MoNK: Mortgages in a New-Keynesian Model

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Introduction

- A tractable framework for monetary policy analysis in which both short- and long-term debt affect equilibrium outcomes

- Why do we need such a framework?
  - Many investment decisions facilitated through long-term loans
  - The cost of long-term financing important to policy makers
  - In NK models, long-term loans are redundant assets

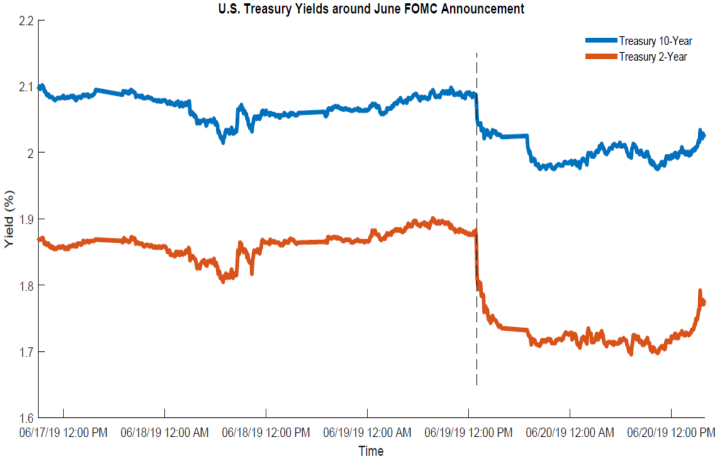
- MoNK: both the NK channel and long-term debt matter
  - Mortgage debt: 15-30 yrs, main liability of households, ...
  - Long-term debt = stream of contractual cash flows
  - Cash flows depend on future policy rates (*risk premia*, ...)
  - Two literatures find policy affects expect. future int. rates

Monetary policy and interest rates

1. Nominal interest rates and the nature of mon. policy shocks

- SVAR shocks: actions, only affect short rates (Evans and Marshal, 1998)
- Markets pay attention also to statements
- High frequency studies: all yields move after a FOMC meeting
- Gürkaynak, Sack, Swanson (2005), ...
- Two latent factors account for most of the movements
- GSS interpret them as an action factor and a statement factor about expected future policy rates

FOMC June 2019 policy shock

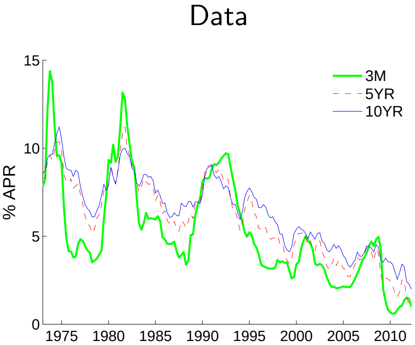


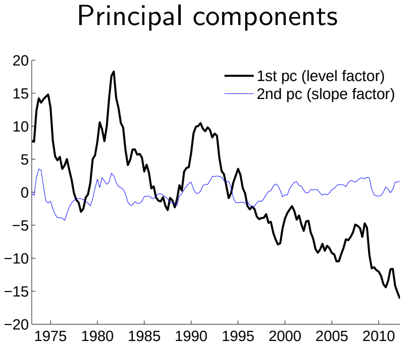
Monetary policy and interest rates

2. Behavior of nominal interest rates over time

- Monthly or quarterly frequencies
- Extract latent factors from yields (Ang and Piazzesi, 2003, ...)
- Two latent factors account for most of the movements
- One is very persistent (close to random walk): "level factor"
- Moves expected rates (Cochrane and Piazzesi, 2008, ...)
- Often attributed to monetary policy due to strong correlation with inflation (Duffee, 2012, ...)

Nominal rates over time: Germany



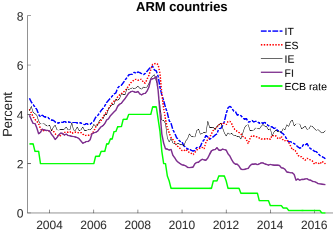


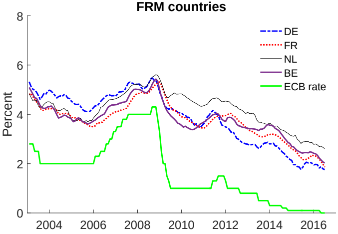
Long-term debt

- Passthrough of the policy rate
  - Flow vs. stock
  - FRM vs. ARM

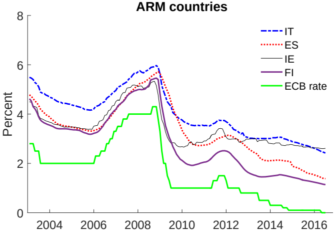
Illustration: ECB and mortgage rates

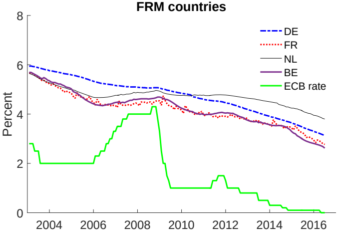
New loans (flow)





