State dependent effects of monetary policy: The refinancing channel

Martin Eichenbaum, Sergio Rebelo and Arlene Wong

ECB, 2019

State dependent effects of monetary policy: The refinancing channel

Martin Eichenbaum Sergio Rebelo Arlene Wong

Sept 2019

Motivation

- In the U.S. most mortgages have fixed rates.
  - Refi decisions depend on potential interest savings vs costs.
- We study how the impact of monetary policy depends on distribution of savings from refinancing existing pool of mortgages.
- Show that efficacy of monetary policy is state dependent, varying in systematic way with the pool of savings from refinancing.
- Construct a quantitative dynamic life-cycle model that highlights new trade-offs in the design of monetary policy.

Introduction

- Results are interesting to extent our model is credible representation of the data.
- Model accounts for
  - life-cycle dynamics of home-ownership rates, consumption of non-durable goods, household debt-to-income ratios and net worth.
  - probability that a mortgage is refinanced conditional on potential savings from doing so.
  - empirical state-dependent effects of monetary policy on refinancing decisions.

Introduction

- Use our model to study how potency of monetary policy is affected by history of interest rates.
- In response to financial crisis, central banks kept interest rates low for extended period of time.
- Potentially important cost: such a policy reduces potency of monetary policy during period of low interest rates as well as during renormalization period and its aftermath.
- Sizable effects
  - When interest rates are below their steady-state values for six years, monetary policy is less potent for up to three years after renormalization.

Data

- Empirical work primarily based on Core Logic Loan-Level Market Analytics,
  - loan-level panel data set with observations beginning in 1995.
  - Borrower characteristics (e.g. FICO and ZIP code), loan-level information.
    - principal, mortgage rate, LTV, purpose of loan (new or refinance).
- For each borrower, we obtain county-level demographic information
  - age structure, share of employment in manufacturing, lender competitiveness, measures of home-equity accumulation, educational attainment, unemployment, and per capita income.

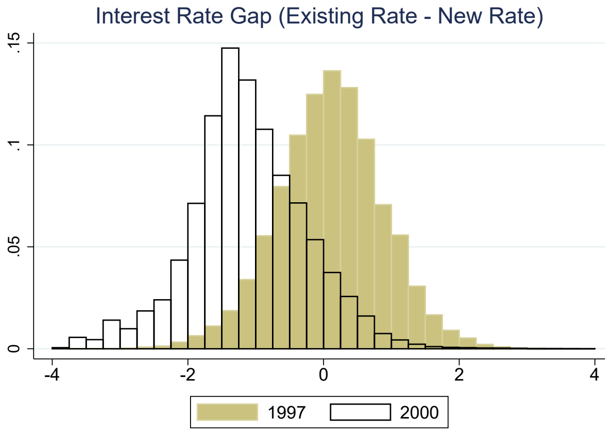
Potential savings from refinancing

- Simple measure of potential savings that household would realize by refinancing its mortgage at current mortgage rate.

$$A_t = \frac{1}{n_t} \sum_{i=1}^{n_t} \left[r_{it}^{\text{old}} - r_{it}^{\text{new}} \right]$$

- r_{it}^{new}: time t interest rate for new 30-year conforming mortgage for the same FICO and region as original mortgage.
- n_t: number of mortgages outstanding at time t.
- Annualized unconditional quarterly mean, standard deviation of A_t: -14, 70 basis points.

Distribution of interest rate gaps in 1997 and 2000



Savings

State dependent effects of monetary policy

For county c in quarter t, we estimate

$$\rho_{c,t+4} = \beta_0 + \beta_1 \Delta R_t^M + \beta_2 \Delta R_t^M \times A_{c,t-1} + \beta_3 A_{c,t-1} + \beta_4 Z_{t-1} + \beta_5 Z_{t-1}^c + \eta_{ct}.$$

where $\rho_{c,t+4}$ is fraction of mortgages refinanced between t and $t+4$, Z's are time-varying controls.

Potential challenges to identification:

- Shocks and unobservable variables affecting both refinancing propensities and mortgage rates.
- IV with high frequency data on Federal Funds futures and Treasury yields, and its interactions with $\psi_{c,t-1}$.
- Kuttner (2001), Rigobon and Sacks (2004), Nakamura and Steinsson (2013), Gorodnichenko and Weber (2015), Gertler and Karadi (2015), etc.

