Long run rates and monetary policy

Bayesian Analysis and Modeling (BAM) Summer Workshop 2018

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

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.

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- 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

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- ... 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

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  - 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

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  - 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

Literature

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

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- Few empirical applications in nonlinear models–van Bindesberger *et al.*(2012), Andreasen (2012) ...

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- Resource constraint

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

The model

- Policy rule

$$i_t = const. + \psi_\Pi (\pi_t - \pi^*) + \psi_Y (\widetilde{y}_t - \widetilde{y}) + \rho_I i_{t-1} + \eta_{t+1}$$

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- Note: constant target π^*

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- Shocks: productivity (stationary and integrated), gov. spending, mark-up, policy
- Two-state, independent Markov switching in the innovation variances:

$$\varepsilon_{i,t+1} \sim N\left(0, \sigma_{i,s_{i,t}}\right) \qquad \text{for } i = z, G, \eta$$

$$\sigma_{i,s_{i,t}} = \sigma_{i,0} s_{i,t} + \sigma_{i,1}\left(1 - s_{i,t}\right)$$

with constant transition probabilities

$$p(s_{i,t+1} = k, s_{i,t} = j) = p_{i,jk}$$

Distinguishing feature: preferences

- Epstein-Zin-Weil preferences

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

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- γ = risk aversion, ψ = inverse of EIS
- Temporary utility with Trabandt and Uhlig (2011) specification

$$u = (C_t - h\Xi_t C_{t-1}) \left(1 - \eta\,(1-\psi)\, N_t^{1+\frac{1}{\phi}}\right)^{\frac{\psi}{1-\psi}}$$

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

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- 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

$$\mathrm{E}_t \left[f \left\{ \mathbf{x}_{t+1}, \mathbf{y}_{t+1}, \mathbf{x}_t, \mathbf{y}_t, ; s_{t+1}, s_t \right\} \right] = \mathbf{0}$$

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

$$\begin{aligned} f\left(\mathbf{x}_t, \sigma; s_t\right) = & f\left(\overline{\mathbf{x}}; 0; s_t\right) + \mathbf{F}_{s_t}\left(\mathbf{x}_t - \overline{\mathbf{x}}_{s_t}\right) \\ & + \frac{1}{2}\left(\mathbf{I}_{n_y} \otimes \left(\mathbf{x}_t - \overline{\mathbf{x}}_{s_t}\right)'\right) \mathbf{E}_{s_t}\left(\mathbf{x}_t - \overline{\mathbf{x}}_{s_t}\right) + \mathbf{k}_{y,s_t}\sigma^2 \end{aligned}$$

Solution II

- Only impact of heteroskedasticity in constant term

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

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- Similarly for predetermined variables

Estimation I

- Model is nonlinear

$$\mathbf{y}^{o}_{t+1} = \mathbf{k}_{y,j} + F\hat{\mathbf{x}}_{t+1} + \frac{1}{2}\left(I_{n_y} \otimes \hat{\mathbf{x}}'_{t+1}\right) E\hat{\mathbf{x}}_{t+1} + D\mathbf{v}_{t+1}$$

$$\mathbf{x}_{t+1} = \mathbf{k}_{x,i} + P\hat{\mathbf{x}}_{t} + \frac{1}{2}\left(I_{n_x} \otimes \hat{\mathbf{x}}'_{t}\right) G\hat{\mathbf{x}}_{t} + \widetilde{\sigma}\Sigma_i\mathbf{w}_{t+1}$$

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

$$\mathbf{y}^{o}_{t+1} = \widetilde{k}^{(i,j)}_{y,t+1} + \widetilde{F}^{(i,j)}_{t+1}\hat{\mathbf{x}}_{t+1} + Dv_{t+1}$$
$$\widehat{\mathbf{x}}_{t+1} = \widetilde{k}^{(i)}_{x,t} + \widetilde{\mathbf{P}}^{(i)}_{t}\widehat{\mathbf{x}}_{t} + \Sigma_i\mathbf{w}_{t+1}$$

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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

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- 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:

$$\widehat{i_t} = 0.09 \ \left[3.09 \ (\pi_t - \pi^*) + 0.57 \ (\widetilde{y}_t - \widetilde{y})\right] + 0.91 \ \widehat{i}_{t-1} + \eta_{t+1}.$$

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- High inertia

Parameter estimates

	post mean	post sd	prior mean	prior sd
Π	1.0061	0.0007	1.0062	0.0007
ψ_π	0.2676	0.0241	0.1990	0.1001
ψ_y	0.0497	0.0075	0.0200	0.0010
ρ_i	0.9135	0.0169	0.8494	0.1002
Ξ	1.0045	0.0004	1.0050	0.0010
ι	0.7333	0.1116	0.5003	0.1899
ϕ	0.6156	0.0846	1.0022	0.5049
γ	11.5185	3.6747	10.9537	6.9730
ψ	1.3075	0.0868	1.2035	0.2830
ζ	33.8071	3.1344	14.9744	6.9819
h	0.8619	0.0261	0.4996	0.1886
β	0.9984	0.0006	0.9986	0.0014