Outstanding debt (stock)





Long-term debt

- Passthrough of the policy rate
  - Flow vs. stock
  - FRM vs. ARM
- The real value of cash flows depends on inflation, which (in equilibrium) is related to the policy rate
- These are the effects we want to capture

Questions

1. Effects of action vs. statement policy shocks
   - Motivated by the above two literatures
2. Sticky prices vs. long-term debt?
   - Debate on intertemporal vs. income channels of mon. policy (eg., Kaplan, Moll, Violante 2018)
   - Direct link from mon. policy to household disposable income
3. Interactions between the two channels?
   - Transparently document the mechanism
   - Hopefully informative for future research

Outline

1. The model
2. Calibration and steady state
3. Findings for benchmark policy shocks
4. Mechanism
5. Shocks as in GSS 2005, Nakamura and Steinsson 2018
6. Conclusions

The model

Key features

- Two-agent economy, split by Campbell and Cocco (2003)
- *Homeowners*: stand-in for 3rd & 4th quintile of wealth dist.
  - Supply labor; buy housing w/ mortgages; trade a bond at a cost (resemble "rich hand-to-mouth")
- *Capital owners*: stand-in for 5th quintile
  - Supply labor; invest in capital and mortgages; trade the bond at no cost
- The agents thus differ in access to cap. and bond markets
  - $\Rightarrow$ (i) value cash flows differently, (ii) have different MPCs
- Standard NK production w/ sticky prices
- Taylor rule /w two types of policy shocks
- Abstract from habits, labor market frictions, indexation, ...

Relationship with other models

- Measure of homeowners $= 0$: MoNK $\rightarrow$ RANK (w/ capital)
- No mortgages: MoNK $\rightarrow$ TANK (eg., Debortoli and Galí, 2018)
- Richer heterogeneity: MoNK $\rightarrow$ HANK (KMV 2018) with mortgages

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- No sticky prices, no labor supply: MoNK $\rightarrow$ GKŠ (2017) without optimal refi & mortgage choice (secondary effects)
- Compared with Doepke and Schneider (2006), Auclert (2018): in MoNK cash flows matter, not just the real PV of debt

Capital owners

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \log c_{1t} - [\omega_1/(1+\sigma)] n_{1t}^{1+\sigma} \right\}$$

s.t.

$$c_{1t} + q_{Kt} x_{Kt} + \frac{b_{1,t+1}}{p_t} + \frac{l_{1t}}{p_t} = r_t^* k_t + \epsilon_w w_t^* n_{1t} + (1 + i_{t-1}) \frac{b_{1t}}{p_t} + \frac{m_{1t}}{p_t} + \tau_{1t} + \Pi_t$$

$$k_{t+1} = (1 - \delta_K) k_t + x_{Kt}$$

l_{1t}: new nominal mortgage loans

m_{1t}: receipts of nominal payments on outstanding mortgage debt

Individual state: k_t, b_{1t}, m_{1t}

Decisions: c_{1t}, n_{1t}, x_{Kt}, $b_{1,t+1}$, l_{1t}, k_{t+1}

Homeowners

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \varrho \log c_{2t} + (1-\varrho)\log h_t - [\omega_2/(1+\sigma)] n_{2t}^{1+\sigma} \right\}$$

s.t.

$$c_{2t} + q_{Ht}x_{Ht} + \frac{b_{2,t+1}}{p_t} = w_t^* n_{2t} + (1 + i_{t-1} + \Upsilon_{t-1})\frac{b_{2t}}{p_t} - \frac{m_{2t}}{p_t} + \frac{l_{2t}}{p_t} + \tau_{2t}$$

$$\frac{l_{2t}}{p_t} = \theta q_{Ht} x_{Ht}$$

$$h_{t+1} = (1-\delta_H)h_t + x_{Ht}$$

l_{2t}: new nominal mortgage loans taken out to purchase *new* housing

m_{2t}: nominal payments on outstanding mortgage debt

Υ_{t-1}: bond market participation cost (increasing and convex in b_{2t}/p_{t-1})

Indiv. state: h_t, b_{2t}, m_{2t}, dec.: c_{2t}, n_{2t}, x_{Ht}, $b_{2,t+1}$, l_{2t}, h_{t+1}

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$$\gamma_{j,t+1} = (1 - \phi_{jt})(\gamma_{jt})^{\alpha} + \phi_{jt}\kappa$$

$\kappa, \alpha \in (0, 1)$ chosen to approx. amortization of 30-yr mortgage

Example 1 Example 2

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Example 1 Example 2

- Only either ARM or FRM, held to maturity

NK production

- PC: identical final good producers, measure $= 1$

$$\max_{Y_t, \{y_t(j)\}_0^1} p_t Y_t - \int_0^1 p_t(j) y_t(j) dj \quad \text{where} \quad Y_t = \left[\int_0^1 y_t(j)^{\varepsilon} dj \right]^{1/\varepsilon}$$

