Financial Factors in Economic Fluctuations

Lawrence Christiano
Roberto Motto
Massimo Rostagno

Background

- There has been progress in constructing and estimating models that fit quarterly data well by standard econometric criteria.
- In practice the models abstract from details of financial markets and interaction with real economy.
- A common presumption: asset markets passively reflect fluctuations in standard shocks and contribute little to propagation.

What we do

- Integrate financial frictions into a standard DSGE model and estimate the model using EA and US data.

- Decompose 14 aggregate data series into shocks and propagation mechanisms:

  – Identify a new shock, a 'risk' shock

  – Document importance for propagation of non-contingent nominal rates of interest ('Fisher debt-deflation').

Outline

- Sketch the basic ingredients of the model.
- Present 5 results that motivate our conclusion

Standard Model

Firms

$$Y_t = \left[\int_0^1 Y_{jt}^{\frac{1}{\lambda_{f,t}}} dj \right]^{\lambda_{f,t}}, \; 1 \leq \lambda_{f,t} < \infty,$$

$$Y_{jt} = \epsilon_t K_{jt}^{\alpha} (z_t l_{jt})^{1-\alpha}$$

consumption

Investment goods

Supply labor

$$\tau_t^{oil} a(u_t) \bar{K}_t + G_t + C_t + \frac{I_t}{\mu_{\Upsilon,t}} \leq Y_t.$$

Rent capital

Households

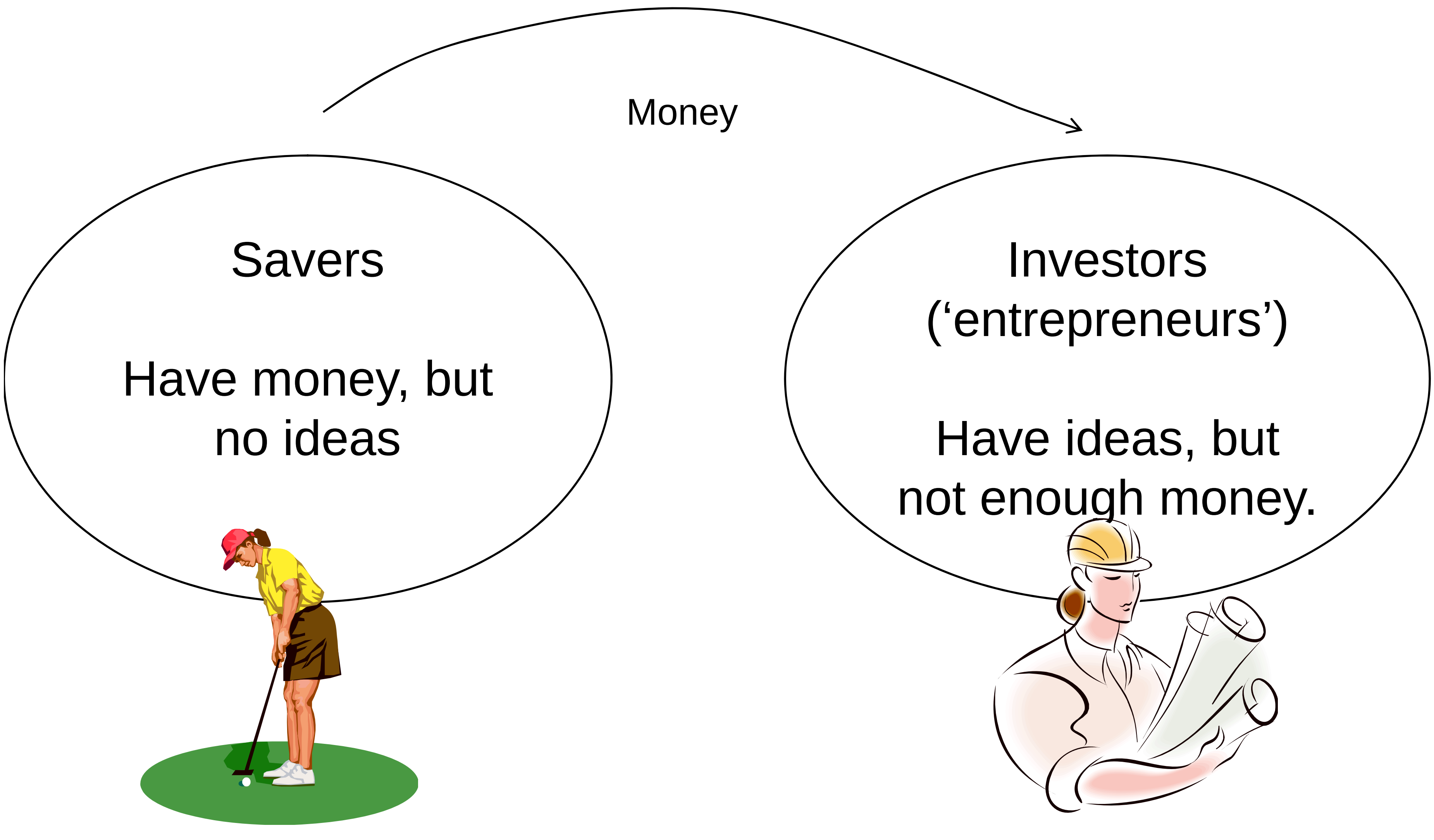
Backyard capital accumulation: $\bar{K}_{t+1} = (1-\delta)\bar{K}_t + G(\zeta_{i,t}, I_t, I_{t-1})$

Savers and investors are the same: NO FRICTIONS!

