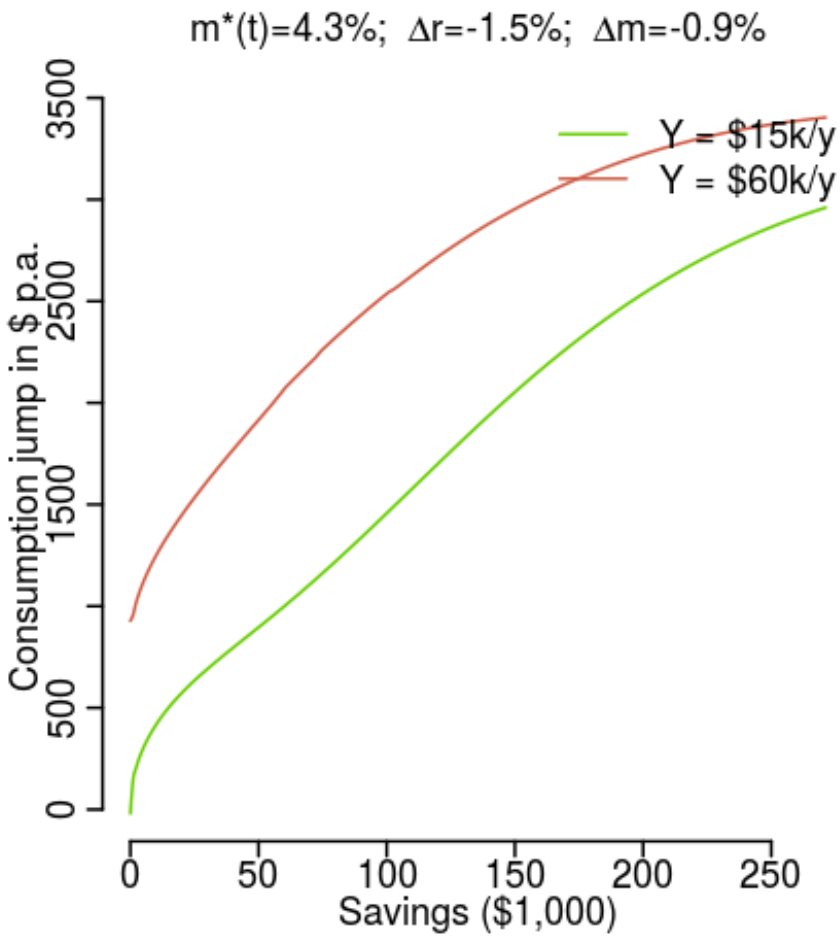
Households' Savings Policy: Example

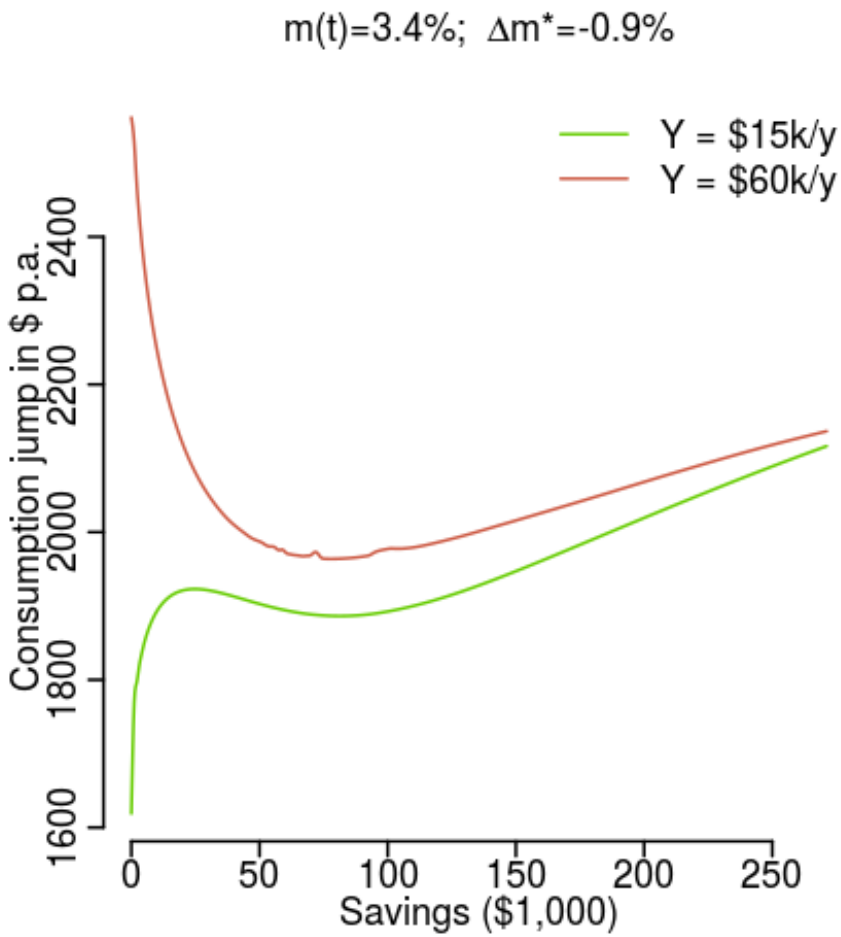




