Risk Shocks

Lawrence J. Christiano　Roberto Motto Massimo　Rostagno（2014,AER）

汇报人：高崧耀
2022年11月13日
中央财经大学中国经济与管理研究院

和BGG的区别

- 家庭+工资惯性
- 企业家+考虑risk shocks（讨论news shock）
- 中间品生产商+资本利用率
- 最终品生产商+价格粘性+通胀粘性+产品不同用途的转化成本
- 资本品生产商+更复杂的调节成本

- 故事：risk shocks是驱动经济的最重要因素

Introduction

Strategy

At the level of details, our model follows **Christiano, Motto, and Rostagno (2003)** by introducing the entrepreneurs into a version of the model proposed by **Christiano, Eichenbaum, and Evans (2005)** and by introducing the risk shock studied here.

Abstract

- We augment a standard monetary dynamic general equilibrium model to include a **BGG financial accelerator mechanism.**
- We fit the model to US data, allowing the volatility of cross-sectional **idiosyncratic uncertainty** to fluctuate over time.
- We refer to this measure of **volatility as risk**.
- We find that **fluctuations** in risk are the most important shock driving the business cycle.

Introduction

- Financial intermediation → standard model of business cycles
  - asymmetric information and costly monitoring *Townsend (1979).*
  - Integrating the csv model into a full-blown dsge model. *BGG(1999)*
- Entrepreneurs
  - raw capital → effective capital

Idiosyncratic uncertainty ω → *risk* σ

- Risk ↑ ⇒ the credit spread ↑, and credit extended to entrepreneurs ↓
- With fewer financial resources, entrepreneurs acquire less raw capital.
  - Because investment is a **key input** into the production of capital, it follows that investment↓.

  ⇒ the purchase of goods, output, consumption, and employment↓ .

A. Standard Part of the Model

1.Goods Production

- Final goods producer, Dixit-Stiglitz technology: $Y_t = \left[\int_0^1 Y_{jt}^{\frac{1}{\lambda_{f,t}}} dj\right]^{\lambda_{f,t}}, \quad 1 \le \lambda_{f,t} < \infty$
- The intermediate good

$$z_t^* = z_t \Upsilon^{\left(\frac{\alpha}{1-\alpha}\right)^t}$$

$$Y_{jt} = \begin{cases} \varepsilon_t K_{jt}^{\alpha} \left(z_t l_{jt}\right)^{1-\alpha} - \Phi z_t^* & \text{if } \varepsilon_t K_{jt}^{\alpha} \left(z_t l_{jt}\right)^{1-\alpha} > \Phi z_t^*, \quad 0 < \alpha < 1 \\ 0 & \text{otherwise} \end{cases}$$

Covariance stationary technology shock

Stationary growth rate.

A. Standard Part of the Model

1.Goods Production

- The monopoly supplier of Y_{jt} sets its price, P_{jt}, subject to Calvo-style frictions. $1-\xi_p$, can reoptimize their price.

- The complementary fraction sets its price :

$$P_{jt} = \tilde{\pi}_t P_{j,t-1}$$

  - Where $\tilde{\pi}_t = \left(\pi_t^{\text{target}}\right)^{\iota} \left(\pi_{t-1}\right)^{1-\iota} \quad \pi_{t-1} \equiv P_{t-1} / P_{t-2}$
  - 根据上一期的通胀水平和通胀目标调价。

A. Standard Part of the Model

2.Labor Market

- Production function: $$l_t = \left[\int_0^1 \left(h_{t,i}\right)^{\frac{1}{\lambda_w}} di\right]^{\lambda_w}, \quad 1 \le \lambda_w$$
- For each labor type *i*, there is a monopoly union which represents all workers of that type in the economy.
- The union sets the wage rate, $W_{i,t}$, for that labor type, subject to Calvo-style frictions.
  - $1-\xi_w$ monopoly unions sets their wage optimally
  - the complementary subset sets the wage $W_{it} = \left(\mu_{z^*,t}\right)^{\iota_\mu} \left(\mu_{z^*}\right)^{1-\iota_\mu} \tilde{\pi}_{wt} W_{i,t-1}$
  - Also $\tilde{\pi}_{w,t} \equiv \left(\pi_t^{target}\right)^{\iota_w} \left(\pi_{t-1}\right)^{1-\iota_w}, \quad 0 < \iota_w < 1$

A. Standard Part of the Model

3.Households

- The representative household

$$\text{Max:}\quad E_0\sum_{t=0}^{\infty}\beta^t\zeta_{c.t}\left\{\log\left(C_t-bC_{t-1}\right)-\psi_L\int_0^1\frac{h_{it}^{1+\sigma_L}}{1+\sigma_L}di\right\},b,\sigma_L>0$$

one-period bonds

long-term (ten-year) bond

$$\text{s.t.}\quad \left(1+\tau^c\right)P_tC_t+B_{t+1}+B_{t+40}^L+\left(\frac{P_t}{\Upsilon^t\mu_{\Upsilon,t}}\right)I_t+Q_{K,t}(1-\delta)\bar{K}_t$$

$$\leq\left(1-\tau^l\right)\int_0^1W_t^ih_{i,t}di+R_tB_t+\left(R_t^L\right)^{40}B_t^L+Q_{K,t}\bar{K}_{t+1}+\Pi_t$$

These pay gross return, R_t^L, in period $t+40$, at a quarterly rate.

Note that:

- The one-period bond is the source of funding for Entrepreneurs.
- The long-term bond plays no direct role in resource allocation, and the market for this bond clears at $B_{t+40}^L=0$
- The household's **sources of the revenues from selling raw capital.**

A. Standard Part of the Model

3.Households

Households produce raw capital to minimize the number of agents.

$$\overline{K}_{t+1} = (1 - \delta)\overline{K}_t + \left(1 - S(\zeta_{I,t}\, I_t/I_{t-1})\right) I_t.$$

Increasing and convex function

Shock to the marginal efficiency of investment in producing capital

often used in DSGE models in part because **it improves their fit to aggregate data** (see, e.g., the work of **CEE and Smets and Wouters 2007**).

B.Financial Frictions

2.One day in life of entrepreneur

◆ Entrepreneur at end of t

- buys raw $Q_{K,t}\bar{K}_{t+1}^{N} = N + B_{t+1}^{N}$
- After purchasing the capital, Efficiency capital $\omega\bar{K}_{t+1}^{N}$
  - standard deviation of log ω by σ_t.

◆ Entrepreneur at end of $t+1$

- Effective capital and supplies an amount of capital services $u_{t+1}^{N}\omega\bar{K}_{t+1}^{N}$
- After goods production, entrepreneur sells capital $(1-\delta)\omega\bar{K}_{t+1}^{N}$ after depreciation.

Return rate: $\omega R_{t+1}^{k} \longrightarrow R_{t+1}^{k} \equiv \dfrac{\left(1-\tau^{k}\right)\left[u_{t+1}r_{t+1}^{k} - a\left(u_{t+1}\right)\right]\Upsilon^{-(t+1)}P_{t+1} + (1-\delta)Q_{K,t+1} + \tau^{k}\delta Q_{K',t}}{Q_{\bar{K},t}}$

the increasing and convex function a captures the idea that capital utilization is costly

A.Financial Frictions

3.standard debt contract

Standard debt contract: (Z_{t+1}, L_t)

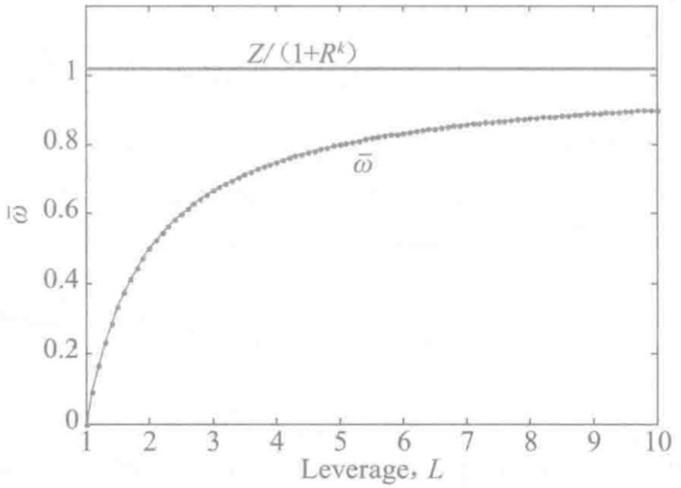
Gross nominal rate of interest on debt

Leverage: $L_t \equiv \left(N + B_{t+1}^N\right)/N$

- **Cutoff** $R_{t+1}^k \bar{\omega}_{t+1} Q_{K,t} \bar{K}_{t+1}^N = B_{t+1}^N Z_{t+1}$
  - Case1: bankruptcy $\omega \leq \bar{\omega}_{t+1}$, loses everything, monitoring cost
  - Case2: otherwise, $\omega > \bar{\omega}_{t+1}$, $\max\left\{R_{t+1}^k \omega Q_{\bar{K},t} \bar{K}_{t+1}^N - B_{t+1}^N Z_{t+1}\right\}$

Note that:

Cutoff value of Risk $\bar{\omega}_{t+1} = \dfrac{B_{t+1}^N Z_{t+1}}{R_{t+1}^k Q_{K,t} \bar{K}_{t+1}^N} = \dfrac{Z_{t+1}}{R_{t+1}^k} \dfrac{(Q_{K,t}\bar{K}_{t+1}^N - N)/N}{Q_{K,t}\bar{K}_{t+1}^N / N} = \dfrac{Z_{t+1}}{R_{t+1}^k} \dfrac{L-1}{L}$



$$\frac{\mathrm{d}\bar{\omega}}{\mathrm{d}L} = \frac{Z}{\left(1+R^k\right)} \frac{1}{L^2} > 0$$

Cutoff higher with:

– higher leverage L

– higher $\dfrac{Z_{t+1}}{R_{t+1}^k}$

A.Financial Frictions

3.standard debt contract

- Expected payoff for entrepreneur:

$$E_t\left\{\int_{\bar{\omega}_{t+1}}^{\infty}\left[R_{t+1}^k \omega Q_{K,t}\bar{K}_{t+1}^N - B_{t+1}^N Z_{t+1}\right] dF\left(\omega,\sigma_t\right)\right\}$$

$$\Longrightarrow \quad = E_t\left[1-\Gamma_t\left(\bar{\omega}_{t+1}\right)\right]R_{t+1}^k L_t N$$

- Entrepreneur’s rate of return (Entrepreneur Utility)

$$\frac{\int_{\bar{\omega}_{t+1}}^{\infty}\left[R_{t+1}^k \omega Q_{K,t}\bar{K}_{t+1}^N - B_{t+1}^N Z_{t+1}\right] dF\left(\omega,\sigma_t\right)}{N(1+R)}$$

$$\Gamma\left(\bar{\omega};\sigma\right)\equiv\bar{\omega}\left(1-F\left(\bar{\omega}\right)\right)+G\left(\bar{\omega};\sigma\right), G\left(\bar{\omega};\sigma\right)\equiv\int_0^{\bar{\omega}}\omega\,\mathrm{d}F\left(\omega\right) \qquad (5.4.11)$$

则 $\Gamma(\bar{\omega})$ 表示投资项目回报中，未扣除清算成本且由银行占有的部分。此处，为了表达

A.Financial Frictions

3. **constraint**

Note that: 在有银行或金融中介部门中，此部分叫做Bank zero profit condition，在risk shocks这篇文章中，直接将金融中介部分放入企业中，称作***cash constraint*** 。

- The funds received in each period t + 1 state of nature must be no less than the funds paid to households in that state of nature. **Obtain the cash constraint**:

$$\Rightarrow \quad \underbrace{\int_{\bar{\omega}_{t+1}}^{\infty} Z_{t+1} B_{t+1}^{N} dF_t(\omega)}_{fraction\ entrepreneur\ whose\ \omega_{t+1}>\bar{\omega}_{t+1}} + \underbrace{(1-\mu)\int_{0}^{\bar{\omega}_{t+1}} \omega dF_t(\omega) R_{t+1}^{k} Q_{\bar{K}',t} \bar{K}_{t+1}^{N}}_{fraction\ entrepreneur\ whose\ \omega_{t+1}<\bar{\omega}_{t+1}} = \underbrace{B_{t+1}^{N} R_t}_{amount\ \text{paid to households by mutual fund}}$$

$$\Rightarrow \quad \left[1-F_t\left(\bar{\omega}_{t+1}\right)\right] Z_{t+1} B_{t+1}^{N} + (1-\mu)\int_{0}^{\bar{\omega}_{t+1}} \omega dF_t(\omega) R_{t+1}^{k} Q_{\bar{K}',t} \bar{K}_{t+1}^{N} \geq B_{t+1}^{N} R_t$$

$$\Rightarrow \quad \Gamma_t\left(\bar{\omega}_{t+1}\right) - \mu G_t\left(\bar{\omega}_{t+1}\right) = \frac{L_t - 1}{L_t} \frac{R_t}{R_{t+1}^{k}}$$

