Coordination Failure & the Financial Accelerator

Oliver de Groot

Federal Reserve Board

August 11, 2014

Disclaimer: The views expressed are solely mine & do not necessarily reflect those of the Federal Reserve Board or its staff. All errors are mine alone.

Coordination problems are pervasive across credit markets

- Affects firms' access to finance when borrowing from multiple banks
  - Hertzberg, Liberti, & Paravisini (2011)
- Bankruptcy laws try to prevent disorderly (costly) liquidation of assets
  - Chapter 11 in U.S
- Liquidity dry ups in commercial paper markets
  - Penn Central bankruptcy 1970, LTCM crisis 1998, Enron scandal 2002
  - U.S. CPFF in 2009. No issuer defaulted on its debt obligations.
- Financial sector bank / credit runs
  - Northern Rock, Bear Sterns, Lehman Brothers
  - Pre-crisis increase in maturity transformation of shadow banking sector
  - Exposed many institutions to illiquidity (rollover) risk

Build model of maturity mismatch, illiquidity risk & credit cycle

- Model
  - Standard DSGE model
    +
  - **Coordination game among intermediaries in credit market**
- Impulse responses
  - Significant amplification of **technology shocks**
  - **Illiquidity shocks** cause large contractions
- Policy experiment
  - **Direct lending**:
    - Weakly dampens effect of illiquidity shocks
  - **Equity injections**:
    - Strongly dampens contemporaneous effect of illiquidity shocks
    - Increases the persistence of illiquidity shocks

Literature review

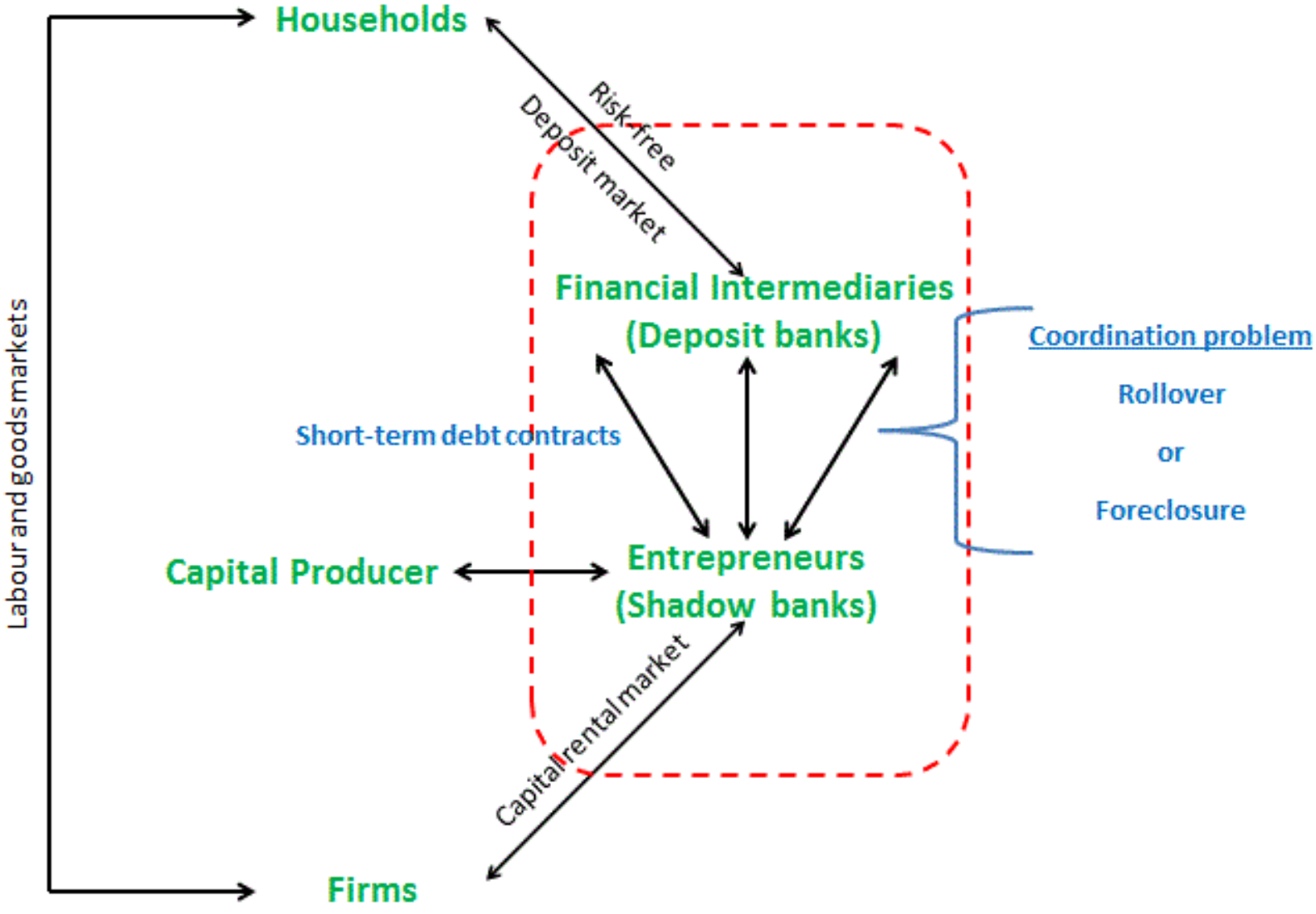
- **Empirical literature:** Bagehot (1873), Jackson (1986), Bruche & González-Aguado (2010), Kacperczyk & Schnabl (2010), Blazy & Nigam (2011), Hertzberg, Liberti, & Paravisini (2011)