Mortgage rates and monetary policy shocks

$$\triangle \text{Mortgage rate}_{t,t+k} = \alpha_0 + \alpha_1 \epsilon_t + \eta_t$$

Change in mortgage rate	30-year	15-year
	(I)	(II)
Shock based on Fed Funds Futures	0.599**	0.585**
	(0.281)	(0.249)

- Mortgage rates respond to identified shocks.
- F-statistic on first stage estimates exceed 20.

State dependent effects of monetary policy

For county c in quarter t, we estimate

$$\rho_{c,t+4} = \beta_0 + \beta_1 \Delta R_t^M + \beta_2 \Delta R_t^M \times A_{c,t-1} + \beta_3 A_{c,t-1} + \beta_4 Z_{t-1} + \beta_5 Z_{t-1}^c + \eta_{ct}.$$

IV with Fed funds futures shocks, and its interaction with ψ.

Refinancing	**Fraction**
ΔR(t)	0.040***
	(0.023)
ΔR(t) x Average rate gap	0.266***
	(0.076)
County Fixed Effects	Yes
SPF Controls	Yes
Additional county controls	Yes

State dependent effects of monetary policy

For county c in quarter t, we estimate

$$\rho_{c,t+4} = \beta_0 + \beta_1 \Delta R_t^M + \beta_2 \Delta R_t^M \times A_{c,t-1} + \beta_3 A_{c,t-1} + \beta_4 Z_{t-1} + \beta_5 Z_{t-1}^c + \eta_{ct}.$$

IV with Fed funds futures shocks, and its interaction with ψ.

Refinancing	**Fraction**
ΔR(t)	0.040***
	(0.023)
ΔR(t) x Average rate gap	0.266***
	(0.076)
County Fixed Effects	Yes
SPF Controls	Yes
Additional county controls	Yes

- Average refi rate is 7.9%. Suppose mortgage rates fell by 25bp.

State dependent effects of monetary policy

For county c in quarter t, we estimate

$$\rho_{c,t+4} = \beta_0 + \beta_1 \Delta R_t^M + \beta_2 \Delta R_t^M \times A_{c,t-1} + \beta_3 A_{c,t-1} + \beta_4 Z_{t-1} + \beta_5 Z_{t-1}^c + \eta_{ct}.$$

IV with Fed funds futures shocks, and its interaction with ψ.

Refinancing	**Fraction**
ΔR(t)	0.040***
	(0.023)
ΔR(t) x Average rate gap	0.266***
	(0.076)
County Fixed Effects	Yes
SPF Controls	Yes
Additional county controls	Yes

- Average refi rate is 7.9%. Suppose mortgage rates fell by 25bp.
- If rate gap is -14bp (mean), refi rate rises to 8.6ppts ($\beta_1 * 0.25 + \beta_2 * 0.25 * -0.14 * A_{c,t-1} = 8.6\%$).

State dependent effects of monetary policy

For county c in quarter t, we estimate

$$\rho_{c,t+4} = \beta_0 + \beta_1 \Delta R_t^M + \beta_2 \Delta R_t^M \times A_{c,t-1} + \beta_3 A_{c,t-1} + \beta_4 Z_{t-1} + \beta_5 Z_{t-1}^c + \eta_{ct}.$$

IV with Fed funds futures shocks, and its interaction with ψ.

Refinancing	**Fraction**
ΔR(t)	0.040***
	(0.023)
ΔR(t) x Average rate gap	0.266***
	(0.076)
County Fixed Effects	Yes
SPF Controls	Yes
Additional county controls	Yes

- Average refi rate is 7.9%. Suppose mortgage rates fell by 25bp.
- If rate gap is -14bp (mean), refi rate rises to 8.6ppts ($\beta_1 * 0.25 + \beta_2 * 0.25 * -0.14 * A_{c,t-1} = 8.6\%$).
- If rate gap is 56bps (mean+1sd), refi rate rises to 13.2ppts

State dependent effects of monetary policy

For county c in quarter t, we estimate

$$\rho_{c,t+4} = \beta_0 + \beta_1 \Delta R_t^M + \beta_2 \Delta R_t^M \times \psi_{c,t-1} + \beta_3 A_{c,t-1} + \beta_4 Z_{t-1} + \beta_5 Z_{t-1}^c + \eta_{ct}.$$

IV with Fed funds futures shocks, and its interaction with ψ.