- M: intermediate good producer $j \in [0, 1]$

$$\max_{p_t(j)} E_t \sum_{i=0}^{\infty} \psi^i Q_{1,t+i} \left[\frac{p_t(j)}{p_{t+i}} y_{t+i}(j) - \chi_{t+i} y_{t+i}(j) \right] - \Delta$$

s.t. a demand function of PC

$$\chi_t y_t(j) = \min_{k_t(j), n_t(j)} r_t k_t(j) + w_t n_t(j) \quad \text{s.t.} \quad k_t(j)^{\varsigma} n_t(j)^{1-\varsigma} = y_t(j)$$

- $\Rightarrow$ NK Phillips Curve

Aggregate expenditures

$$C_{1t} + C_{2t} + q_{Kt}(X_{Kt})X_{Kt} + q_{Ht}(X_{Ht})X_{Ht} + G = Y_t$$

$$q_{Kt}(.)' > 0 \quad q_{Kt}(.)'' > 0$$
$$q_{Xt}(.)' > 0 \quad q_{Xt}(.)'' > 0$$

- Implies a concave production possibilities frontier (eg., Fisher, 1997)
- A short cut for a multi-sectoral model (eg., Davis and Heathcote, 2005)
- q_{Ht}, q_{Ht} work like capital adjustment costs; limit consumption smoothing in the aggregate

Equilibrium

- Market clearing

$$(1-\Psi)l_{1t} = \Psi l_{2t}, \qquad \text{(mortgage)}$$

$$(1-\Psi)b_{1,t+1} = -\Psi b_{2,t+1}, \qquad \text{(one-period bond)}$$

$$\int_0^1 n_t(j) = \epsilon_w(1-\Psi)n_{1t} + \Psi n_{2t}, \qquad \text{(labor)}$$

$$\int_0^1 k_t(j) = (1-\Psi)k_t, \qquad \text{(capital)}$$

$$C_{1t} + C_{2t} + q_{Kt}X_{Kt} + q_{Ht}X_{Ht} + G = Y_t \qquad \text{(goods)}$$

- Aggregate consistency

$$(1-\Psi)d_{1t} = \Psi d_{2t}, \quad \gamma_{1t} = \gamma_{2t}, \quad R_{1t} = R_{2t}$$

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  - 1st=near random walk, moves the level, affects exp. rates
  - 2nd=less persistent, moves the slope, small effect on exp. rates

Taylor rule and policy shocks (cont.)

- Benchmark TR shocks: two independent AR(1) processes
- Persistent shock modeled as an inflation target shock

$$i_t = r + \mu_t + \nu_\pi(\pi_t - \mu_t) + \eta_t, \quad \nu_\pi > 1$$

- $\mu_{t+1} = (1 - \rho_\mu)\pi + \rho_\mu \mu_t + \xi_{\mu,t+1} \qquad \rho_\mu = 0.99$
- $\eta_{t+1} = \rho_\eta \eta_t + \xi_{\eta,t+1} \qquad \rho_\eta = 0.3$
- μ_t, η_t can be combined to form shocks as in GSS 2005, NS 2018
- Interest rate smoothing, output gap?

Equilibrium short rate

- Euler eqs. of capital owner for bonds and capital + Taylor rule, solve forward, exclude bubbles

$$i_t \approx \mu_t + \left[\sum_{j=0}^{\infty} \left(\frac{1}{\nu_\pi} \right)^j E_t r^*_{t+j} - \frac{\rho_\eta}{\nu_\pi - \rho_\eta} \eta_t \right] \equiv level_t + slope_t$$

- level/slope split if μ_t has no effect on real rates (will be the case)

Equilibrium inflation

- Using the above expression for i_t back in the Taylor rule gives

$$\pi_t \approx \mu_t + \left[\frac{1}{\nu_\pi} \sum_{j=0}^{\infty} \left(\frac{1}{\nu_\pi} \right)^j E_t r^*_{t+j} - \frac{1}{\nu_\pi - \rho_\eta} \eta_t \right]$$

- Sum of near random walk and temporary components (Stock and Watson, 2007)

- μ_t same effect on i_t and π_t

Equilibrium FRM rate

- No-arbitrage pricing by the cap. owner b/w the bond and a new loan

$$1 = E_t\left[\frac{i_t^F + \gamma_{1,t+1}}{1+i_t} + \frac{i_t^F + \gamma_{1,t+2}}{(1+i_t)(1+i_{t+1})}(1-\gamma_{1,t+1}) + ...\right] + \Psi_t$$

