Macro models with a financial sector

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Based on Gersbach et al.(2017)

"FINANCIAL INTERMEDIATION AND CAPITAL ACCUMULATION"

Recessions and crises: some stylized facts

During recessions and financial crises:

- Volume of loans decreases but bonds increase (Kashyap Stein Wilcox 1993).
- Interest rates (both on loans and bonds) increase (Adrian Colla Shin 2012).
- Bank leverage is pro-cyclical (Adrian and Shin 2008).

Both bank loans and bonds are qualitatively important in the financing of firms.

This paper

- Develops a simple equilibrium model with two types of financing: bank loans and bonds.
- Dynamic extension of Gersbach-Rochet (2017)
- In this model, financial frictions generate pro-cyclical bank leverage (Adrian-Shin 2008).
- Dynamic extension captures the impact of leverage pro-cyclicality on growth and amplification of real and financial shocks.

This paper (2)

- Simple Ramsey model of capital accumulation with two types of capital (informed-uninformed).
- Financial frictions slow down convergence to steady state and distort capital allocation in the long run.
- Different speeds of recovery from different shocks (productivity, banking crisis, stock market crash).
- Derives policy implications for financial stability, both ex-ante (bank capital regulation) and ex-post (crisis management and capital injections).

Literature

New DSGE models with an explicit banking sector look at impact of financial frictions on:

- Efficiency of monetary policy: Gertler Kiyotaki (2010), Gertler Karadi (2011)
- Role of bank capital in propagating shocks: Angeloni Faia (2013) Meh Moran (2010), Rampini Visvanathan (2014)
- Bank leverage cycles and crises: Adrian-Boyarchenko (2012), Brunnermeier Sannikov (2014)

Objective of the paper

- Parsimonious model where long term impact of financial frictions can be analyzed.
- Objective is not to guide monetary policy nor to study credit cycles.
- Rather we want to derive policy implications for financial stability: crisis prevention (capital requirements) and crisis management (capital injections).

OUTLINE

1. Model
2. Static equilibrium
3. Dynamic equilibrium
4. Impact of shocks
5. Policy Implications

MODEL

Discrete time (*t=0,1,2,…*) Ramsey model with:

- two goods (consumption/capital and labor),

- two sectors:

  large/mature firms financed by bonds,
  small/young firms financed by bank loans.

- Capital depreciates at rate δ.

MODEL (2)

Four types of competitive agents:

- Workers (each supplies one unit of labor).
- Entrepreneurs (manage non financial firms)
- Investors (own “uninformed” capital Ω_t).
- Bankers (manage banks, own “informed” capital E_t).

TECHNOLOGIES

- At each period agents decide how much to consume and how much to save
- Total capital $K_t = E_t + \Omega_t$ allocated between two sectors: *j=M* (firms getting **market** finance) and *j=I* (firms needing **intermediated** finance).
- Cobb Douglas technologies:

$$Y_t^j = az^j (K_t^j)^{\alpha} (L_t^j)^{1-\alpha}$$

- *a*=TFP, z^j specific productivity in each sector: allows to calibrate relative size of two sectors.

TECHNOLOGIES (2)

- Competitive firms maximize profits given interest rates r_t^j and wages w_t^j .
- Segmented labor markets, fixed labor supply.
- Segmented capital markets:

  I-firms only financed by banks (loan rate r_t^I);

  M-firms financed by markets (interest rate r_t^M).
- At equilibrium: positive spread between loan and bond rates $r_t^I > r_t^M$

PREFERENCES

- Bankers and investors (households) choose their saving and consumption levels to maximize:

$$\sum_{t=0}^{\infty}(\beta^k)^t \ln(C_t^k),\ k = B, H. \qquad \beta^B \equiv \frac{1}{1+\rho^B} < \beta^H \equiv \frac{1}{1+\rho^H}.$$

- Investors are indifferent between bonds and deposits.
- Banks issue deposits to leverage their equity.
- Workers supply labor and own no assets. For simplicity: focus on case where they consume all of their income.
- Entrepreneurs are competitive and make zero profits.

