Monetary policy and Long term interest rates

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1 Views expressed here are not those of the ECB or of the FRB
Motivation
Motivation
Motivation

⇒ "Movements in the [...] yield spread are associated with movements in risk" (Atkeson and Kehoe, 2010; Cochrane, 2010)

- In the conventional view, the short rate drops at the beginning of a recession, but it is expected to return the steady state within at least 10 years. In fact, taking account of risk premia, 10 year expected interest rates fall just as fast as the 1 year rate.
Our questions

- If yield spreads are associated with movements in risk, what produces them? Are they caused by monetary policy or are they exogenous?

- If long term yields net of risk premia are not constant, what do they imply for expectations of the future path of monetary policy rates ...

- ... and for inflation expectations?
Our paper

- A single model-feature can reconcile the macro and the finance views: \textit{heteroskedasticity} (in the form of regime switching)

- Uncertainty shocks also amount to \textit{variation in risk}: during recessions volatility drives the increase in risk premia. Risk premia are countercyclical—as in the finance literature

- "Uncertainty shocks" change precautionary saving: during recessions volatility increases and real rates fall. Nominal 10 year expected interest rates fall together with policy rates—as "observed" in the data
Our paper

- The quantitative story:
  - Risk-neutrality (EH holding) an artifax of linearization \( \Rightarrow \)
    we analyse the nonlinear solution of a DSGE model

  - We estimate the nonlinear model on both macro and yields data for the U.S.

  - We show that the model fits both sets of data reasonably well
Outline

- Bird’s eye overview of the literature
- Key features of the model
- Solutions and estimation
- Results
Literature

- On heteroskedastic shocks in macroeconomic—Sims-Zha (2006), Primiceri (2005), Justiniano-Primiceri (2008) ...

- Papers suggesting that consumption-based models with exotic preferences are OK at fitting *unconditional* moments of yields—Piazzesi-Schneider (2006); HTV (2008); Rudebusch-Swanson (2012); Swanson (2014) ...

- Few empirical applications in nonlinear models—Fernandez-Villaverde and Rubio-Ramirez, Andreasen (2012) ...
Key features of the model
Model

- Simple new Keynesian model with Rotemberg adj. costs and inflation index., (ext.) habits

- Level and growth technology shocks
  \[ Y_t = (Z_t B_t) L_t^\alpha \]

- Resource constraint
  \[ Y_t = C_t + G_t + \frac{\zeta}{2} \left( \Pi_t - (\Pi^*_t)^{1-\lambda} \Pi_{t-1}^* \right)^2 Y_t \]
Model

- Policy rule

\[ i_t = const. + \psi_\pi \left( \pi_t - \pi^* \right) + \psi_Y \left( \tilde{y}_t - \tilde{y} \right) + \rho_I i_{t-1} + \eta_{t+1} \]

- Note: constant target \( \pi^* \)
Distinguishing feature: heteroskedasticity

- Shocks: productivity (stationary and integrated), gov. spending, mark-up, policy

- Two-state, independent Markov switching in the innovation variances:

\[ \varepsilon_{i,t+1} \approx N \left( 0, \sigma_{i,s_{i,t}} \right) \quad \text{for } i = z, G, \eta \]

\[ \sigma_{i,s_{i,t}} = \sigma_{i,0}s_{i,t} + \sigma_{i,1}(1 - s_{i,t}) \]

with constant transition probabilities

\[ p(s_{i,t+1} = k, s_{i,t} = j) = p_{i,jk} \]
Distinguishing feature: preferences

- Epstein-Zin-Weil preferences

\[ U \left[ u_t, (E_t V_{t+1}^{1-\gamma}) \right] = \left\{ (1 - \beta) u_t^{1-\psi} + \beta \left( E_t V_{t+1}^{1-\gamma} \right)^{\frac{1-\psi}{1-\gamma}} \right\}^{\frac{1}{1-\psi}} \]

- Temporary utility

\[ u_t (j) = u \left[ C_t (j) - h \Xi_t C_{t-1}, N_t (j) \right] \]
Numerical application

- Trabandt and Uhlig (2011) specification

\[ u = (C_t - h \Xi_t C_{t-1}) \left( 1 - \eta (1 - \psi) N_t^{1+\frac{1}{\phi}} \right)^{\frac{\psi}{1-\psi}} \]
Properties of the model