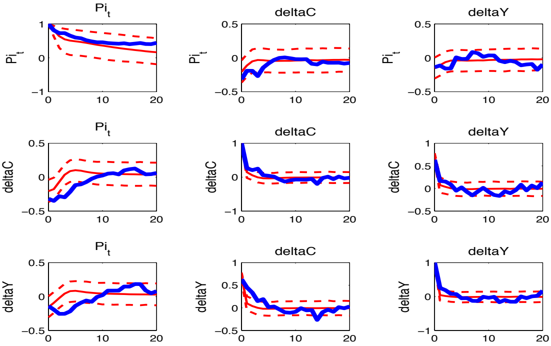
Parameter estimates

	post mean	post sd	prior mean	prior sd
$p_{G,11}$	0.8760	0.0556	0.8997	0.0657
$p_{G,00}$	0.9413	0.0351	0.8994	0.0662
$p_{\eta,11}$	0.9595	0.0196	0.8996	0.0657
$p_{\eta,00}$	0.9079	0.0447	0.8998	0.0658
$p_{z,11}$	0.9728	0.0091	0.9013	0.0651
$p_{z,00}$	0.9317	0.0190	0.8993	0.0662
ρ_{μ}	0.5487	0.0581	0.8552	0.0916
ρ_{z}	0.9889	0.0018	0.8582	0.0899
ρ_{G}	0.9091	0.0298	0.8559	0.0906

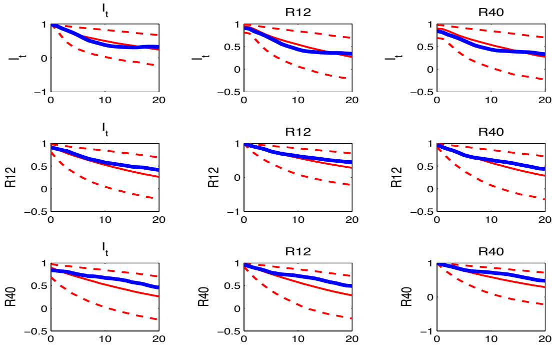
Parameter estimates

	post mean	post sd	prior mean	prior sd
$\sigma_{me,\pi}$	1.4E-06	1.6E-06	1.4E-06	1.3E-06
$\sigma_{me,\Delta c}$	1.3E-06	6.8E-07	1.4E-06	1.1E-06
$\sigma_{me,\Delta y}$	0.0036	0.0006	0.0005	0.0003
$\sigma_{me,i}$	1.3E-06	7.5E-07	1.4E-06	1.0E-06
$\sigma_{me,i_{12}}$	0.0007	7.6E-05	0.0014	0.0010
$\sigma_{me,i40}$	0.0004	5.0E-05	0.0014	0.0010

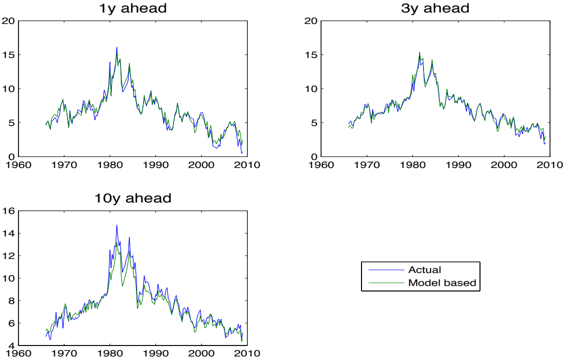
Dynamic correlations: macro variables



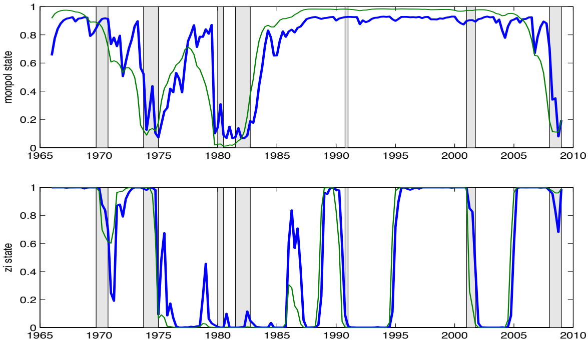
Dynamic correlations: yields



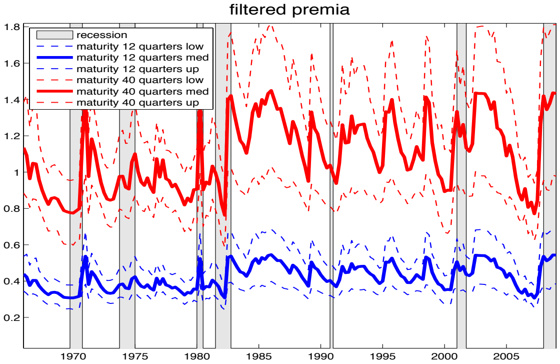
Forward rates



Probability of low-variance regimes



Expected excess holding period returns



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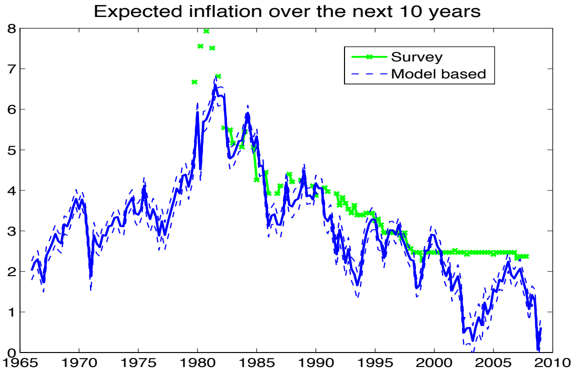
- Indeed, Ei $\downarrow$ because demand for precautionary saving $\uparrow$, consumption $\downarrow$ and adds $\downarrow$ pressure on y and π
- After recession "confidence" returns. Uncertainty dynamics are reversed. It becomes clear that i will rise quickly. Risk premia $\downarrow$ and forward rates become closer to Ei

Narrative: expectations



Determinants of long-term inflation expectations

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- 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

Conclusions

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- 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 $\uparrow$ not due to Ei. When recession ends, uncertainty and risk premia fall, and Ei rise; changes in forward rate reflect expected future interest rates.

Conclusions (II)

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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