Ψ_t: covariance terms between the pricing kernel and cash flows

Equilibrium ARM rate

- The interest rate of ARM is the short rate i_t
- Straightforward to verify the following no-arbitrage condition holds for any stochastic sequence of i_t

$$1 = E_t \left[\frac{i_t + \gamma_{1,t+1}}{1 + i_t} + (1 - \gamma_{1,t+1}) \frac{i_{t+1} + \gamma_{1,t+2}}{(1 + i_t)(1 + i_{t+1})} + ... \right]$$

Demand for mortgages

- Financing constraint: $l_{2t} = \theta p_t q_{Ht} x_{Ht}$
- First-order condition for x_{Ht}

$$q_{Ht}(1 + \tau_{Ht}) = \beta E_t \frac{V_{h,t+1}}{v_{ct}},$$

$$\tau_{Ht} = -\theta \left\{ 1 - E_t \left[Q_{2,t+1} \frac{i^M_{t+1} + \gamma_{2,t+1}}{1+\pi_{t+1}} + Q_{2,t+2} \frac{(i^M_{t+2} + \gamma_{2,t+2})(1-\gamma_{2,t+1})}{(1+\pi_{t+1})(1+\pi_{t+2})} + \ldots \right] \right\}$$

Calibration and steady-state

Calibration (selected parameters)

Symbol	Value	Description
Population		
Ψ	2/3	Share of homeowners
Preferences		
ω_1	8.4226	Disutility from labor (capital owner)
ω_2	12.818	Disutility from labor (homeowner)
ϱ	0.6258	Weight on consumption (homeowner)
Technology		
ζ	3.2	Curvature of PPF
ϵ_w	2.3564	Rel. productivity of cap. owners
Fiscal		
G	0.138	Government expenditures
τ_N	0.235	Labor income tax rate
τ_K	0.3361	Capital income tax rate
$\overline{\tau}_2$	0.05853	Transfer to homeowner
Goods market		
ψ	0.75	Fraction not adjusting prices
Mortgage market		
θ	0.6	Loan-to-value ratio
Bond market		
ϑ	0.15	Participation cost function
Monetary policy		
ν_π	1.5	Weight on inflation
Exogenous processes		
ρ_μ	0.99	Persistence of the level factor shock
ρ_η	0.3	Persistence of standard mon. pol. shock

Values in red: calibrated to cross-sectional moments (and aggregate hours)

Steady-state cross-sectional implications

Symbol	Model	Data	Description
Targeted in calibration:			
$m_2/(wn_2+\overline{\tau}_2)$	0.15	0.15	Mortgage payments to income
$\overline{\tau}_2/(wn_2+\overline{\tau}_2)$	0.12	0.12	Transfers in homeowner's income
$\epsilon_w wn_1/income_1$	0.53	0.53	Labor income in cap. owner's income
Not targeted:			
A. Capital owner's variables			
$(rk+m_1)/income_1$	0.42	0.39[§]	Income from assets in total income
$\tau_1/income_1$	0.05	0.08	Transfers in total income
$m_1/netincome_1$	0.07	N/A	Mortg. income to post-tax income
B. Homeowner's variables			
$wn_2/(wn_2+\tau_2)$	0.88	0.82	Labor income in total income
$m_2/[(1-\tau_N)wn_2+\tau_2]$	0.18	N/A	Mortgage payments to post-tax income
C. Earnings distribution			
$\epsilon_w wN_1/(\epsilon_w wN_1+wN_2)$	0.59	0.54	Capital owners' share
$wN_2/(\epsilon_w wN_1+wN_2)$	0.41	0.46	Homeowners' share
D. Income distribution			
$Income_1/[Income_1+(wN_2+\Psi\tau_2)]$	0.70	0.61	Capital owners' share
$(wN_2+\Psi\tau_2)/[Income_1+(wN_2+\Psi\tau_2)]$	0.30	0.39	Homeowners' share

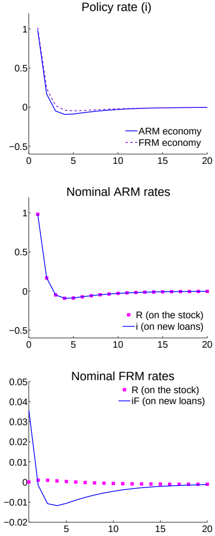
Benchmark experiments:

AR(1) shocks

1. Temporary vs. persistent shock
2. ARM vs. FRM
3. MoNK vs. Mo (flexible prices) vs. NK (no mortgage loans)

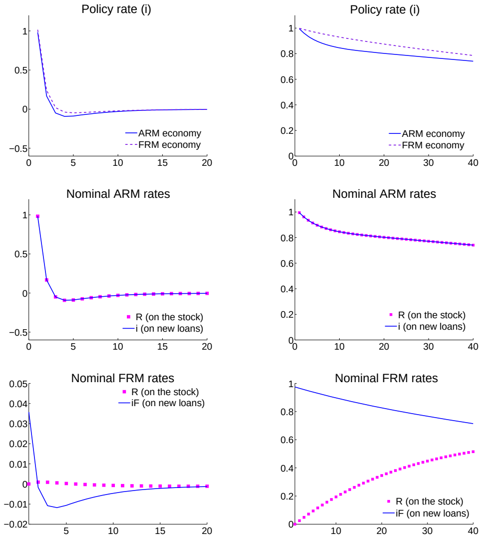
Long-term mortgage debt channel

Temporary policy shock

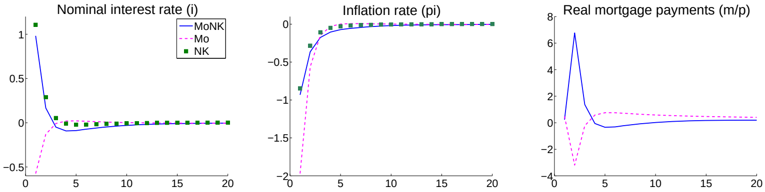


Long-term mortgage debt channel

Temporary policy shock | Persistent policy shock



Temporary shock (1pp), ARM



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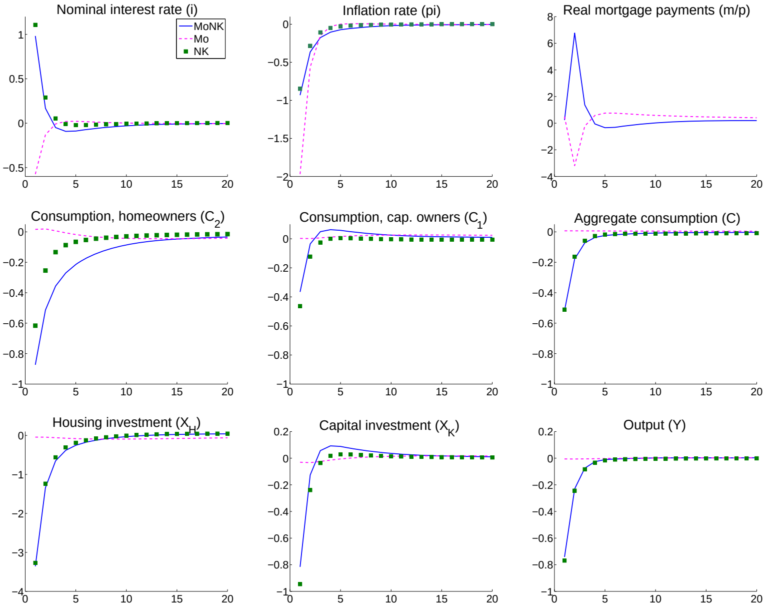
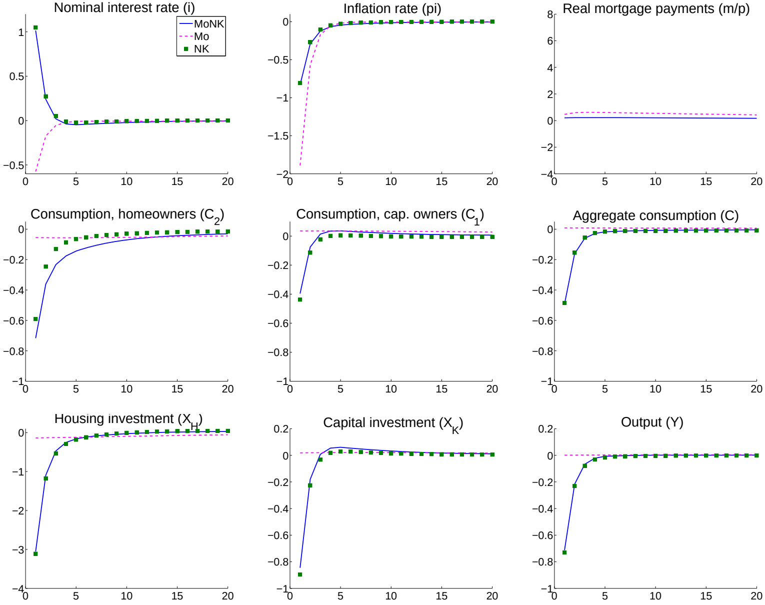


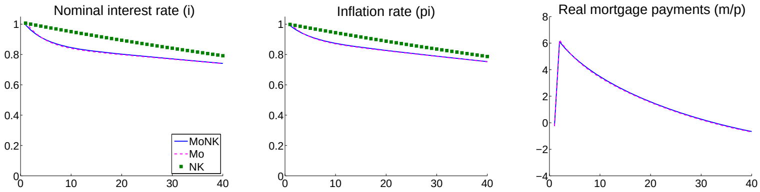
Temporary shock (1pp), FRM



Main takeaways so far

- Temporary shock
  - MoNK similar to NK (except c_t^H) $\Rightarrow$ contract irrelevance
  - Cons. of homeowners (c_t^H)
    - Affected more than cons. of capital owners
    - Affected more in MoNK than in NK

