Financial Factors in Economic Fluctuations

Lawrence Christiano
Roberto Motto
Massimo Rostagno

What we do

- Integrate financial frictions into standard equilibrium model and estimate the model using Euro Area and US data.
  - Asymmetric information and costly state verification (Townsend (1978), Bernanke-Gertler-Gilchrist (1999))
  - Endogenous determination of financial liabilities, like M1 and M3 (Chari-Christiano-Eichenbaum (1995))
- Decompose 14 aggregate data series into shocks and propagation mechanisms:
  - A new shock, a ‘risk’ shock
  - A new source of propagation: non-state contingent nominal rates of interest.

Outline

- Describe the basic ingredients of the model.
- Results

Standard Model

'Marginal Efficiency of Investment'

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

$$G_t + C_t + \frac{I_t}{\mu_{\Upsilon,t}} \leq Y_t.$$

Supply labor

Rent capital

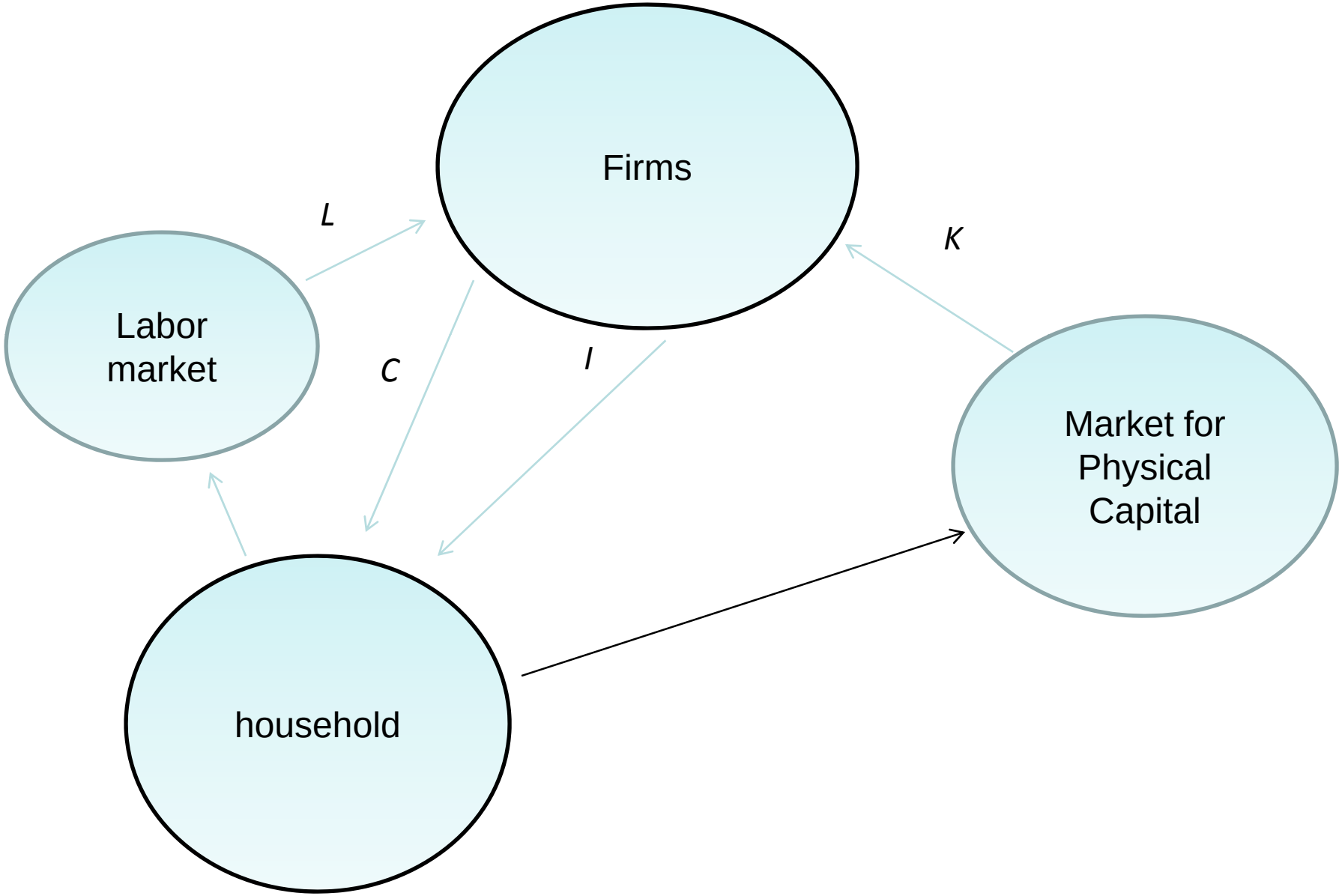
Households

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

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

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

Standard Model



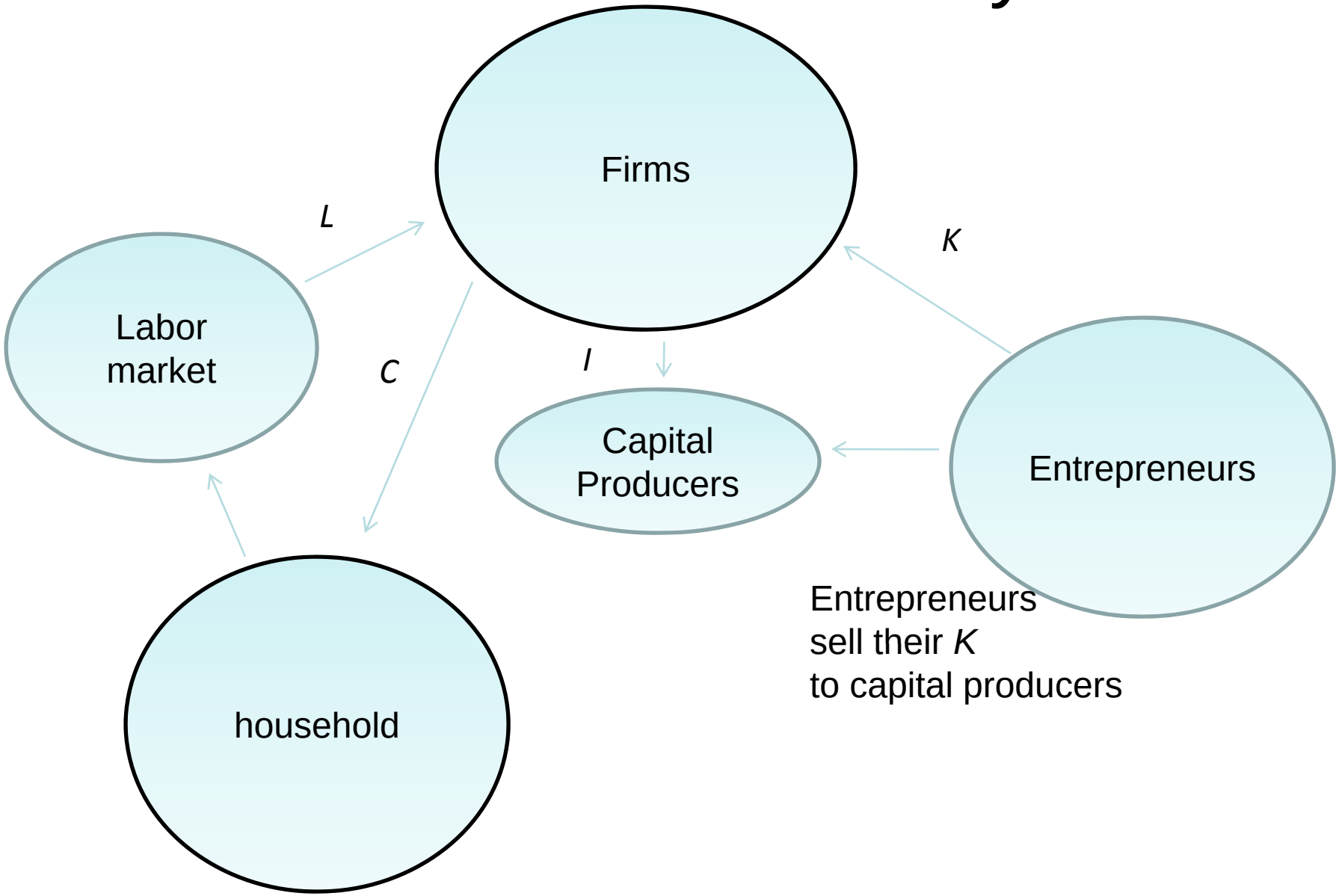
Financing

- In the standard model, already have borrowing by firms for working capital.
  - will now have banks intermediate this borrowing between households and firms.