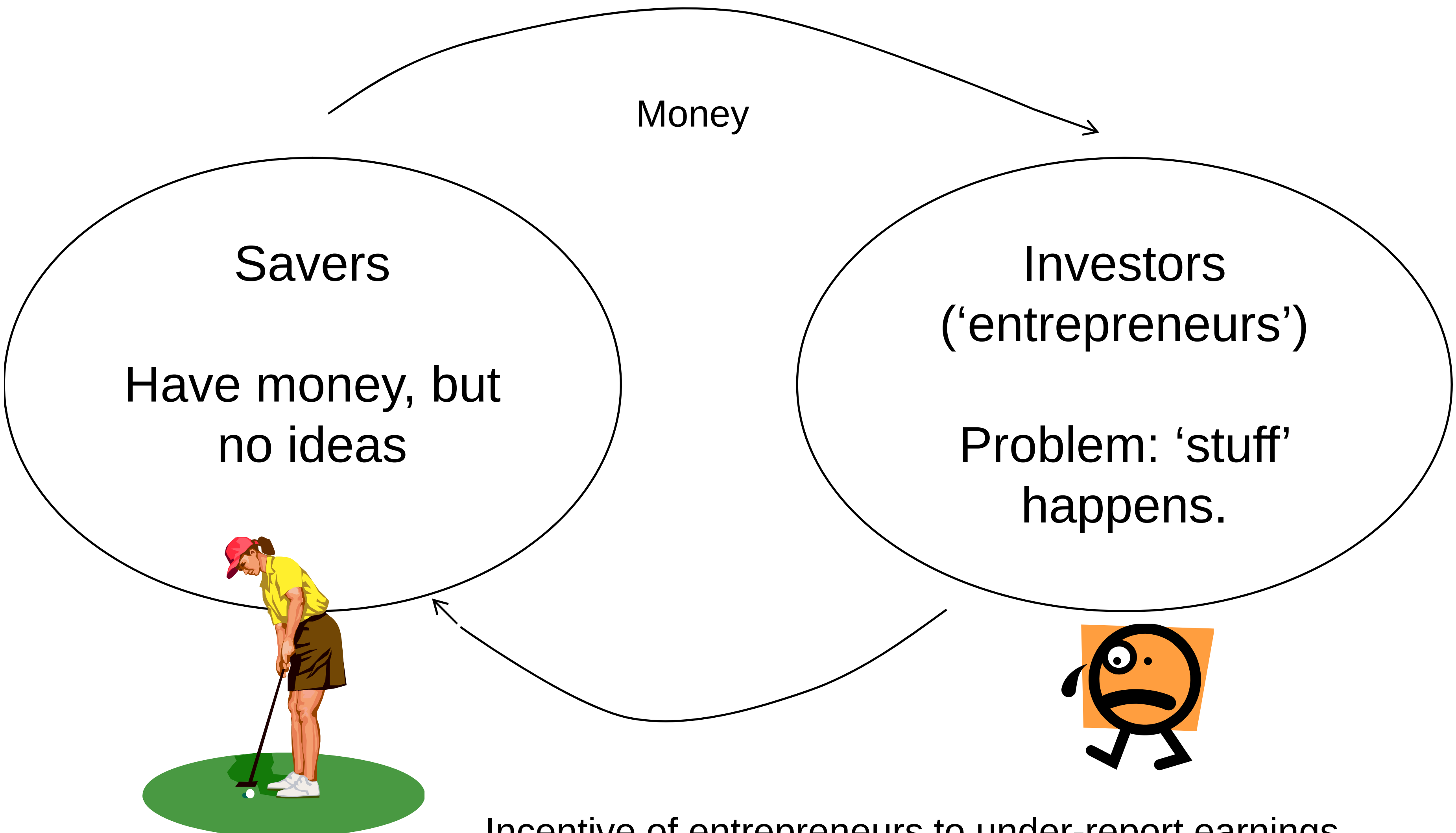
$$u_{c,t} = E_t \beta \zeta_{c,t} u_{c,t+1} \frac{R_{t+1}^k}{\pi_{t+1}}$$

$$R_{t+1}^k = \frac{u_{t+1} r_{t+1}^k + (1-\delta) P_{k',t+1}}{P_{k',t}}$$

Frictions in Financing of Physical Capital



Frictions in Financing of Physical Capital



Incentive of entrepreneurs to under-report earnings

Extension to Incorporate Financial Frictions

- Borrowing for two purposes:
  - Short term financing of working capital
  - Longer-term financing of capital.

- ‘Banks’:
  - Issue assets that provide various degrees of transactions services to finance short term bank assets
  - Issue ‘time deposits’ to finance longer-term loans.

Banks

- Financial system assets and liabilities:

Short-term Assets	**Short-term Liabilities**
- *Reserves*	- *Household demand deposits*
	D_t^h
- *Short-term Working Capital Loans*	- *Firm demand deposits*
	D_t^f
"Long-term" loans (to entrepreneurs)	**"Long-term" Liabilities (to households)**
	T_{t-1}
	D_t^m

- Technology for producing transactions services:
  - (Chari-Christiano-Eichenbaum (1995)):

$$\frac{D_t^h + D_t^f + \varsigma D_t^m}{P_t} = a_t\left(\left(K_t^b\right)^{\alpha}\left(z_t l_t^b\right)^{1-\alpha}\right)^{\xi_t}\left(\frac{E_t^r}{P_t}\right)^{1-\xi_t}$$

Households

- Preferences:

$$E_t^j \sum_{l=0}^{\infty} \beta^l \zeta_{c,t+l} \Big\{ u(C_{t+l} - bC_{t+l-1}) - \psi_L \frac{h_{j,t+l}^{1+\sigma_L}}{1+\sigma_L}$$

$$- \upsilon \frac{\left[\left(\frac{(1+\tau^c)P_{t+l}C_{t+l}}{M_{t+l}} \right)^{(1-\chi_{t+l})\theta} \left(\frac{(1+\tau^c)P_{t+l}C_{t+l}}{D_{t+l}^h} \right)^{(1-\chi_{t+l})(1-\theta)} \left(\frac{(1+\tau^c)P_{t+l}C_{t+l}}{D_{t+l}^m b} \right)^{\chi_{t+l}} \right]^{1-\sigma_q}}{1-\sigma_q} \Big\},$$

- Features:
  - Habit formation in consumption, differentiated Labor
  - Monopolistic supplier of specialized labor input (EHL)
  - Enjoy deposits services of two bank assets
  - Hold time deposits
  - Access to 10-year bond, with gross return

$$\overbrace{\sigma_t^{long}}^{\text{exogenous shock designed to capture any failure of the model to match } R_t^{long}} \qquad (1 + \overbrace{R_t^{long}}^{\text{compared with data on 10 year bond returns}})$$

Monetary Policy

- Nominal rate of interest function of:
  - Anticipated inflation.
  - Slowly moving inflation target.
  - Deviation of output from ss growth path.