On-Impact Consumption Response

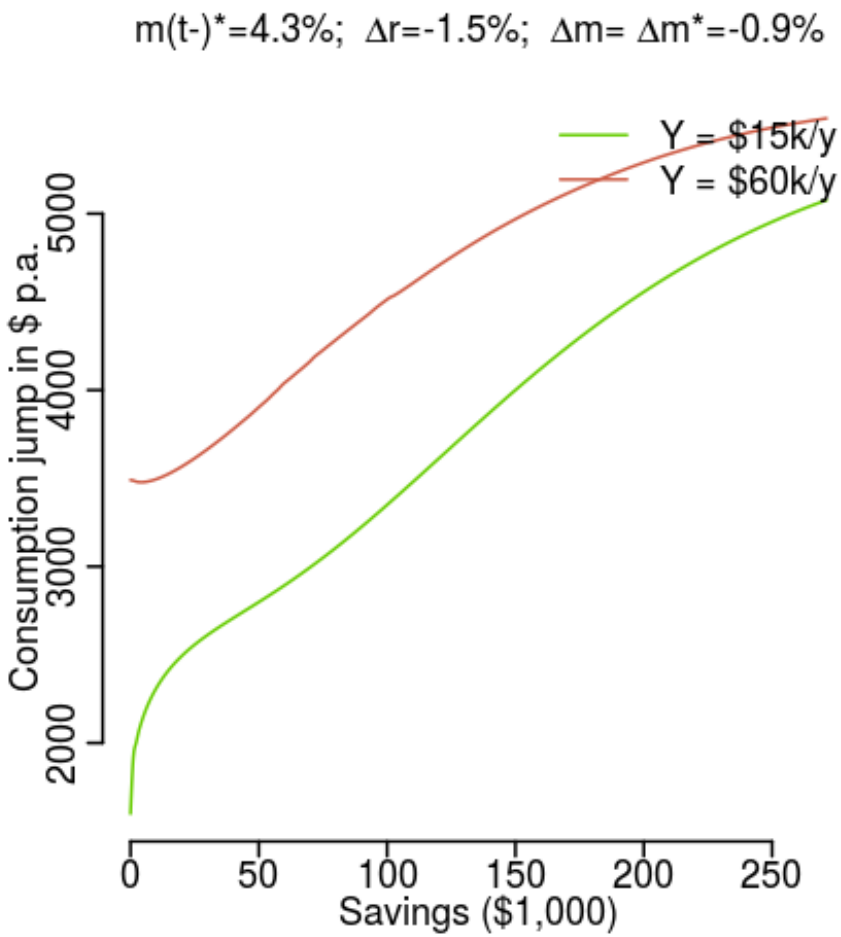
(1) rate decrease without refi vs. (2) refi without rate decrease