- **Coordination games:** Diamond & Dybvig (1983), Carlsson & van Damme (1993), Morris & Shin (2003, 2004), Rochet & Vives (2004), Goldstein & Pauzner (2005)

- **Financial frictions:** Bernanke & Gertler (1989), Carlstrom & Fuerst (1997), Kiyotaki & Moore (1997), Bernanke, Gertler, & Gilchrist (1999)

- **The crisis & policy responses:** Sargent & Wallace (1982), Gertler & Karadi (2011), Cúrdia & Woodford (2010), Reis (2010)

DSGE model with coordination problem in credit market



2 stylized features of coordination problems

1. Maturity mismatch on entrepreneurs' balance sheet
   Liquid liabilities (short-term debt) & illiquid assets (physical capital)

2. Multiple lenders, unable to coordinate their actions
   Intermediaries' decision: rollover or foreclose

2 effects on the system of equilibrium equations:

1. Drive endogenous wedge between return on capital & risk-free rate
   Illiquidity premium increasing in entrepreneurial leverage

$$E_t R^E_{t+1} \geq R_{t+1}$$

2. Entrepreneurs capture rents
   Endogenous entrepreneurial net worth equation, N_{t+1}

- **At end of** t
  - Entrepreneurs homogenous, except for $N_{t+1}(e)$
  - Purchase $Q_t K_{t+1}(e)$ by borrowing $B_{t+1}(e) = Q_t K_{t+1}(e) - N_{t+1}(e)$
- **At start of** $t+1$
  - Aggregate state of world realized
  - Entrepreneurs receive their idiosyncratic productivity, $\omega_{t+1}(e)$
    - $i.i.d.$ across time & entrepreneurs with $E(\omega) = 1$
    - If not foreclosed, transform capital from $K_{t+1}(e)$ to $\omega_{t+1}(e) K_{t+1}(e)$
  - Intermediaries receive signal

$$\widetilde{\omega}_t(f, e) = \omega_t(e) + \varepsilon_t(f) \text{ where } \varepsilon_t(f) \sim U\left[-\overline{\varepsilon}, \overline{\varepsilon}\right] \ \& \ \overline{\varepsilon} \to 0$$

- **In middle of** $t+1$
  - Intermediaries decide whether to rollover or foreclose
    - Depends on signal received relative to some threshold, ω_t^*
    - Foreclosing intermediaries receive $K_t(f)$ & rent out $\gamma K_t(f)$

Intermediaries' payoffs

- Entrepreneur owns K units of capital, of which λK is "liquid". $0 < \lambda < 1$.
- Suppose a proportion, $0 < p < 1$ intermediaries foreclose.
- Face value of the (rolled over) debt: $\overline{\omega} R^E QK$.
- Foreclosing intermediary gets $\overline{\omega} K$ units of capital if $\lambda > p\overline{\omega}$ (& $\frac{\lambda}{p} K$ otherwise).
- The entrepreneur is left with $\left(1 - \frac{p\overline{\omega}}{\lambda}\right) K$ units of captial if $\lambda > p\overline{\omega}$ (& 0 otherwise).

Intermediaries' payoffs

- $0 < \gamma < 1$ is the intermediaries' "productivity".
- Gross return for foreclosing intermediary: $\gamma \overline{\omega} R^E QK$ if $\lambda > p\overline{\omega}$ (& $\gamma \frac{\lambda}{p} R^E QK$ otherwise).
- Gross return for entrepreneur: $\omega \left(1 - \frac{p\overline{\omega}}{\lambda}\right) R^E QK$ if $\lambda > p\overline{\omega}$ (& 0 otherwise).
- Gross return for rolled over intermediary: $\overline{\omega} R^E QK$ if $\omega \left(1 - \frac{p\overline{\omega}}{\lambda}\right) > \overline{\omega}$ (& $\omega \left(1 - \frac{p\overline{\omega}}{\lambda}\right) R^E QK$ otherwise).

Intermediaries' problem

Rollover or foreclosure

- Intermediary f's payoff from investing in entrepreneur e is

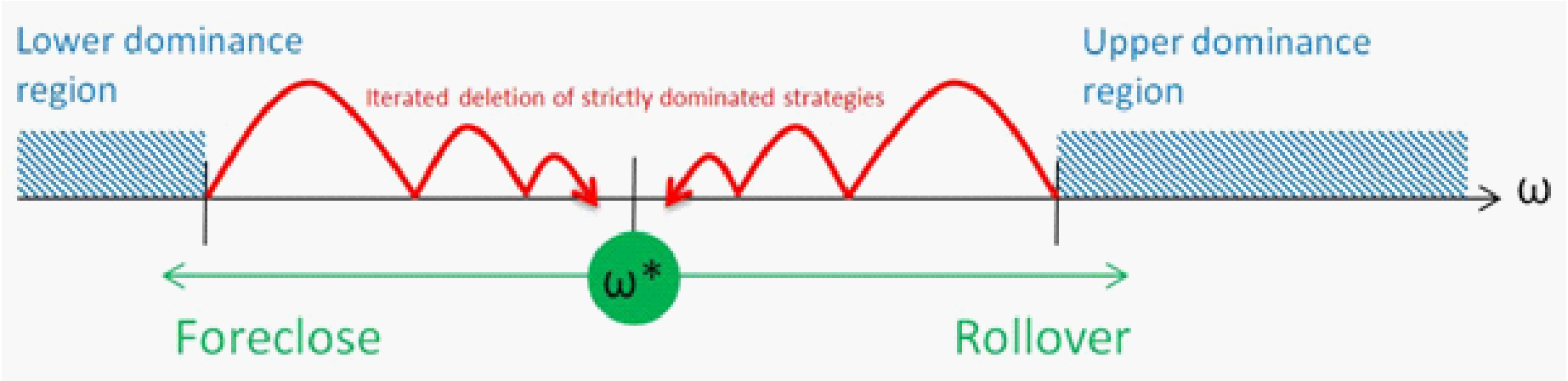
$$x_t R_t^E Q_{t-1} K_t(e) \text{ where } x_t \text{ is}$$