- Special case with constant labour supply

\[ \hat{i}_t = E_t u_{t+1} - \frac{1}{2} \text{Var}_t u_{t+1} - (\gamma - \psi) \left[ \text{Cov}_t (u_{t+1}, v_{t+1}) - \frac{1}{2} (\psi - 1) \text{Var}_t v_{t+1} \right] \]

where

\[ v_t = \sum_{i=0}^{\infty} \left( \beta \Xi^{1-\psi} \right)^i E_t \left[ \xi_{t+i} + (1 - \beta \Xi^{1-\psi}) \overset{\leftarrow}{c}_{t+i} \right] \]

\[ u_t \equiv \psi \left( \Delta \overset{\leftarrow}{c}_t + \xi_t \right) + \pi_t, \quad \overset{\leftarrow}{c}_t = \hat{c}_t - h\hat{c}_{t-1} \]

- Uncertainty as to revisions in fut. expect. c matters for i
Properties of the model

- Expected excess holding period returns

\[ \frac{H_{n,t}}{I_t} = \frac{E_t B_{n-1,t+1}}{B_{n,t}} \]

- In the model

\[ \hat{h}_{n,t} - \hat{i}_t = -\text{Cov}_t \left[ \hat{b}_{t+1,n-1}, \hat{q}_{t,t+1} \right] \]
Solution and estimation
Solution

- As usual

\[ \mathbb{E}_t [f \{x_{t+1}, y_{t+1}, x_t, y_t, ; s_{t+1}, s_t\}] = 0 \]

- We look for solutions of the form (Amisano and Tristani, JEDC 2011—a special case of recent Foerster, Waggoner, Rubio-Ramirez and Zha, 2014)

\[
\begin{align*}
    f(x_t, \sigma; s_t) &= f(\bar{x}; 0; s_t) + F_s(x_t - \bar{x}_{s_t}) \\
    &\quad + \frac{1}{2} \left( I_{n_y} \otimes (x_t - \bar{x}_{s_t})' \right) \mathbf{E}_{s_t} (x_t - \bar{x}_{s_t}) + k_{y,s_t} \sigma^2
\end{align*}
\]
Solution

- Only impact of heteroskedasticity in constant term

\[ \hat{y}_t = F\hat{x}_t + \frac{1}{2} \left( I_{n_y} \otimes \hat{x}_t' \right) E\hat{x}_t + k_{y,s_t} \]

- Similarly for predetermined variables
Estimation method

- Model is nonlinear

\[ y_{t+1}^o = k_{y,j} + F\hat{x}_{t+1} + \frac{1}{2} \left( I_{ny} \otimes \hat{x}_{t+1}' \right) E\hat{x}_{t+1} + Dv_{t+1} \]

\[ x_{t+1} = k_{x,i} + P\hat{x}_{t} + \frac{1}{2} \left( I_{nx} \otimes \hat{x}_{t}' \right) G\hat{x}_{t} + \bar{\sigma}\Sigma_i w_{t+1} \]

- but main source of nonlinearity are intercept shifts. Hence extended Kalman filter

\[ y_{t+1}^o = \tilde{k}_{y,t+1}^{i,j} + \tilde{F}_{t+1}^{i,j} \hat{x}_{t+1} + Dv_{t+1} \]

\[ \hat{x}_{t+1} = \tilde{k}_{x,t}^{i} + \tilde{P}^{i}_t \hat{x}_{t} + \Sigma_i w_{t+1} \]
Estimation

- We use Kim’s (1994) approximate filter to compute the likelihood

- Combine the likelihood with a prior and sample using a tuned Metropolis-Hastings algorithm
Data and results
Data

- Quarterly US data: 1966:q1 to 2009:q1

- Six observables: real per-capita GDP; real personal per-capita consumption; consumption deflator; 3-month nominal rate; 3-year and 10-year zero-coupon yields

- "Measurement errors" on all variables
Parameter estimates

- Monetary policy rule:

\[ \hat{i}_t = 0.09 \ [3.09 \ (\pi_t - \pi^*) + 0.57 \ (\bar{y}_t - \bar{y})] + 0.91 \ \hat{i}_{t-1} + \eta_{t+1}. \]

- High inertia
Parameter estimates

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Parameter estimates

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Dynamic correlations
Dynamic correlations
Forward rates

1y ahead

3y ahead

10y ahead

Actual

Model based
Actual and 1-step ahead
Actual and 1-step ahead
Probability of low-variance regimes
Excess holding period returns
### Variance decomposition

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Impulse responses to a technology variance regime
Long-term rates over the business cycle

- "Risk" or "uncertainty" shocks important for \( E_i \)

- With recessions, uncertainty \( \uparrow \) and drives up risk premia. Forward rates \( \uparrow \), but not \( E_i \). Indeed, \( E_i \downarrow \) because demand for precautionary saving \( \uparrow \), consumption \( \downarrow \) and adds \( \downarrow \) pressure on \( y \) and \( \pi \).