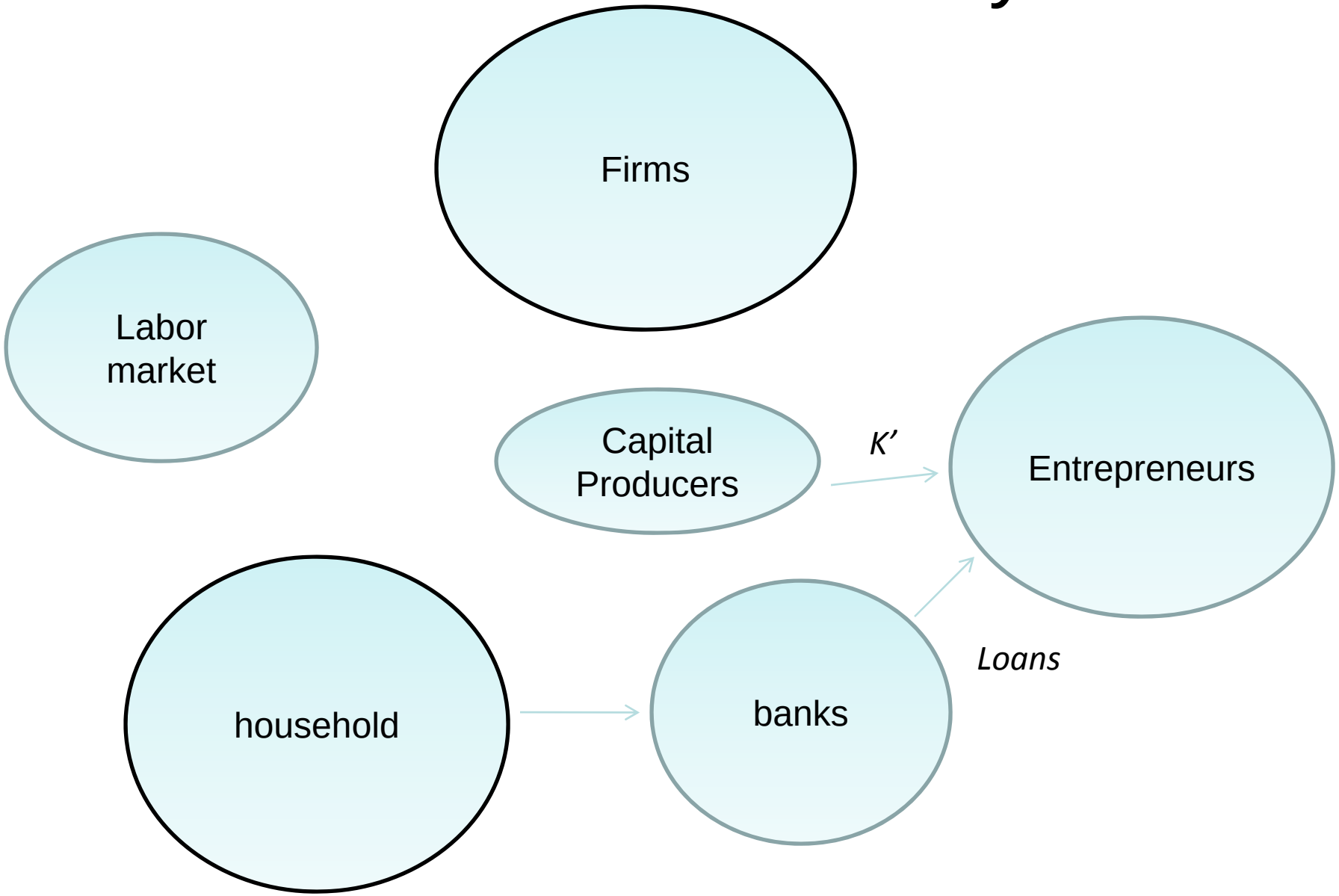
- In standard model, ‘putting capital to work’ is completely straightforward and is done by households. They just rent capital into a homogeneous capital market.

- Now: ‘putting capital to work’ involves a special kind of creativity that only some households – entrepreneurs – have.
  - Entrepreneurs finance the acquisition of capital in part by themselves, and in part by borrowing from regular ‘households’.
  - Conflict of interest, because there is asymmetric information about the payoff from capital.
  - Standard sharing contract between entrepreneur and household not feasible.

Financial Frictions with Physical *K*



Financial Frictions with Physical *K*



Extension to Incorporate Financial Frictions

- General idea:
  - Asset Side of Bank Balance Sheets:
    - Short term financing of working capital
    - Financing of physical capital (subject to CSV)
  - Liability Side of Bank Balance Sheets:
    - Assets that provide various degrees of transactions services.
    - ‘Time deposits’ to help finance capital.

Assets and Liabilities, Financial System

Assets	Liabilities
Reserves	
Working capital loans to firms	Household demand deposits
	Firm demand deposits
Loans to entrepreneurs to purchase capital	Savings deposits
	Time deposits

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

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

Households

- Preferences:

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

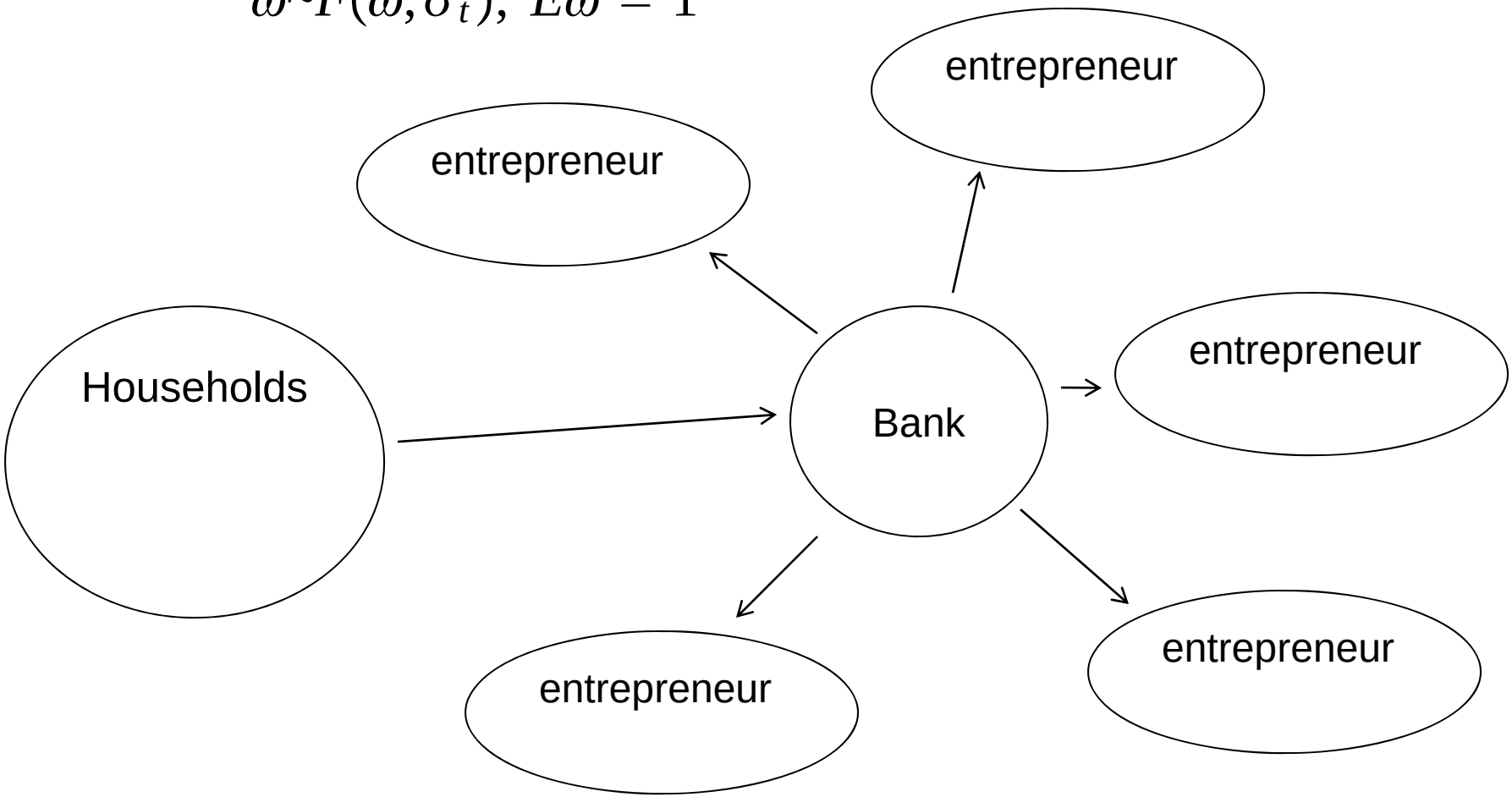
$$- \upsilon \frac{\left[\left(\frac{(1+\tau^c) P_{t+l} C_{t+l}}{M_{t+l}} \right)^{(1-\chi_{t+l})\theta} \left(\frac{(1+\tau^c) P_{t+l} C_{t+l}}{D_{t+l}^h} \right)^{(1-\chi_{t+l})(1-\theta)} \left(\frac{(1+\tau^c) P_{t+l} C_{t+l}}{D_{t+l}^m b} \right)^{\chi_{t+l}} \right]^{1-\sigma_q}}{1-\sigma_q} \},$$

- Features:
  - Habit formation in consumption, differentiated Labor
  - Monopolistic supplier of specialized labor input (EHL)
  - Enjoy deposits services of two bank assets
  - Hold time deposits

Accounts for about 30% of GDP

Banks, Households, Entrepreneurs

$$\omega \sim F(\omega, \sigma_t),\ E\omega = 1$$



Standard debt contract

- Net worth of an entrepreneur who goes to the bank to receive a loan in period *t*:

$$n_t = \overbrace{P_{k',t}(1-\delta)\omega\bar{K}_t}^{\text{value of capital after production}} + \overbrace{r_t^k \omega \bar{K}_t}^{\text{earnings from capital after utilization costs}} - B_{t-1}\frac{Z_{t-1}}{\pi_t}$$

An entrepreneur who bought capital in *t-1* experienced an idiosyncratic shock, ω.

This log-normal shock has mean unity across all entrepreneurs, $\omega \sim F(\omega, \sigma_t)$.

An entrepreneur's shock can only be observed by lender by paying a monitoring cost.

Under standard debt contract, entrepreneur either pays the interest rate on the debt, or (if ω is too low) declares bankruptcy, in which case he/she is monitored and loses everything to the bank.