Persistent shock (1pp), ARM



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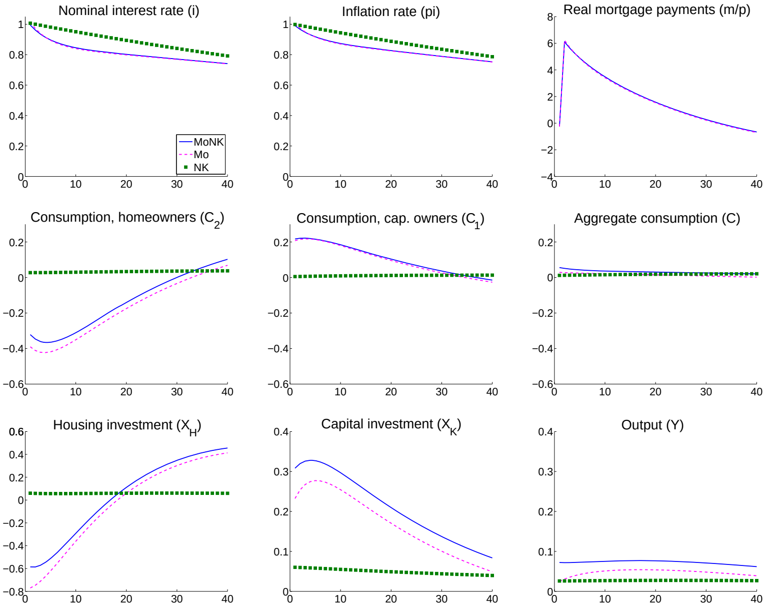
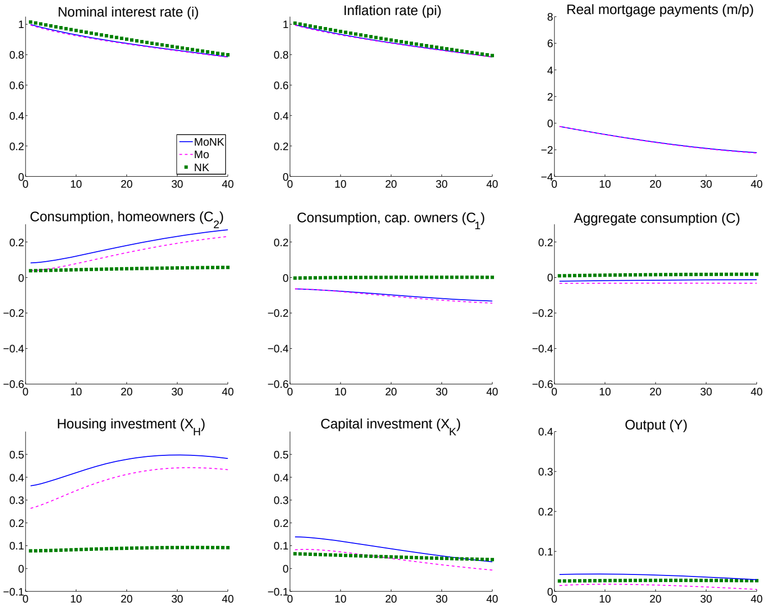


Persistent shock (1pp), FRM



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  - Cons. of homeowners (c_t^H)
    - Affected more than cons. of capital owners
    - Affected more in MoNK than in NK
- Persistent shock
  - MoNK similar to Mo (sticky prices small effect)
  - Effects mainly redistributive
  - Contract matters
  - Real effects despite no change in the real rate
  - Cons. of homeowners again affected by more than of capital owners

The mechanism

1. New-Keynesian channel
2. Long-term debt channel

New-Keynesian channel

The New-Keynesian Phillips Curve is where the action is!

$$\pi_t = \frac{(1-\psi)(1-\beta\psi)}{\psi}\Theta\widehat{\chi}_t + \beta E_t \pi_{t+1},$$

where

$$\widehat{\chi}_t \sim \widehat{Y_t} \qquad \text{and} \qquad \beta \to 1$$

$$\Rightarrow \quad \pi_t - E_t \pi_{t+1} \approx \frac{(1-\psi)(1-\beta\psi)}{\psi}\Theta\widehat{Y_t}$$

Hence $\quad \pi_t < E_t \pi_{t+1} \Rightarrow \widehat{Y_t} < 0 \quad$ and $\quad \pi_t \approx E_t \pi_{t+1} \Rightarrow \widehat{Y_t} \approx 0$

Long-term debt channel I

Effect on budged constraint ("income effect")

