Long run rates and monetary policy

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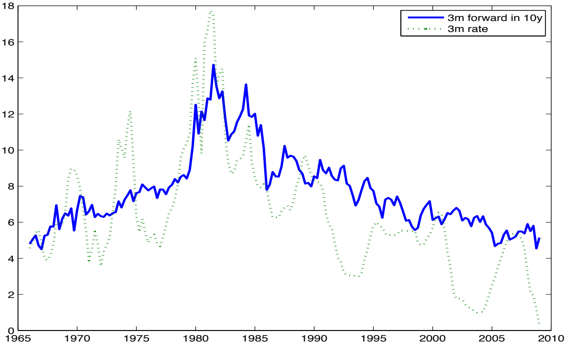
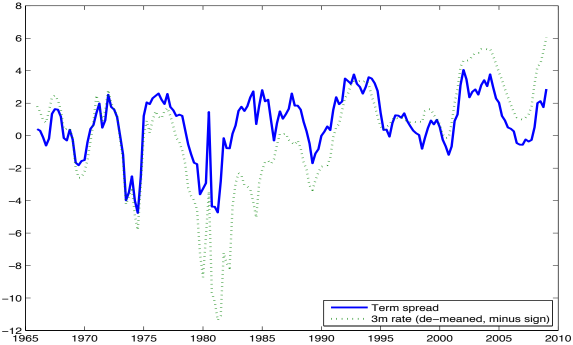
[1] Views expressed here are not those of the ECB or of the FRB

Motivation, I



Motivation, II



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 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
  - 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) ...
- 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 et al.(2011), Andreasen (2012) ...

The 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

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

The model

- Policy rule

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

- Note: constant target π^*

Distinguishing feature: heteroskedasticity

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

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

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

with constant transition probablities

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

Distinguishing feature: preferences

- Epstein-Zin-Weil preferences

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

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

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

Why recursive preferences *and* habits

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

$$P_t C_t(i) + \mathrm{E}_t Q_{t,t+1} W_{t+1}(i) \leq W_t(i) + w_t(i) N_t(i) + \int_0^1 \Psi_t(j)\, \mathrm{d}j$$

  - demand for hours worked by household i

$$N_t(i) = L_t \left(\frac{w_t(i)}{w_t} \right)^{-\theta_{w,t}}$$

Properties of the model

- Special case with constant labour supply

$$\widehat{i}_t = \mathrm{E}_t u_{t+1} - \frac{1}{2}\mathrm{Var}_t u_{t+1} +$$

$$-(\gamma-\psi)\left[\mathrm{Cov}_t\left(u_{t+1}, v_{t+1}\right) - \frac{1}{2}(\psi-1)\,\mathrm{Var}_t v_{t+1}\right]$$

where

$$v_t = \sum_{i=0}^{\infty}\left(\beta\Xi^{1-\psi}\right)^i \mathrm{E}_t\left[\widehat{\xi}_{t+i} + \left(1-\beta\Xi^{1-\psi}\right)\widehat{\overleftrightarrow{c}}_{t+i}\right]$$

$$u_t \equiv \psi\left(\Delta\widehat{\overleftrightarrow{c}}_t + \widehat{\xi}_t\right) + \widehat{\pi}_t, \qquad \widehat{\overleftrightarrow{c}}_t = \widehat{\widetilde{c}}_t - h\widehat{\widetilde{c}}_{t-1}$$

- Uncertainty as to revisions in fut. expect. c matters for i

Properties of the model

- Expected excess holding period return

$$\frac{H_{n,t}}{I_t} = \frac{\mathrm{E}_t B_{n-1,t+1}}{B_{n,t}}$$

- In the model

$$\widehat{h}_{n,t} - \widehat{i}_t = -\mathrm{Cov}_t\left[\widehat{b}_{t+1,n-1}, \widehat{q}_{t,t+1}\right]$$

Solution

- As usual

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

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

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

Solution

- Only impact of heteroskedasticity in constant term

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

- Similarly for predetermined variables

Estimation

- Model is nonlinear

$$\mathbf{y}^o_{t+1} = \mathbf{k}_{y,j} + F\hat{\mathbf{x}}_{t+1} + \frac{1}{2}\left(I_{n_y} \otimes \hat{\mathbf{x}}^{'}_{t+1}\right) E\hat{\mathbf{x}}_{t+1} + D\mathbf{v}_{t+1}$$
$$\mathbf{x}_{t+1} = \mathbf{k}_{x,i} + P\hat{\mathbf{x}}_t + \frac{1}{2}\left(I_{n_x} \otimes \hat{\mathbf{x}}^{'}_{t}\right) G\hat{\mathbf{x}}_t + \widetilde{\sigma}\Sigma_i\mathbf{w}_{t+1}$$