Accelerator and Debt Deflation Effects

- Net worth, averaged across entrepreneurs:

$$N_t = \underbrace{P_{k',t}(1-\delta)\bar{K}_t + r_t^k \bar{K}_t}_{\text{Source of standard 'accelerator effects'}} - \underbrace{B_{t-1}\frac{Z_{t-1}}{\pi_t}}_{\text{source of 'Fisher deflation effects'}}$$

- Shocks that raise output tend to be amplified if the shock also raises capital values and entrepreneurial income ('accelerator effects')

- Shocks that reduce the price level hurt entrepreneurial net worth and depress output ('Fisher deflation effect')

- Finding based on estimated model of US and EA (CMR):
  - Financial frictions magnify output effect of shocks that raise *Y* and *P*.
  - Financial frictions have little impact on shocks that move *Y* and *P* in opposite directions.

Five Adjustments to Standard DSGE Model for CSV Financial Frictions

- Drop: household intertemporal equation for capital.
- Add: characterization of the loan contracts that can be offered in equilibrium (zero profit condition for banks).
- Add: efficiency condition associated with entrepreneurial choice of contract.
- Add: Law of motion for entrepreneurial net worth (source of accelerator and Fisher debt-deflation effects).
- Introduce: bankruptcy costs in the resource constraint.

Risk Shock and News

- Assume

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

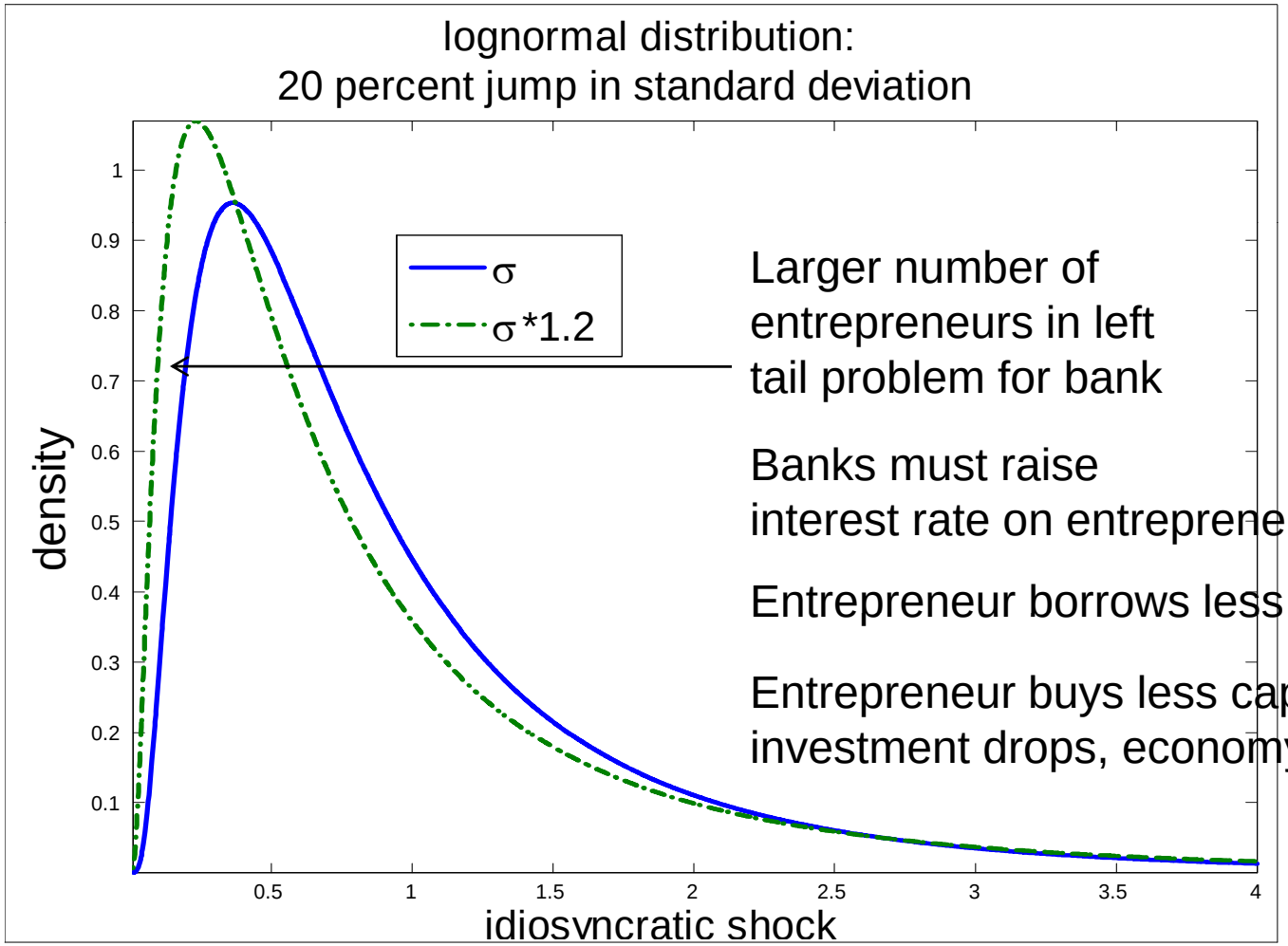
- Agents have advance information about pieces of u_t

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

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

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

Economic Impact of Risk Shock



Larger number of entrepreneurs in left tail problem for bank

Banks must raise interest rate on entrepreneur

Entrepreneur borrows less

Entrepreneur buys less capital, investment drops, economy tanks

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:

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

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

Monetary Policy

- Nominal rate of interest function of:
  - Anticipated level of inflation and change.
  - Slowly moving inflation target.
  - Deviation of output growth from ss path.
  - Growth of credit in case of EA.
  - Monetary policy shock.

Estimation

- EA and US data covering 1985Q1-2008Q2

$$X_t = \begin{pmatrix} \Delta \log\left(\frac{\text{per capita stock market index}_t}{P_t}\right) \\ GDP \text{ deflator inflation}_t \\ \log(\text{per capita hours}_t) \\ \Delta \log\left(\frac{\text{per capita credit}_t}{P_t}\right) \\ \Delta \log(\text{per capita GDP}_t) \\ \Delta \log\left(\frac{\text{Hourly compensation}_t}{P_t}\right) \\ \Delta \log(\text{per capita investment}_t) \\ \Delta \log\left(\frac{\text{per capita } M1_t}{P_t}\right) \\ \Delta \log\left(\frac{\text{per capita } M3_t}{P_t}\right) \\ \Delta \log(\text{per capita consumption}_t) \\ \text{Risk Spread}_t \\ R_t^{long} - R_t^e \\ R_t^e \\ \Delta \log(P_{It}) \\ \Delta \log(\text{real oil price}_t) \\ \Delta \log(\frac{\text{per capita Bank Reserves}_t}{P_t}) \end{pmatrix}$$

- Standard Bayesian methods

Key Result

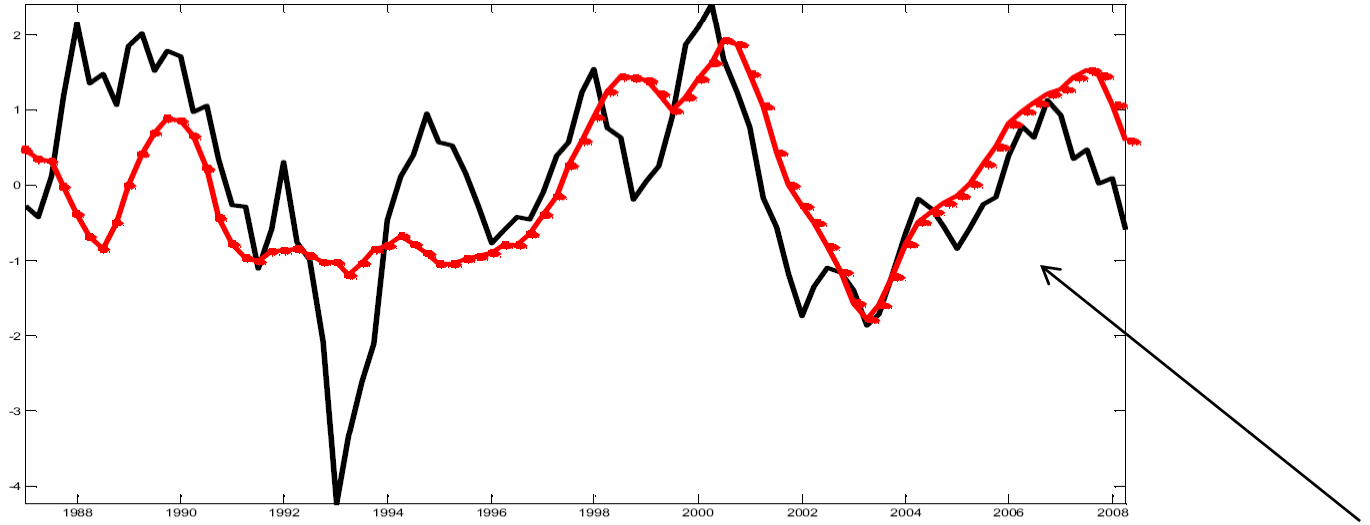
- Risk shocks:
  - important source of fluctuations.
- Out-of-Sample evidence suggests the model deserves to be taken seriously.

Risk Shocks

- Important
- Why are they important?
- What shock do they displace, and why?