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Nominal mortgage payments over the remaining life of a loan

$$m_t = (i_t^M + \gamma_t)d_t, \quad \{\gamma_t\}_1^J, \quad \gamma_1 \approx 0 \; ... \; \gamma_J = 1$$

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Rewrite in real terms

$$\widetilde{m}_{t+1} = \frac{(i_{t+1}^M + \gamma_{t+1})}{(1+\pi_{t+1})}\widetilde{d}_{t+1}, \quad \ldots \quad \widetilde{m}_{t+j} = \frac{(i_{t+j}^M + \gamma_{t+j})}{(1+\pi_{t+1})\ldots(1+\pi_{t+j})}\widetilde{d}_{t+j},$$

$$\approx i_{t+1}^M \widetilde{d}_{t+1} \qquad\qquad \approx \frac{1}{(1+\pi_{t+1})\ldots(1+\pi_{t+j})}\widetilde{d}_{t+j}$$

In the immediate future, i_{t+1}^M is all that matters! (ARM vs. FRM)

Long-term debt channel II

Effect on the cost of new housing ("price effect")

F.O.C. for x_{Ht}

$$q_{Ht}(1+\tau_{Ht}) = \beta E_t \frac{V_{h,t+1}}{v_{ct}},$$

$$\tau_{Ht} = -\theta \left\{ 1 - E_t \left[Q_{2,t+1} \frac{i^M_{t+1}+\gamma_{2,t+1}}{1+\pi_{t+1}} + Q_{2,t+2} \frac{(i^M_{t+2}+\gamma_{2,t+2})(1-\gamma_{2,t+1})}{(1+\pi_{t+1})(1+\pi_{t+2})} + ... \right] \right\}$$

Alternative formulations of the shocks

Shocks as in GSS (2005)

- Action vs. statement shock

$$i_t = i + \nu_\pi(\pi_t - \pi) + v^\top z_t,$$

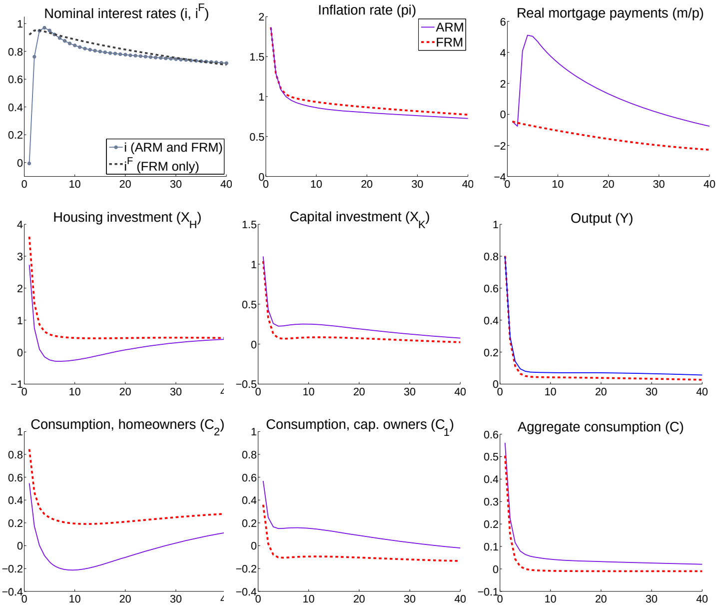
$$v^\top \equiv [1-\nu_\pi, 1],\ z_{1t} \equiv \mu_t - \pi,\ z_{2t} \equiv \eta_t$$

$$z_t^* = M z_t$$

$$i_t = i + \nu_\pi(\pi_t - \pi) + v^\top M^{-1} z_t^*,$$

M restricted so that z_{1t}^*, z_{2t}^* are orthogonal and z_{1t}^* has no effect on i_t in equilibrium, only forecasts future z_{2t}^*

Statement shock (1pp), ARM and FRM



Shocks as in NS (2018)

- Policy shock vs. signal about the future state of the economy

$$i_t = r_t^* + \pi + \nu_\pi(\pi_t - \pi) + \eta_t$$

$$\begin{bmatrix} A_t \\ S_t \end{bmatrix} = \begin{bmatrix} \rho_A & 1 \\ 0 & \rho_S \end{bmatrix} \begin{bmatrix} A_{t-1} \\ S_{t-1} \end{bmatrix} + \begin{bmatrix} \xi_{At} \\ \xi_{St} \end{bmatrix}$$