A.Financial Frictions

5. Supplementary explanation

Maximize Utility:

$$U=\int_{\bar{\omega}}^{\infty}[\omega-\bar{\omega}]dF(\omega)\frac{(1+R^k)}{(1+R)}L$$

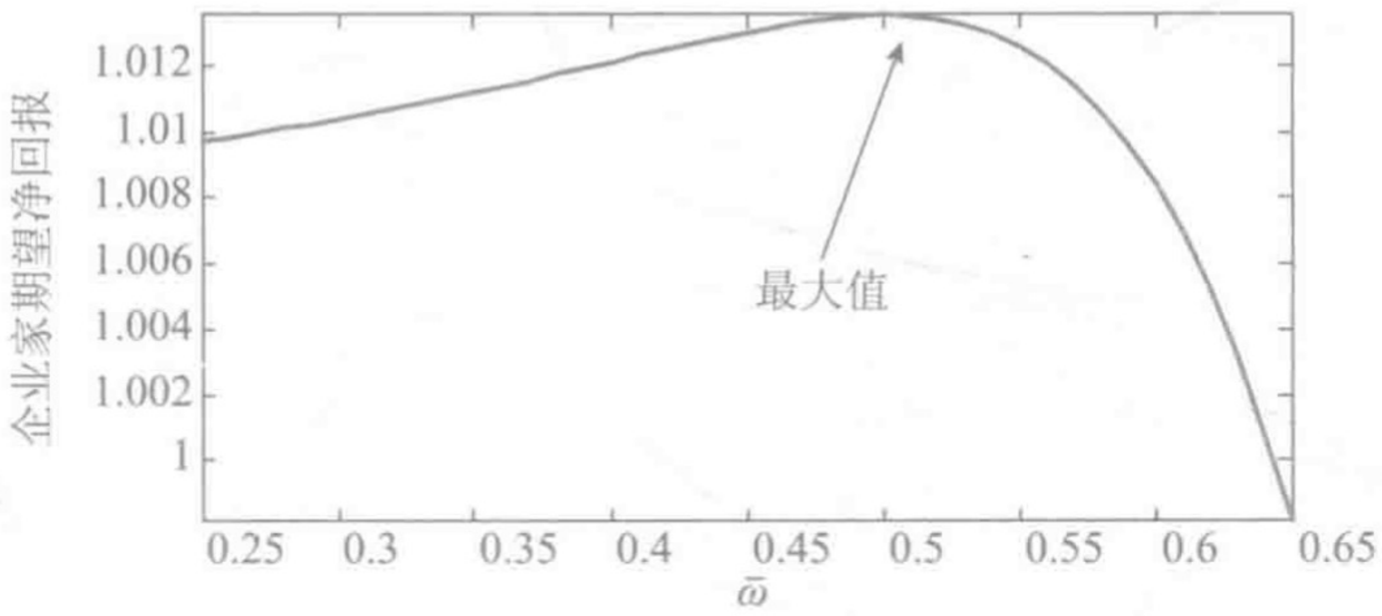
$$=(1-\Gamma(\bar{\omega}))\times\frac{(1+R^k)}{(1+R)}L$$

$$\Rightarrow \log U = \underbrace{\log(1-\Gamma(\bar{\omega}))}_{\text{Larger cutoff will low the utility, bad!}} + \log\left(\frac{(1+R^k)}{(1+R)}\right)\underbrace{-\log\left(1-\frac{1+R^k}{1+R}(\Gamma(\bar{\omega})-\mu G(\bar{\omega}))\right)}_{\text{Larger cutoff will improve leverage, good!}}$$

Note that: The two effeects will cancel with each other and finally there will be a balance. So, by intuition, there will be a unique $\bar{\omega}$ that achieves maximum.

A.Financial Frictions

5. Supplementary explanation



A.Financial Frictions

4. Optimal Contract $(\bar{\omega}_{t+1}, L)$

- Entrepreneurs select the contract that maximizes their objective, (12).
- The $\left(\bar{\omega}_{t+1}, L_t\right)$ combinations which satisfy (14) define a menu of state (t + 1)-contingent standard debt contracts offered to entrepreneurs

$$\begin{cases} \max \quad E_t\left[1-\Gamma_t\left(\bar{\omega}_{t+1}\right)\right] R_{t+1}^k L_t N & (12) \\ s.t.\ \Gamma_t\left(\bar{\omega}_{t+1}\right)-\mu G_t\left(\bar{\omega}_{t+1}\right)=\dfrac{L_t-1}{L_t} \dfrac{R_t}{R_{t+1}^k} & (14) \end{cases}$$

➢ The first-order condition associated with the entrepreneur's optimization problem is

$$E_t\left\{\left[1-\Gamma_t\left(\bar{\omega}_{t+1}\right)\right] \frac{R_{t+1}^k}{R_t}+\frac{\Gamma_t'\left(\bar{\omega}_{t+1}\right)}{\Gamma_t'\left(\bar{\omega}_{t+1}\right)-\mu G_t'\left(\bar{\omega}_{t+1}\right)}\left[\frac{R_{t+1}^k}{R_t}\left(\Gamma_t\left(\bar{\omega}_{t+1}\right)-\mu G_t\left(\bar{\omega}_{t+1}\right)\right)-1\right]\right\}=0$$

A.Financial Frictions

6.Implications for Aggregates

- The quantity of physical capital purchased by entrepreneurs must equal the quantity produced by households:

$$\bar{K}_{t+1} = \int_0^\infty \bar{K}_{t+1}^N f_t(N) dN$$

- The aggregate supply of capital services by entrepreneurs is:

$$\int_0^1 K_{j,t} dj \longleftarrow K_t = \int_0^\infty \int_0^\infty u_t^N \omega \bar{K}_t^N f_{t-1}(N) dF(\omega) dN = u_t \bar{K}_{t+1}$$

- Aggregate entrepreneurial net worth: $N_{t+1} = \gamma_t \left[1 - \Gamma_{t-1}\left(\bar{\omega}_t\right)\right] R_t^k Q_{\bar{K},t-1} \bar{K}_t + W_t^e$

- Aggregate quantity of debt : $B_{t+1} = \int_0^\infty B_{t+1}^N f_t(N) dN = \int_0^\infty \left[Q_{K,t} \bar{K}_{t+1}^N - N\right] f_t(N) dN = Q_{K,t} \bar{K}_{t+1} - N_{t+1}$

C.Monetary Policy and Resource Constraint

- Monetary authority's policy rule directly in linearized form:

$$R_t - R = \rho_p\left(R_{t-1} - R\right) + \left(1-\rho_p\right)\left[\alpha_\pi\left(\pi_{t+1} - \pi_t^*\right) + \alpha_{\Delta y}\frac{1}{4}\left(g_{y,t} - \mu_{z^*}\right)\right] + \frac{1}{400}\varepsilon_t^p$$

- Resource constraint:

$$Y_t = D_t + G_t + C_t + \frac{I_t}{\Upsilon^t \mu_{\Upsilon,t}} + a\left(u_t\right)\Upsilon^{-t}\bar{K}_t$$

  - the aggregate resources used for monitoring by mutual funds:

$$D_t = \mu G\left(\bar{\omega}_t\right)\left(1 + R_t^k\right)\frac{Q_{\bar{K},t-1}\bar{K}_t}{P_t}$$

  - government consumption:

$$G_t = z_t^* g_t$$

D.Adjustment Costs, Shocks, Information and Model Perturbations
1.Adjustment Costs

- The adjustment cost function for investment:

$$S(x_t) = \frac{1}{2}\left\{\exp\left[\sqrt{S''}(x_t - x)\right] + \exp\left[-\sqrt{S''}(x_t - x)\right] - 2\right\}$$

$$x_t \equiv \zeta_{I,t} I_t / I_{t-1}$$

$$S(x) = S'(x) = 0 \qquad S''(x) = S''$$

- The utilization adjustment cost function:

$$a(u) = r^k\left[\exp\left(\sigma_a(u-1)\right) - 1\right]\frac{1}{\sigma_a}$$

$$\sigma_a > 0$$

C.Adjustment Costs, Shocks, Information and Model Perturbations
2.Shocks

- Error shock on the long term interest rate: exogenous measurement error shock

$$\left(R_t^L\right)^{40} = \left(\tilde{R}_t^L\right)^{40} \eta_{t+1} \cdots \eta_{t+40}$$

- 12 aggregate shocks: $\eta_t, \ _t, \mu_{zt}, \lambda_{ft}, \pi_t^*, \zeta_{c,t}, \mu_{\Upsilon,t}, \zeta_{I,t} \gamma_t, \sigma_t, \varepsilon_t^p, g_t$

- Shock representation: $x_t = \rho_x x_{t-1} + \overbrace{\xi_{0,t} + \xi_{1,t-1} + \ldots + \xi_{p,t-p}}^{=u_t}$
- These bits of news correlation structure:

$$\rho_{x,n}^{|i-j|} = \frac{E\xi_{i,t}\xi_{j,t}}{\sqrt{\left(E\xi_{i,t}^2\right)\left(E\xi_{j,t}^2\right)}}, i, j = 0, \ldots, p$$

  - The variances of the news shocks:

$$E\xi_{0,t}^2 = \sigma_x^2, \quad E\xi_{1,t}^2 = E\xi_{2,t}^2 = \ldots E\xi_{p,t}^2 = \sigma_{x,n}^2$$

Equilibrium conditions

✓ ***Price***

$$(1)p_t^* - \left[(1-\xi_p) \left(\frac{K_{p,t}}{F_{p,t}} \right)^{\frac{\lambda_f}{1-\lambda_f}} + \xi_p \left(\frac{\tilde{\pi}_t}{\pi_t} p_{t-1}^* \right)^{\frac{\lambda_f}{1-\lambda_f}} \right]^{\frac{1-\lambda_f}{\lambda_f}} = 0$$

$$(2)E_t \left\{ \zeta_{c,t} \lambda_{z,t} y_{z,t} + \left(\frac{\tilde{\pi}_{t+1}}{\pi_{t+1}} \right)^{\frac{1}{1-\lambda_f}} \beta \xi_p F_{p,t+1} - F_{p,t} \right\} = 0,$$

$$(3)\zeta_{c,t} \lambda_{z,t} \lambda_f y_{z,t} s_t + \beta \xi_p \left(\frac{\tilde{\pi}_{t+1}}{\pi_{t+1}} \right)^{\frac{\lambda_f}{1-\lambda_f}} K_{p,t+1} - K_{p,t} = 0.$$

$$(4)F_{p,t} \left[\frac{1 - \xi_p \left(\frac{\tilde{\pi}_t}{\pi_t} \right)^{\frac{1}{1-\lambda_f}}}{1-\xi_p} \right]^{1-\lambda_f} = K_{p,t}, \ \tilde{p}_t = \frac{K_{p,t}}{F_{p,t}},$$