Monetary Policy

- Monetary policy rule:

$$\hat{R}_t^e = \rho_i \hat{R}_{t-1}^e + (1-\rho_i)\alpha_\pi \frac{\pi}{R^e}\left[E_t(\hat{\pi}_{t+1}) - \hat{\pi}_t^{target}\right]$$

$$+ (1-\rho_i)\frac{\alpha_y}{4R^e}\log\left(\frac{GDP_t}{\mu_{z^*}GDP_{t-1}}\right) + (1-\rho_i)\alpha_{d\pi}\frac{\pi}{R^e}(\hat{\pi}_t - \hat{\pi}_{t-1})$$

$$+ (1-\rho_i)\frac{\alpha_b}{4R^e}\log\left(\frac{B_{t+1}}{\mu_{z^*}B_t}\right)\frac{1}{400R^e}\varepsilon_t,$$

- Monetary policy shock:

$$\varepsilon_t \sim \text{white noise}$$

- Inflation target:

$$\hat{\pi}_t^{target} = \rho_\pi \hat{\pi}_{t-1}^{target} + \varepsilon_t^{target}, \quad E\left(\varepsilon_t^{target}\right)^2 = \sigma_\pi,$$

$$\rho_\pi = 0.965,\ \sigma_\pi = 0.00035$$

Entrepreneurs (BGG)

- Own and Rent the Stock of Capital
- Period t :
  - Go to bank with own net worth and obtain loan
  - Purchase new capital from capital producers: $\bar{K}_{t+1}$
  - Experience an idiosyncratic productivity shock: $\omega\bar{K}_{t+1}$, $\omega \sim F(\omega;\sigma_t)$

- Periot $t+1$:
  - Choose capital utilization rate and rent out capital services: $u_{t+1}\omega\bar{K}_{t+1}$
  - Cost of utilization: $\tau_{t+1}^{oil}a(u_{t+1})\Upsilon^{-(t+1)}\omega\bar{K}_{t+1}$

$$V_{t+1} = \text{real earnings on capital (rent plus capital gains)}_t - \frac{\text{nominal rate of interest}_{t-1}}{\pi_t}\text{real debt to banks}_{t-1}$$

$$\text{Net Worth}_{t+1} = \gamma(V_{t+1} + W_{t+1}^e) + (1-\gamma)W_{t+1}^e$$

Prediction of financial friction model:

- Shocks that drive output and price in the same direction (‘demand’) accelerated by financial frictions.
  - Fisher and earnings effects reinforce each other.

- Shocks that drive output and price in opposite directions (‘supply’) not much affected by financial frictions.
  - Fisher and earnings effects cancel each other.

Risk Shock and News

- Assume

$$\hat{\sigma}_t = \rho_1 \hat{\sigma}_{t-1} + \overbrace{u_t}^{\text{iid, univariate innovation to } \hat{\sigma}_t}$$

- Agents have advance information about pieces of u_t

$$u_t = \xi_t^0 + \xi_{t-1}^1 + \ldots + \xi_{t-8}^8$$

$$\xi_{t-i}^i \sim \text{iid}, E(\xi_{t-i}^i)^2 = \sigma_i^2$$

$$\xi_{t-i}^i \sim \text{piece of } u_t \text{ observed at time } t-i$$

Estimation

- EA and US data covering 1985Q1-2007Q2

$$X_t = \begin{pmatrix} \Delta\log\left(\frac{N_{t+1}}{P_t}\right) \\ \pi_t \\ \log(\text{per capita hours}_t) \\ \Delta\log\left(\frac{\text{per capita credit}_t}{P_t}\right) \\ \Delta\log(\text{per capita GDP}_t) \\ \Delta\log\left(\frac{W_t}{P_t}\right) \\ \Delta\log(\text{per capita } I_t) \\ \Delta\log\left(\frac{\text{per capita } M1_t}{P_t}\right) \\ \Delta\log\left(\frac{\text{per capita } M3_t}{P_t}\right) \\ \Delta\log(\text{per capita consumption}_t) \\ \text{External Finance Premium}_t \\ R_t^{long} - R_t^e \\ R_t^e \\ \Delta\log P_{I,t} \\ \Delta\log \text{real oil price}_t \\ \Delta\log\left(\frac{\text{per capita Bank Reserves}_t}{P_t}\right) \end{pmatrix},$$

- Standard Bayesian methods
- We remove sample means from data and set steady state of X to zero in estimation.

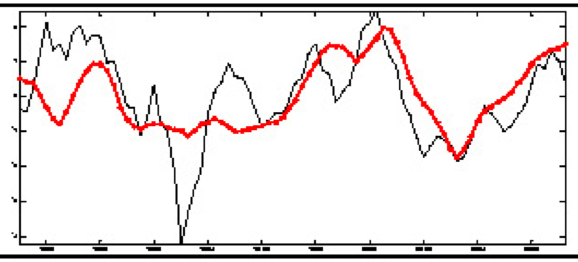
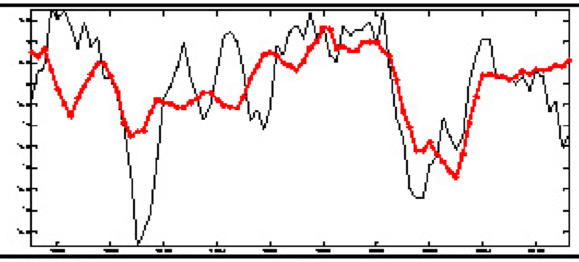
Summary of results

- Risk shocks:
  - important source of fluctuations.
  - news on the risk shock important
- The Fisher debt-deflation channel has a substantial impact on propagation.
- Money demand and mechanism of producing inside money:
  - relatively unimportant as a source of shocks
  - modest contribution to forecast ability
- Model accounts or substantial fraction of fluctuations in term structure.
- Out-of-Sample RMSEs of the model perform well compared with BVAR and simpler models.

