Long run rates and monetary policy

Bayesian Analysis and Modeling (BAM) Summer Workshop 2018

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University of Melbourne 12/03/2018

\(^1\)Views expressed here are not those of the ECB or of the FRB
"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.
"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 to 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?
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- 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 ...
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- 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 literature: *heteroskedasticity* (in the form of regime switching)
- Uncertainty shocks also amount to variation in risk: during recessions volatility drives the increase in risk premia. Risk premia are *countercyclical*—as in the finance literature
Our paper

- A single model-feature can reconcile the macro and the finance literature: heteroskedasticity (in the form of regime switching)
  - Uncertainty shocks also amount to 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: we analyse the nonlinear solution of a DSGE model
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  - We estimate the nonlinear model on both macro and yields data for the U.S.
Motivation

Our paper

- The quantitative story
  - Risk-neutrality (EH holding) an artifax of linearization: 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
On heteroskedastic shocks in macroeconomic–Sims-Zha (2006), Primiceri (2005), Justiniano-Primiceri (2008) ...
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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) ...
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–van Bindesberger *et al.*(2012), Andreasen (2012) ...
The model

- Simple new Keynesian model with Rotemberg adj. costs and inflation indexation, (external) habits
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- Level and growth technology shocks

\[ Y_t = (Z_t B_t) L_t^\alpha \]
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\[ Y_t = (Z_t B_t) L_t^\alpha \]

- Resource constraint

\[ Y_t = C_t + G_t + \frac{\zeta}{2} \left( \Pi_t - \left( \Pi^* \right)^{1-\iota} \Pi_{t-1}^\iota \right)^2 Y_t \]
The model

- Policy rule

\[ i_t = \text{const.} + \psi_{\pi}(\pi_t - \pi^*) + \psi_Y(\tilde{y}_t - \tilde{y}) + \rho_i i_{t-1} + \eta_{t+1} \]
The model

- Policy rule
  
  \[ i_t = \text{const.} + \psi_{\Pi} (\pi_t - \pi^*) + \psi_Y (\tilde{y}_t - \tilde{y}) + \rho_i i_{t-1} + \eta_{t+1} \]

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

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

- **Shocks:** productivity (stationary and integrated), gov. spending, mark-up, policy
- Two-state, independent Markov switching in the innovation variances:
  
  \[ \varepsilon_{i,t+1} \sim N\left(0, \sigma_{i,s_i,t}\right) \quad \text{for } i = z, G, \eta \]

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

  with constant transition probabilities

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

- Epstein-Zin-Weil preferences

\[ U \left[ u_t, (E_t V_{t+1}^{1-\gamma}) \right] = \left\{ (1 - \beta) u_t^{1-\psi} + \beta (E_t V_{t+1}^{1-\gamma})^{\frac{1-\psi}{1-\gamma}} \right\}^{\frac{1}{1-\psi}} \]
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- \( \gamma = \) risk aversion, \( \psi = \) inverse of EIS
Distinguishing feature: preferences

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\]

• \( \gamma = \text{risk aversion}, \ \psi = \text{inverse of EIS} \)

• Temporary utility with Trabandt and Uhlig (2011) specification

\[
u = (C_t - h\Xi_t C_{t-1}) \left( 1 - \eta (1 - \psi) N_t^{1 + \frac{1}{\phi}} \right)^{\frac{\psi}{1-\psi}}
\]
Why recursive preferences and habits

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

As usual

\[
E_t \left[ f \{x_{t+1}, y_{t+1}, x_t, y_t, ; s_{t+1}, s_t\} \right] = 0
\]
Solution 1

- As usual
  \[ E_t \left[ f \{x_{t+1}, y_{t+1}, x_t, y_t, ; s_{t+1}, s_t\} \right] = 0 \]

- We seek solutions of the form (Amisano and Tristani, JEDC 2011—a special case of recent Foerster et al., 2016)

\[
f (x_t, \sigma; s_t) = f (\bar{x}; 0; s_t) + F_{s_t} (x_t - \bar{x}_{s_t}) \\
+ \frac{1}{2} \left( I_{ny} \otimes (x_t - \bar{x}_{s_t})' \right) E_{s_t} (x_t - \bar{x}_{s_t}) + k_{y,s_t} \sigma^2
\]
Solution II