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

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

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

- 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:

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

- High inertia

Parameter estimates

	post mean	post sd	prior mean	prior sd
Π	1.006143	0.00069	1.006255	0.00072
ψ_π	0.267607	0.024073	0.199031	0.10011
ψ_y	0.049662	0.007535	0.02004	0.009968
ρ_i	0.913538	0.016879	0.849432	0.10022
Ξ	1.004527	0.000413	1.005008	0.001003
ι	0.733358	0.111614	0.500288	0.189923
ϕ	0.615584	0.084646	1.002252	0.504916
γ	11.51852	3.674717	10.95369	6.972984
ψ	1.307529	0.086758	1.203535	0.28997
ζ	33.80709	3.134418	14.97439	6.981933
h	0.861861	0.026101	0.499611	0.188565
β	0.998395	0.000567	0.998567	0.001429

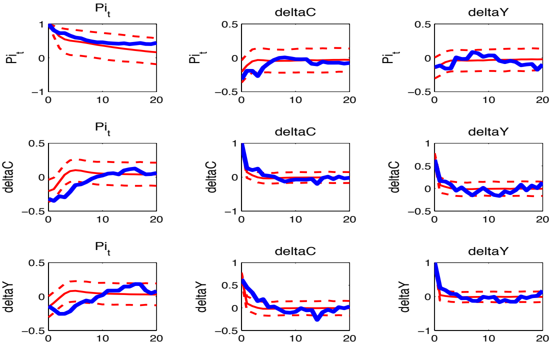
Parameter estimates

	post mean	post sd	prior mean	prior sd
$p_{G,11}$	0.875997	0.055635	0.899727	0.065687
$p_{G,00}$	0.941294	0.035121	0.899437	0.066248
$p_{\eta,11}$	0.959538	0.019619	0.899591	0.065683
$p_{\eta,00}$	0.907894	0.044664	0.899823	0.065774
$p_{z,11}$	0.972819	0.009089	0.901282	0.065122
$p_{z,00}$	0.931666	0.019045	0.899314	0.066243
ρ_μ	0.548747	0.058116	0.855175	0.091594
ρ_z	0.988924	0.001815	0.858245	0.089933
ρ_G	0.909108	0.029819	0.855938	0.090583

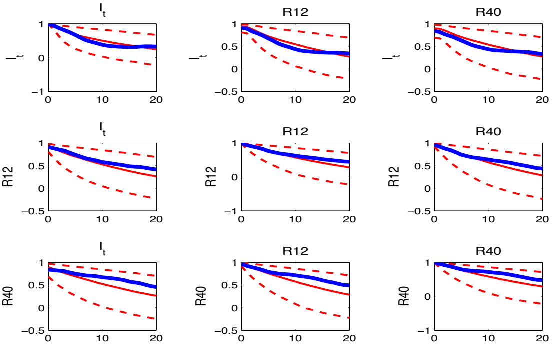
Parameter estimates

	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
$\sigma_{me,\Delta y}$	0.003607	0.000617	0.000505	0.00027
$\sigma_{me,i}$	1.3E-06	7.5E-07	1.4E-06	1.0E-06
$\sigma_{me,i_{12}}$	0.00072	7.6E-05	0.001378	0.001037
$\sigma_{me,i40}$	0.000437	5.0E-05	0.001381	0.000999