Risk Shocks are Important

Actual data versus what actual data would have been if there were only risk Shocks:

Figure 19. GDP Growth

Shocks	**Euro Area**	**US**
Riskiness, σ_t: whole process		

Note:

(1) as suggested by the picture, risk shocks are relatively important at the lower frequencies

(2) We find that they are the single most important source of low frequency fluctuation in the EA, and a close second (after permanent tech shocks) in the US

Table: Variance Decomposition, HP filtered data, EA

x

	shock	output	consumption	investment	hours	inflation	labor productivity	interest rate
Markup	σ_{λ_f}	15.02	23.05	2.63	16.37	35.74	1.40	20.46
Banking tech	σ_{x^b}	0.59	1.29	0.02	0.44	0.52	1.44	0.24
Capital tech	σ_{μ_Υ}	0.32	0.01	0.12	0.18	0.08	0.01	0.04
Money demand	σ_χ	0.02	0.06	0.00	0.02	0.00	0.00	0.00
Government	σ_g	3.26	3.11	0.00	3.34	0.87	0.21	0.48
Permanent tech	$\sigma_{\mu_z^*}$	3.72	1.16	0.24	1.42	1.07	10.29	0.72
Gamma shock	σ_γ	0.43	0.06	0.92	0.80	0.24	1.52	0.30
Temporary tech	σ_ϵ	10.54	21.68	0.49	7.46	16.10	27.52	8.56
Monetary policy	$\sigma_{\varepsilon^{\text{policy}}}$	6.22	11.27	1.01	4.14	5.40	0.10	33.15
Risk, contemp	σ_σ	2.88	0.19	5.11	6.57	0.88	13.17	1.08
Signals on risk	$\sigma_{\sigma^{\text{signal}}}$	20.09	1.81	38.09	15.96	9.22	38.24	9.80
Risk and signals	σ_σ and $\sigma_{\sigma^{\text{signal}}}$	22.96	2.00	43.20	22.53	10.09	51.41	10.88
Discount rate	σ_{ξ_c}	11.68	32.75	0.15	12.20	11.26	0.83	10.15
Marginal eff of I	σ_{ξ_i}	24.57	1.72	51.14	30.69	10.17	5.22	11.56
Price of oil	$\sigma_{\tau^{\text{oil}}}$	0.42	1.39	0.03	0.24	2.21	0.04	1.32
Long rate error	σ_{long}	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	measurement error	0.00	0.00	0.00	0.00	0.00	0.00	1.26
	inflation target	0.24	0.43	0.05	0.16	6.23	0.01	0.87
	all shocks	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table: Variance Decomposition, HP filtered data, EA

	shock	x output	consumption	investment	hours	inflation	labor productivity	interest rate
Markup	σ_{λ_f}	15.02	23.05	2.63	16.37	35.74	1.40	20.46
	all shocks	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Markup shock uncomfortably important as a source of fluctuations in inflation

Table: Variance Decomposition, HP filtered data, EA

	shock	x output	consumption	investment	hours	inflation	labor productivity	interest rate
Banking tech	σ_{x^b}	0.59	1.29	0.02	0.44	0.52	1.44	0.24
Money demand	σ_{χ}	0.02	0.06	0.00	0.02	0.00	0.00	0.00
	all shocks	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Banking and money demand sector not a source of shocks

Table: Variance Decomposition, HP filtered data, EA

x

shock	output	consumption	investment	hours	inflation	labor productivity	interest rate
σ_γ	0.43	0.06	0.92	0.80	0.24	1.52	0.30
σ_σ	2.88	0.19	5.11	6.57	0.88	13.17	1.08
$\sigma_{\sigma^{\text{signal}}}$	20.09	1.81	38.09	15.96	9.22	38.24	9.80
σ_σ and $\sigma_{\sigma^{\text{signal}}}$	22.96	2.00	43.20	22.53	10.09	51.41	10.88
all shocks	100.00	100.00	100.00	100.00	100.00	100.00	100.00

It's the signals! →

Table: Variance Decomposition, HP filtered data, EA

	shock	x					
		stock market	credit	spread	term structure	real M1	real M3
Markup	σ_{λ_f}	1.83	13.15	0.16	12.36	44.28	1.82
Banking tech	σ_{x^b}	0.00	0.14	0.00	0.10	5.04	42.39
Capital tech	σ_{μ_Υ}	0.18	0.07	0.03	0.07	0.03	0.02
Money demand	σ_χ	0.00	0.00	0.00	0.00	13.17	22.63
Government	σ_g	0.03	0.10	0.01	0.07	0.44	0.02
Permanent tech	$\sigma_{\mu_z^*}$	0.17	0.07	0.05	0.14	0.42	1.29
Gamma shock	σ_γ	5.37	25.82	1.86	0.33	0.13	0.15
Temporary tech	σ_ϵ	0.10	4.06	0.00	3.40	9.89	0.61
Monetary policy	$\sigma_{\varepsilon^{\text{policy}}}$	4.89	1.81	0.99	25.76	13.15	1.58
Risk, contemp	σ_σ	13.94	5.07	20.58	0.97	1.39	0.76
Signals on risk	$\sigma_{\sigma^{\text{signal}}}$	68.29	44.23	75.90	6.79	5.98	6.20
Risk and signals	σ_σ and $\sigma_{\sigma^{\text{signal}}}$	82.22	49.30	96.48	7.76	7.38	6.96
Discount rate	σ_{ξ_c}	0.02	1.72	0.02	3.99	2.46	15.40
Marginal eff of I	σ_{ξ_i}	1.90	2.54	0.27	8.77	1.18	6.17
Price of oil	$\sigma_{\tau^{\text{oil}}}$	0.14	0.94	0.05	0.56	1.87	0.15
Error in long rate	σ_{long}	0.00	0.00	0.00	36.05	0.00	0.00
	measurement error	2.89	0.19	0.02	0.32	0.21	0.02
	inflation target	0.24	0.10	0.05	0.34	0.35	0.80
	all shocks	100.00	100.00	100.00	100.00	100.00	100.00

Table: Variance Decomposition, HP filtered data, EA

	shock	stock market	credit	spread	x term structure
Gamma shock	σ_{γ}	5.37	25.82	1.86	0.33
Risk, contemp	σ_{σ}	13.94	5.07	20.58	0.97
Signals on risk	$\sigma_{\sigma^{\text{signal}}}$	68.29	44.23	75.90	6.79
Risk and signals	σ_{σ} and $\sigma_{\sigma^{\text{signal}}}$	82.22	49.30	96.48	7.76
	all shocks	100.00	100.00	100.00	100.00

Signal matters!