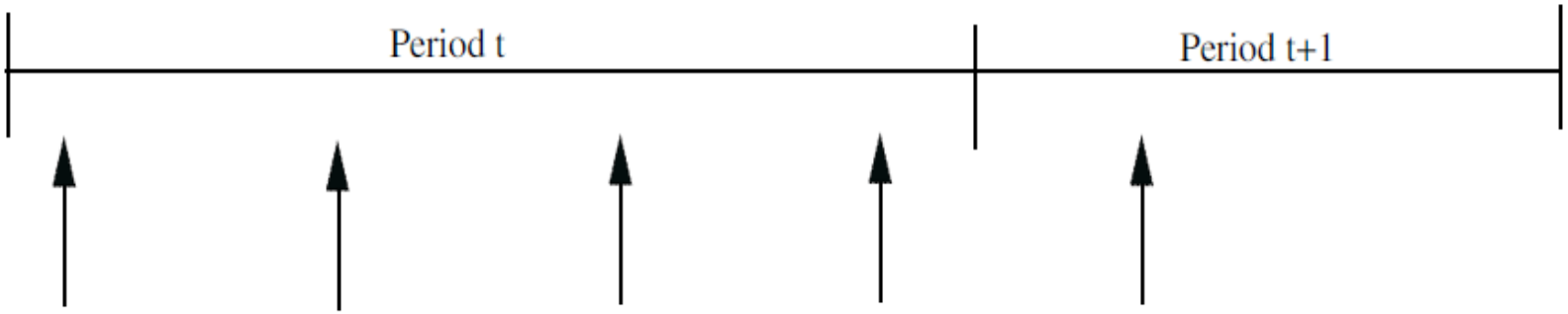
BANKS

- Finance themselves by equity e_t (E_t) and deposits d_t (D_t)
- Bank leverage $$\lambda_t = \frac{e_t + d_t}{e_t} = \frac{k_t^I}{e_t}$$

- Financial friction: bank profit cannot be less than multiple θ of volume of assets (bank size):

$$(1+r_t^I)k_t^I - (1+r_t^D)(k_t^I - e_t) \geq \theta k_t^I$$

TIMING OF EVENTS



- Households own Ω_t
- Bankers own E_t

- Bankers collect D_t
- Markets for capital K_t^I and K_t^M clear
- Labor markets clear

- Production takes place
- Commodity markets clear

- Consumption/ saving decisions (C_t^H, C_t^B)
- Depreciation of used capital stock Ω_t

- Households own Ω_{t+1}
- Bankers own E_{t+1}

PERIOD t EQUILIBRIUM

For all (E_t, Ω_t) there is a unique equilibrium:

- When $E_t \geq E_{\min}(\Omega_t)$, financial frictions do not matter, bank leverage irrelevant , marginal productivity of capital is the same in both sectors: $r_t^I = r_t^M$
- When $E_t < E_{\min}(\Omega_t)$, financial constraint binds and leverage determined by