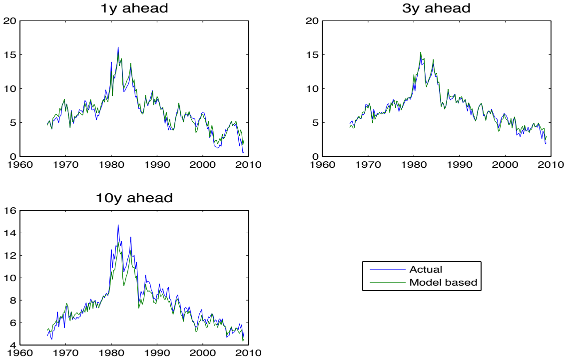
Dynamic correlations: macro variables



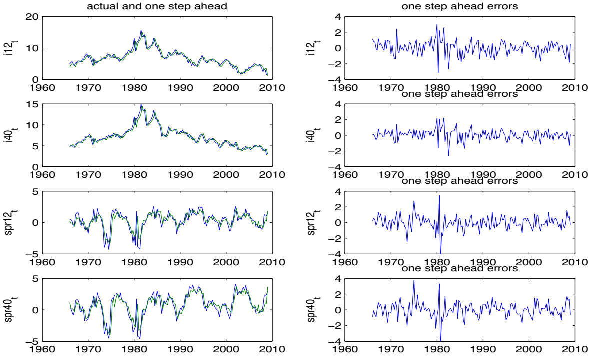
Dynamic correlations: yields



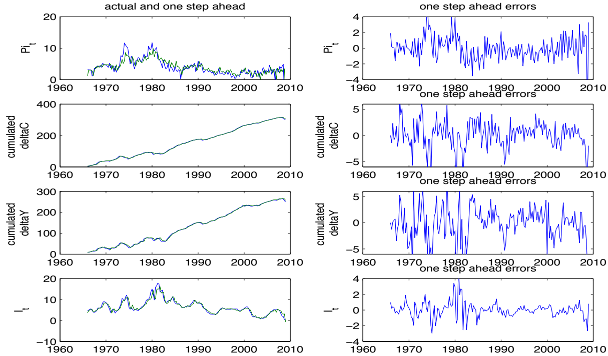
Forward rates



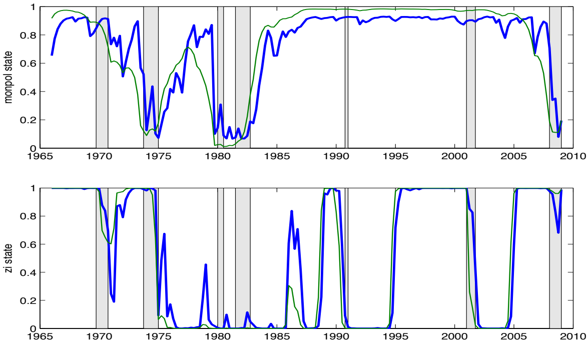
Actual and one step ahead forecasts: yields



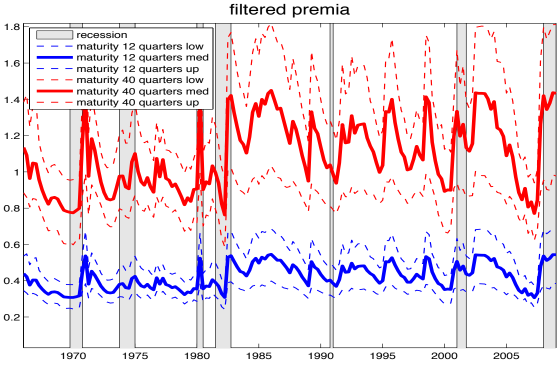
Actual and one step ahead forecasts: macro