Rollover	**Foreclosure**	
$\overline{\omega}$	$\gamma\overline{\omega}$	when $0 \leq p \leq \frac{\lambda}{\overline{\omega}}$ & $\omega \geq \frac{\overline{\omega}(1-p)\lambda}{\lambda - p\overline{\omega}}$
$\frac{\omega}{(1-p)}\left(1 - \frac{p\overline{\omega}}{\lambda}\right)$	$\gamma\overline{\omega}$	when $0 \leq p \leq \frac{\lambda}{\overline{\omega}}$ & $\omega < \frac{\overline{\omega}(1-p)\lambda}{\lambda - p\overline{\omega}}$
0	$\frac{\gamma\lambda}{p}$	when $\frac{\lambda}{\overline{\omega}} < p \leq 1$

Unique (symmetric) switching threshold

Key Result The "game" among intermediaries has a unique (symmetric) switching strategy equilibrium, with intermediaries foreclosing for all realizations of $\omega_t(e) < \omega_t^*$ & rolling over for $\omega_t(e) > \omega_t^*$

$$\omega_t^* = \gamma\lambda_t \frac{\frac{\lambda_t}{\overline{\omega}_t}\left(1 - \ln\left(\frac{\lambda_t}{\overline{\omega}_t}\right)\right)}{\frac{\lambda_t}{\overline{\omega}_t} + \left(1 - \frac{\lambda_t}{\overline{\omega}_t}\right)\ln\left(1 - \frac{\lambda_t}{\overline{\omega}_t}\right)}$$



Inefficiency of the coordination problem

Definition Let $\omega^*_{t,eff}$ be the switching threshold if intermediaries could costlessly coordinate their actions

$$\omega^*_{t,eff} = \gamma\lambda_t$$

Key Result *The non-coordination outcome is inefficient:*

$$\omega^*_t > \omega^*_{t,eff}$$

Intermediaries will foreclose on some entrepreneurs, for which it would have been efficient to rollover.

Entrepreneurs' problem

Intermediaries' payoff

$$\underbrace{\left(\overline{\omega}_t \int_{\overline{\omega}_t}^{\infty} f(\omega)\, d\omega\right)}_{\text{i. Rollover pay in full}} + \underbrace{\int_{\omega_t^*}^{\overline{\omega}_t} \omega f(\omega)\, d\omega}_{\text{ii. Rollover don't pay in full}} + \underbrace{\gamma\lambda_t \int_0^{\omega_t^*} f(\omega)\, d\omega\Big)}_{\text{iii. Foreclosure}} R_t^E Q_{t-1} K_t(e)$$

Rewrite

$$\left(\Gamma(\overline{\omega}_t) - G(\omega_t^*)\right) R_t^E Q_{t-1} K_t(e)$$

where

$$\begin{aligned} \Gamma(\overline{\omega}_t) &= \overline{\omega}_t \int_{\overline{\omega}_t}^{\infty} f(\omega)\, d\omega + \int_0^{\overline{\omega}_t} \omega f(\omega)\, d\omega \\ G(\omega_t^*) &= \int_0^{\omega_t^*} (\omega - \gamma\lambda_t) f(\omega)\, d\omega \end{aligned}$$

where $G(\omega_t^*)$ is the deadweight cost of coordination failure

Entrepreneurs' problem

Problem

Choose $Q_t K_{t+1}(e)$ & (aggr.state-contingent) $\overline{\omega}_{t+1}$

max expected profits

s.t. intermediaries' participation constraint

Solution (Aggregate) illiquidity premium / leverage tradeoff

$$\frac{E_t R^E_{t+1}}{R_{t+1}} = \Xi\left(\frac{Q_t K_{t+1}}{N_{t+1}}, \lambda_{t+1}\right) \quad \text{where} \quad \Xi_1(.) > 0$$

(Aggregate) net worth dynamics

$$N_{t+1} = v\left(\left(1 - G\left(\omega^*_{t+1}\right)\right) R^E_t Q_{t-1} K_t - R_t\left(Q_{t-1} K_t - N_t\right)\right)$$

Bernanke, Gertler, & Gilchrist (1999)