- Only impact of heteroskedasticity in constant term

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

- 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 I

- Model is nonlinear

\[
\begin{align*}
y_{t+1}^o &= k_{y,j} + F\hat{x}_{t+1} + \frac{1}{2} \left( I_{ny} \otimes \hat{x}'_{t+1} \right) E\hat{x}_{t+1} + Dv_{t+1} \\
x_{t+1} &= k_{x,i} + P\hat{x}_t + \frac{1}{2} \left( I_{nx} \otimes \hat{x}'_t \right) G\hat{x}_t + \tilde{\sigma}\Sigma_i w_{t+1}
\end{align*}
\]
Estimation I

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x_{t+1} = k_{x,i} + P\hat{x}_t + \frac{1}{2} \left( I_n_x \otimes \hat{x}'_t \right) G \hat{x}_t + \tilde{\sigma}\Sigma_i w_{t+1}
\]

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

\[
y_{t+1}^o = \tilde{k}^{(i,j)}_{y,t+1} + \tilde{F}^{(i,j)}_{t+1} \hat{x}_{t+1} + Dv_{t+1} \\
\hat{x}_{t+1} = \tilde{k}^{(i)}_{x,t} + \tilde{P}^{(i)}_{t} \hat{x}_t + \Sigma_i w_{t+1}
\]
Estimation II

- We use Kim’s (1994) approximate filter to compute the likelihood.
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- Combine the likelihood with a prior and sample using a tuned Metropolis-Hastings algorithm.
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- Combine the likelihood with a prior and sample using a tuned Metropolis-Hastings algorithm.
- Tried unscented KF and particle filter without changes in the results.
Data

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

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- 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
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- 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:

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

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- High inertia
## Parameter estimates

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<td>0.9986</td>
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<td>(p_{G,11})</td>
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<td>0.8559</td>
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<td>$\sigma_{me,\Delta c}$</td>
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<td>0.0006</td>
<td>0.0005</td>
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<td>$\sigma_{me,i}$</td>
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<td>0.0004</td>
<td>5.0E-05</td>
<td>0.0014</td>
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Dynamic correlations: macro variables
Dynamic correlations: yields
Forward rates

1y ahead

3y ahead

10y ahead

Actual
Model based

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LR rates and mon pol

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Probability of low-variance regimes
Expected excess holding period returns

Data and results

Amisano (FRB), Tristani (ECB)  LR rates and mon pol  BAM 2018  25 / 30
Long-term rates over the business cycle

- "Risk" or "uncertainty" shocks important for $E_i$

After recessions, uncertainty dynamics are reversed. It becomes clear that $i$ will rise quickly. Risk premia ↓ and forward rates become closer to $E_i$.
Long-term rates over the business cycle

- "Risk" or "uncertainty" shocks important for $E_i$
- With recessions, uncertainty ↑ and drives up risk premia. Forward rates ↑, but not $E_i$
Long-term rates over the business cycle

- "Risk" or "uncertainty" shocks important for $E_i$
- With recessions, uncertainty ↑ and drives up risk premia. Forward rates ↑, but not $E_i$
- Indeed, $E_i$ ↓ because demand for precautionary saving ↑, consumption ↓ and adds ↓ pressure on $y$ and $\pi$
Long-term rates over the business cycle

- "Risk" or "uncertainty" shocks important for $E_i$
- With recessions, uncertainty ↑ and drives up risk premia. Forward rates ↑, but not $E_i$
- Indeed, $E_i$ ↓ because demand for precautionary saving ↑, consumption ↓ and adds ↓ pressure on $y$ and $\pi$
- After recession "confidence" returns. Uncertainty dynamics are reversed. It becomes clear that $i$ will rise quickly. Risk premia ↓ and forward rates become closer to $E_i$
Expected inflation over the next 10 years

Survey
Model based

Amisano (FRB), Tristani (ECB)
LR rates and mon pol

BAM 2018 27 / 30
Determinants of long-term inflation expectations

- Anchoring in the 1980s?
Determinants of long-term inflation expectations

- Anchoring in the 1980s?
- A sequence of highly persistent, adverse shocks led to an increase in trend inflation in the 1970s. The shocks were slowly reabsorbed over the 1980s. Long-term inflation expectations moved accordingly.
Determinants of long-term inflation expectations

- Anchoring in the 1980s?
- A sequence of highly persistent, adverse shocks led to an increase in trend inflation in the 1970s. The shocks were slowly reabsorbed over the 1980s. Long-term inflation expectations moved accordingly
- Inflation was never conquered. Prolonged deviations of inflation from price stability can happen again
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.
Conclusions

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