$$ROE \equiv \theta\lambda = 1 + r_t^M + \lambda(r_t^I - r_t^M)$$

Intuition why bank leverage is pro-cyclical

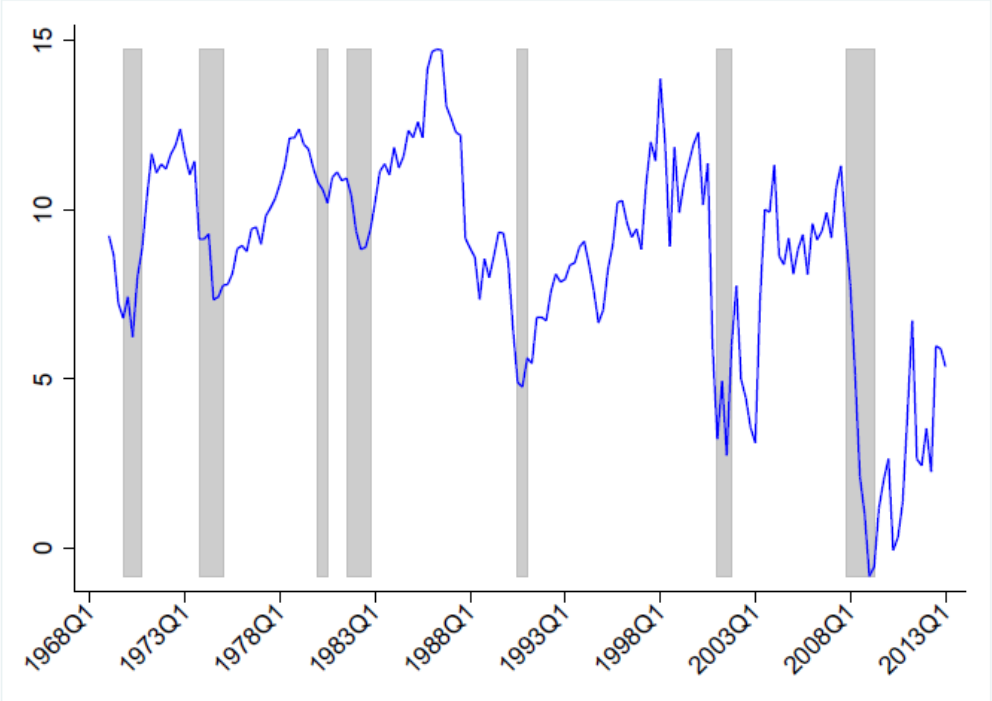
- In Adrian-Shin (2008) and Adrian-Boyarchenko (2013) banks are confronted with VaR constraints: the higher the risk the lower the leverage. Then leverage is pro-cyclical because risk is anti-cyclical.
- In our model leverage is given by the "skin in the game" constraint for bankers:

$$\lambda = \frac{1 + ar^M}{\theta - a(r^I - r^M)}$$

increases in TFP a

PROCYCLICALITY OF BANK LENDING

Figure I: Procyclicality of Intermediary Financial Assets



Total growth of US banks' assets. Source: Adrian-Boyarchenko (2013). NBER recessions in grey