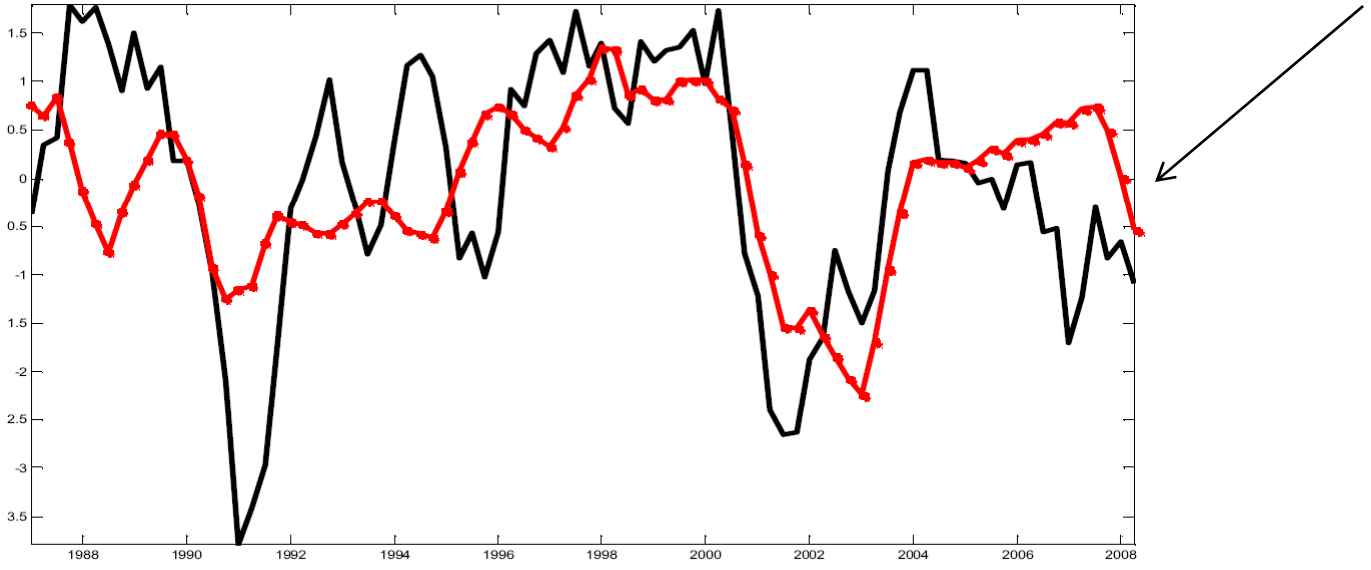
Figure: Year-over-year GDP Growth Rate - Data (black) versus what data would have been with only the risk shock

US



Risk shock important

EA



Variance Decomposition, US Data

Percent Variance Due to Risk Shock, σ_t	
Business Cycle Frequencies (8-32 quarters)	Low Frequencies (cycles longer than 8 years)
Output	
30	47
Investment	
57	64
Consumption	
4	27
Risk Spread	
96	95
Real Value of Stock Market	
83	74

- Not surprisingly in view of earlier chart, more important in the lower frequencies, for output, consumption, investment
- Very important for financial variables

Why Risk Shock is so Important

- A. Our econometric estimator ‘thinks’

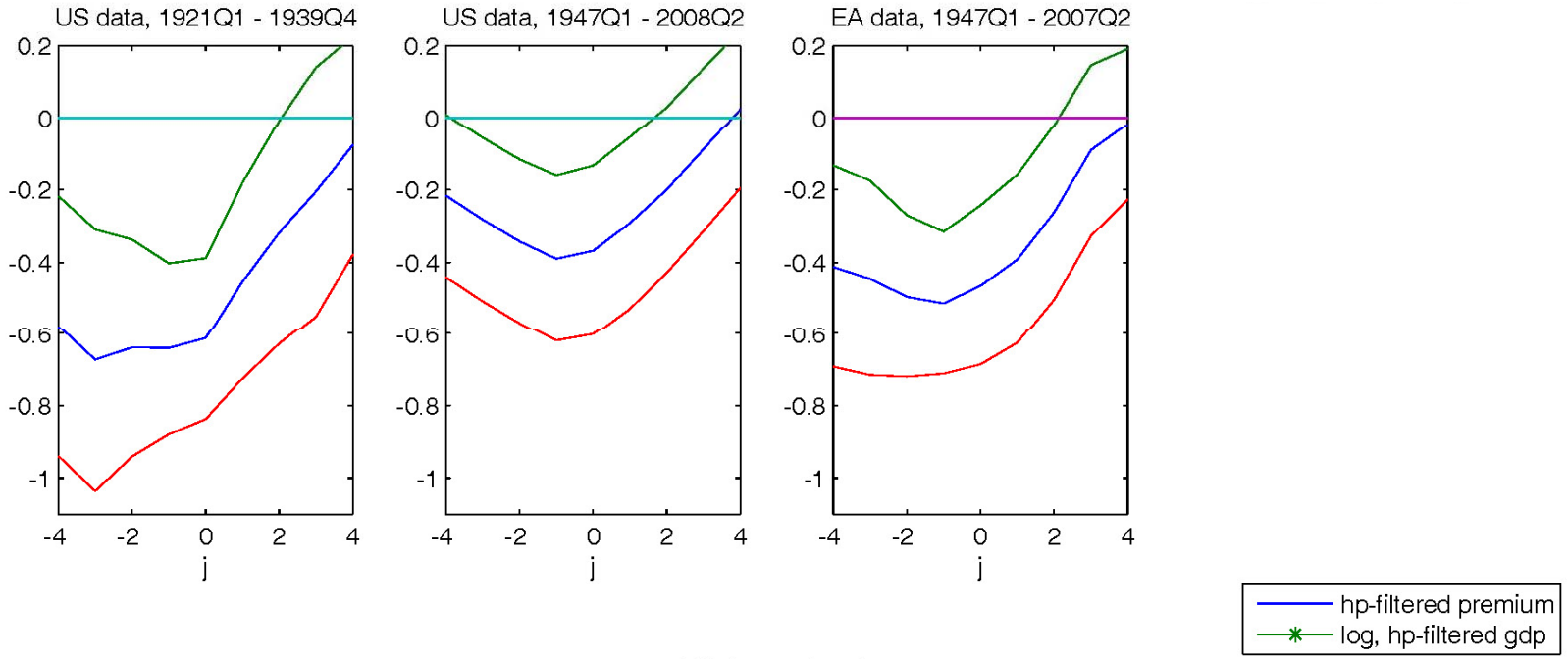
  risk spread ~ risk shock.

- B. In the data: the risk spread is strongly negatively correlated with output.

- C. In the model: bad risk shock generates a response that resembles a recession.

- A+B+C suggests risk shock important.

Correlation (risk spread(t),output(t-j)), HP filtered data, 95% Confidence Interval



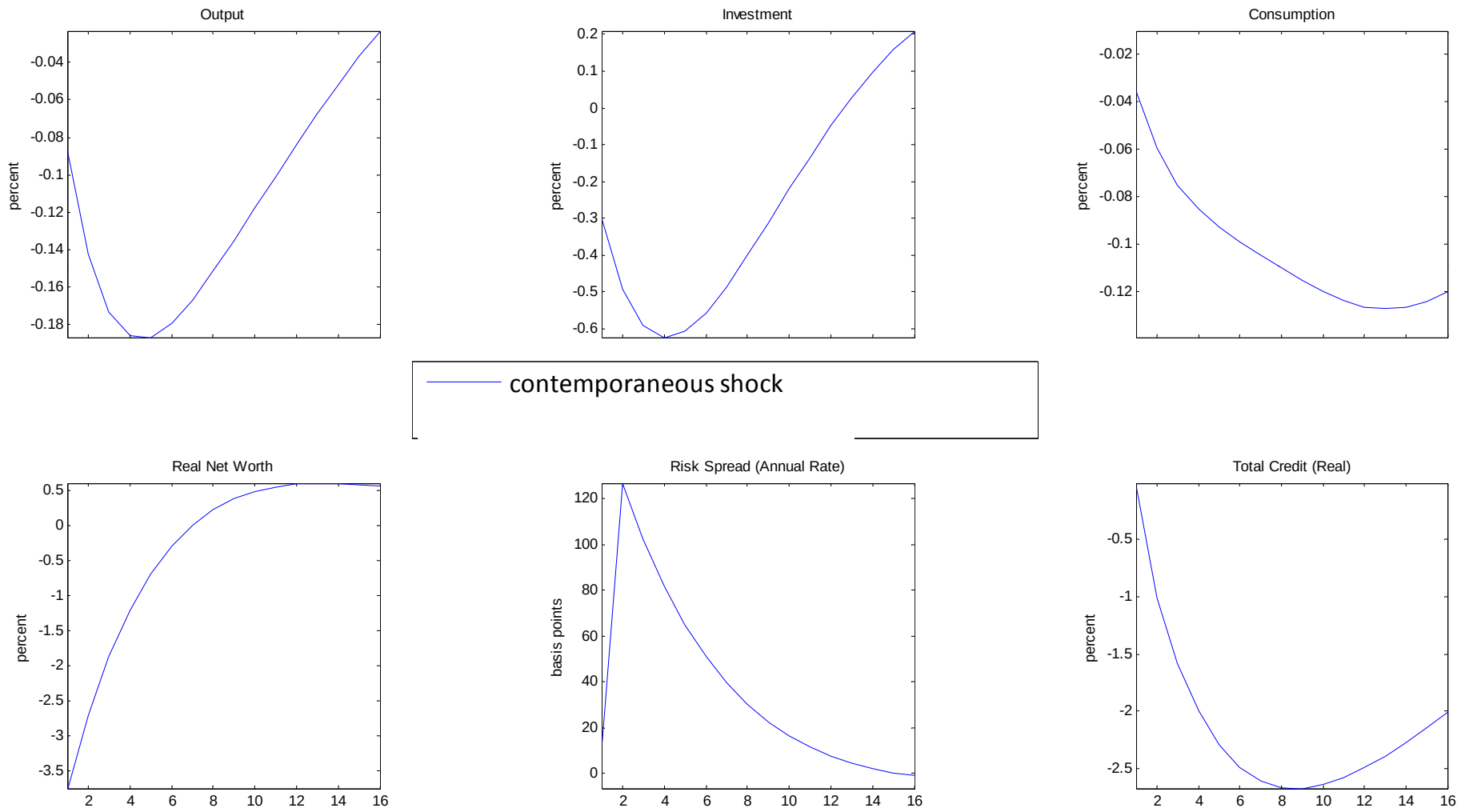
The risk spread is significantly negatively correlated with output and leads a little.