Technical Appendix

✓ *Wage*

$$(5)\ E_t\left\{\zeta_{c,t}\lambda_{z,t}\frac{\left(w_t^*\right)^{\frac{\lambda_w}{\lambda_w-1}}h_t\left(1-\tau_t^l\right)}{\lambda_w}+\beta\xi_w\left(\mu_{z^*}\right)^{\frac{1-\iota\mu}{1-\lambda w}}E_t\left(\mu_{z^*,t+1}\right)^{\frac{\iota\mu}{1-\lambda w}-1}\left(\frac{1}{\pi_{w,t+1}}\right)^{\frac{\lambda_w}{1-\lambda w}}\frac{\tilde{\pi}_{w,t+1}^{\frac{1}{1-\lambda_w}}}{\pi_{t+1}}F_{w,t+1}-F_{w,t}\right\}=0$$

$$(6)\ E_t\{\zeta_{c,t}\zeta_t\left[(w_t^*)^{\frac{\lambda_w}{\lambda_w-1}}h_t\right]^{1+\sigma_L}+\beta\xi_w\left(\frac{\tilde{\pi}_{w,t+1}\left(\mu^*_{z,t+1}\right)^{\iota_\mu}\left(\mu_z^*\right)^{1-\iota_\mu}}{\pi_{wt+1}}\right)^{\frac{\lambda_w}{1-\lambda_w}(1+\sigma_L)}K_{w,t+1}-K_{w,t}\}=0.$$

$$(7)\ \frac{1}{\psi_L}\left[\frac{1-\xi_w\left(\frac{\tilde{\pi}_{w,t}}{\pi_{w,t}}\left(\mu_{z^*}\right)^{1-\iota_\mu}\left(\mu_{z^*,t}\right)^{\iota_\mu}\right)^{\frac{1}{1-\lambda_w}}}{1-\xi_w}\right]^{1-\lambda_w(1+\sigma_L)}\tilde{w}_tF_{w,t}-K_{w,t}=0$$

$$(8)\ w_t^* = [(1-\xi_w)\left(\frac{1-\xi_w\left(\frac{\tilde{\pi}_{w,t}}{\pi_{w,t}}\left(\mu_{z^*}\right)^{1-\iota_\mu}\left(\mu_{z^*,t}\right)^{\iota_\mu}\right)^{\frac{1}{1-\lambda_w}}}{1-\xi_w}\right)^{\lambda_w}\ldots$$

$$+\xi_w\left(\frac{\tilde{\pi}_{w,t}\left(\mu^*_{z,t}\right)^{\iota_\mu}\left(\mu_z^*\right)^{1-\iota_\mu}}{\pi_{wt}}w_{t-1}^*\right)^{\frac{\lambda_w}{1-\lambda_w}}]^{\frac{1-\lambda_w}{\lambda_w}}$$

✓ *Capital utilization, marginal cost, return on capital, investment, monetary policy*

- ***Utilization cost function*** $(9)\ r_t^k = \tau_t^o r^k \exp(\sigma_a [u-1]).$

- ***Marginal cost 1*** $$(10)\ r_t^k = \frac{\alpha \varepsilon_t}{[1+\psi_{k,t} R_t]} \left(\frac{\Upsilon \mu_{z,t}^* L_t \left(w_t^*\right)^{\frac{\lambda_w}{\lambda_w - 1}}}{u_t k_t} \right)^{1-\alpha} s_t$$

- ***Marginal cost 2*** $$(11)\ s_t = \frac{1}{\varepsilon_t} \left(\frac{r_t^k [1+\psi_{k,t} R_t]}{\alpha} \right)^{\alpha} \left(\frac{\tilde{w}_t [1+\psi_{l,t} R_t]}{1-\alpha} \right)^{1-\alpha}$$

- ***Resource constraint*** $$(12)\ \tau_t^o a(u_t) \frac{k_t}{\Upsilon \mu_{z,t}^*} + g_t + c_t + \frac{i_t}{\mu_{\Upsilon,t}} = y_{z,t}$$

- ***Capital*** $$(13)\ k_{t+1} = (1-\delta) \frac{1}{\mu_{z,t}^* \Upsilon} k_t + \left[1 - S\left(\frac{\zeta_{i,t}\, i_t \mu_{z,t}^* \Upsilon}{i_{t-1}} \right) \right] i_t,$$

$$(14)\ E_t\{\beta \frac{1}{\pi_{t+1} \mu_{z,t+1}^*} \zeta_{c,t+1} \lambda_{z,t+1} (1+R_t) - \zeta_{c,t} \lambda_{z,t}\} = 0$$

✓ *Capital utilization, marginal cost, return on capital, investment, monetary policy*

- ***Foc: interest rate***

$$(14)E_t\{\beta\frac{1}{\pi_{t+1}\mu^*_{z,t+1}}\zeta_{c,t+1}\lambda_{z,t+1}(1+R_t)-\zeta_{c,t}\lambda_{z,t}\}=0$$

- ***Foc: consumption***

$$(15)E_t\left[(1+\tau^C)\zeta_{c,t}\lambda_{z,t}-\frac{\mu^*_{z,t}\zeta_{c,t}}{c_t\mu^*_{z,t}-bc_{t-1}}+b\beta\frac{\zeta_{c,t+1}}{c_{t+1}\mu^*_{z,t+1}-bc_t}\right]=0,$$

- ***Foc: capital(CEE version)***

$$(16)E_t\left\{-\zeta_{c,t}\lambda_{zt}+\frac{\beta}{\pi_{t+1}\mu^*_{z,t+1}}\zeta_{c,t+1}\lambda_{zt+1}\left(1+R^k_{t+1}\right)\right\}=0,$$

- ***Return rate on capital***

$$(17)\ 1+R^k_t=\frac{(1-\tau^k_{t-1})\left[u_tr^k_t-\tau^o_ta(u_t)\right]+(1-\delta)q_t}{\Upsilon q_{t-1}}\pi_t+\tau^k_{t-1}\delta$$

- ***Foc: investment***

$$(18)\ E_t\{\zeta_{c,t}\lambda_{zt}q_t\left[1-S(\frac{\zeta_{i,t}\mu^*_{z,t}\Upsilon i_t}{i_{t-1}})-S'(\frac{\zeta_{i,t}\mu^*_{z,t}\Upsilon i_t}{i_{t-1}})\frac{\zeta_{i,t}\mu^*_{z,t}\Upsilon i_t}{i_{t-1}}\right]$$
$$-\frac{\zeta_{c,t}\lambda_{zt}}{\mu_{\Upsilon,t}}+\frac{\beta\lambda_{zt+1}\zeta_{c,t+1}q_{t+1}}{\mu^*_{z,t+1}\Upsilon}S'(\frac{\zeta_{i,t+1}\mu^*_{z,t+1}\Upsilon i_{t+1}}{i_t})\left(\frac{\zeta_{i,t+1}\mu^*_{z,t+1}\Upsilon i_{t+1}}{i_t}\right)^2\}\ =\ 0,$$

✓ *Capital utilization, marginal cost, return on capital, investment, monetary policy*

- ***Aggregate output***

$$(19)\ y_{z,t} \equiv \frac{Y_t}{z_t^*} = (p_t^*)^{\frac{\lambda_f}{\lambda_f - 1}} \left[\varepsilon_t \left(\frac{u_t k_t}{\mu_{z,t}^* \Upsilon} \right)^{\alpha} \left((w_t^*)^{\frac{\lambda_w}{\lambda_w - 1}} h_t \right)^{1-\alpha} - \phi \right]$$

- ***Monetary policy rule:***

$$\begin{aligned}(20)\ \log(1+R_t) \quad = \quad & (1-\tilde{\rho})\log(1+R) + \tilde{\rho}\log(1+R_{t-1}) \\ & + \frac{1-\tilde{\rho}}{1+R}\left[\tilde{a}_p \pi \log\frac{\pi_{t+1}}{\pi_t^*} + \tilde{a}_y \frac{1}{4}\log\frac{y_t}{y}\right] + x_t^p,\end{aligned}$$

- ***Scaled GDP***

$$(21)\ y_t = g_t + c_t + \frac{i_t}{\mu_{\Upsilon,t}}.$$

✓ *Entrepreneurs*

➢ ***Zero profit condition***

$$(22)\ \frac{q_t k_{t+1}}{n_{t+1}} \frac{1+R^k_{t+1}}{1+R_t}\left[\Gamma_t(\omega_{t+1}) - \mu G_t(\omega_{t+1})\right] - \frac{q_t k_{t+1}}{n_{t+1}} + 1 = 0,$$

➢ ***FOC***

$$(16) E_t\left\{[1-\Gamma_t(\omega_{t+1})]\frac{1+R^k_{t+1}}{1+R_t} + \frac{\Gamma_t'(\omega_{t+1})}{\Gamma_t'(\omega_{t+1}) - \mu G_t'(\omega_{t+1})}\left[\frac{1+R^k_{t+1}}{1+R_t}\left(\Gamma_t(\omega_{t+1}) - \mu G_t(\omega_{t+1})\right) - 1\right]\right\} = 0,$$

➢ ***Net worth***

$$(23)\ n_{t+1} = \frac{\gamma_t}{\pi_t \mu^*_{z,t}}\left\{R^k_t - R_{t-1} - \mu\int_0^{\omega_t} \omega dF_{t-1}(\omega)\left(1+R^k_t\right)\right\} k_t q_{t-1} + w^e + \gamma_t\left(\frac{1+R_{t-1}}{\pi_t \mu^*_{z,t}}\right) n_t.$$

对数线性化后

- Entrepreneur 1:

$$\mathbb{E}_t \widehat{R}^k_{t+1} - \hat{R}_t + \omega_a \mathbb{E}_t \hat{\bar{\omega}}_{t+1} + \sigma_a \hat{\sigma}_{\omega,t+1} = \frac{s-1}{s}\tilde{s}_t + \hat{n}_t - \hat{q}_t - \hat{k}_t$$

- Entrepreneur 2 :

$$\hat{R}^k_t - \widehat{R}_{t-1} - \frac{s-1}{s}\widehat{s}_{t-1} + \omega_b \hat{\bar{\omega}}_t + \sigma_b \hat{\sigma}_{\omega,t} = \bar{b}_{t-1} - \hat{q}_{t-1} - \hat{k}_{t-1}$$

A.Data

- 12 variables ,1985Q1-2010Q2.
- Use standard macro data:
  - GDP, consumption, investment, inflation, the real wage, the relative price of investment goods, hours worked and the federal funds rate.
- Four financial variables
  - B_{t+1} : data on credit to non-financial .rms taken from the Flow of Funds dataset constructed by the US Federal Reserve Board.
  - $R_t^L - R_t$: the difference between the 10-year constant maturity US government bond yield and the Federal Funds rate.
  - N_{t+1} : Dow Jones Wilshire 5000 index.
  - $Z_t - R_t$: the difference between the interest rate on BAA-rated corporate bonds and the 10 year US government bond rate.

B. Priors and Posteriors

The first set contains parameters that we simply fix a priori.

TABLE 1—CALIBRATED PARAMETERS (*Time unit of model: quarterly*)

β	Discount rate	0.9987
σ_L	Curvature on disutility of labor	1.00
ψ_L	Disutility weight on labor	0.7705
λ_w	Steady-state markup, suppliers of labor	1.05
μ_z	Growth rate of the economy	0.41
Υ	Trend rate of investment-specific technological change	0.42
δ	Depreciation rate on capital	0.025
α	Power on capital in production function	0.40
λ_f	Steady-state markup, intermediate good firms	1.20
$1-\gamma$	Fraction of entrepreneurial net worth transferred to households	$1-0.985$
W^e	Transfer received by entrepreneurs	0.005
η_g	Steady-state government spending–GDP ratio	0.20
π^{target}	Steady-state inflation rate (APR)	2.43
τ^c	Tax rate on consumption	0.05
τ^k	Tax rate on capital income	0.32
τ^l	Tax rate on labor income	0.24

The first set contains parameters that we simply fix a priori.

B. Priors and Posteriors

The second set of parameters to be assigned values consists of the 36 parameters listed in Table 2.

TABLE 2—MODEL PRIORS AND POSTERIORS

		Prior distribution			Posterior distribution	
Parameter name	Parameter	Prior dist	Mean	SD	Mode	SD
Panel A. Economic parameters						
Calvo wage stickiness	ξ_w	beta	0.75	0.1	0.81	0.019
Habit parameter	b	beta	0.5	0.1	0.74	0.050
Steady-state probability of default	$F(\overline{\omega})$	beta	0.007	0.0037	0.0056	0.0023
Monitoring cost	μ	beta	0.275	0.15	0.21	0.073
Curvature, utilization cost	σ_a	normal	1	1	2.54	0.70
Curvature, investment adjust cost	S''	normal	5	3	10.78	1.71
Calvo price stickiness	ξ_p	beta	0.5	0.1	0.74	0.035
Policy weight on inflation	α_π	normal	1.5	0.25	2.40	0.16
Policy smoothing parameter	ρ_p	beta	0.75	0.1	0.85	0.015
Price indexing weight on inflation target	ι	beta	0.5	0.15	0.90	0.049
Wage indexing weight on inflation target	ι_w	beta	0.5	0.15	0.49	0.11
Wage indexing weight on persistent technology growth	ι_μ	beta	0.5	0.15	0.94	0.029
Policy weight on output growth	$\alpha_{\Delta y}$	normal	0.25	0.1	0.36	0.099

The price and wage stickiness parameters, ξ_p and ξ_w, are given relatively tight priors around values that imply prices and wages remain unchanged for, on average, one-half and one year, respectively.