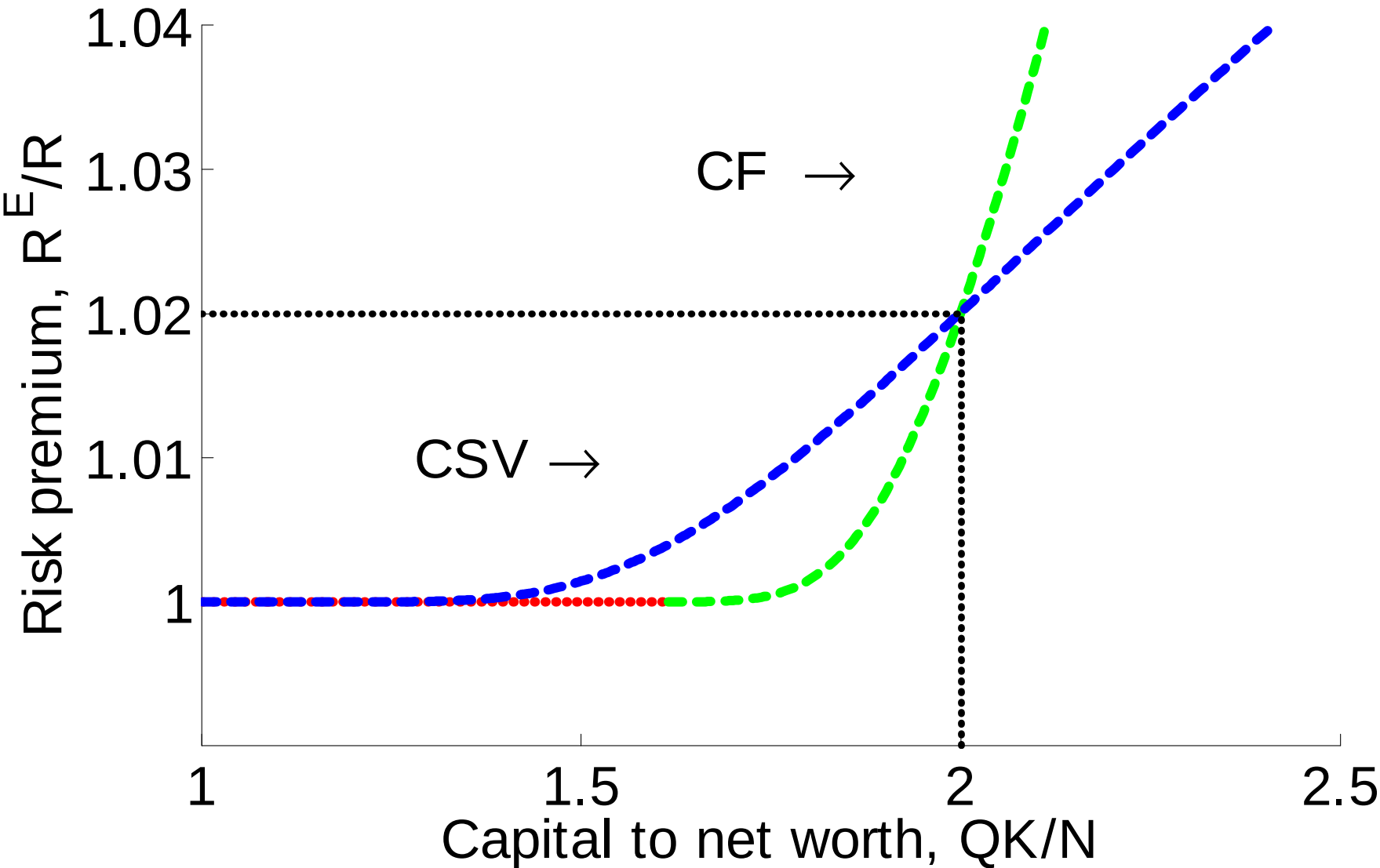
- The reduced form model bares a resemblance to

  "The financial accelerator in a quantitative business cycle framework"

- Friction: Costly state verification (CSV)
  Townsend (1979)

- "Long-term" debt with intermediaries unable to observe entrepreneurs' returns without paying a monitoring cost

Risk premium - leverage ratio tradeoff



Parameterization

- Standard values for the common DSGE model parameters

	Moment	Description	Value	Source
1.	$R^E - R$	Risk premium†	2%	Bernanke et al (1999)
2.	$F(\overline{\omega})$	Bankruptcy rate††	3%	Bernanke et al (1999)
3.	K/N	Capital to net worth ratio	2	Bernanke et al (1999)
4.	$\int_0^{\omega^*} \frac{\gamma\lambda}{\omega} f(\omega)\, d\omega$	Average recovery ratio of liquidated assets	50%	Berger et al. (1996)

† Spread between the prime lending rate & the six month Treasury bill rate. †† Annualized