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

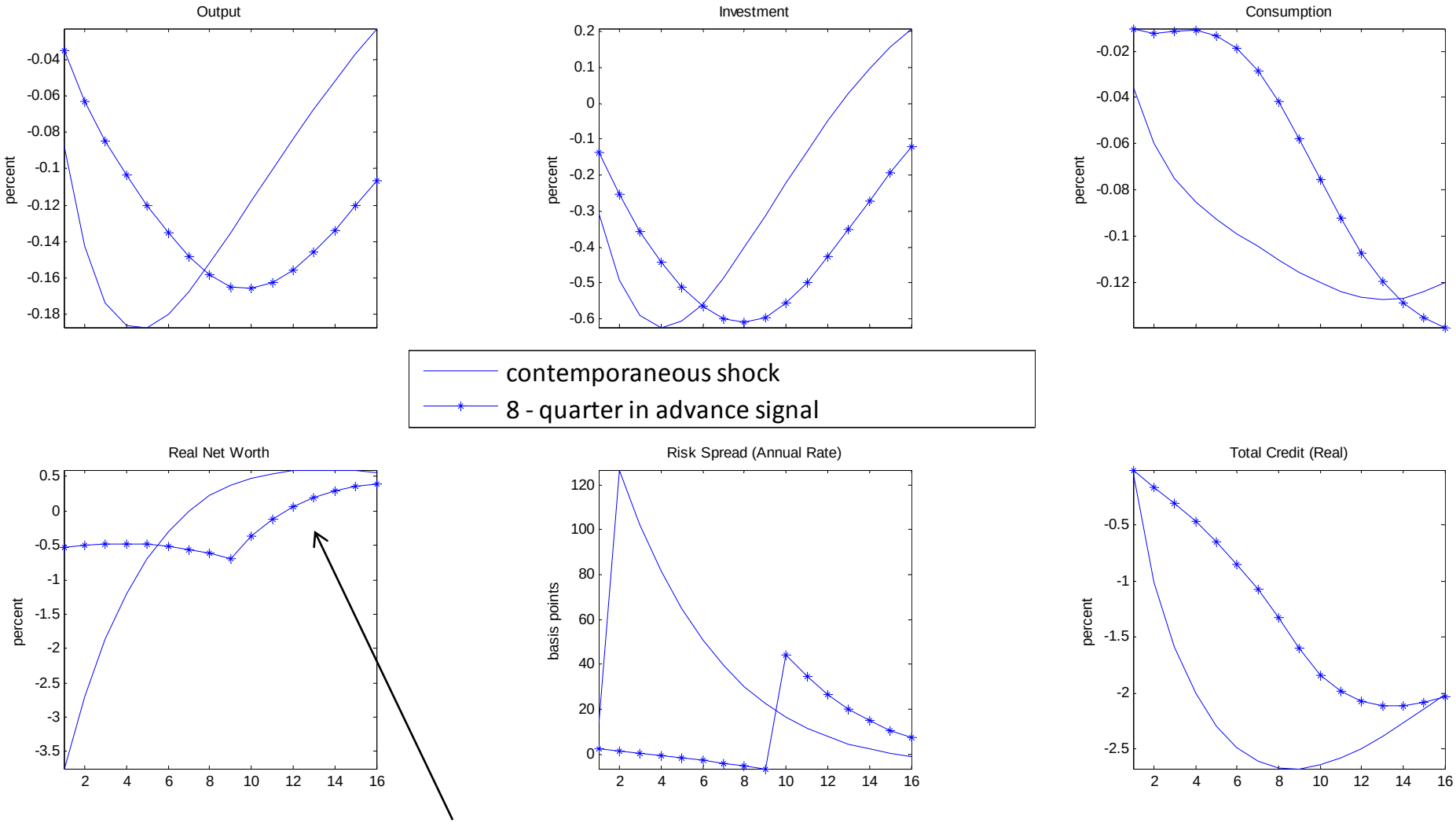
Another Reason the Risk Shock is so Important

- Positive shock to risk triggers what looks like a recession

Dynamic response to contemporaneous and 8 period lagged news about risk, σ_t



Dynamic response to contemporaneous and 8 period lagged news about risk, σ_t



Response to signal about risk 8 quarters in future

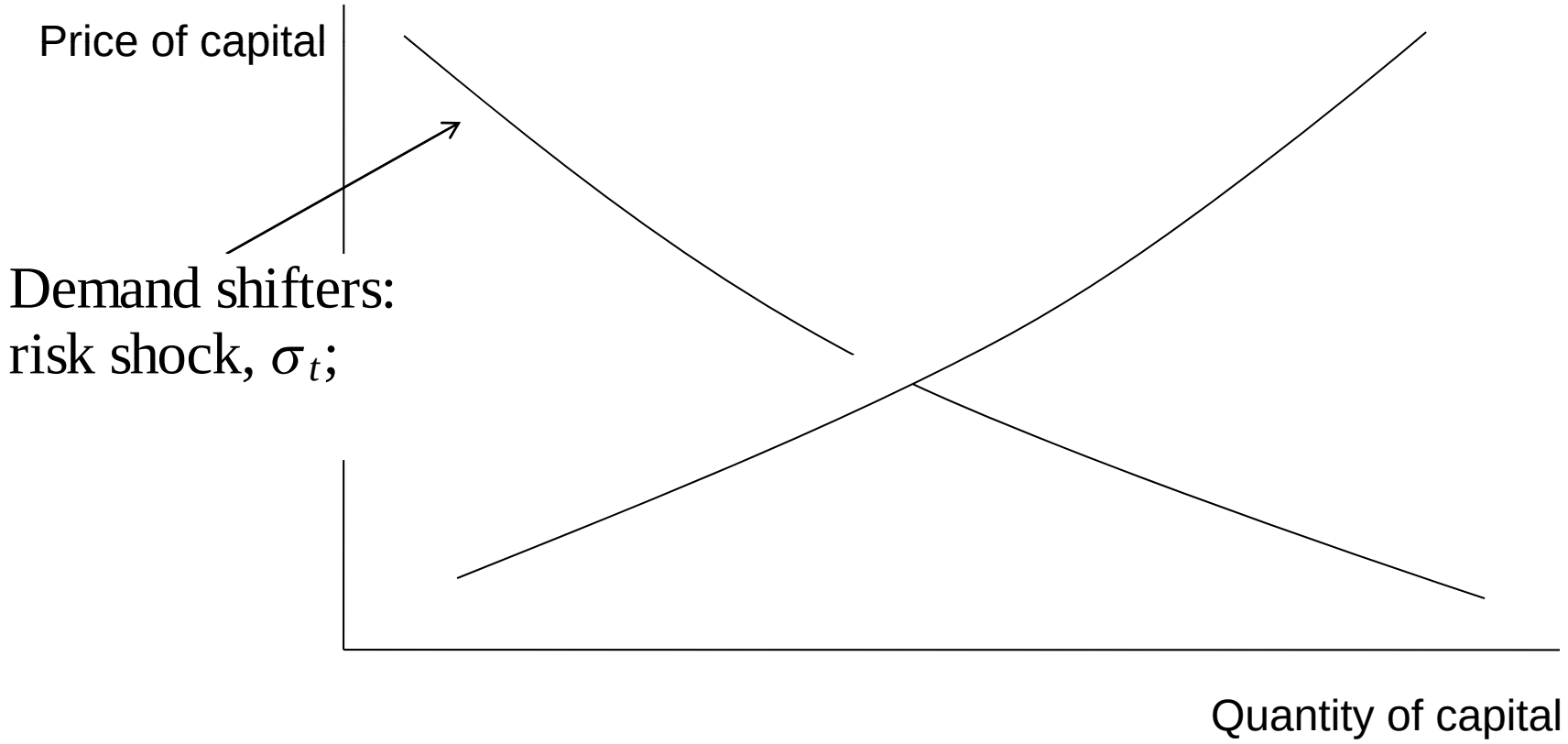
What Shock Does the Risk Shock Displace, and why?

- The risk shock crowds out some of the role of the marginal efficiency of investment shock.