Refinancing	**Fraction**
ΔR(t)	0.040***
	(0.023)
ΔR(t) x Average rate gap	0.266***
	(0.076)
County Fixed Effects	Yes
SPF Controls	Yes
Additional county controls	Yes

- Marginal impact of a 1sd increase in rate gap is 4.6 ppts.

State dependent effects of monetary policy

For county c in quarter t, we estimate

$$\rho_{c,t+4} = \beta_0 + \beta_1 \Delta R_t^M + \beta_2 \Delta R_t^M \times A_{c,t-1} + \beta_3 A_{c,t-1} + \beta_4 Z_{t-1} + \beta_5 Z_{t-1}^c + \eta_{ct}.$$

IV with Fed funds futures shocks, and its interaction with A.

Refinancing	Fraction
ΔR(t)	0.040***
	(0.023)
ΔR(t) x Average rate gap	0.266***
	(0.076)
County Fixed Effects	Yes
SPF Controls	Yes
Additional county controls	Yes

- Results are robust to including controls, such as SPF expectations and county controls (lender competitiveness, home equity, house price accumulation, unemployment, manufacturing share, average age, share college edu, share ARM, etc).

Cash-out refinancing response

For county c in quarter t, we estimate

$$\rho_{c,t+4} = \beta_0 + \beta_1 \Delta R_t^M + \beta_2 \Delta R_t^M \times A_{c,t-1} + \beta_3 A_{c,t-1} + \beta_4 Z_{t-1} + \beta_5 Z_{t-1}^c + \eta_{ct}.$$

Cash-out refinancing	**Fraction**	**Balance**
ΔR(t)	0.074***	0.237***
	(0.007)	(0.026)
ΔR(t) x Average rate gap	0.176***	0.215***
	(0.027)	(0.132)
County Fixed Effects	Yes	Yes
SPF Controls	Yes	Yes
Additional county controls	Yes	Yes

- Suppose mortgage rates fell by 25bp:
  - If rate gap is -14bp (mean), refinancing increases by 1.2 ppts.
  - If rate gap is 56bp (mean+1sd), refinancing increases by 4.3 ppts.

Cash-out refinancing response

For county c in quarter t, we estimate

$$\rho_{c,t+4} = \beta_0 + \beta_1 \Delta R_t^M + \beta_2 \Delta R_t^M \times A_{c,t-1} + \beta_3 A_{c,t-1} + \beta_4 Z_{t-1} + \beta_5 Z_{t-1}^c + \eta_{ct}.$$

Cash-out refinancing	**Fraction**	**Balance**
ΔR(t)	0.074***	0.237***
	(0.007)	(0.026)
ΔR(t) x Average rate gap	0.176***	0.215***
	(0.027)	(0.132)
County Fixed Effects	Yes	Yes
SPF Controls	Yes	Yes
Additional county controls	Yes	Yes

- Marginal impact of a 1sd increase in rate gap is 3.1 ppts.
- Effect is large relative to average annual cash-out refinancing rate, 5.5%.

Log change in balance of mortgages with cash-out refinancing

For county c in quarter t, we estimate

$$\rho_{c,t+4} = \beta_0 + \beta_1 \Delta R_t^M + \beta_2 \Delta R_t^M \times A_{c,t-1} + \beta_3 A_{c,t-1} + \beta_4 Z_{t-1} + \beta_5 Z_{t-1}^c + \eta_{ct}.$$

Cash-out refinancing	Fraction	Balance
ΔR(t)	0.074***	0.237***
	(0.007)	(0.026)
ΔR(t) x Average rate gap	0.176***	0.215***
	(0.027)	(0.132)
County Fixed Effects	Yes	Yes
SPF Controls	Yes	Yes
Additional county controls	Yes	Yes

Suppose mortgage rates fell by 25bp:

- If rate gap is -14bp (mean), balance increases by 5.2 ppts.
- If rate gap is 56bps (mean+1sd), balance increases by 8.9 ppts.
- Marginal impact of a 1sd increase in rate gap is 3.8 ppts. Represents a $4,600 equity extraction, on a mortgage of $123K. More

State-dependent effects and real outcomes

$$\Delta U_{c,t+4} = \beta_0 + \beta_1 \Delta R_t^M + \beta_2 \Delta R_t^M \times A_{c,t-1} + \beta_3 A_{c,t-1} + \eta_{ct}.$$

$$\Delta ln(Permits_{c,t+4}) = \beta_0 + \beta_1 \Delta R_t^M + \beta_2 \Delta R_t^M \times A_{c,t-1} + \beta_3 A_{c,t-1} + \eta_{ct}.$$

	Change in unemployment rate over the year (I)	**Housing permit growth over the year (II)**
ΔR(t)	-0.034*	0.248***
	(0.014)	(0.043)
ΔR(t) x Average rate gap	-0.065***	0.234***
	(0.014)	(0.087)
County Fixed Effects	Yes	Yes
SPF Controls	Yes	Yes
Additional county controls	Yes	Yes

Household model: set-up

1. Life-cycle
2. Idiosyncratic income risk and aggregate shocks
3. Assets: - liquid one-period asset
   - illiquid housing and fixed rate mortgage
4. Fixed cost of adjusting the mortgage and housing
   - F: calibrated to match average refi rate.
5. Borrowing constraints: short-term constraint; mortgage LTV constraint

Demographics and preferences

- First period of life corresponds to 25 years of age. Households can live up to $T = 60$ periods: Work for 40, retired for 20. Probability of survival π_a.
- Preferences

$$\frac{\left(c_{jat}^{\alpha} \cdot h_{jat}^{1-\alpha}\right)^{1-\sigma} - 1}{1-\sigma}$$

Bequest motive

$$B\left(W_{jat}^{1-\sigma} - 1\right)/(1-\sigma)$$

Labor income

- Labor income process for household j of age a at time t:

$$\log(y_{jat}) = \chi_a + \eta_{jt} + \phi_a \log(Y_t)$$

$\chi_a =$ age-dependent component and $\eta_{jt} =$ idiosyncratic component (important so that borrowing constraints occasionally bind)

$$\eta_{jt} = \rho_\eta \eta_{j,t-1} + \psi_{jt}$$

- Retirement income modeled as in Guvenen and Smith (2014).

More

Structure of fixed-rate mortgages

Household j who enters a loan at date 0:

- Has a fixed rate R_{j0} and payment M_{j0}.
- Principal evolves as: $b_{j,t+1} = b_{jt}(1 + R_{j0}) - M_{j0}$.
- To conserve on state variables we assume that, if not refinanced, mortgages are amortized over remaining life of the individual.
- Fixed cost F applies to refinancing and new loans.

Borrowing constraints

- Constraint on maximum mortgage balance

$$b' \leq (1-\phi)ph'^{o}$$

which applies if loan is new or refinanced

- Short-term asset constraint

$$s' \geq 0$$

Value function and budget constraints

$$V(z) = \max\{V(z)^{\text{own \& adjust}}, V(z)^{\text{own \& noadjust}}, V(z)^{\text{rent}}\}$$

where

$$V(z)^k = \max u(c, h^k) + \beta E\left[V(z')\right] \quad s.t.$$

- Own home and adjust loan:
  - balance and mortgage rate can adjust
  - housing owned can adjust
  - pay cost F
- Own home and do not adjust loan
- Rent

State Variables

$$z = \{a, \eta, K, S\}$$

- a, η, K: age, idiosyncratic labor income, and asset holdings.
- K: short-term assets, housing stock, mortgage balance, and existing mortgage rate.
- S: aggregate state $[\log Y, \log(p), \log(r)]\ ln(\psi)]$ where ψ denotes economy-wide average positive savings from refinancing.

State Variables

- Aggregate states: $S = [logY, log(p), log(r), ln(\psi)]$

$$S_t = A_0(Z_{t-1}) + A_1(Z_{t-1}) \cdot S_{t-1} + u_t$$

  where Z_{t-1} includes S_{t-1} and the distribution of individual states across households.