II. Inference About Parameters and Model Fit

B. Priors and Posteriors

- The posterior mode of the standard deviation of the unanticipated component of the shock to $\log\sigma_t$, $\xi_{0,t}$, is 0.07.
- The corresponding number associated with the anticipated components, $\xi_{i,t}, i = 1, \ldots, 8$, is 0.0283.

- This implies that **a substantial 57 percent of the variance in the statistical innovation in log σ is anticipated.**

$$0.57 = \frac{8 \times 0.0283^2}{8 \times 0.0283^2 + 0.07^2}.$$

- The posterior mode on the correlation among anticipated and unanticipated shocks is 0.4.

TABLE 2—MODEL PRIORS AND POSTERIORS

Parameter name	Parameter	Prior distribution: Prior dist	Prior distribution: Mean	Prior distribution: SD	Posterior distribution: Mode	Posterior distribution: SD
Panel B. Shocks						
Correlation among signals	$\rho_{\sigma,n}$	normal	0	0.5	0.39	0.095
Autocorrelation, price markup shock	ρ_{λ_f}	beta	0.5	0.2	0.91	0.034
Autocorrelation, price of investment goods shock	ρ_{μ_Ψ}	beta	0.5	0.2	0.99	0.0085
Autocorrelation, government	ρ_g	beta	0.5	0.2	0.94	0.023
Autocorrelation, persistent technology growth	ρ_{μ_z}	beta	0.5	0.2	0.15	0.070
Autocorrelation, transitory technology	ρ_ϵ	beta	0.5	0.2	0.81	0.065
Autocorrelation, risk shock	ρ_σ	beta	0.5	0.2	0.97	0.0093
Autocorrelation, consumption preference shock	ρ_{ζ_c}	beta	0.5	0.2	0.90	0.031
Autocorrelation, marginal efficiency of investment	ρ_{ζ_I}	beta	0.5	0.2	0.91	0.017
Autocorrelation, term structure shock	ρ_η	beta	0.5	0.2	0.97	0.025
Standard deviation, anticipated risk shock	$\sigma_{\sigma,n}$	invg2	0.001	0.0012	0.028	0.0028
Standard deviation, unanticipated risk shock	$\sigma_{\sigma,0}$	invg2	0.002	0.0033	0.07	0.0099
SD, measurement error on net worth		Weibull	0.01	5	0.018	0.0009
Standard deviations, shock innovations						
Price markup	σ_{λ_f}	invg2	0.002	0.0033	0.011	0.0022
Investment price	σ_{μ_Ψ}	invg2	0.002	0.0033	0.004	0.0003
Government consumption	σ_g	invg2	0.002	0.0033	0.023	0.0016
Persistent technology growth	σ_{μ_z}	invg2	0.002	0.0033	0.0071	0.0005
Equity	σ_γ	invg2	0.002	0.0033	0.0081	0.001
Temporary technology	σ_ε	invg2	0.002	0.0033	0.0046	0.0003
Monetary policy	σ_{ε^p}	invg2	0.583	0.825	0.49	0.037
Consumption preference	σ_{ξ_c}	invg2	0.002	0.0033	0.023	0.003
Marginal efficiency of investment	σ_{ξ_I}	invg2	0.002	0.0033	0.055	0.012
Term structure	σ_η	invg2	0.002	0.0033	0.0016	0.0007

Note: invg2: "inverse gamma distribution, type 2."

B. Priors and Posteriors

TABLE 3—STEADY-STATE PROPERTIES, MODEL AT PRIORS VERSUS DATA

Variable	Model	Sample averages
$\frac{i}{y}$	0.25	0.24[a]
$\frac{c}{y}$	0.54	0.59[b]
$\frac{g}{y}$	0.20	0.16
$\frac{k}{y}$	7.6	10.9[c]
$\frac{N}{K-N}$ (Equity-to-debt ratio)	1.91	1.3–4.7[d]
Transfer received by new entrepreneurs as percent of GDP	0.18	not known
Banks monitoring costs as percent of GDP	0.45	not known
Credit velocity	1.53	1.67[e]
Inflation (APR)	2.43	2.47[f]
Short-term risk free rate (APR)	4.67	4.80[g]

Notes: All sample averages are computed over the period 1985:I–2008:II, except inflation and the short-term interest rate, which are computed over 1987:I–2008:II. Model objects are computed on the basis of the parameters evaluated at the prior mode.

An exception is the model's **capital output ratio**, which is **a little low**. In part, the relatively low stock of capital reflects the effects of the financial frictions in the model.

C. Where is the 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

'signals' or 'news'

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

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

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

C. Where is the News?

we place **news shocks on risk** and **not on other variables**

TABLE 4—MARGINAL LIKELIHOOD OF PLACING NEWS ON ALTERNATIVE SHOCKS

News on:	Marginal likelihood
Risk shock, σ_t (baseline specification)	4,564.95
No news on any shock	4184.10
Persistent technology shock, $\mu_{z,t}$	4,184.74
Government spending shock, g_t	4,195.93
Transitory technology shock, ε_t	4,423.39
Monetary policy shock, ε_t^p	4,486.08
Equity shock, γ_t	4,491.44
Marginal efficiency of investment shock, $\xi_{I,t}$	4,531.97
All technology shocks, $\varepsilon_t, \mu_{z,t}, \xi_{I,t}$	4,557.14

Notes: The marginal likelihood is computed using Geweke's (1999) modified harmonic mean method. The computations are based on a Monte Carlo Markov chain of length 200,000 for each model.

- First, **news shocks** have the potential to substantially **improve the econometric fit** of a model.
- Second, if one wants to place news on only one shock (as we do, for parameter parsimony reasons), then **putting news on the risk shock is the best choice** because **it adds the most to model fit.**

⇒ **the most preferred shock to put news on is the risk shock.**

C. Where is the News?

-Table4 code

```
varobs
@# if some_financial_data
@# for fvar in financial_data
      @{fvar},
@# endfor
@# endif
      inflation_obs, hours_obs,  gdp_obs,
      wage_obs, investment_obs, consumption_obs,
      Re_obs, pinvest_obs;

options_.weibull = 1;
options_.plot_priors = 0;

estimation(datafile = data_BAAoverTB, order = 1, smoother,
         mode_file = cmr_mode, loglinear, presample = 16,
         mh_replic = 200000, mh_nblocks = 1, mh_jscale = 0.28,
         mode_compute = 0, nograph) volEquity;
```

以baseline为例，实际上是进行估计，mcmc 200000次后，得到边际似然值。运行这个估计，需要相当多的时间，若测试建议将循环次数改为2000甚至更低。

III. The Risk Shock

- We begin this section**(A)** by discussing the various quantitative indicators which suggest that the risk shock is the most important driver of the business cycle.
- We then review(B) what it is about our model and data that explains our finding. Previous studies of business cycles have stressed other shocks as the primary driving force.
- The last part of this section(C) discusses which of those shocks are displaced by the risk shock.

III. The Risk Shock

A. Measuring the Importance of the Risk Shock

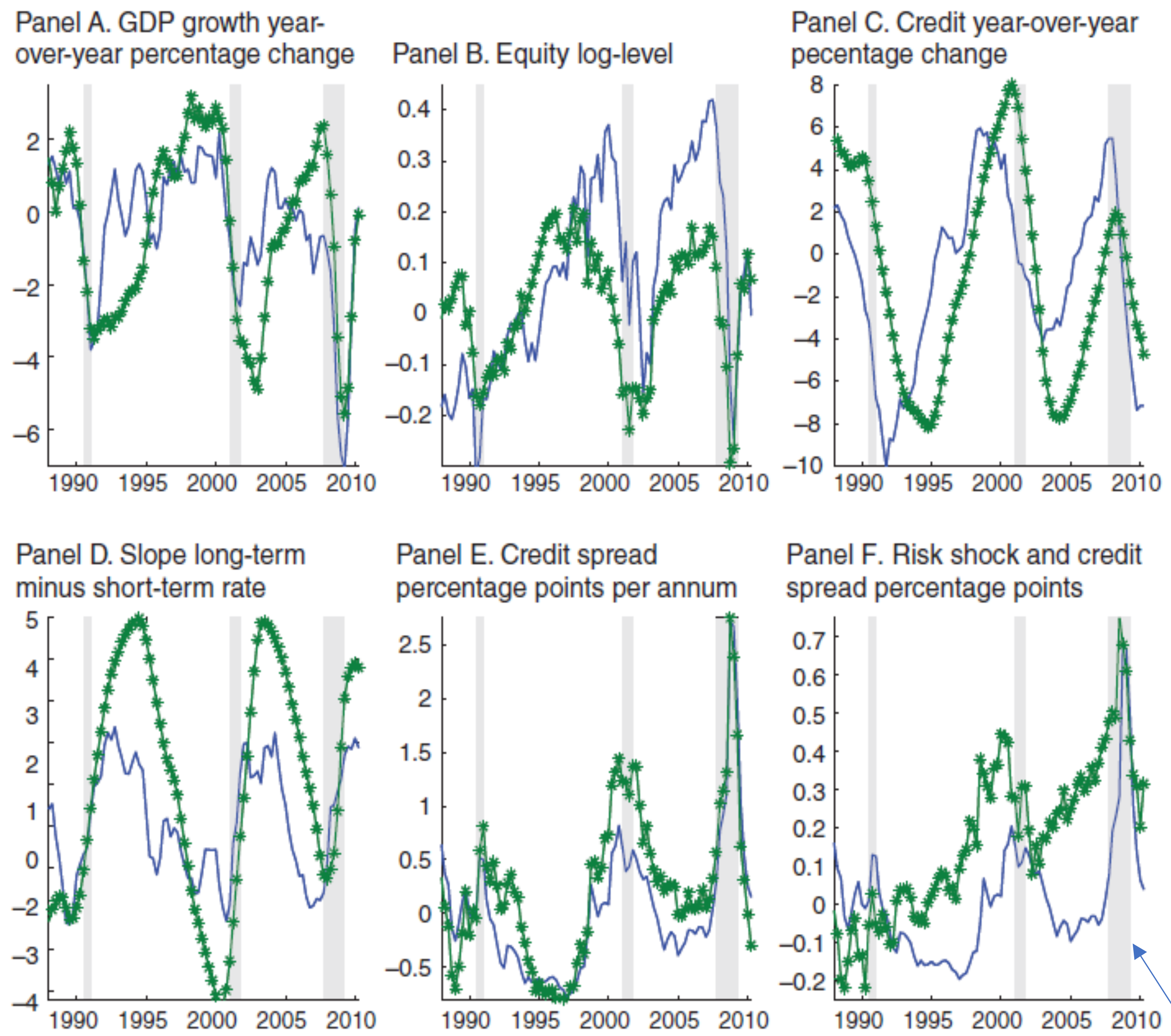


Figure 1. The Role of the Risk Shock in Selected Variables

Shaded areas indicate NBER recession dates.

Panel A.

- over **60 percent** of the business cycle variance in output is **accounted for by the risk shock**.
- the risk shock is by **far more important for GDP** than are any of the other shocks.
- **The risk shock is also closely associated with aggregate financial variables.**

Panel B. **The risk shock** alone **accounts for a large portion** of the **fluctuations** in the log level of per capita, real equity.

Panel C. a large part of the **movements** in the year-over-year growth rate in **real per capita credit** are **accounted for by the risk shock.**

Panel D. **the risk shock accounts for a substantial component of the fluctuations** in the slope of the term structure of **interest rates.**

Panel E. **the risk shock accounts for** a **very large** part of the **movements in the credit spread.**

Panel E.F.