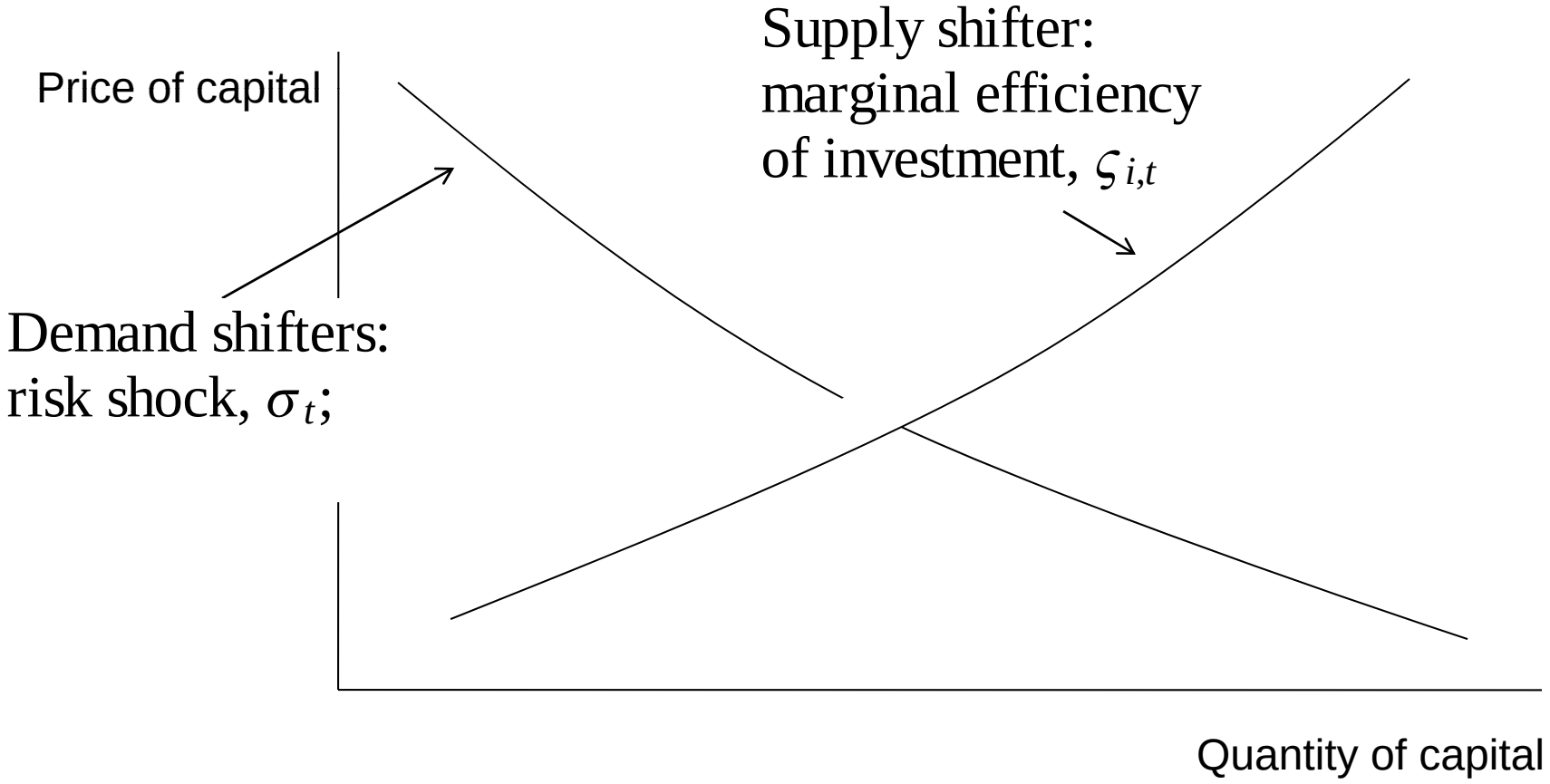
Model	Business Cycle Frequencies: Risk shock, σ_t	marginal efficiency of investment shock, $\varsigma_{i,t}$
	Output	
Baseline	30	14
CEE-SW	na	44
	Investment	
Baseline	57	34
CEE-SW	na	87

Risk shock appears to crowd out the marginal efficiency of investment shock

Why does Risk Crowd out Marginal Efficiency of Investment?



Why does Risk Crowd out Marginal Efficiency of Investment?



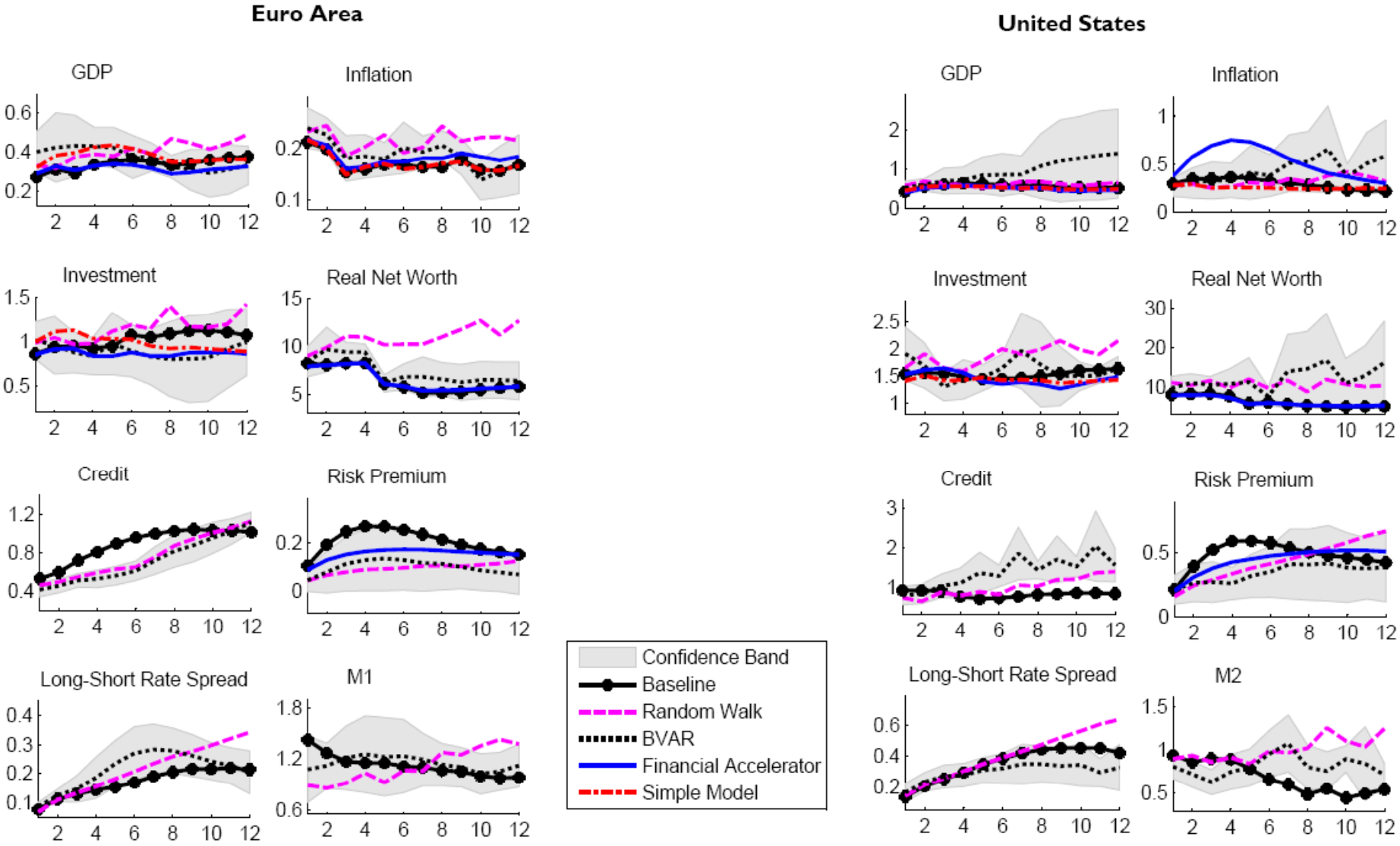
- Marginal efficiency of investment shock can account well for the surge in investment and output in the 1990s, *as long as the stock market is not included in the analysis.*

- When the stock market is included, then explanatory power shifts to financial market shocks.

‘Out of Sample Evidence’

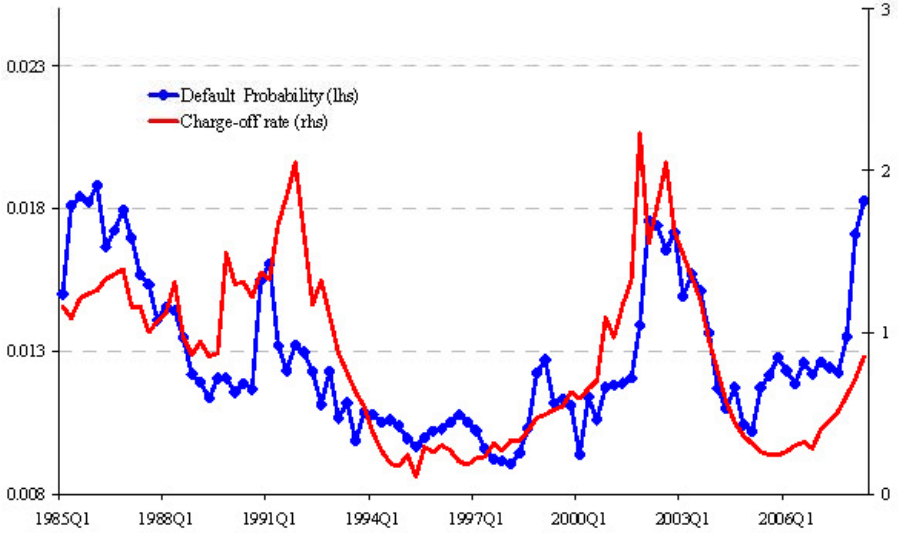
- Out of sample forecasting performance good.
- Predictions for aggregate bankruptcy rate good.
- Correlates well with Bloom evidence on cross-sectional uncertainty.