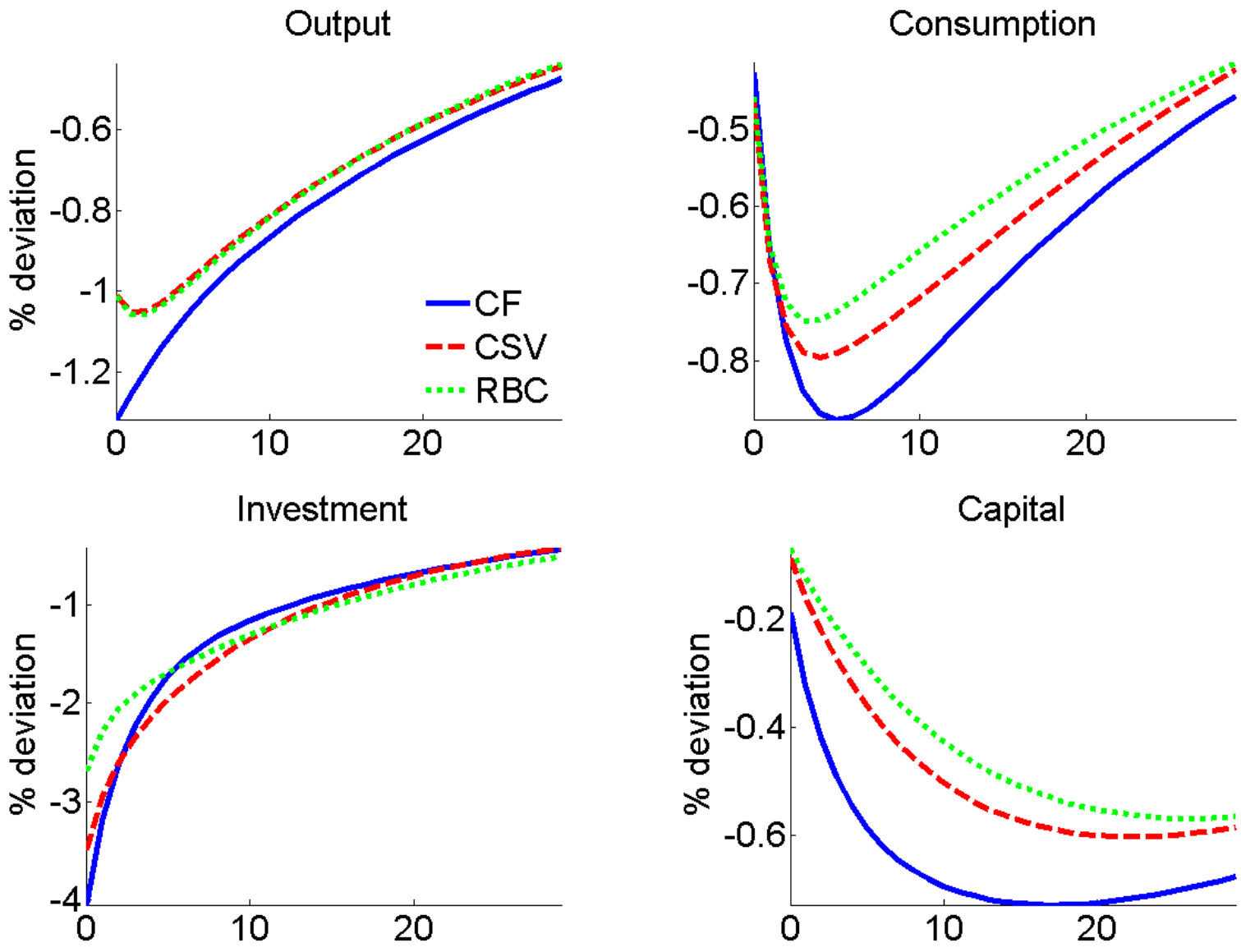
Parameterization

Parameter	Description	Value
v	Entrepreneur survival probability	0.954 (0.956)
σ_ω^2	Variance of idiosyncratic shock	0.119 (0.118)
γ	Productivity of financial intermediaries	0.445 (−)
λ	Intra-period liquidity of capital	0.380 (−)
μ	Monitoring cost	− (0.166)

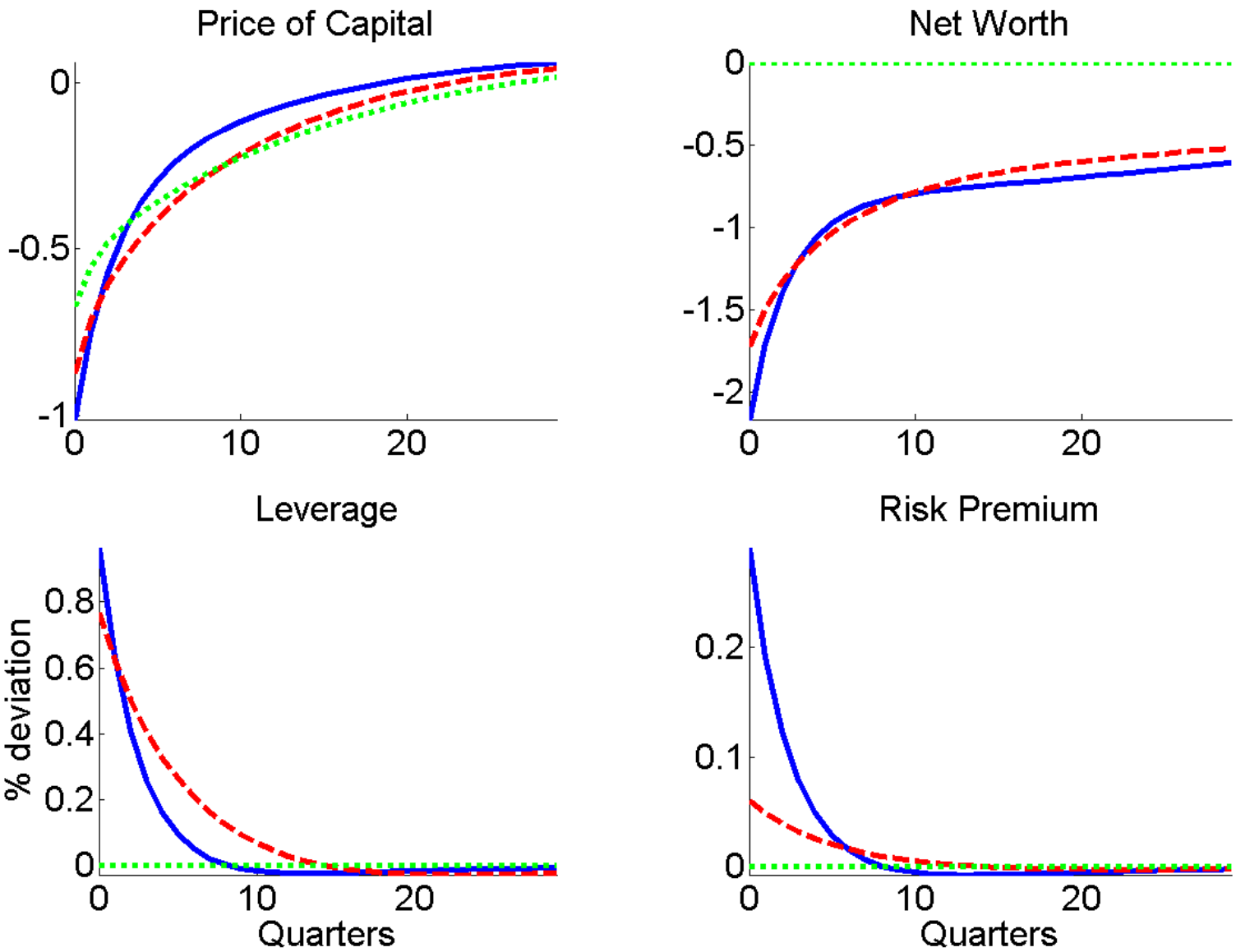
† Values in brackets refer to the parameterization of the CSV model

- Linearized trade-off between leverage & risk premium is 0.299 in CF vs. 0.095 in CSV.