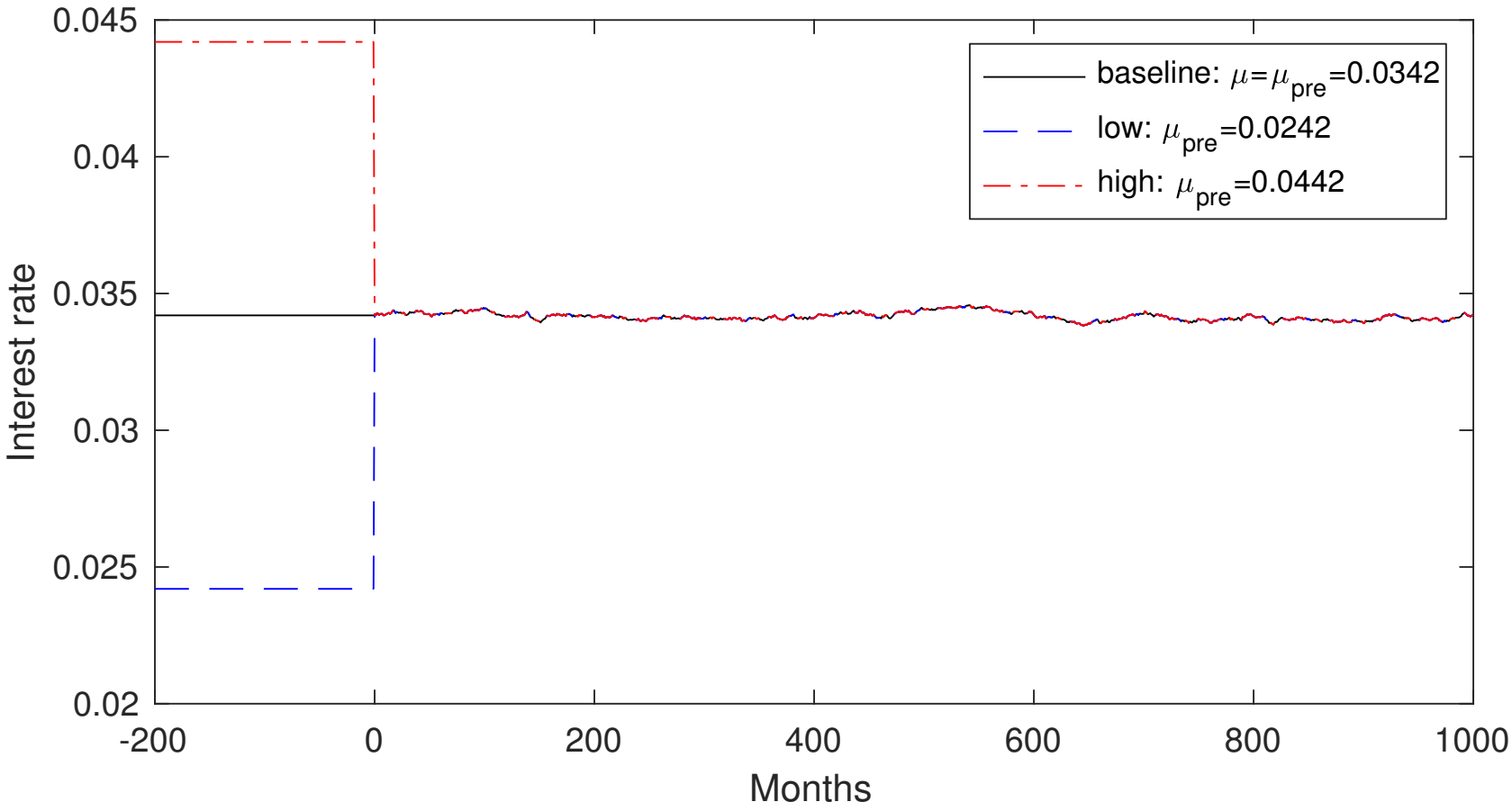
On-Impact Consumption Response

total response following rate decrease and refi

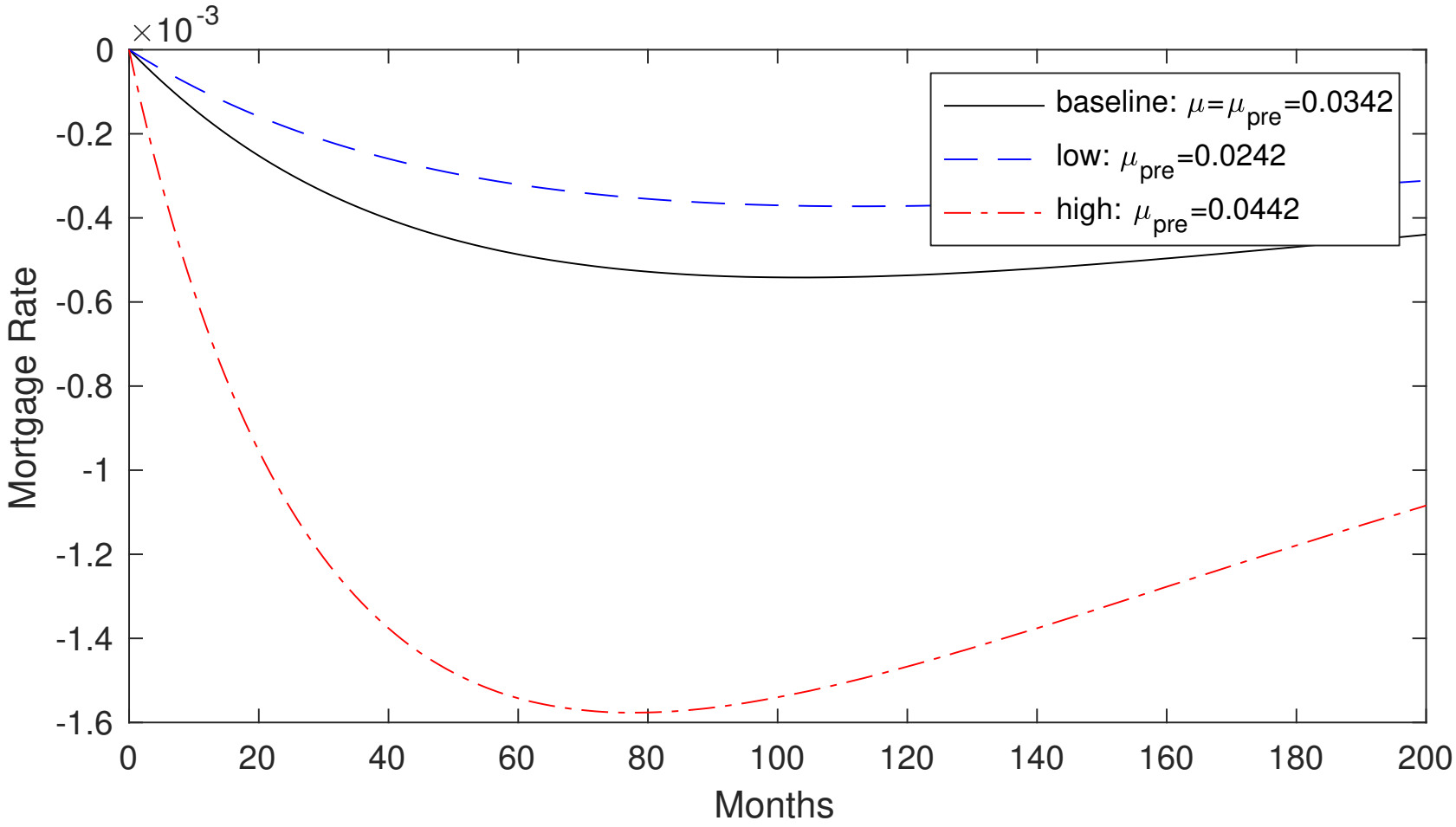


Result 2: Path-Dependence in Ergodic "Steady-State"

- Again explore effects of transitioning from high to low rate regimes or vice versa, but now in ergodic steady-state:



IRF of Average Coupon



Result 3: Firing ammunition faster than reloading

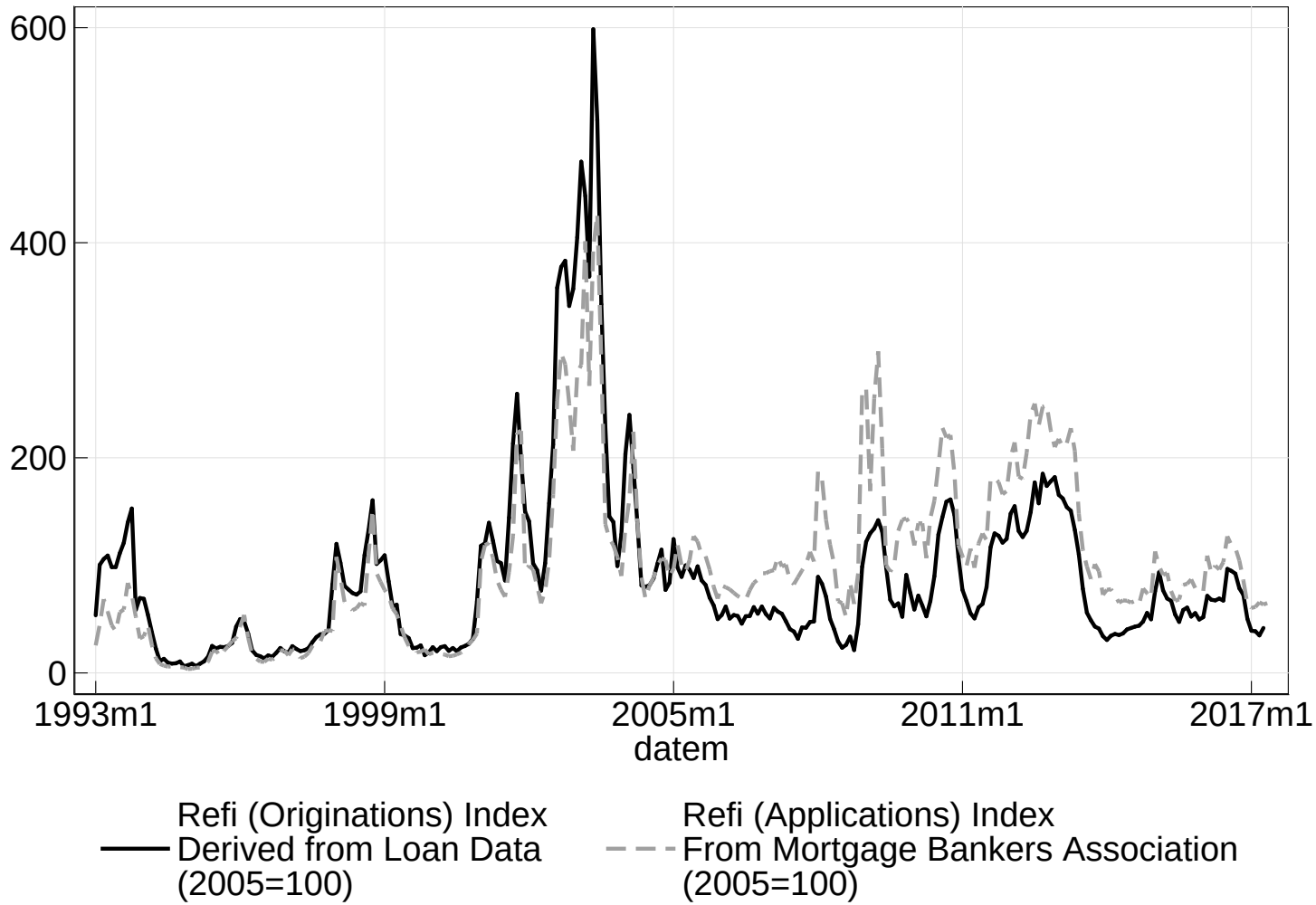
- How quickly does monetary policy gain stimulus ability as rates rise?
- Contrast response to first 100bp rate cut with "max stimulus" from cutting rates to 0
- If rates have recently increased:
  - Response to first 100bp rate cut is decreased
  - Maximum stimulus increases since more room to cut, but not by much
- Eventually (but convergence very slow):
  - Response to first 100bp rate cut rises
  - Maximum stimulus increases substantialy