- Note that although **the risk shock, σ , and the credit spread are positively related**, they are by no means perfectly correlated.
- **The credit spread is a complicated dynamic function of the news about the risk shock, σ , and not just a simple function of the σ itself. ---Table5**

III. The Risk Shock

A. Measuring the Importance of the Risk Shock

Code- Set parameters

```
when stopshock = 1, then non-risk shocks are all turned off
@# define stopshock = 0
That is:
```

因此，stopshock=1，只开风险冲击，为dotted line。
而stopshock=0，所有冲击开，为solid line。

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Shock equations
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
log(epsil / epsil_p)        = rhoepsil_p    * log(epsil(-1) / epsil_p)       + (1 - @{stopshock}) * e_epsil;
log(g / g_ss)               = rhog_p        * log(g(-1) / g_ss)              + (1 - @{stopshock}) * e_g;
@# if cee == 0
log(gamma / gamma_p)        = rhogamma_p    * log(gamma(-1) / gamma_p)       + (1 - @{stopshock}) * e_gamma;
@# endif
log(lambdaf / lambdaf_p)    = rholambdaf_p  * log(lambdaf(-1) / lambdaf_p)   + (1 - @{stopshock}) * e_lambdaf;
log(muup / muup_p)          = rhomuup_p     * log(muup(-1) / muup_p)         + (1 - @{stopshock}) * e_muup;
log(muzstar / muzstar_p)    = rhomuzstar_p  * log(muzstar(-1) / muzstar_p)   + (1 - @{stopshock}) * e_muzstar;
log(pitarget / pitarget_p)  = rhopitarget_p * log(pitarget(-1) / pitarget_p) + (1 - @{stopshock}) * e_pitarget;
@# if cee == 0
log(term / term_p)          = rhoterm_p     * log(term(-1) / term_p)         + (1 - @{stopshock}) * e_term;
@# endif
log(zetac / zetac_p)        = rhozetac_p    * log(zetac(-1) / zetac_p)       + (1 - @{stopshock}) * e_zetac;
log(zetai / zetai_p)        = rhozetai_p    * log(zetai(-1) / zetai_p)       + (1 - @{stopshock}) * e_zetai;
```

III. The Risk Shock

A. Measuring the Importance of the Risk Shock

Code- Process resutls

```
% the following computes the historical decompositions and places them in the matrix oo_.shock_decomposition(i,j,t), where i indicates the endogenous variable, j indicates the shock (j=1,...,end-2 has the shocks, j=end-1 initial conditions and j=end raw data)
shock_decomposition(parameter_set = posterior_mode) gdp_obs;
```

上面这个函数很关键，提取了冲击分解，为后续画图做准备。

Unanticipated and anticipated两条线根据以下方式取出，下面只举例了GDP的取法，其他变量相似：

(1)

```
gdp = squeeze(oo_.shock_decomposition(9, 22, :));
gdp4=gdp(4:end) + gdp(3:(end-1)) + gdp(2:(end-2)) + gdp(1:(end-3));
```

(2)

```
gdps = sum(squeeze(oo_.shock_decomposition(9, 8:16, :)), 1);
gdps4=gdps(4:end) + gdps(3:(end-1)) + gdps(2:(end-2)) + gdps(1:(end-3));
```

两条线的值有了，就可以画图了，当然还需要很多小处理。

若想要用自己的数据复现，待解决的疑惑，存在oo_.shock_decomposition具体是以怎样的规则保存，我怎么找出自己需要的变量。

III. The Risk Shock

A. Measuring the Importance of the Risk Shock

anticipated and unanticipated

unanticipated

anticipated

Shock variable	Risk σ_t X | Y | Z
GDP	62 | 16 | 38
drop all fin. var	1 | 0 | 1
CEE	[–]
Consumption	16 | 3 | 12
drop all fin. var	0 | 0 | 0
CEE	[–]
Investment	73 | 18 | 46
drop all fin. var	2 | 0 | 2
CEE	[–]
Equity	69 | 23 | 35
Credit spread	95 | 39 | 42
Credit	64 | 12 | 46
Slope	56 | 12 | 38

Table 5—**Variance Decomposition** at Business Cycle Frequency (*Percent*)

- with one exception the risk shock affects the economy primarily via its unanticipated component.
- The unanticipated component of risk is more than twice as important as the anticipated component, for GDP.
- It is four times as important in the case of consumption.
- In the exceptional case, the credit spread, the anticipated and unanticipated components of risk are of roughly equal importance.

✓ **The risk shock is particularly important for the financial variables.**

✓ **More than half the business cycle variance in the slope of the term structure is attributed to the risk shock**

III. The Risk Shock

B. Why is the Risk Shock So Important?

the risk shock generates responses that resemble the business cycle

The economic intuition

◆ **Magnifing the impact of the jump in risk through standard accelerator effects.**

risk ↑ ⟹ probability of a low ω ↑ ⟹ the interest rate charged on loans ↑ *(entrepreneurs to cover the resulting costs)*

⟹ borrowing ↓ credit ↓ ⟹ financial resources ↓ ⟹ purchase capital ↓ ⟹ investment ↓ ⟹ output consumption ↓

⟹ Capital price ↓ ⟹ net worth ↓ ⟹ **magnifies** the impact of the **jump in risk** through **accelerator effects**

- output ↓ ⟹ costs ↓ ⟹ inflation
- credit ↓ **smaller** in percentage terms than net worth ↓
  - because in these dynamic responses there is a **partially offsetting** effect on credit
  - Capital price ↓ , there is an expectation that it will return to steady state.
- prospective return on capital ↑ ⟹ credit ↑
  - The net impact of all these effects on credit is **negative**. But, the decline is **muted**, and this is why credit falls less than net worth, in percentage terms.

III. The Risk Shock

B. Why is the Risk Shock So Important?

Impulse Response Functions

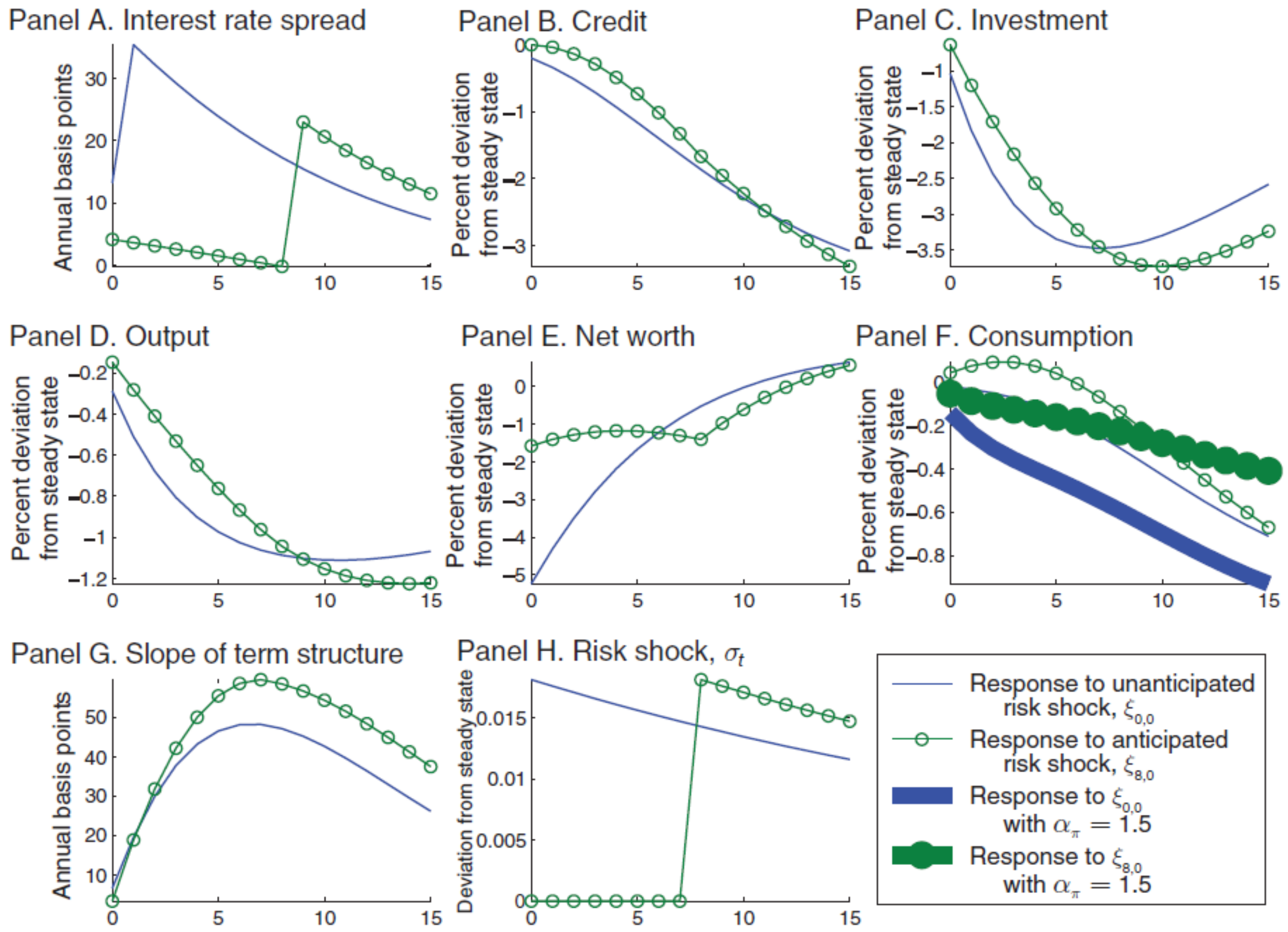


Figure 2. Dynamic Responses to Unanticipated and Anticipated Components of the Risk Shock

- the response of the credit spread is **countercyclical** in each case.
- The rise in risk in effect corresponds to an increased tax on investment, and this is why investment falls.
- In fact, consumption does rise in response to a jump in risk in the flexible wage and price version of our model.
- Consumption falls after a rise in risk in our model is that the real interest rate is not exclusively determined by market forces when wages and prices are not flexible.
- consumption falls after a rise in risk because the real interest rate falls by less than it would if wages and prices were flexible.

B. Why is the Risk Shock So Important?

Setting- Figure 2.

You have to run dynare twice. On the first run, set the Taylor rule inflation parameter to 1.5 by setting taylor1p5 = 1.

```
@# define taylor1p5 = 1
```

After running Dynare the first time, change taylor1p5 to be zero.