COMPARATIVE STATICS

Shocks	Bank leverage	Loans	Bonds	Output
TFP↓	-	-	+	-
Ω↓	-	-	-	-
E ↓	+	-	+	-

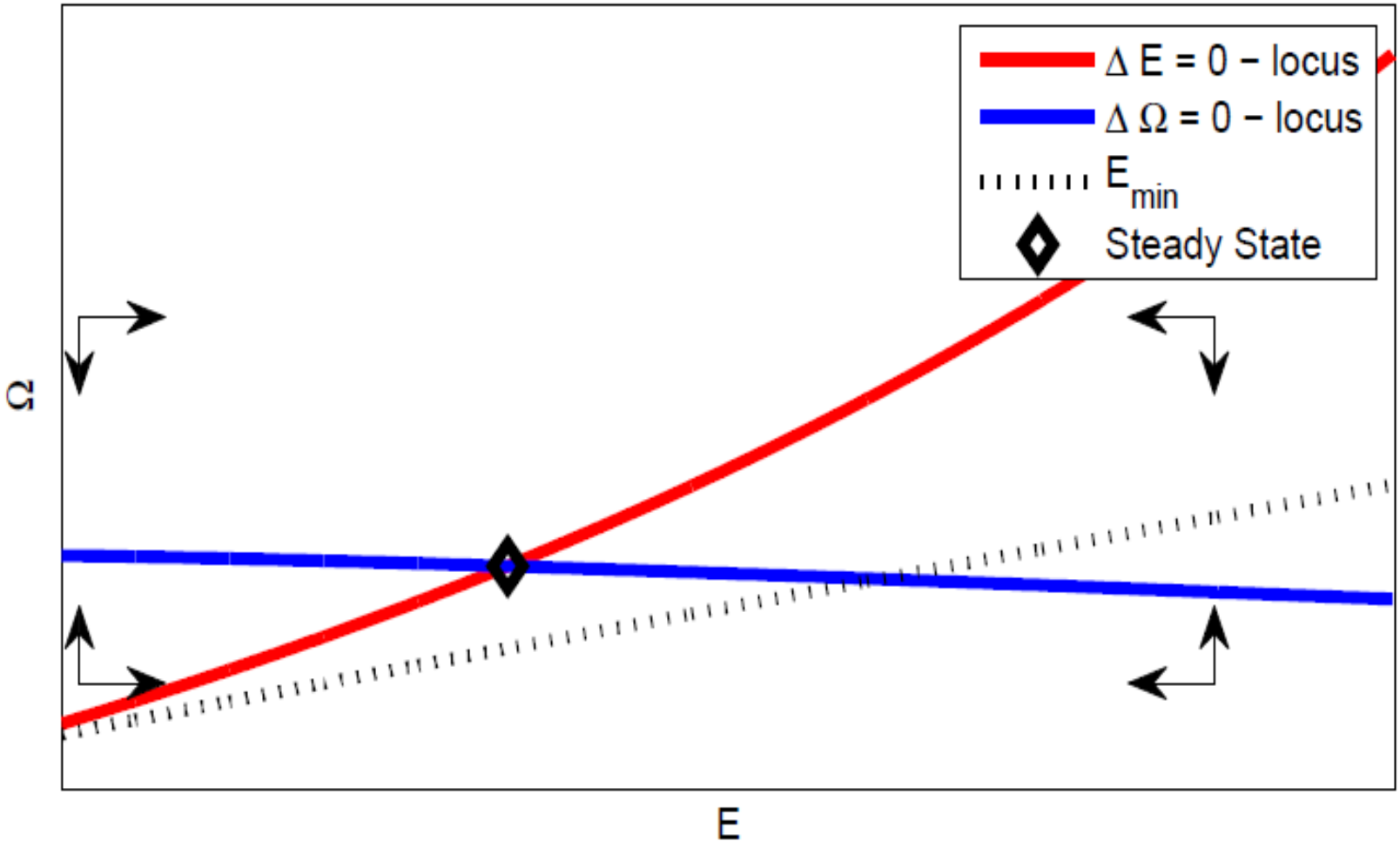
COMPARATIVE STATICS

- First row (recession): bank leverage and bank assets decrease, bond issuance increases. Conform with empirical evidence: Adrian-Shin 2008), Adrian- Colla-Shin (2013).
- Second row (financial crisis) both bank loans and bond issuance decreases (??...)
- Third row (banking crisis without capital injections): bank leverage increases, bank credit decreases, bond issuance increases.

DYNAMICS

- Log-utilities $\Longrightarrow$ investors and bankers consume a constant fraction of their wealth.
- Bankers are more impatient than investors: bank capital accumulates more slowly than uninformed capital.
- Financial frictions always bind for *t* large: in the unconstrained region $\frac{E_t}{\Omega_t}$ goes to zero.

PHASE DIAGRAM



Steady State

System converges to a unique steady state:

$$\hat{r}^M = \delta + \rho_H, \quad \theta\hat{\lambda} = 1 + \delta + \rho_B, \quad \hat{r}^I = \hat{r}^M + \frac{\theta(\rho_B - \rho_H)}{1 + \delta + \rho_B}$$

$$\hat{K}^M = \left(\frac{\alpha z^M}{\hat{r}^M}\right)^{\frac{1}{1-\alpha}}, \quad \hat{K}^I = \left(\frac{\alpha z^I}{\hat{r}^I}\right)^{\frac{1}{1-\alpha}}$$

Compare with frictionless case:

$$\bar{r}^M = \bar{r}^I = \delta + \rho_H, \quad \bar{K}^M = \left(\frac{\alpha z^M}{\bar{r}^M}\right)^{\frac{1}{1-\alpha}} = \hat{K}^M, \quad \bar{K}^I = \left(\frac{\alpha z^I}{\bar{r}^I}\right)^{\frac{1}{1-\alpha}} > \hat{K}^I$$

IMPACT OF FINANCIAL FRICTIONS

- They reduce the steady state capital stock in the intermediated sector (but not in the market sector).
- Spread between loan rates and bonds rate persists in the limit, due to combination of financial frictions and impatience of bankers.
- Frictions reduce speed of convergence to steady state.