- After recession "confidence" returns. Uncertainty dynamics are reversed. It becomes clear that \( i \) will rise quickly. Risk premia \( \downarrow \) and forward rates become closer to \( E_i \)
Impulse responses to a technology shock

Graphs showing the responses of various economic variables (π, z, y, i) to a technology shock over different horizons.
Narrative
Decomposing long term yields
Expected inflation over the next 10 years

Surveys vs. model-based predictions.
10-year expected interest rates
10-year nominal term premium
Conclusions (I)

- Estimated model to account for key features of the transmission of monetary policy to long-term rates. Uncertainty/volatility shocks are important to explain observed variations in yields.

- In the early parts of recessions, forward spreads are high because uncertainty and risk premia rise, not due to $E_i$. When recession ends, uncertainty and risk premia fall, and $E_i$ rise; changes in forward rate reflect expected future interest rates.

- The model can be extended in a number of directions.
Conclusions (II)

- Movements in risk affecting spreads are not caused by monetary policy actions. But monetary policy responds to changes in risk, because of changes in precautionary saving.

- Changes in real interest rates and in risk premia are important determinants of long term rates.

- 10-year inflation expectations are less firmly anchored than one would conclude, based on survey data.
Why recursive preferences and habits

- Habits
  - Have first order effects (hump shaped IRFs). High risk aversion makes consumption insensitive to real rate

- Recursive preferences
  - Have no effects to first order – dynamics as in a model with EU. Risk aversion parameter "free" to match yields.
Households’ problem

- Choose \( w_s(i) \) and \( C_s(i) \) s.t.

  - budget constraint

    \[
    P_t C_t(i) + E_t Q_{t,t+1} W_{t+1}(i) \leq W_t(i) + w_t(i) N_t(i) + \int_0^1 \psi_t(j) \, dj
    \]

  - demand for hours worked by household \( i \)

    \[
    N_t(i) = L_t \left( \frac{w_t(i)}{w_t} \right)^{-\theta_{w,t}}
    \]
Households’ problem

- FOCs include

\[
\frac{u_{N,t}}{u_{c,t}} = \mu_{w,t} \frac{w_t}{P_t}, \quad \mu_{w,t} \equiv \left( \theta_{w,t} - 1 \right) / \theta_{w,t}
\]

\[
Q_{t,t+1} = \beta \left[ E_t \left( \frac{J_{t+1}}{J_t} \right)^{1-\gamma} \right]^{\gamma-\psi} \left( \frac{J_{t+1}}{J_t} \right)^{-(\gamma-\psi)} \left( \frac{u_{t+1}}{u_t} \right)^{-\psi} \frac{u_{c,t+1}}{u_{c,t}} \frac{1}{\Pi_{t+1}}
\]

where \( J_t^{1-\psi} = (1 - \beta) u_t^{1-\psi} + \beta \left[ E_t J_t^{1-\gamma} \right]^{1-\psi} \)
Equilibrium

- Households’ and firms’ FOCs are satisfied
- Goods and labour markets clear
- Monetary policy follows the Taylor rule
Properties of the model

\[ \hat{i}_t = E_{t} u_{t+1} - \frac{1}{2} \text{Var}_{t} u_{t+1} - (\gamma - \psi) \left[ \text{Cov}_{t} (u_{t+1}, v_{t+1}) - \frac{1}{2} (\psi - 1) \text{Var}_{t} v_{t+1} \right] \]

\[ u_{t+1} \equiv -\Delta \overrightarrow{\lambda}_{t+1} + \psi \hat{\xi}_{t+1} + \hat{\pi}_{t+1} \]

\[ v_{t+1} = E_{t+1} \sum_{i=0}^{\infty} (\beta^{1-\psi})^i \left( \frac{u_c}{u} \overrightarrow{\Delta \overrightarrow{c}}_{t+1+i} + \frac{u_N}{u} N \Delta \hat{i}_{t+1+i} + \hat{\xi}_{t+1+i} \right) \]

\[ \overrightarrow{c}_t = \tilde{C}_t - h \tilde{C}_{t-1} \]
Canzoneri, Cumby and Diba (2007)

Fig. 1. Real interest rates: ex post and CRRA Euler equation.
Nominal interest rates

(actual)

(euler (constant lab supp))
Nominal interest rates