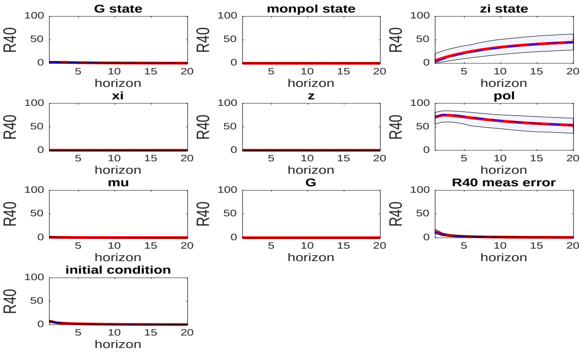
Probability of low-variance regimes



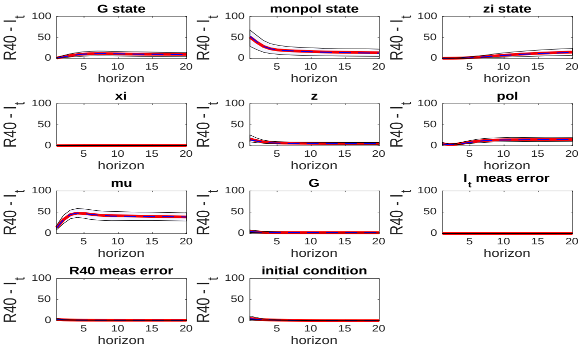
Excess holding period returns



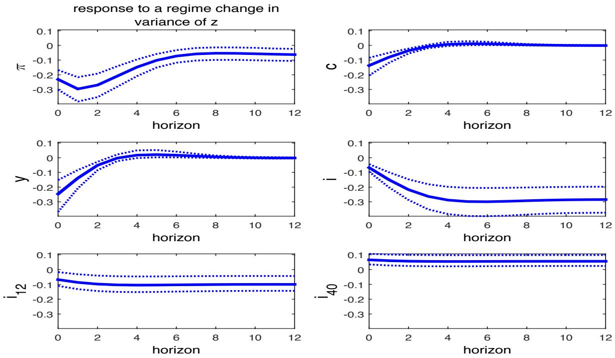
Variance decomposition: long term rate



Variance decomposition: long term spread



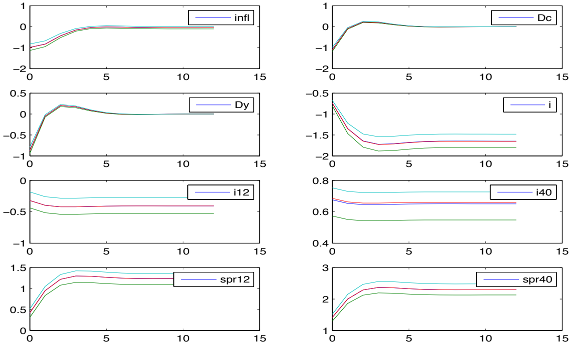
Impulse responses to a tech. var. regime



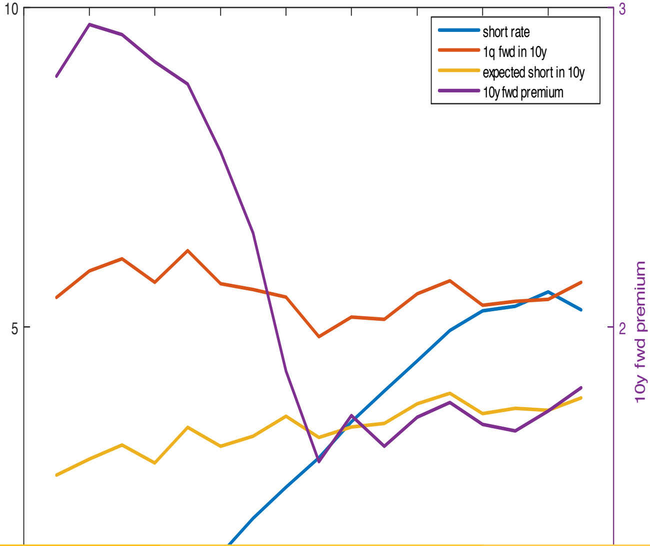
Long-term rates over the business cycle

- "Risk " or "uncertainty" shocks important for Ei
- With recessions, uncertainty $\uparrow$ and drives up risk premia. Forward rates $\uparrow$, but not Ei
- 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

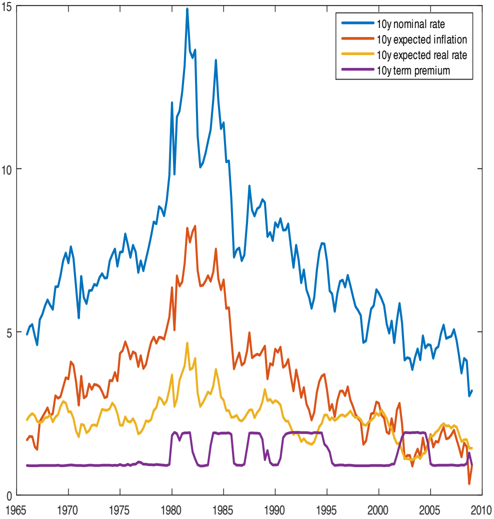
Impulse responses to a technology shock



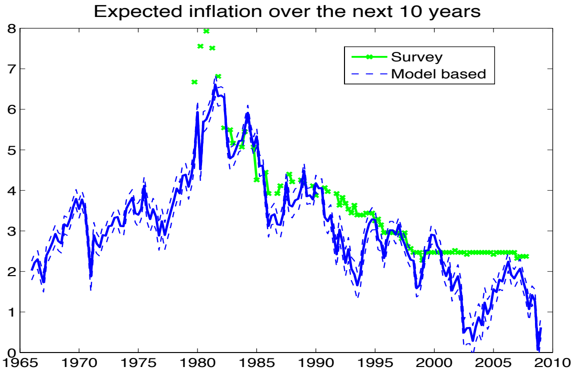
Narrative: conundrum



Narrative: decomposing long term yields



Narrative: expectations



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

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