- Approximate the process with

$$S_t = a_0 + a_1 S_{t-1} + a_2 \psi_{t-1} + a_3 ln(r_{t-1})\psi_{t-1} + u_t$$
$$\psi_t = b_0 + b_1 S_{t-1} + b_2 \psi_{t-1} + b_3 ln(r_{t-1})\psi_{t-1} + v_t$$

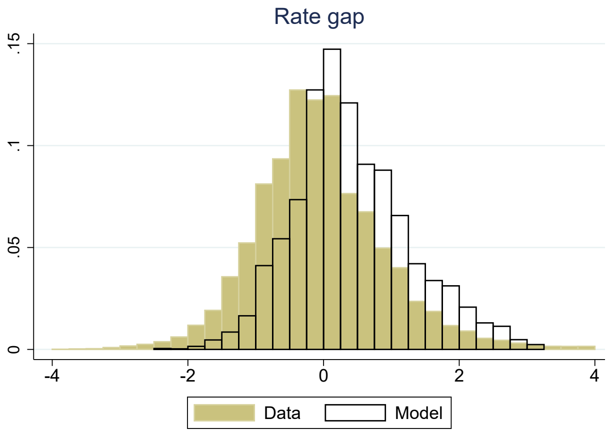
  where ψ_t denotes log of average savings.

- Mortgage rate: $r^M = \alpha_{0,d} + \alpha_{1,d} r + \alpha_{2,d} y$
- Rental rate: $\mathrm{p}^R = \lambda_0 + \lambda_1 r + \lambda_2 y + \lambda_3 \log(p)$

Model fit: state dependent effects of monetary policy

- Start the simulation in 1994, where agents have the distribution of assets, liabilities and mortgage rates that we observe in the data.
- Feed in actual prices and real variables from 1995 to 2007.
- Simulate idiosyncratic income shocks.
- Compute household's decisions.

Model fit: Refinancing, mortgage rate gap distribution (1995-2007)



Model fit: Refinancing, given the interest-rate gap

Model fit: state dependent effects of monetary policy

	Data	Model
Panel A: Fraction of loans that refinanced		
ΔR(t)	0.040***	0.038
	(0.023)	
ΔR(t) x Average rate gap	0.266***	0.299
	(0.076)	
Panel B: Fraction of loans that are cash-out refi		
ΔR(t)	0.074***	0.030
	(0.007)	
ΔR(t) x Average rate gap	0.176***	0.217
	(0.027)	
Panel C: Fraction of loans for home purchases		
ΔR(t)	0.162***	0.085
	(0.014)	
ΔR(t) x Average rate gap	0.147***	0.202
	(0.019)	

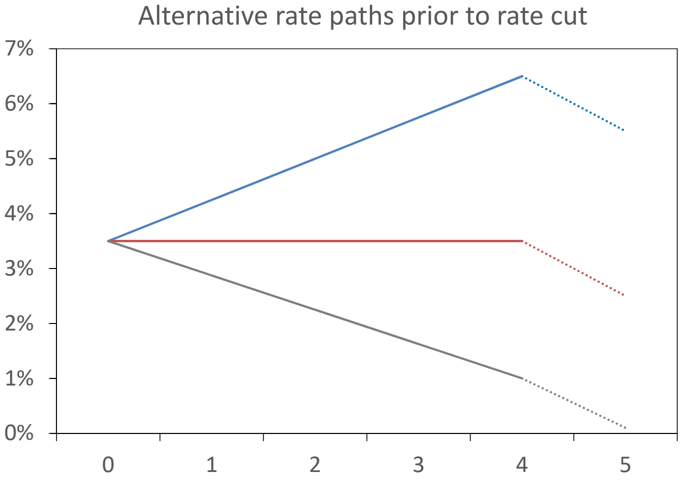
Consumption response and constrained households

- Consumption rises by 1% over the year after a 25bp rate cut.
- Driven by constrained households (40% of all households).
- Of those who refinance, 80% engage in cash-out refinancing
  - in line with evidence from Chen, Michaux, and Roussanov (2013).
- If R_t fell by 25bps, balances rise by about 4% for cash-out refinances
  - in line with evidence from Bhutta and Keys (2016)

Implications for Monetary Policy

1. Study the effect of a monetary shock, that is preceded by:
   - Sequence of monetary shocks that increases rates;
   - Sequence with no monetary shocks so that rates are flat;
   - Sequence of monetary shocks that decreases rates.
2. Study the trade-off between keeping interest rates low and the ability to stimulate the economy in the future.