CALIBRATION

parameter	value	description
EXOGENOUS PARAMETERS		
L^M	1.0000	labor force sector M
L^I	1.0000	labor force sector I
z^M	1.0000	productivity in sector M
ENDGENOUS PARAMETERS		
α	0.3600	capital share in output
θ	0.1407	financial friction
z^I	1.0932	productivity in sector I
δ	0.0667	capital depreciation rate
β_H	0.9614	time preference, household
β_B	0.7462	time preference, banker

CALIBRATION (2)

CALIBRATION TARGETS

	0.3600	capital share in output
λ	10.0000	leverage
Y^M/Y^I	1.0000	relative sector size
K/Y	3.0000	capital-to-output ratio
$r^I - r^M$	0.0300	return difference
s	0.2000	saving rate

STEADY STATE ALLOCATION

$\hat{E}$	0.5210	steady state bank equity
$\hat{K}$	11.8821	steady state capital
$\hat{\Omega} = \hat{K} - \hat{E}$	11.3611	steady state household wealth

IMPACT OF CRISES

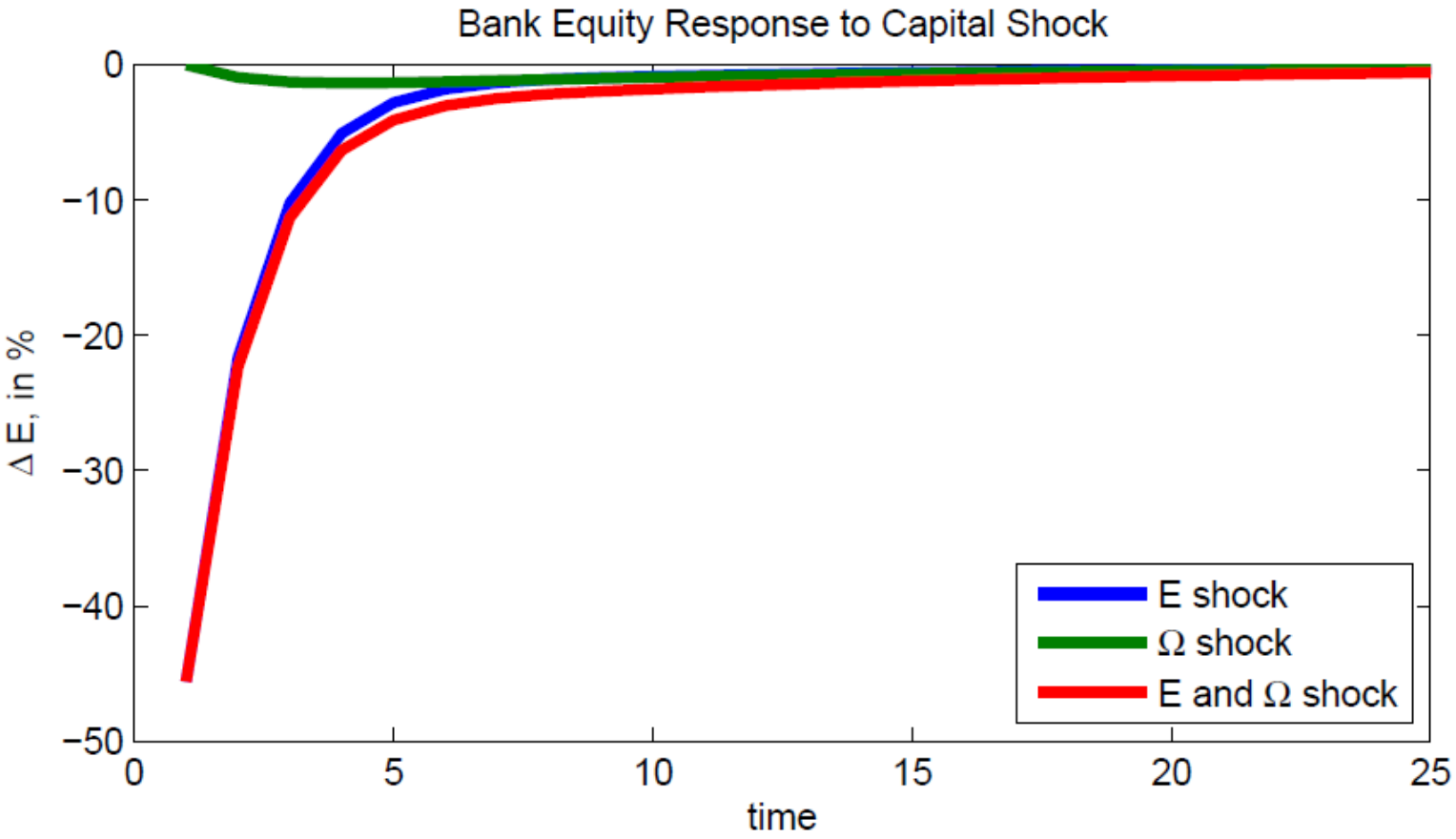
We now simulate the impact on relevant variables (capital, output, consumption, interest rates,..) of different types of crises:

- **Banks' net worth decrease** (2% of K):

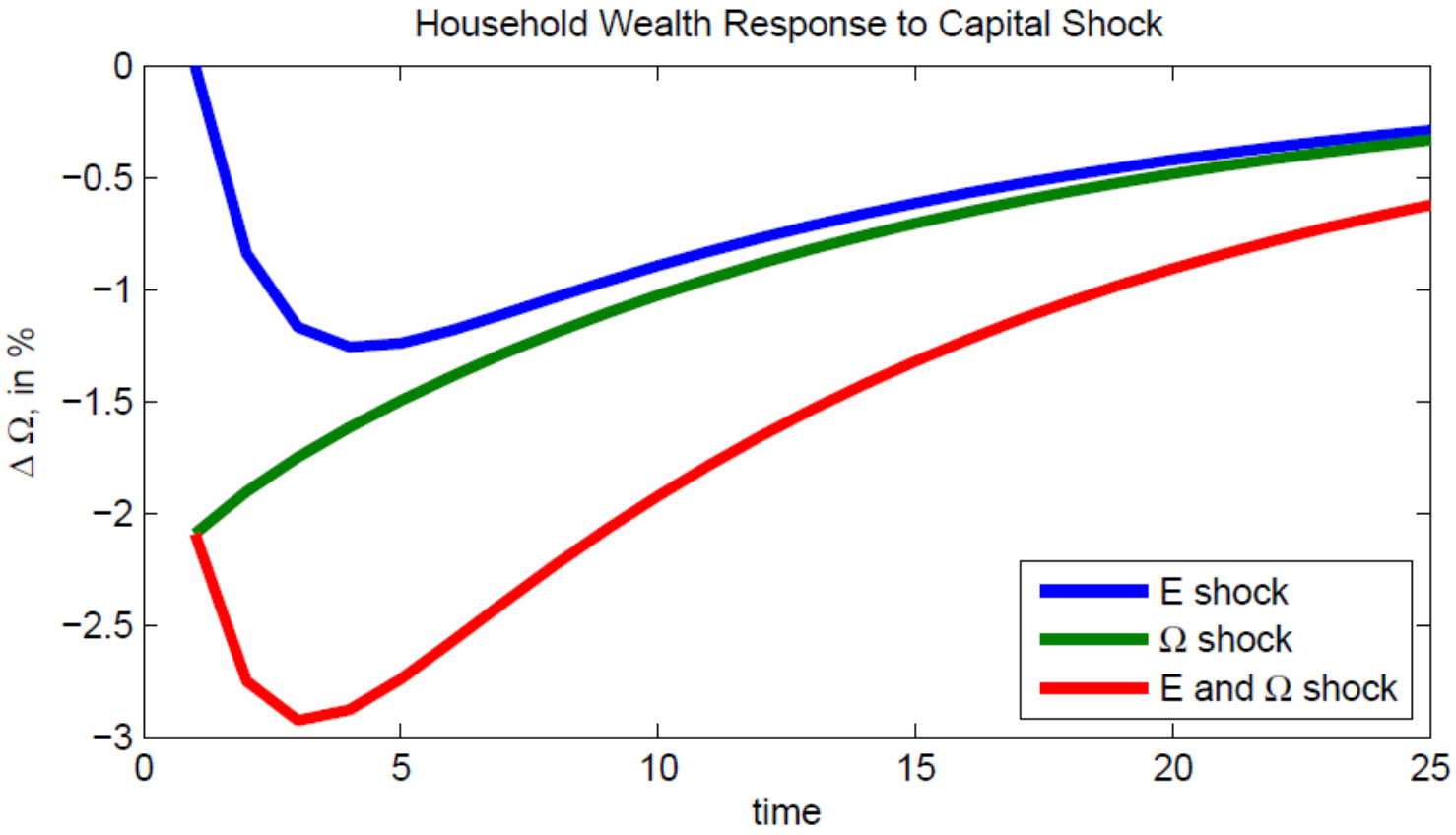
  banking crisis.