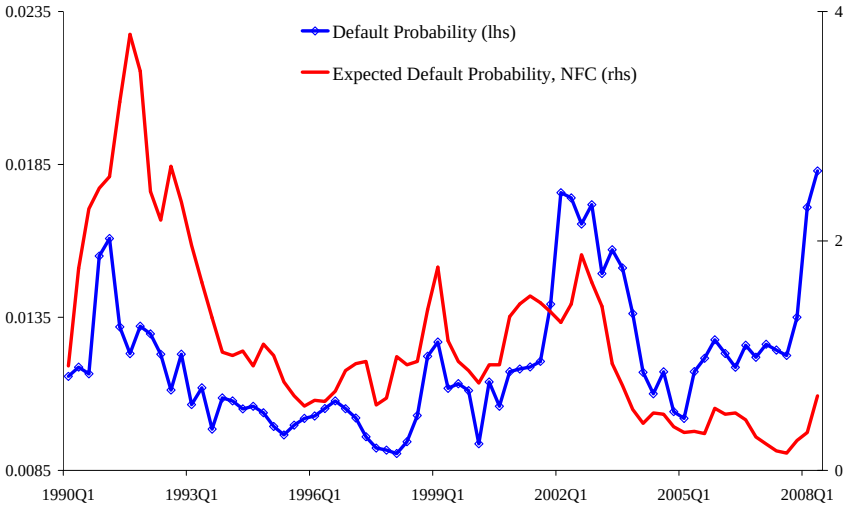
Figure 4. RMSE, Confidence band represents 2 std and is centred around BVAR (in percent)



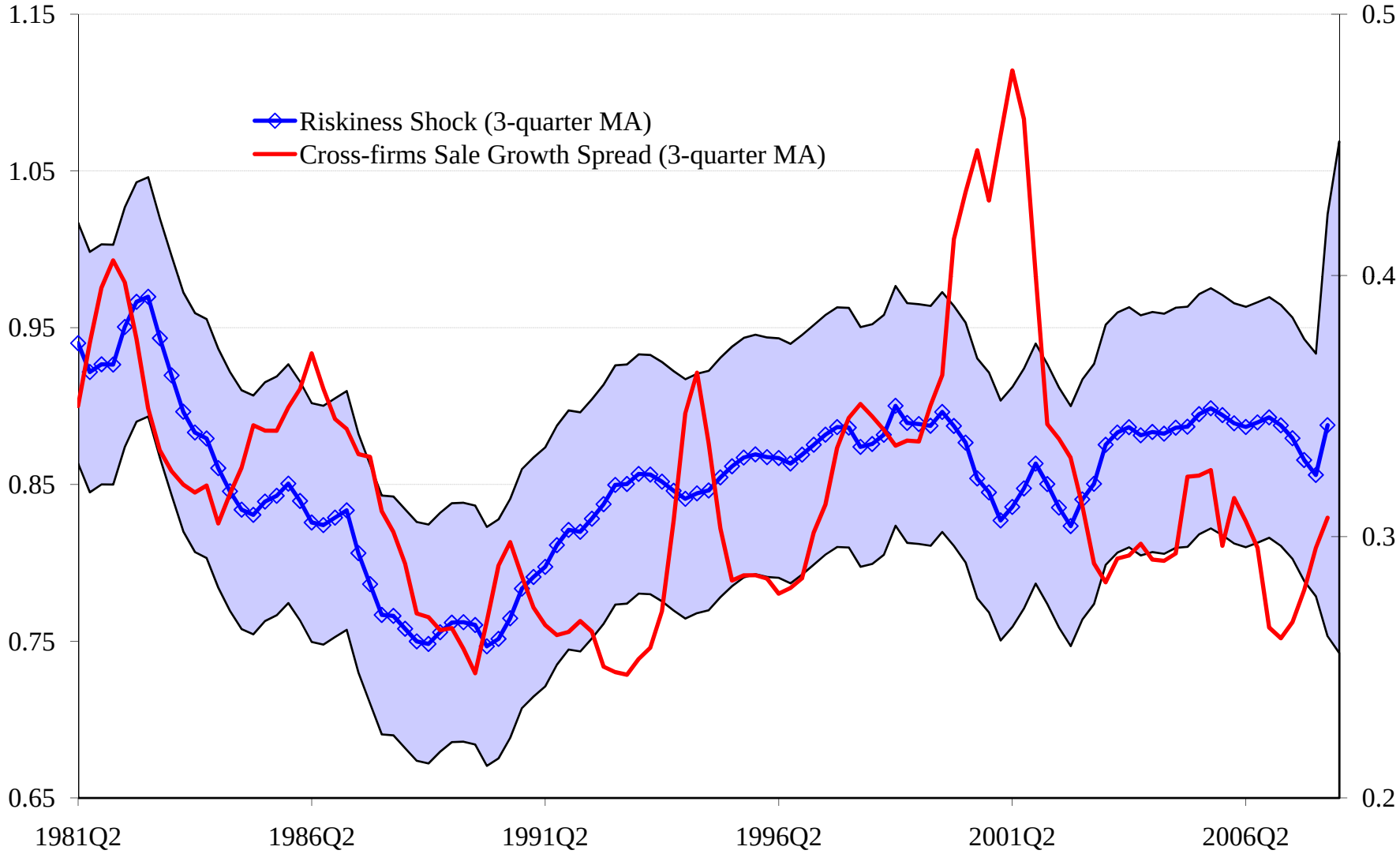
Other support for the model

- Model predicted default rates positively correlated with measures of default in the data.





Our Measure of Idiosyncratic Risk, versus Bloom, et al



A Policy Experiment….

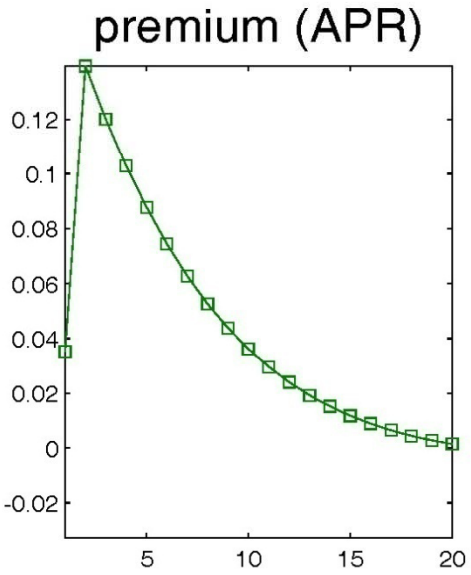
How Should Policy Respond to the Risk Spread?

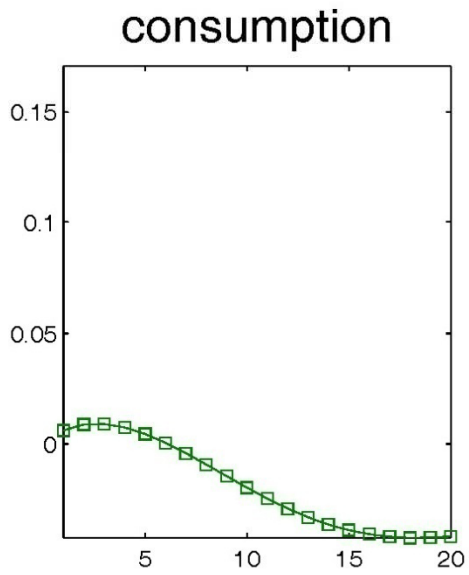
- Taylor's recommendation:

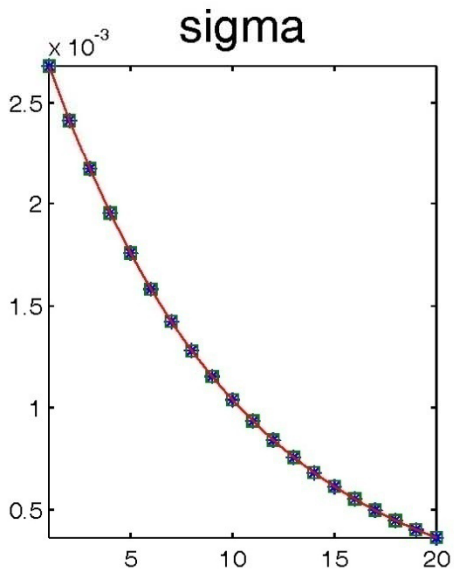
$$R_t = \alpha \pi_t^e + \beta y_t - \gamma(\text{Risky rate}_t - \text{Risk free rate}_t)$$

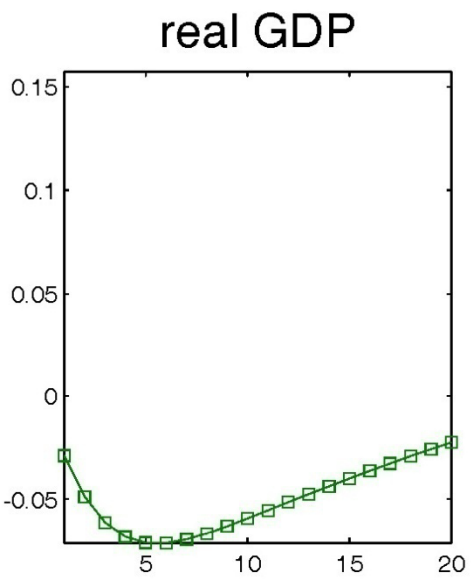
$$\gamma = 1$$

- Evaluate this proposal by comparing performance of economy with $\gamma = 1$ and $\gamma = 0$ against Ramsey-optimal benchmark.