Importance of Risk Signals

News Specification on Risk and Marginal Likelihood (EA data)

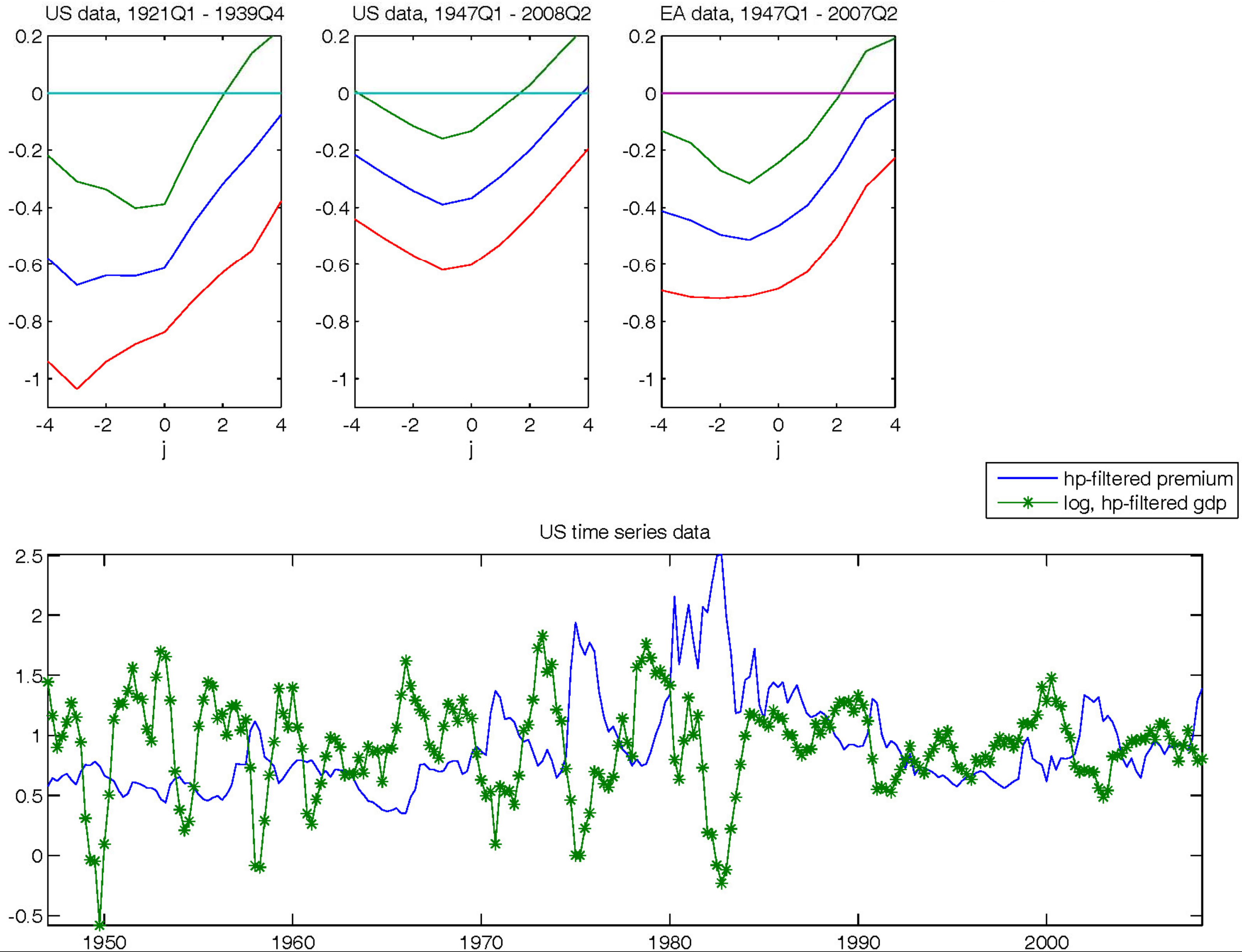
$$\hat{\sigma}_t = \rho_1 \hat{\sigma}_{t-1} + \xi_{t-0}^0 + \xi_{t-1}^1 + \xi_{t-2}^2 + \ldots + \xi_{t-p}^p$$

p	log, marginal likelihood	odds (=exp(difference in log likelihood from baseline))
8 (baseline)	4397.487	1
6	4394.025	31
1	4325.584	∞

Why is Risk Shock so Important?

- According to the model, external finance premium is primarily risk shock.
- To look for evidence that risk might be important, look at dynamics of external finance premium and gdp.
- External finance premium is a negative leading indicator