```
@# define taylor1p5 = 0
```

```
@# if taylor1p5 == 1
aptil_p        =   1.5;
@# else
aptil_p        =   2.396495942700000  ;
```

Note that: $\tilde{a}_\pi$ in monetary policy rule

$$(20)\ \log(1+R_t) = (1-\tilde{\rho})\log(1+R)+\tilde{\rho}\log(1+R_{t-1}) + \frac{1-\tilde{\rho}}{1+R}\left[\boxed{\tilde{a}_p}\pi\log\frac{\pi_{t+1}}{\pi_t^*}+\tilde{a}_y\frac{1}{4}\log\frac{y_t}{y}\right]+x_t^p,$$

B. Why is the Risk Shock So Important?

Dynamic Cross Correlations

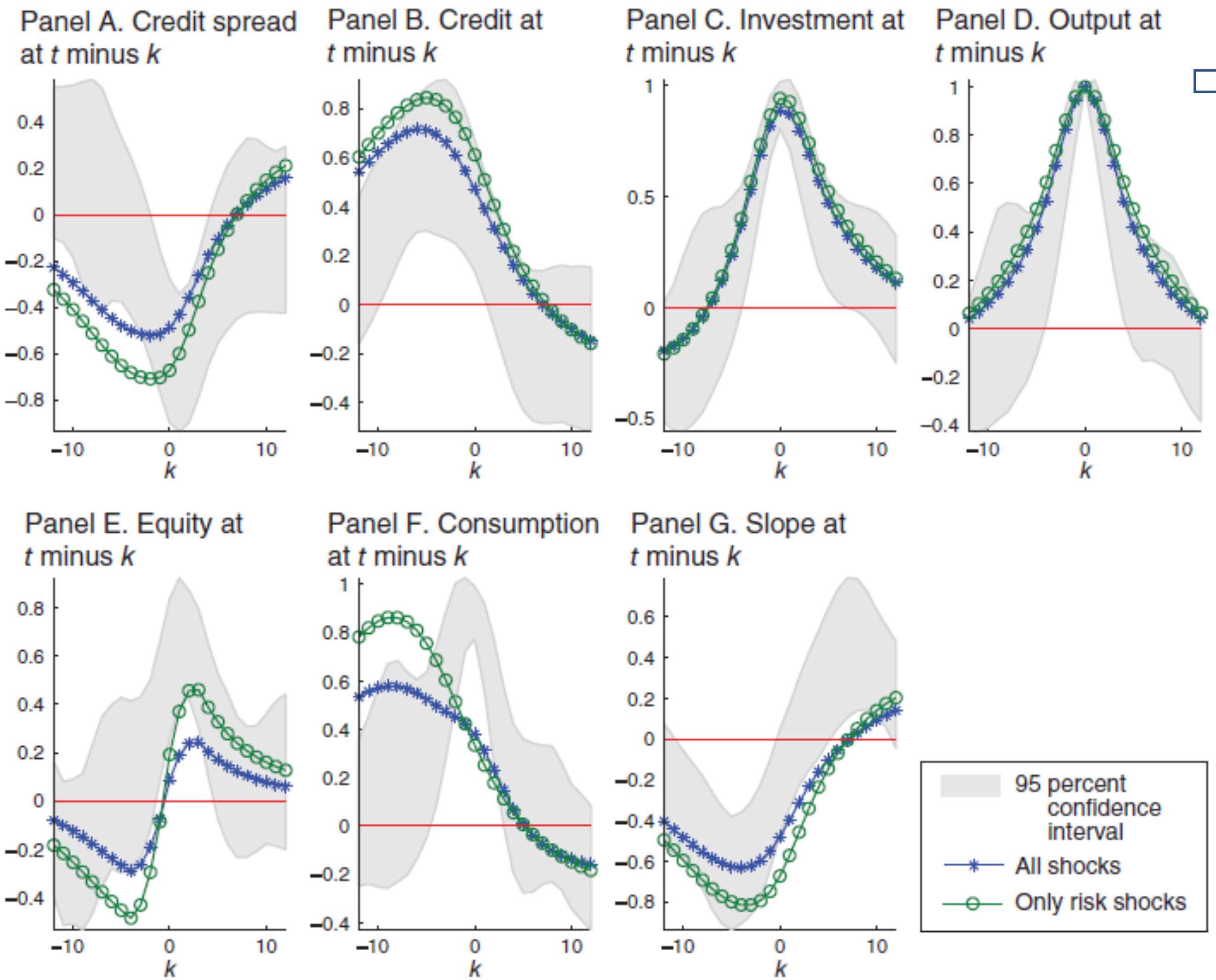


Figure 3. Selected Cross-Correlations with Contemporaneous Output, Model and Data

- First, **This illustrates how risk shocks are a dominant shock in the model.**
- Second, **they generate what looks like a business cycle.**

Code:

操作上实际上要跑两次，第一步需要设定stopshock =1，意味着**只开风险冲击**。第二次设定stopshock =0，意味着**所有冲击都打开**。

画图都集成与cross_corr这个函数里。只需要把模拟后的变量放进这个函数里，画图完成。

cross_corr(spread,ly,lc,premium,credit,li,equity,infl,saving)

当然，作者对这些模拟出来的变量，取了对数。例如，

lc=cumsum(log(consumption_obs));

lpremium=log(premium_obs);

B. Why is the Risk Shock So Important?

Which Data Account for the Importance of the Risk Shock?

TABLE 5—VARIANCE DECOMPOSITION AT BUSINESS CYCLE FREQUENCY (*Percent*)

Shock variable	*Risk* σ_t	*Equity* γ_t	*M.E.I.* $\zeta_{I,t}$	*Technol.* ε_t, $\mu_{z,t}$,	*Markup* $\lambda_{f,t}$,	*M.P.* ϵ_t	*Demand* $\zeta_{c,t}$	*Exog.Spend.* g_t
GDP	62|16|38	0	13	2	12	2	4	3
drop all fin. var	1|0|1	0	44	12	22	3	11	8
CEE	[–]	[–]	[39]	[18]	[31]	[4]	[3]	[5]
Consumption	16|3|12	0	11	3	19	2	46	3
drop all fin. var	0|0|0	0	2	15	26	3	51	2
CEE	[–]	[–]	[6]	[12]	[9]	[1]	[67]	[5]
Investment	73|18|46	0	21	0	4	1	1	0
drop all fin. var	2|0|2	0	85	2	7	2	2	0
CEE	[–]	[–]	[57]	[10]	[24]	[3]	[5]	[0]
Equity	69|23|35	2	23	0	1	2	0	0
Credit spread	95|39|42	1	3	0	0	0	0	0
Credit	64|12|46	10	17	2	4	1	1	0
Slope	56|12|38	0	17	3	8	6	2	0

- the risk shock is the most important shock driving the business cycle depends very much on the fact that we include financial variables in the analysis.
- The key thing to note is that when all financial variables are dropped, then the risk shock vanishes in importance and the marginal effciency of investment shock appears to be the most important driver of the business cycle.
- we conclude that in the absence of financial variables, it is hard to distinguish a parameterization of the model in which the risk shock is important and the marginal efficiency of investment is not important from another in which the reverse is true.

C. *Why Do Risk Shocks Drive Out Other Intertemporal Shocks?*

- Our model includes three shocks that affect intertemporal decisions: **risk,** σ_t **; the marginal efficiency of investment,** $\varsigma_{I,t}$ **; and shocks to equity,** γ_t**.**
- We find that the **risk shock is far more important than the other two shocks.**
  - For example, according to Table 5, disturbances in σ_t account for **62 percent** of the fluctuations in output while shocks to $\varsigma_{I,t}$ and γ_t account for **only 13 and 0 percent** of the business cycle component of output, respectively.
- We discuss the **reasons** for these findings below.

III. The Risk Shock

C. *Why Do Risk Shocks Drive Out Other Intertemporal Shocks?*

1.Marginal Efficiency of Investment Shock.

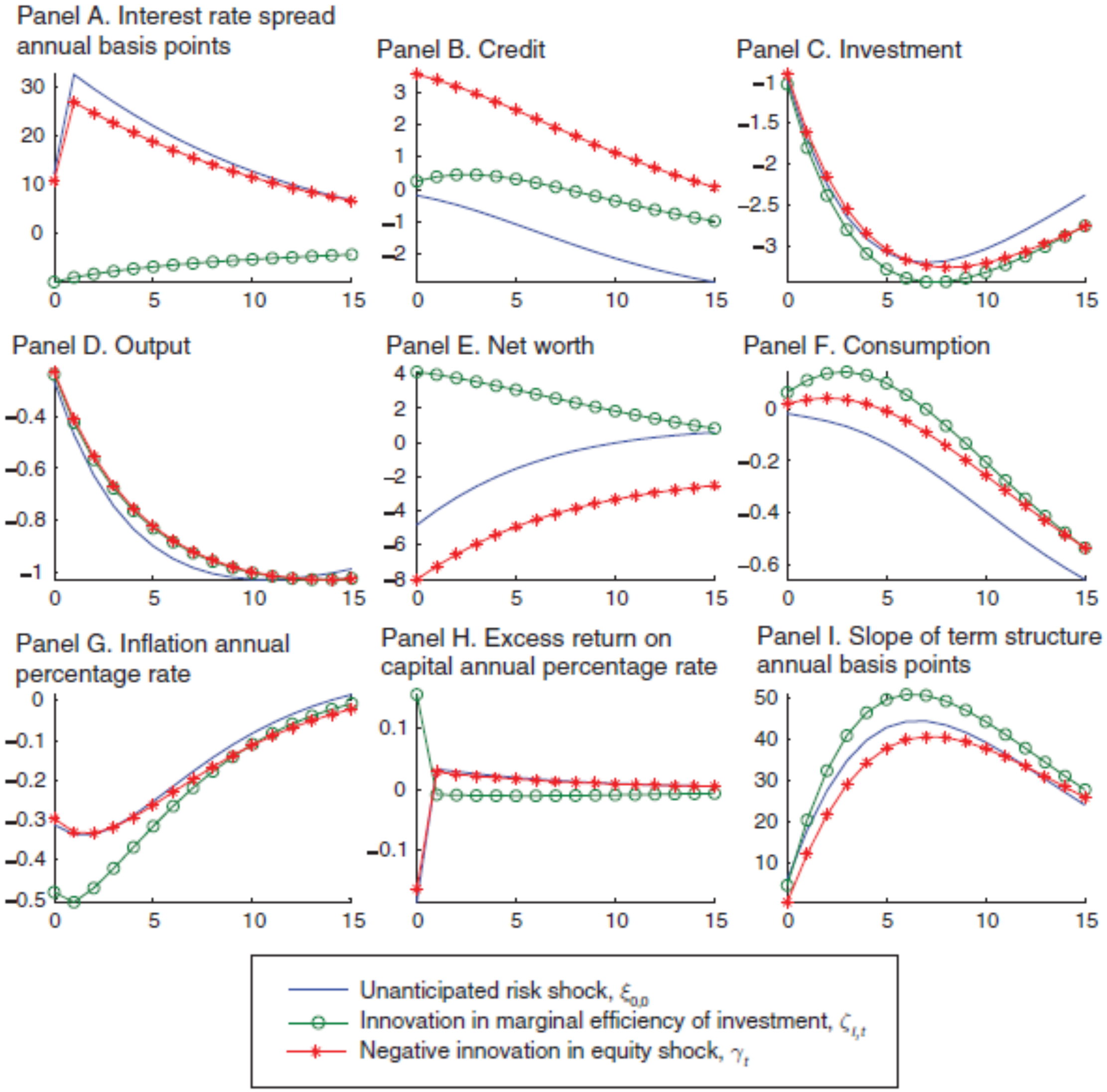


Figure 4. Dynamic Responses to Three Shocks

- it is also clear that the credit spread plays a role in differentiating between the risk shocks and $\zeta_{I,t}$ shocks.

  - Panel A: the marginal efficiency of investment predicts, counterfactually, that the credit spread is procyclical. The risk shock predicts, correctly, that the credit spread is countercyclical.
  - Panel E: the value of equity is **countercyclical**. This stands in sharp contrast to the risk shock, which, consistent with the data, implies that the value of equity is **procyclical**.
  - Panel F :that consumption is countercyclical in the first two years after a ζ *I*, *t* shock.

III. The Risk Shock

C. *Why Do Risk Shocks Drive Out Other Intertemporal Shocks?*

1.Marginal Efficiency of Investment Shock.

Intuition

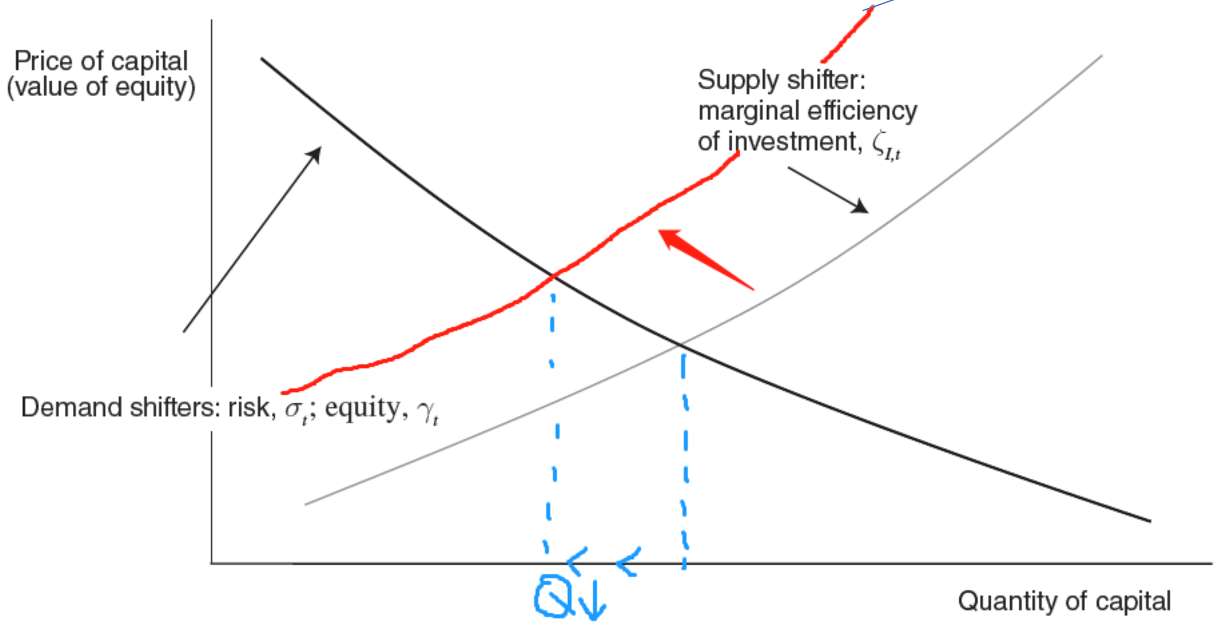


Figure 6. The Risk and Equity Shocks, versus the Marginal Efficiency of Investment

investment goods ↓ ⟹ production and employment ↓

This explains why the $\zeta_{I,t}$ shock implies that investment is **procyclical**

A similar logic: the σ and γ shocks also imply **procyclical** investment.

- The marginal efficiency of investment shock perturbs this supply curve. Entrepreneurs are the source of demand for capital.
- The demand curve is perturbed by the equity and risk shocks, γ and σ , that affect the terms of entrepreneurial loan contracts with banks.
- The price of capital is a major input determining entrepreneurs' net worth.

III. The Risk Shock

C. *Why Do Risk Shocks Drive Out Other Intertemporal Shocks?*

1.Marginal Efficiency of Investment Shock.

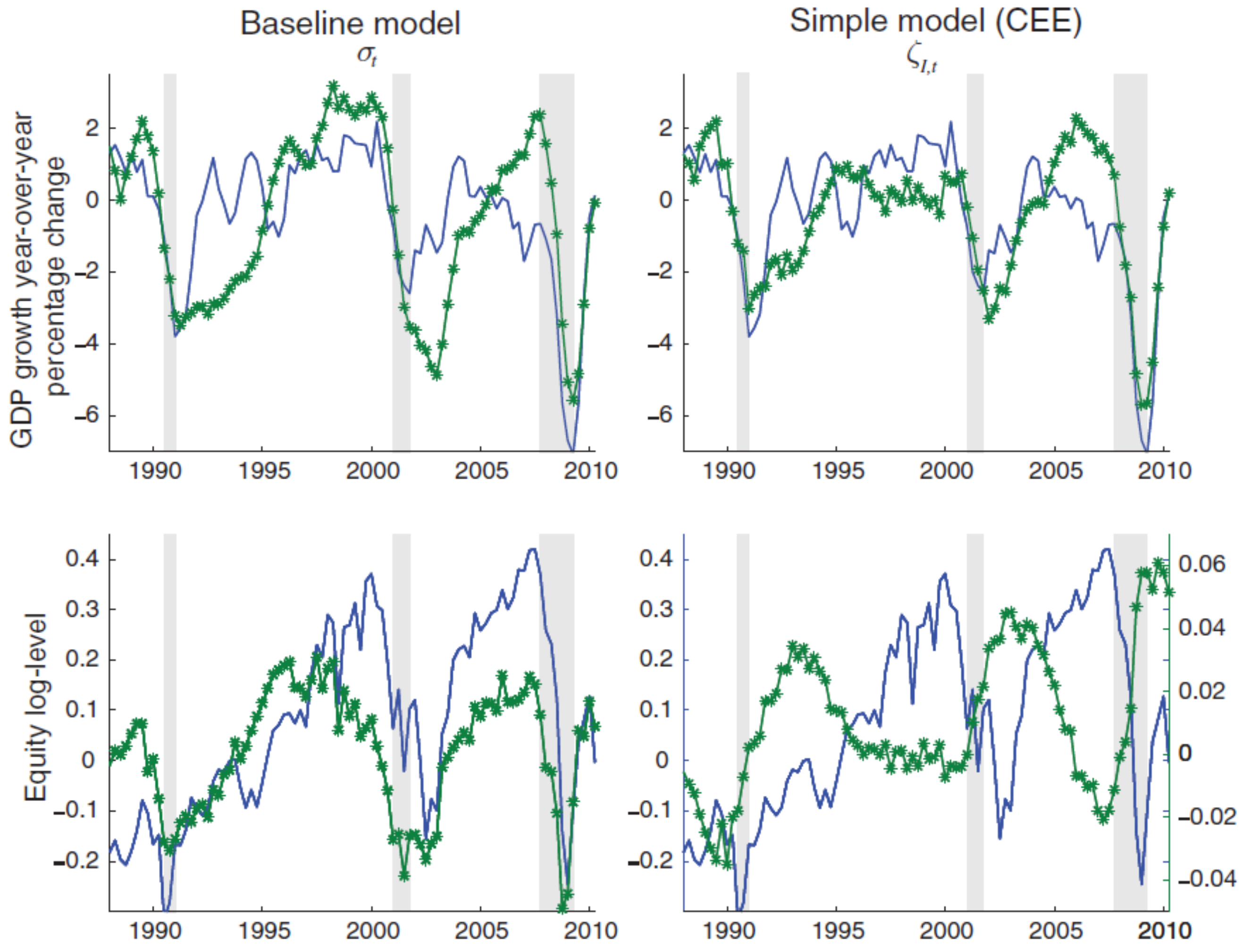


Figure 5. Historical Decompositions in Two Models

- The risk shock accounts well for the fluctuations in equity.
- In contrast, the marginal efficiency of investment shock predicts stock market booms when there are busts and busts when there are booms.

C. *Why Do Risk Shocks Drive Out Other Intertemporal Shocks?*

1.Marginal Efficiency of Investment Shock.

-code Figure4

实际上，Figure4 描述了三个冲击，在模拟之后中，我们只需要将这三个冲击对应的变量提取出来，以消费为例：

- Risk shock: cr = 100 * cumsum(consumption_obs_e_sigma);
- Maginal efficiency of investment: crmei = 100 * cumsum(consumption_obs_e_zetai) * Yr / Yrmei;
- Equity shock: crequity = -100 * cumsum(consumption_obs_e_gamma) * Yr / Yrequity;