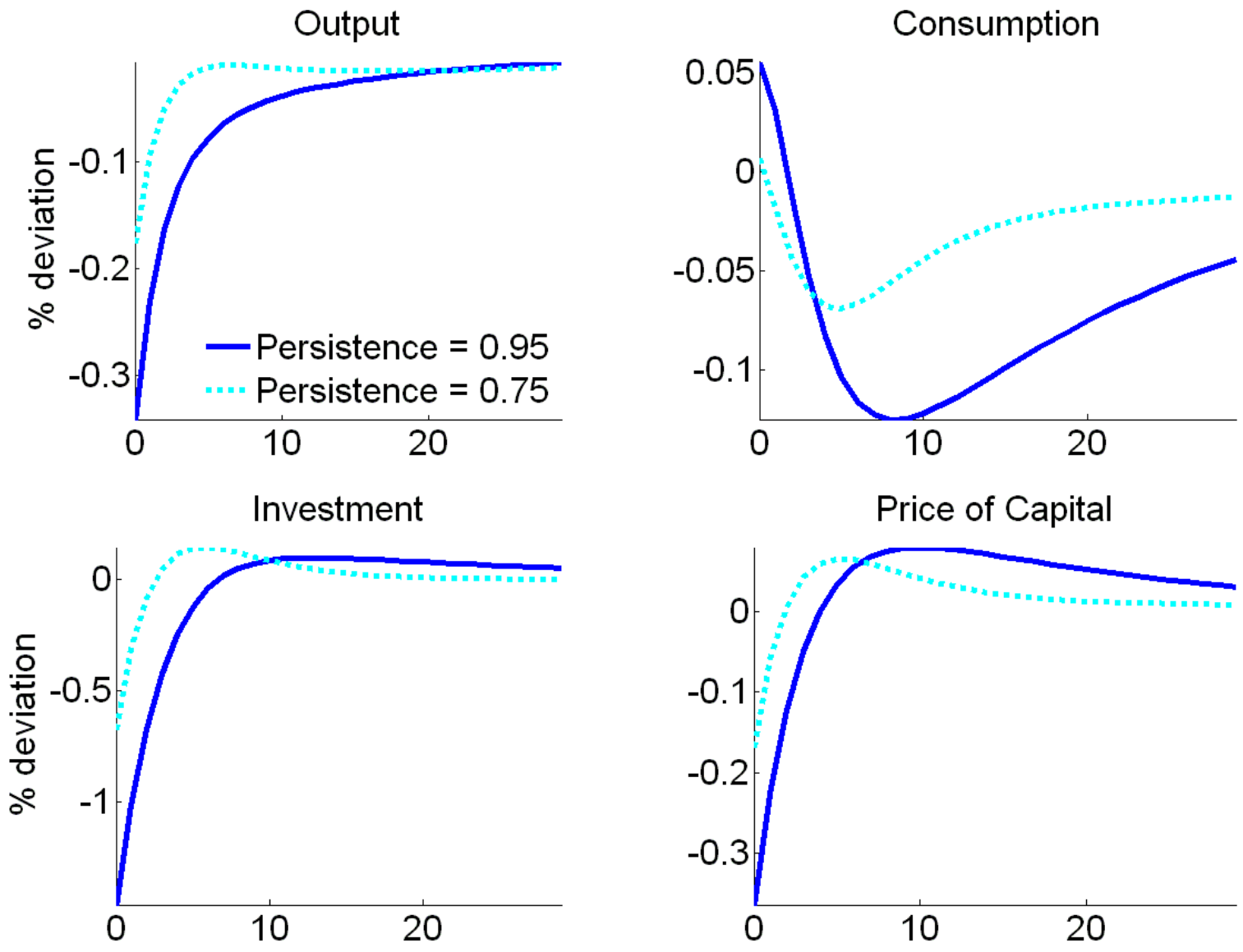
1% negative technology shock



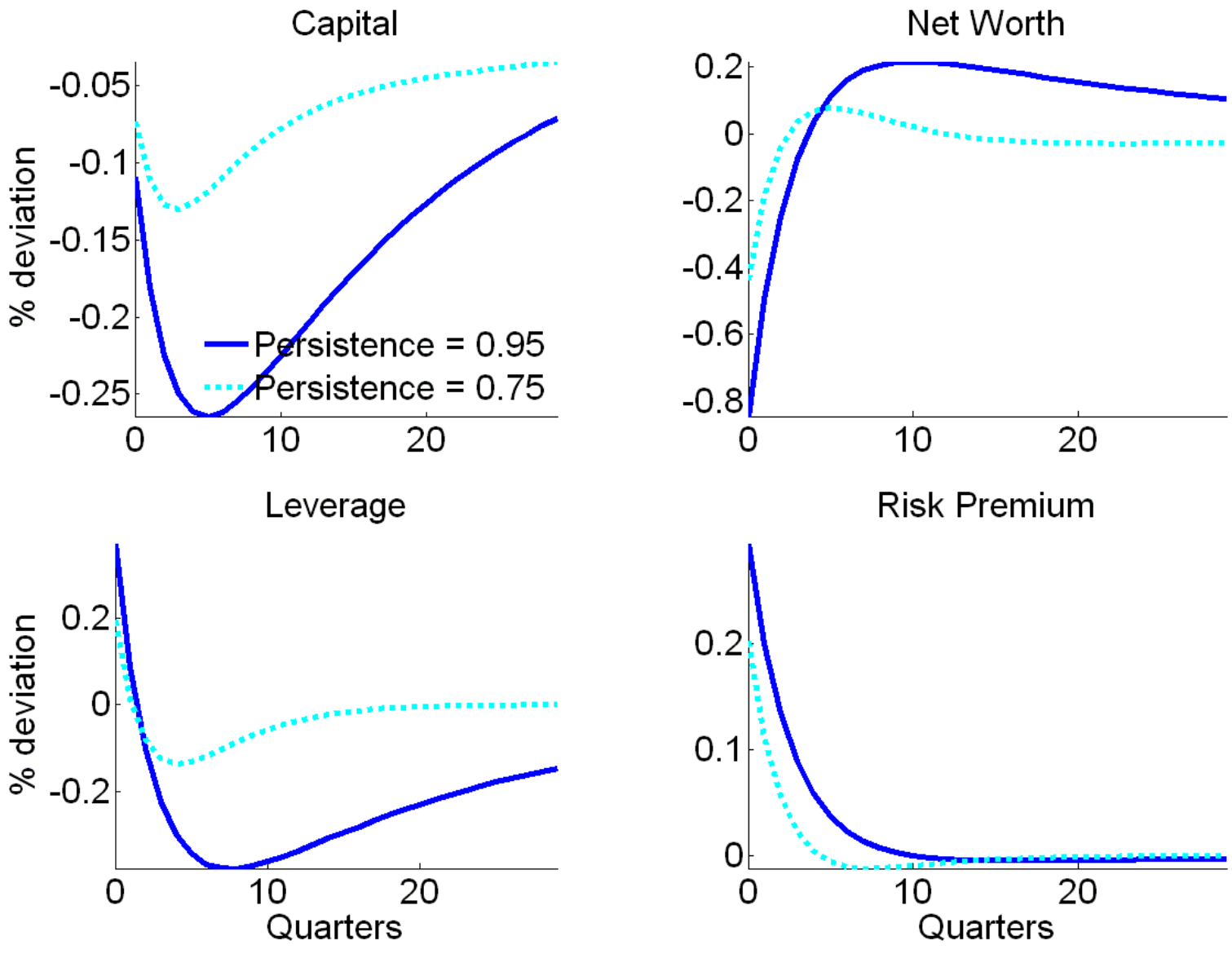
1% negative technology shock



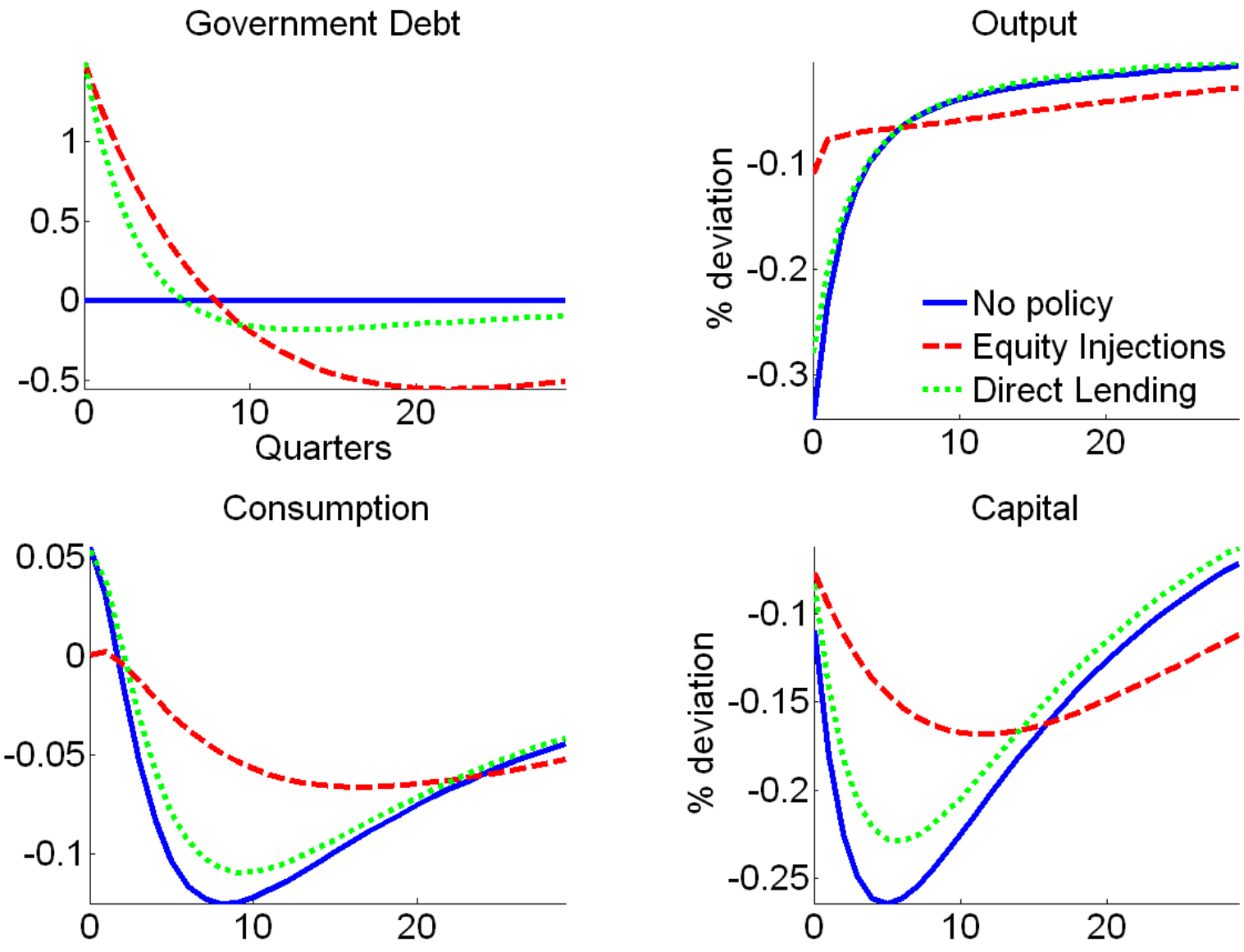
1% fall in liquidity



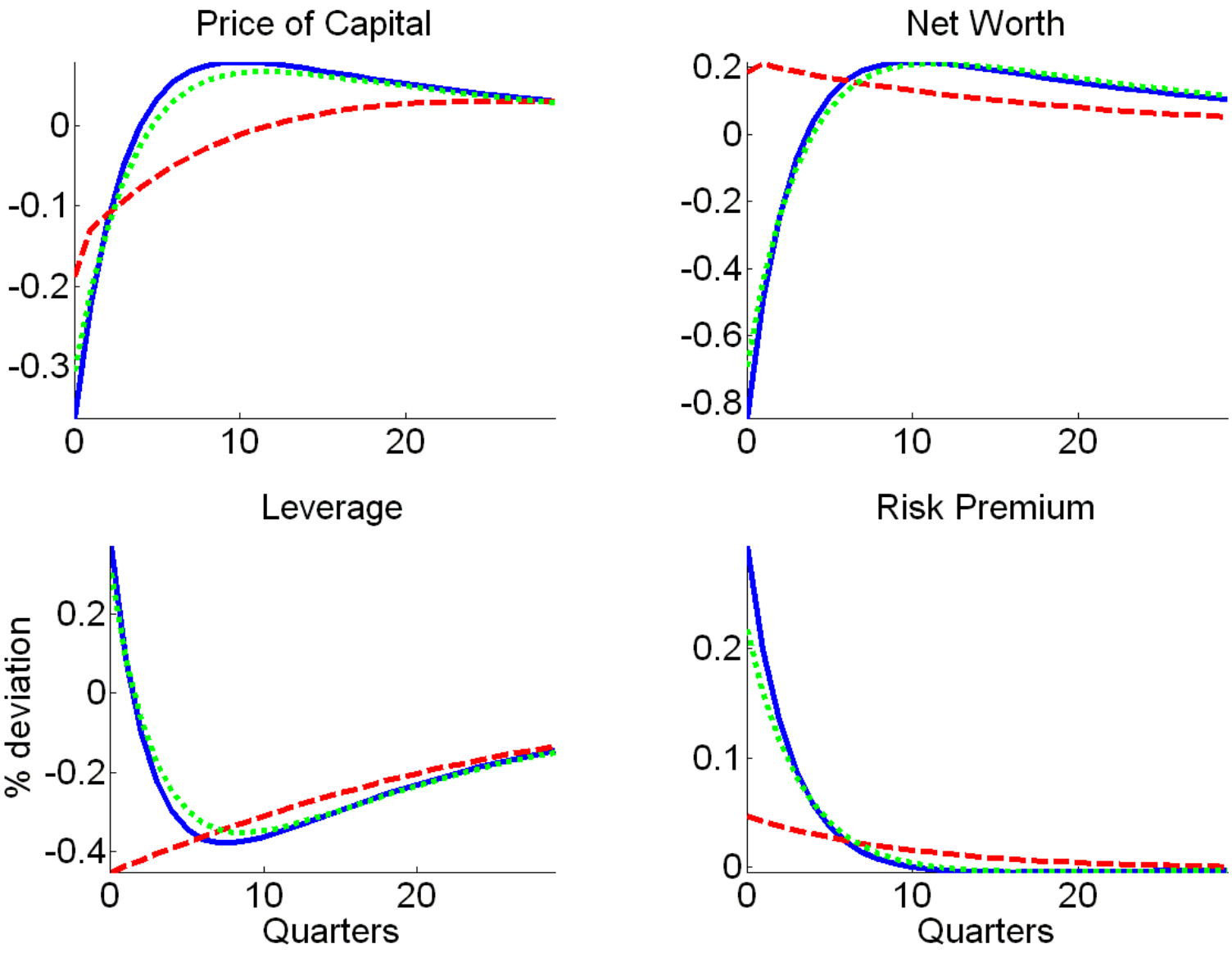
1% fall in liquidity



Credit policy responses to an illiquidity shock



Policy responses to an illiquidity shock



Summary

- Coordination problems in credit markets in a DSGE model
- Coordination failure causes
  - Amplification of technology shocks
  - Contractionary effects on output of illiquidity shocks
- Policy implications
  - Equity injections may be a powerful tool in the near term to stem a crisis
  - Equity injections, however, can lead to longer term problems

Parameter	Description	Value
Non-financial sector		
α	Output elasticity w.r.t. capital	0.35
β	Subjective discount factor	0.99
δ	Depreciation of capital	0.025
h	Habit parameter	0.5
χ	Weight on labor in the utility function	5.6
ρ	Inverse Frisch elasticity of labour supply	3
φ	Price of capital elasticity w.r.t. investment to capital ratio	0.25
ρ_A	Technology shock persistence	0.95