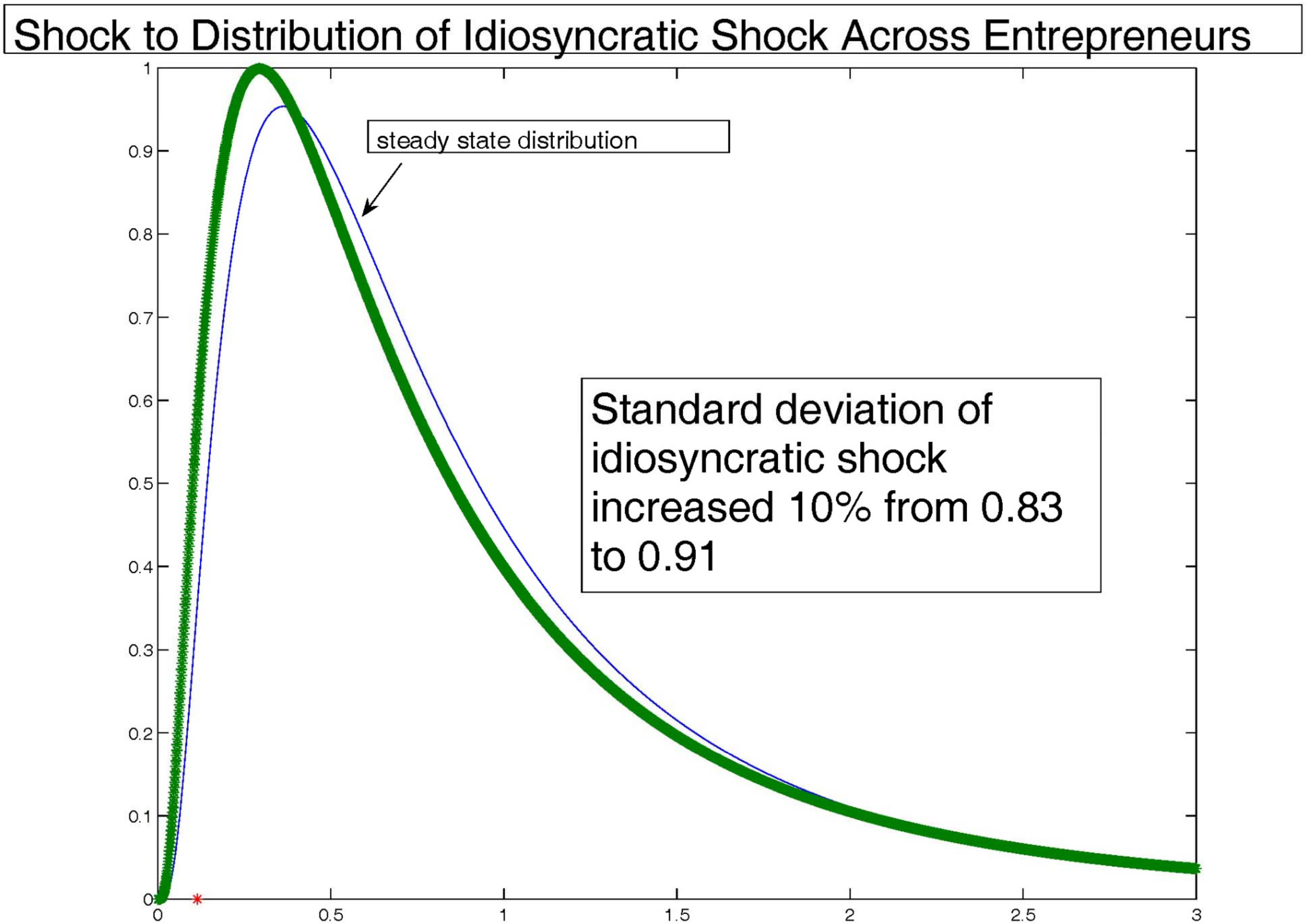
Figure 1: Correlation(finance premium (t),output (t-j)), HP filtered data, 95% confidence interval



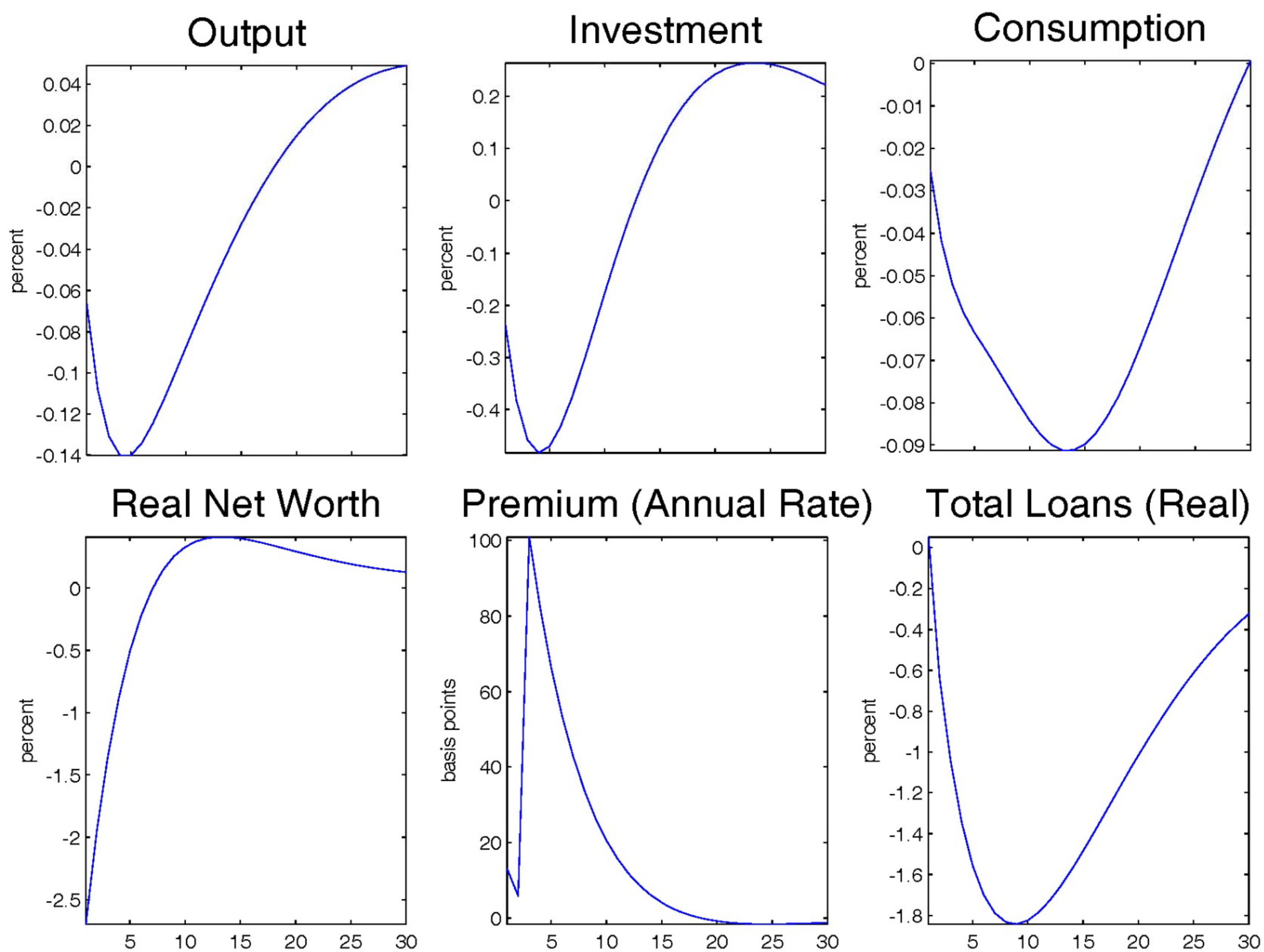
Notes: Premium is measured by the difference between the yield on the lowest rated corporate bonds (Baa) and the highest rated corporate bonds (Aaa). Bond rate data obtained from St. Louis Fed website. GDP data obtained from Balke and Gordon (1986). Filtered output data are scaled so that their standard deviation coincide with that of the premium data.