```
plot(ss, cr(gg), ss, crmei(gg), 'o-', ss, crequity(gg), '*-')

title('F. Consumption')
```

III. The Risk Shock

C. *Why Do Risk Shocks Drive Out Other Intertemporal Shocks?*

1.Marginal Efficiency of Investment Shock.

-code Figure5

代码需要跑两遍：

To create figure 5, set cee = 1 and then run 'dynare cmr’.

Then set cee = 0 and again run 'dynare cmr’.

估计中变量选取差异，如下：

```
@# define financial_data = ["networth_obs", "credit_obs", "premium_obs", "Spread1_obs"]
varobs
@# if cee == 0
@# if some_financial_data
@# for fvar in financial_data
      @{fvar},
@# endfor
@# endif
@# endif
      inflation_obs, hours_obs,  gdp_obs,
      wage_obs, investment_obs, consumption_obs,
      Re_obs, pinvest_obs;

options_.weibull = 1;
options_.plot_priors = 0;

@# if cee == 1
estimation(datafile = data_BAAoverTB, order = 1, smoother,
              mode_file = cmr_mode_cee, loglinear, presample = 16,
              mh_replic = 0, mh_nblocks = 2, mh_jscale = 0.28,
              mode_compute = 0, nograph) gdp_obs;
@# else
estimation(datafile = data_BAAoverTB, order = 1, smoother,
              mode_file = cmr_mode, loglinear, presample = 16,
              mh_replic = 0, mh_nblocks = 2, mh_jscale = 0.28,
              mode_compute = 0, nograph) gdp_obs;
@# endif
```

Process resutls

% the following computes the historical decompositions and places them in the matrix **oo.shock_decomposition(i,j,t)**, where **i indicates the endogenous variable, j indicates the shock** (j=1,...,end-2 has the shocks, j=end-1 initial conditions and j=end raw data)

```
shock_decomposition(parameter_set = posterior_mode) gdp_obs;
close
@# if cee == 1
  cee_shock_decomposition = oo_.shock_decomposition;
  cee_oo_ = oo_;
  save('cee.mat', 'cee_shock_decomposition', 'cee_oo_');
@# else
```

提取数据：

```
load cee.mat
  gdp = squeeze(oo_.shock_decomposition(9, 22, :));
  gdp4=gdp(4:end) + gdp(3:(end-1)) + gdp(2:(end-2)) + gdp(1:(end-3));
  gdps = sum(squeeze(oo_.shock_decomposition(9, 8:16, :)), 1);
  gdps4=gdps(4:end) + gdps(3:(end-1)) + gdps(2:(end-2)) + gdps(1:(end-3));

  eval(['gdps_cee = squeeze(cee_shock_decomposition(7, 9, :));']);
  gdps4_cee=gdps_cee(4:end) + gdps_cee(3:(end-1)) + gdps_cee(2:(end-2)) + gdps_cee(1:(end-3));
  eval(['networth = cumsum(oo_.SmoothedVariables.networth_obs);']);
  networths = cumsum(sum(squeeze(oo_.shock_decomposition(21, 8:16, :)), 1));
  eval(['equity_cee = (squeeze(cee_shock_decomposition(23, 9, :)));']);
```

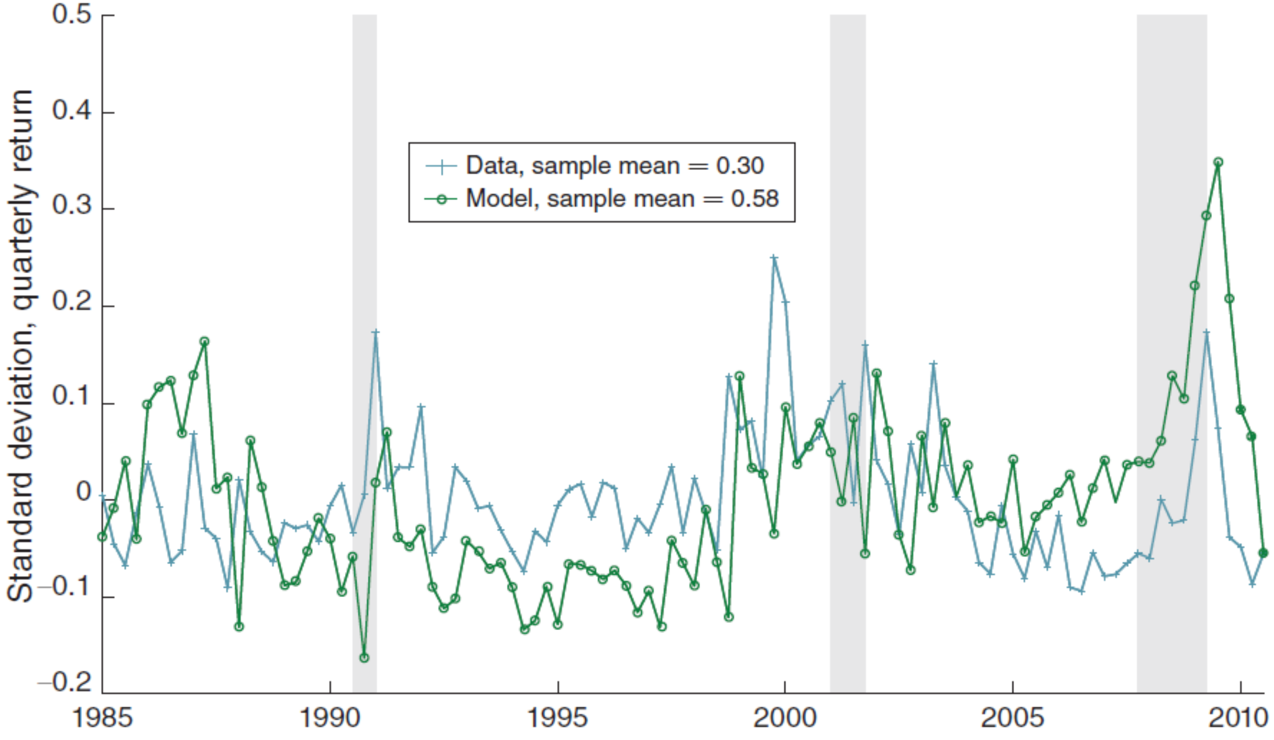
画图：