A_t = TFP, S_t = signal about future TFP

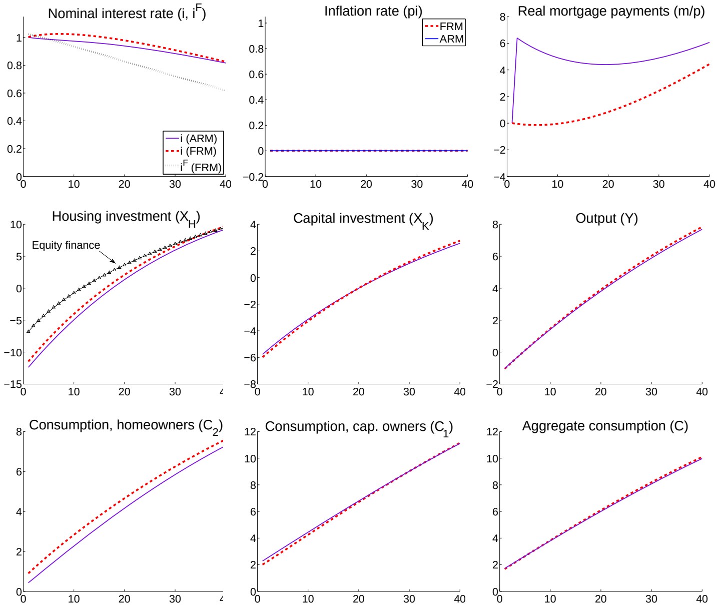
$\rho_S = 0.999$ chosen to match the persistence of the FRM rate

$\Rightarrow$ Bansal and Yaron (2004)-type process for TFP growth

$$\Delta A_t = (\rho_A - 1)A_{t-1} + S_{t-1} + \xi_{At}$$

TR accommodates resulting changes in r_t^* so that $\pi_t = \pi$

Information shock (1pp), ARM and FRM



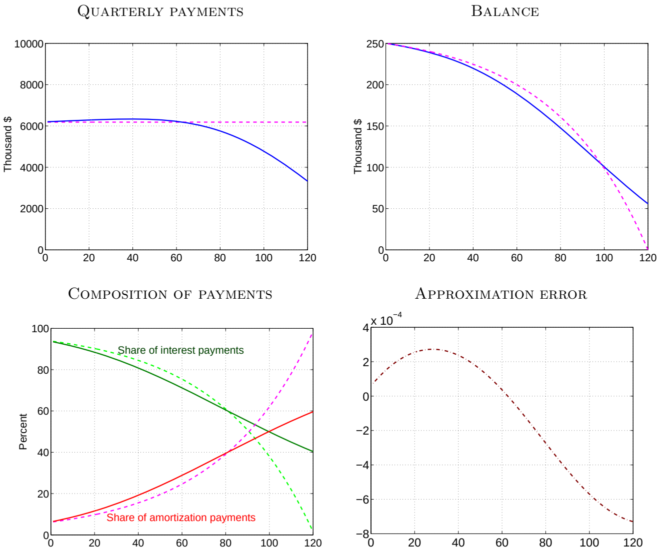
Conclusions

- NK channel dominating for policy shocks affecting the nominal interest rate only temporarily
- Long-term debt channel dominating for policy shocks affecting the nominal rate persistently
- NK channel generates short-lived aggregate effects that are essentially the same under ARM and FRM (with the exception of homeowners consumption)
- The long-term debt channel generates prolonged redistributive effects, which are markedly different across ARM and FRM
- The two channels interact in affecting homeowners consumption under ARM and a temporary shock
- The basic shocks can be combined to form shocks with interesting economic intrepretations

Thank you!

Mortgages: example, 30yr

$$\gamma_t^{\alpha}, \quad \alpha = 0.9946, \ \kappa = 0.00162$$



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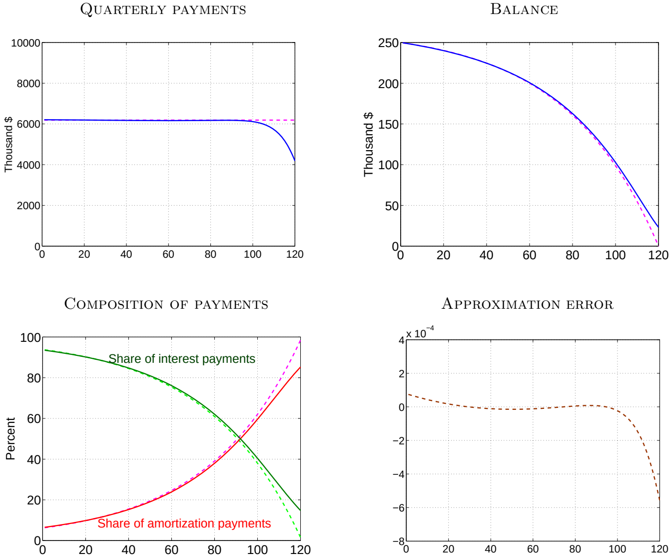
Mortgages: example, 30yr

$$(1-\gamma_t)\gamma_t^{\alpha_1} + \gamma_t \gamma_t^{\alpha_2}, \quad \alpha_1 = 0.9974,\ \alpha_2 = 0.7463,\ \kappa = 0.00162$$



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