Why is Risk Shock so Important?: A second reason

- Our data set includes the stock market
  - Output, stock market, investment all procyclical (surge together in late 1990s)
  - This is predicted by risk shock.


Shock to Distribution of Idiosyncratic Shock Across Entrepreneurs
steady state distribution
Standard deviation of idiosyncratic shock increased 10% from 0.83 to 0.91
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
0.5
1
1.5
2
2.5
3

Response to Shock in Cross-entrepreneur Distribution



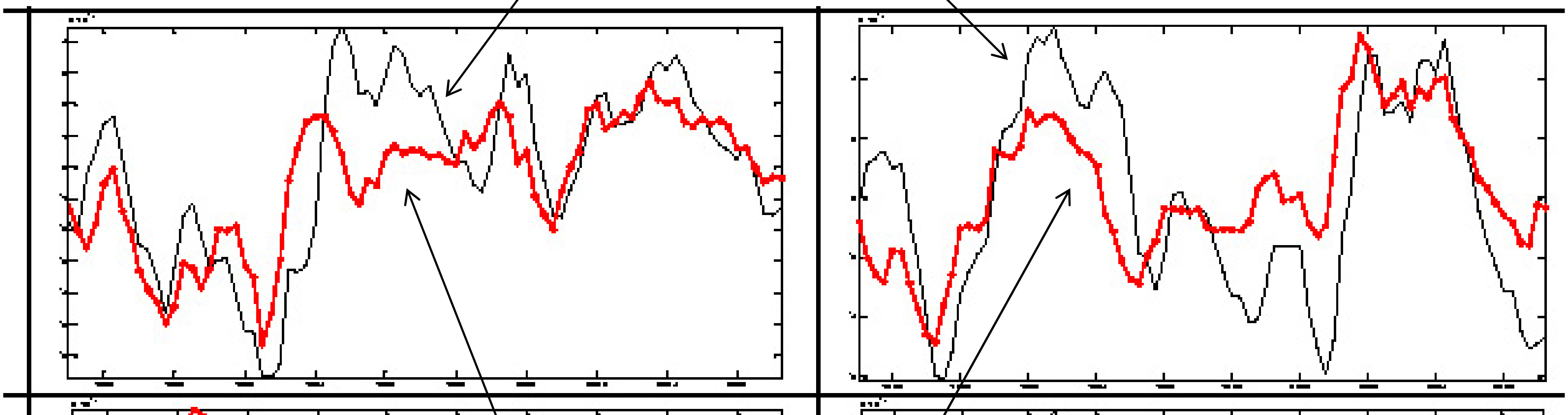
Explaining the Slope of the Term Structure

Difference between the yield on the lowest rated corporate bonds (Baa) and the highest rated corporate bonds (Aaa)

Actual data

Euro Area

US



Data under the assumption
that only the monetary policy shock was
operative.

Table: Variance Decomposition, HP filtered data, EA

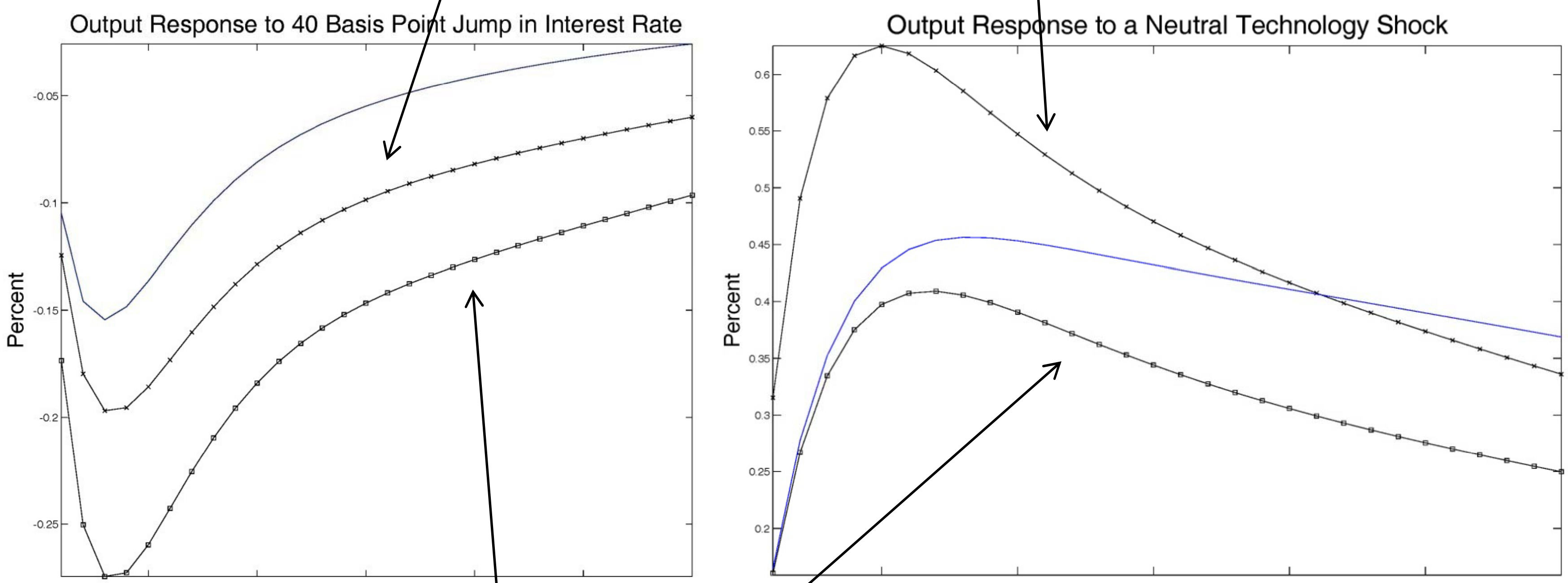
					x		
	shock	stock market	credit	spread	term structure	real M1	real M3
Markup	σ_{λ_f}				12.36		
Banking tech	σ_{x^b}				0.10		
Capital tech	σ_{μ_Υ}				0.07		
Money demand	σ_χ				0.00		
Government	σ_g				0.07		
Permanent tech	$\sigma_{\mu_z^*}$				0.14		
Gamma shock	σ_γ				0.33		
Temporary tech	σ_ϵ				3.40		
Monetary policy	$\sigma_{\varepsilon^{\text{policy}}}$				25.76		
Risk, contemp	σ_σ				0.97		
Signals on risk	$\sigma_{\sigma^{\text{signal}}}$				6.79		
Risk and signals	σ_σ and $\sigma_{\sigma^{\text{signal}}}$				7.76		
Discount rate	σ_{ξ_c}				3.99		
Marginal eff of I	σ_{ξ_i}				8.77		
Price of oil	$\sigma_{\tau^{\text{oil}}}$				0.56		
Error in long rate	σ_{long}				36.05		
	measurement error				0.32		
	inflation target				0.34		
	all shocks				100.00		