```
plot(2010.25-115/4+(1:115)/4, gdp4 * 100, '-',  2010.25-115/4+(1:115)/4, gdps4 * 100, '*-’)
plot(2010.25-115/4+(1:115)/4, gdp4 * 100, '-',  2010.25-115/4+(1:115)/4, gdps4_cee * 100, '*-')
plot(2010.25-118/4+(1:118)/4, networth, '-',  2010.25-118/4+(1:118)/4, networths, '*-');
[AX, H1, H2] = plotyy(2010.25-118/4+(1:118)/4, networth,  2010.25-118/4+(1:118)/4, equity_cee);
```

IV. Various Measures of Model Out-of-Sample Performance

- In this section, we offer a defense of the model based on various out-of-sample measures of fit.
  - We begin by examining two variables not used in our formal econometric analysis. The first of these is a measure of uncertainty recently proposed by Bloom (2009).
  - The second is an indicator of bankruptcy rates. We use our model to project these two variables onto the sample data used in model estimation.
  - We then turn to the Federal Reserve's survey of senior loan officers to test another aspect of our analysis.
  - We also examine a more conventional measure of model fit, the model's pseudoreal-time out-of-sample root mean square forecast errors (RMSE).

A. *Implications for Uncertainty*



Bloom (2009) points to cyclical variation in the cross-sectional standard deviation of firm-level stock returns as evidence of the importance in business cycles of what he calls uncertainty.

Figure 7. Time Series, Cross Section Standard Deviations of Quarterly Rates of Return Model and Data (*Nonfinancial firm equity, CRSP*)

A. *Implications for Uncertainty*

-Figure7 code

- 贝叶斯估计：

```
estimation(datafile = data_BAAoverTB, order = 1, smoother,
           mode_file = cmr_mode, loglinear, presample = 16,
           mh_replic = 0, mh_nblocks = 2, mh_jscale = 0.28,
           mode_compute = 0, nograph) volEquity;
```

- 提取数据，再hp滤波：

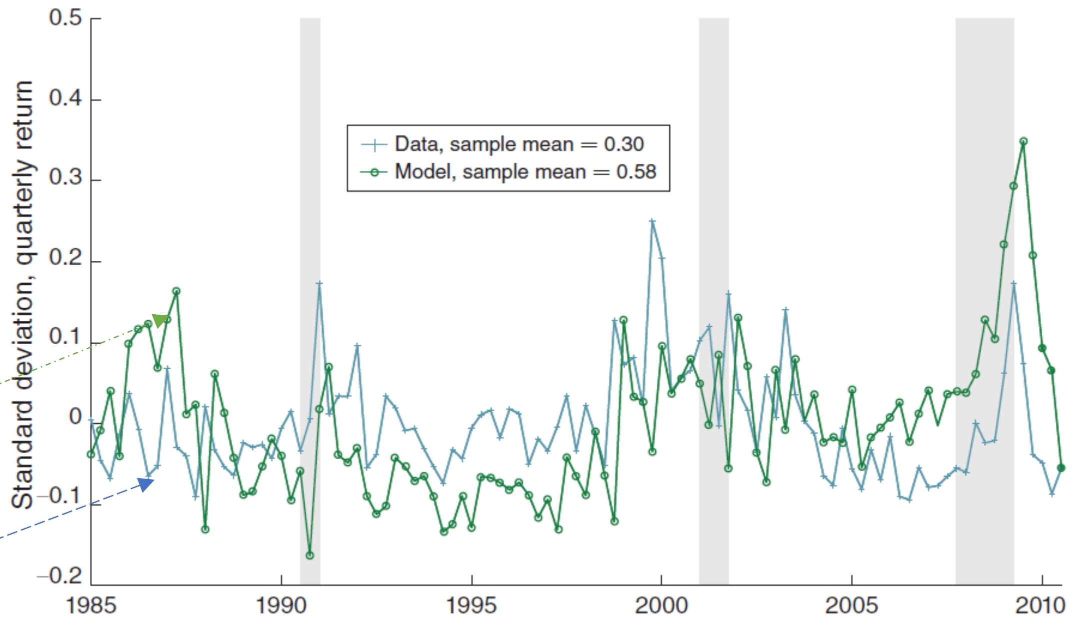
```
hps=1600;
voleq = oo_.SmoothedVariables.volEquity;
```

hpfast是作者自己写的hp滤波函数，：

```
[datad,datat]=hpfast(var_ret_nfin(tt),hps);
[modeld,modelt]=hpfast((voleq(ttt)+1) * voleq_ss,hps);
```

- 画图：

```
plot(dd(tt),modeld,'o-',dd(tt),datad,'*-',dd(tt),zeros(length(tt),1));
```



B. *Implications for Bankruptcy Rates*

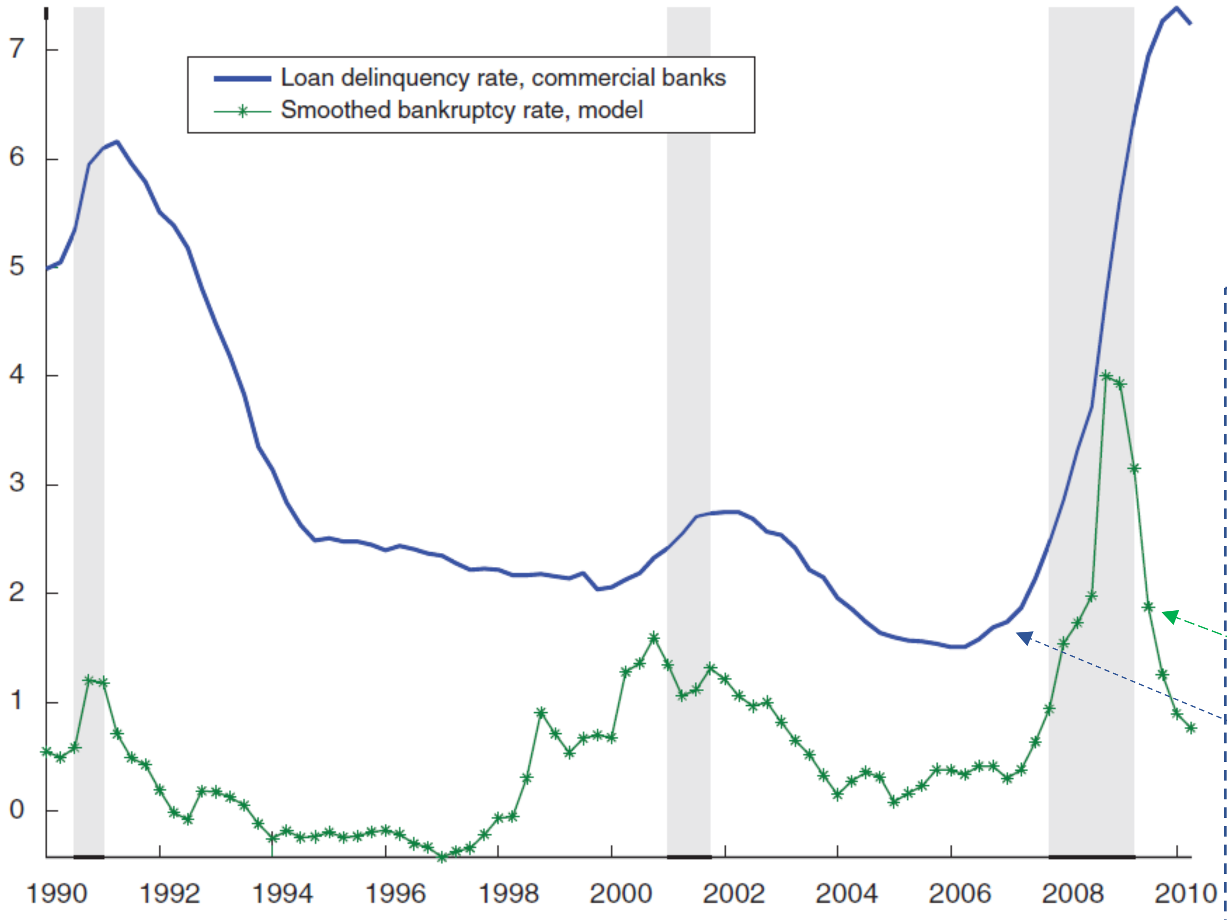


Figure 8. Model Bankruptcy Rate versus Loan Delinquency Rate

For our second out-of-sample test of the model, we use the two-sided Kalman smoother to estimate the period *t* default rate, $F_{t-1}(\bar{\omega}_t)$ implied by our model and compare it with the delinquency rate on all loans extended by commercial banks.

代码说明：

- 贝叶斯估计

```
estimation(datafile = data_BAAoverTB, order = 1, smoother,
          mode_file = cmr_mode, loglinear, presample = 16,
          mh_replic = 0, mh_nblocks = 2, mh_jscale = 0.28,
          mode_compute = 0, nograph) volEquity;
```

- 提取数据：

bankr=100*(**oo_.SmoothedVariables.bankruptcy**+1) * **Fomegabar_p**;

Fomegabar_p这里为0.0056

- 画图

plot(dates(tt),**delinq**(tt),'-',dd,**bankr**,'*-')

C. *Senior Loan Officer Opinion Survey*

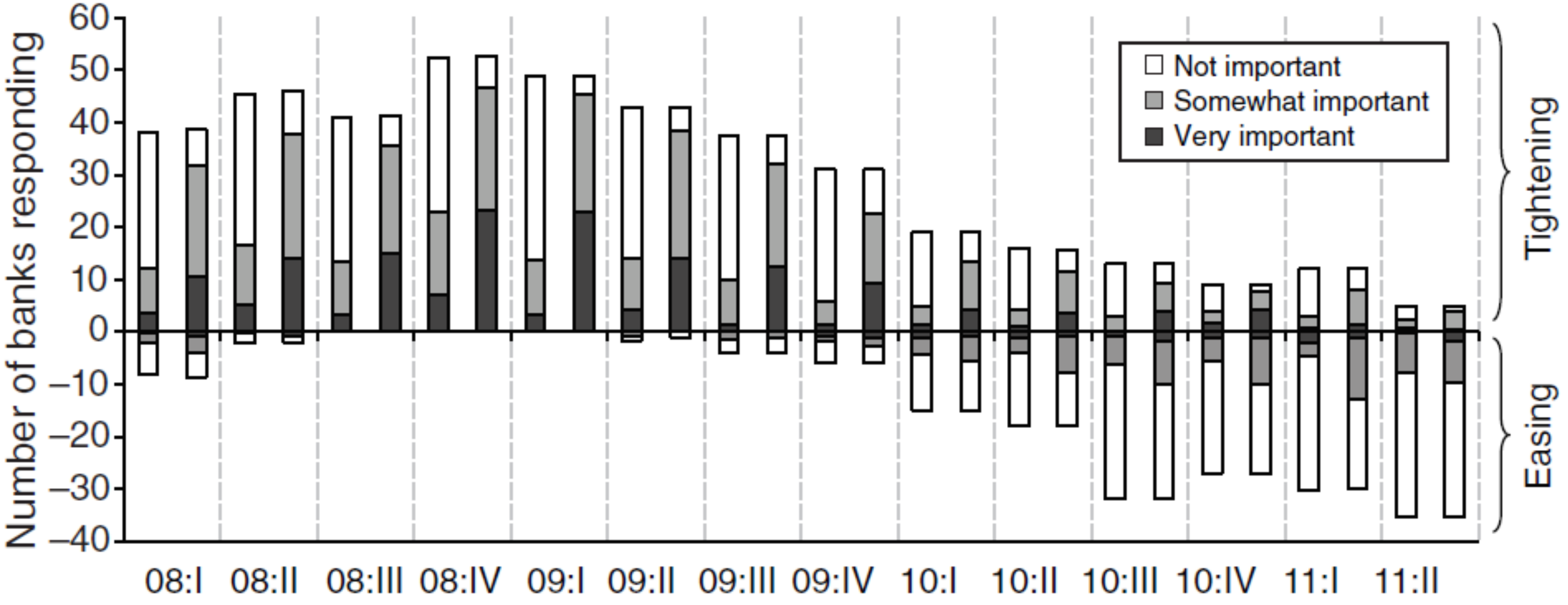


Figure 9. Contribution of Bank Balance Sheet Factors and Nonfinancial Firm Macroeconomic Factors to Tightening/Easing

- The key result is that the black and gray areas extend further for the bars on the right than for the bars on the left.
- That is, changing conditions outside banks' Balance sheets are relatively more important than changes in banks' own balance sheets in determining whether banks tighten or ease credit conditions.

V. Conclusion

- we conclude that the **risk shock accounts for a large share of the fluctuations** in GDP and other macroeconomic variables.
- Our analysis assumes that variations in risk are **exogenous.** Presumably, in reality there is a large **endogenous** component to risk shocks.
- Understanding these endogenous components is an important task for future research.