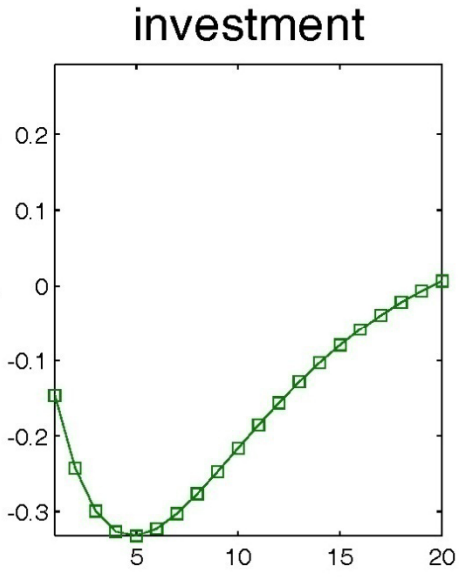




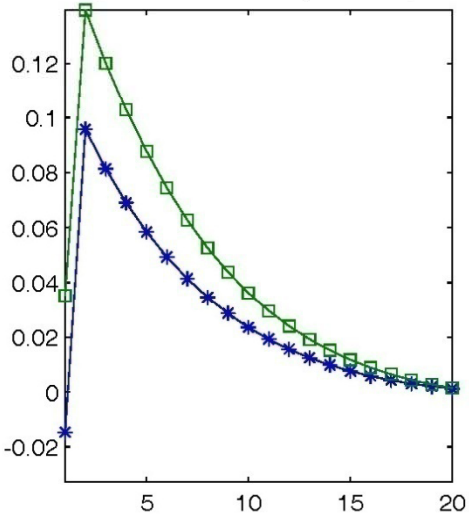


Taylor proposal
Taylor rule without spread
Ramsey Util

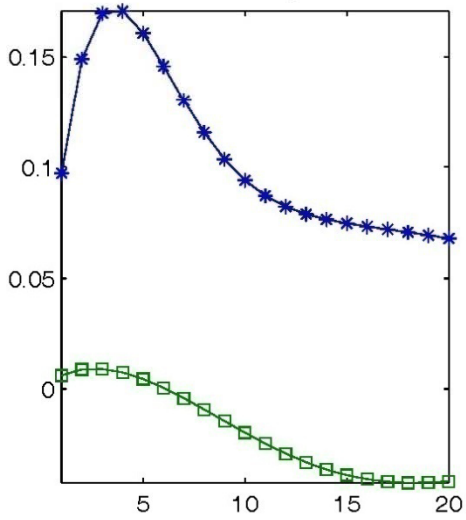
Get a recession, just like in earlier graph



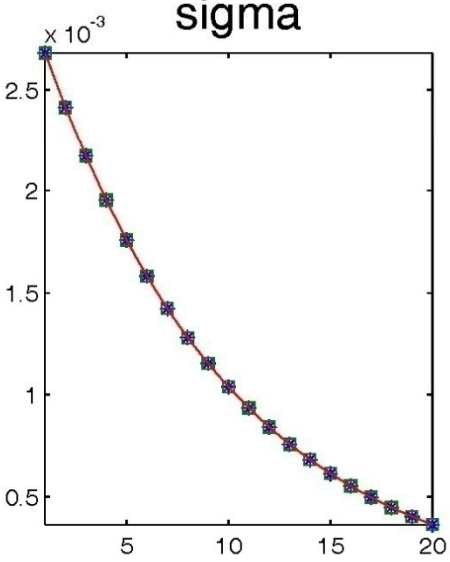
premium (APR)



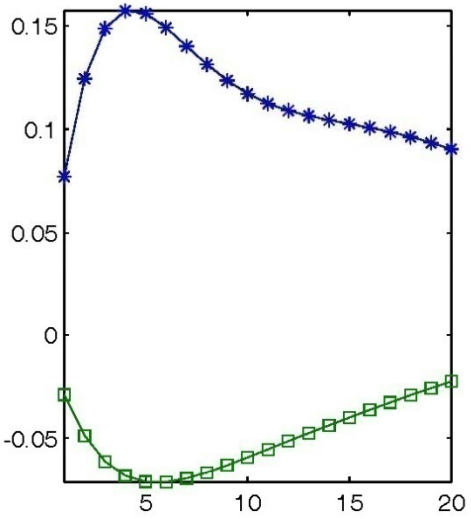
consumption



sigma



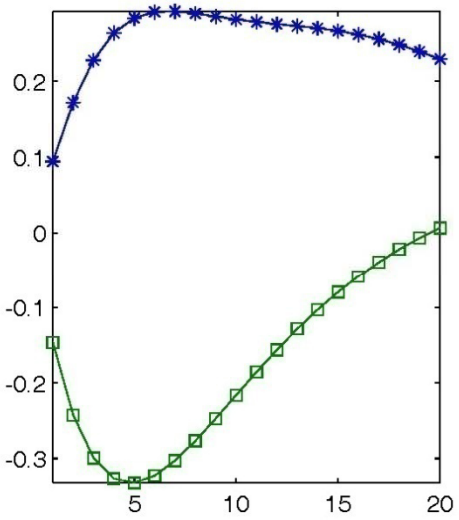
real GDP

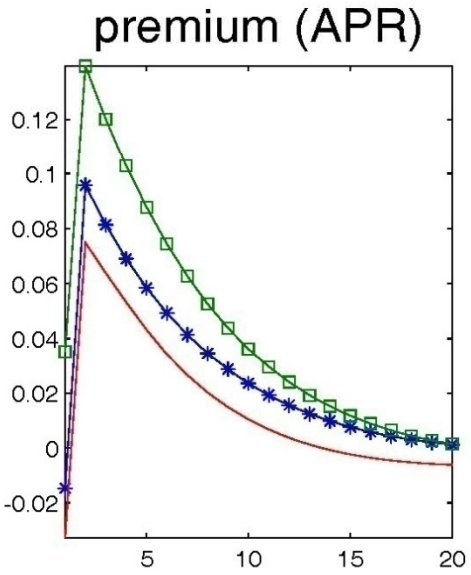


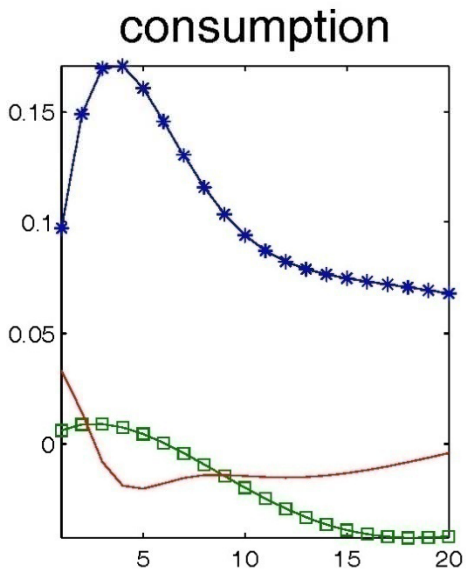
Taylor proposal
Taylor rule without spread
Ramsey

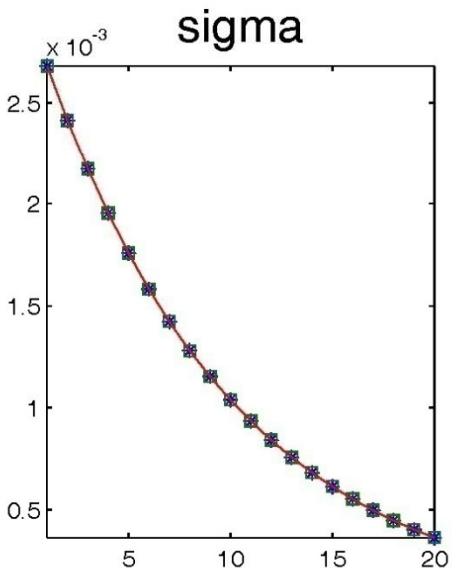
Taylor suggestion creates a boom
Is it too much?

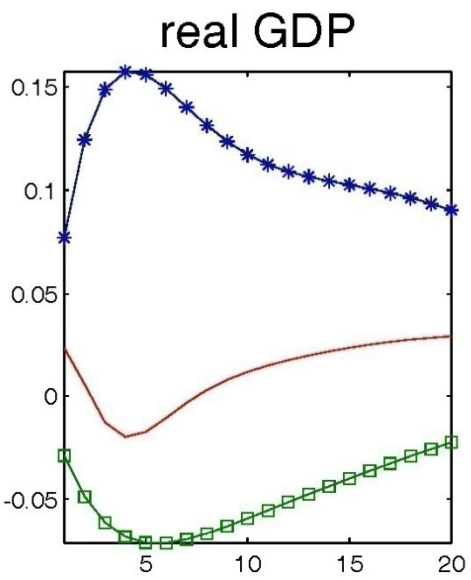
investment



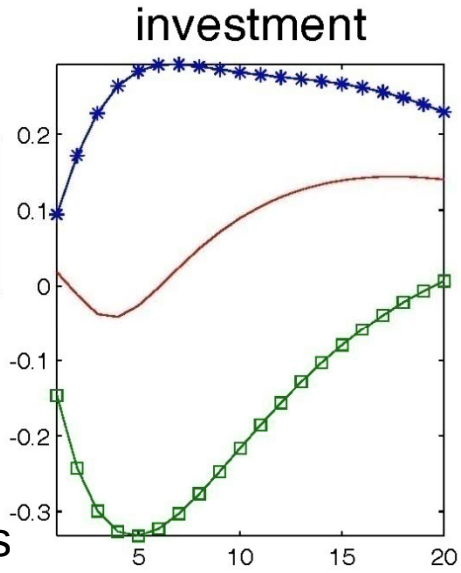








Taylor proposal
Taylor rule without spread
Ramsey Util



Taylor's suggestion overstimulates

Conclusion

- Incorporating financial frictions changes inference about the sources of shocks:
  - risk shock.

- 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?

  - How should monetary policy be structured to avoid excess asset market volatility?

  - What are the pro's and con's of 'unconventional monetary policy'?