Impact of Financial Frictions on Propagation

- Effects of monetary shocks on gdp amplified by BGG financial frictions because P and Y go in same direction.

- Effects of technology shocks on gdp mitigated by BGG financial frictions because P and Y go in opposite directions.

Baseline model with no Fisher Effect



Baseline model

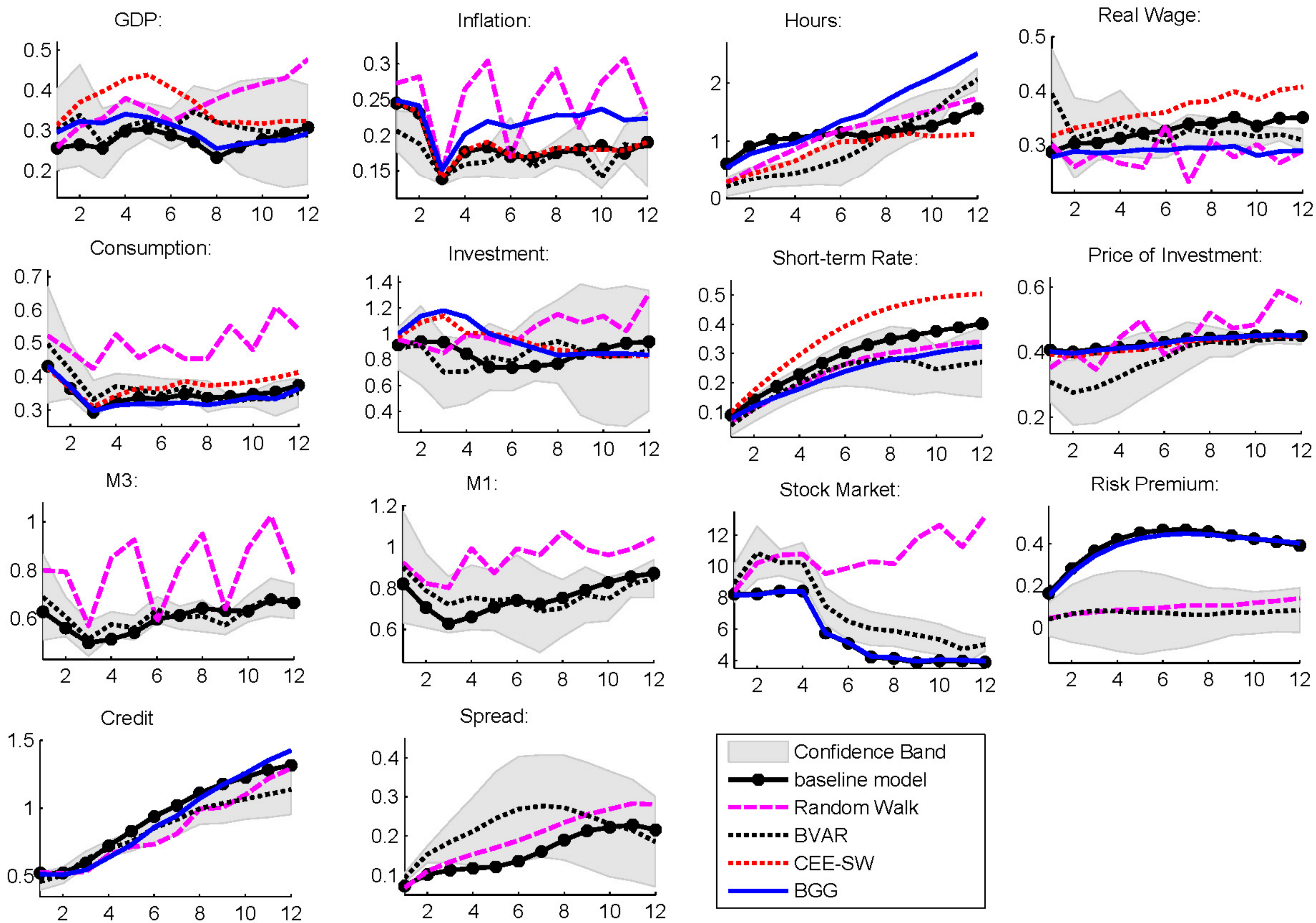
Blue line: baseline model with no financial frictions

Out of Sample RMSEs

- There is not a loss of forecasting power with the additional complications of the model.

- The model does well on everything, except the risk premium.

Figure 6.a. EA, RMSE: Confidence band represents 2 std and is centred around BVAR



Conclusion

- Incorporating financial frictions changes inference about the sources of shocks and of propagation
  – risk shock.
  – Fisher debt deflation

- Models with financial frictions can be used to ask interesting policy questions:
  – When there is an increase in risk spreads, how should monetary policy respond?