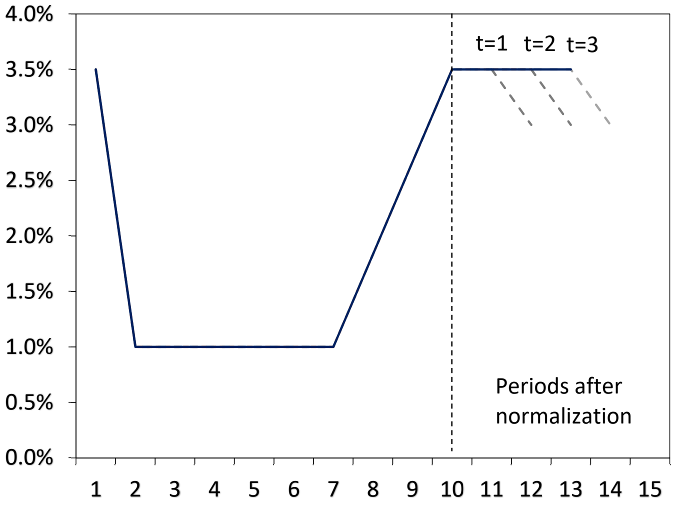
Experiment: Asymmetric paths



Experiment: Asymmetric paths

Rate path prior to a 50bp cut	Average rate gap before cut	Fraction with positive rate gap, after rate cut	Effect on refinancing	Change in consumption	Fraction ST constrained
Panel A: Effects of Flat vs Rising History					
(i) Flat at about 3.5%	0.00%	100%	26%	1.3%	0.48
(ii) Rising from 3.5% to 6.5% over 4 pds	-0.81%	16%	5%	0.1%	0.64
Difference (i)-(ii)	0.81%	84%	21%	1.2%	-0.16
Panel B: Effects of Flat vs Falling History					
(i) Flat at about 3.5%	0.00%	100%	26%	1.3%	0.48
(ii) Falling from 3.5% to 1% over 4 pds	0.46%	100%	23%	0.5%	0.33
Difference (i)-(ii)	-0.46%	0%	3%	0.9%	0.15

Downside of low interest rates



Downside of low interest rates

Rate path prior to a rate cut	Average rate gap before cut	Fraction with positive rate gap, after rate cut	Effect on refinancing	Change in consumption	Fraction ST constrained
Reloading Effect with 50bp cut					
(a) Benchmark case: continuously flat at 3.5% prior to a 50bp rate cut	0.00%	100%	26%	1.3%	48%
(b) 3.5% cut to 1% for 4 pds, rise for 3 pds to 3.5%, flat at 3.5% for **1 pd**	-0.28%	66%	22%	0.9%	57%
(c) 3.5% cut to 1% for 4 pds, rise for 3 pds to 3.5%, flat at 3.5% for **2 pds**	-0.27%	68%	26%	0.9%	58%
(d) 3.5% cut to 1% for 4 pds, rise for 3 pds to 3.5%, flat at 3.5% for **3 pds**	-0.25%	70%	26%	1.3%	58%
Reloading Effect with 100bp cut					
(e) Benchmark case: continuously flat at 3.5% prior to a 100bp rate cut	0.00%	100%	27%	2.5%	47%

Conclusion

- Efficacy of monetary policy is state dependent, varying in a systematic way with the pool of savings from refinancing.
- Our model points to an important cost of fighting recessions with a prolonged period of low interest rates.
    - Reduces potency of monetary policy in period after interest rates are normalized.
    - If economy is affected by a negative shock during that period, policy makers will have less ammunition to counteract effects of that shock.
- Should monetary policy makers use their ammunition to fight an ongoing recession or the next one?

Model fit: life-cycle moments

Model fit: refinancing and rate gap correlation