Summary and Next Steps

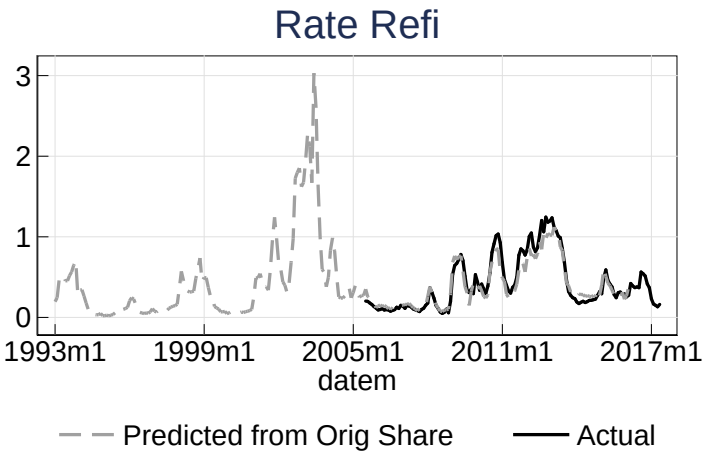
- Frac with positive rate gaps strong empirical power for prepay
- Build model where sufficient-stat for mortgage outcomes
  - Implies substantial path-dependent policy
  - Current rate not very informative about how much room for stimulus
  - Prepayment channel substantially amplified by 30 year downward rate trend
  - "Powder" dries very slowly: Even if Fed keeps raising rates, won't regain substantial breathing room for stimulus very quickly
- Next steps:
  - Explore QE vs. conventional policy
  - More quantitative realism in consumption model
  - Richer short-rate process with additional mortgage pricing implications
  - Empirics: More individual outcomes, richer consumption data

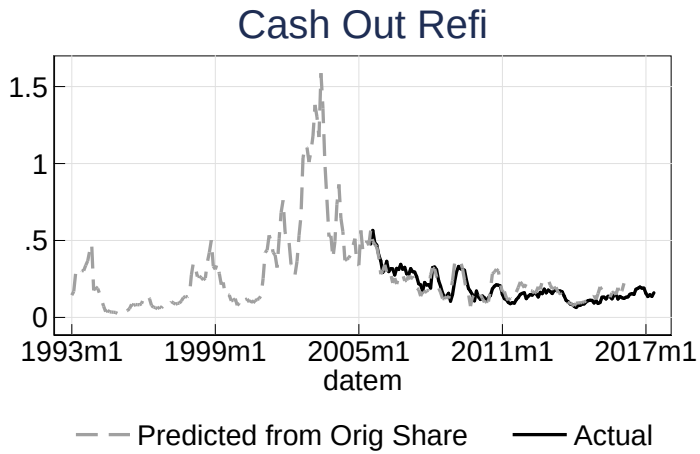
Comparison of Loan-Level Data to Mortgage Bankers' Association data

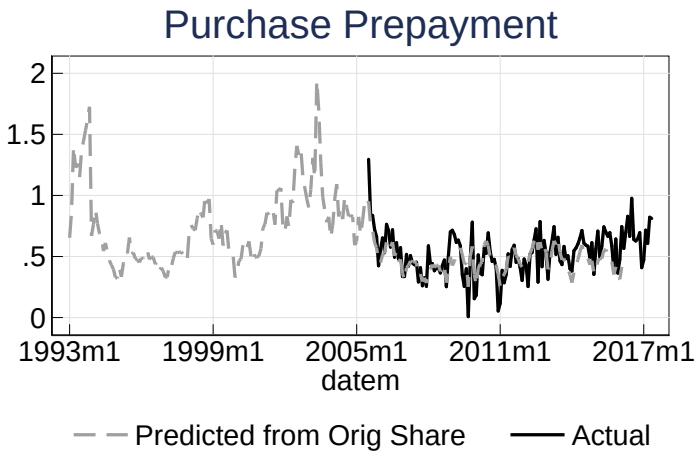
Back



Construction of Prepay Shares by Type







Back