- **Investors' net worth decrease** (2% of K) financial crisis or banking crisis followed by bail out.
- **Combined banking and financial crisis** (4% of K)

Impact of Negative Capital Shock



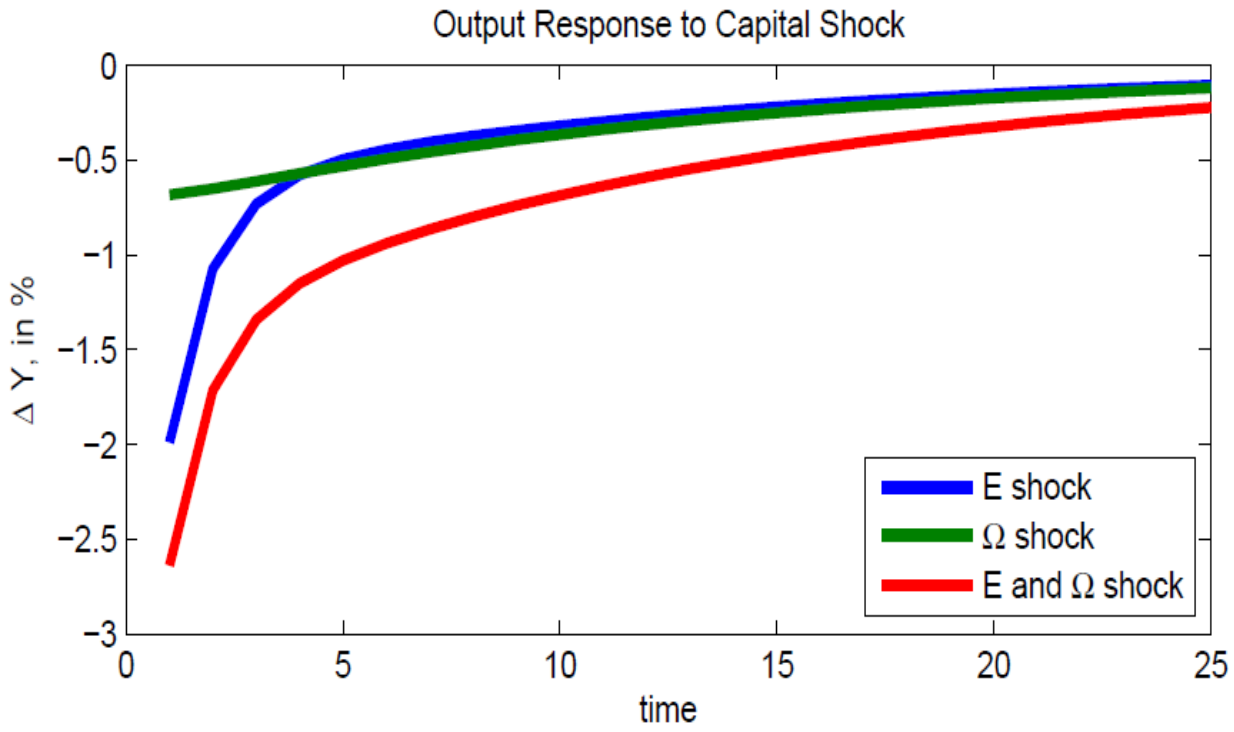
Impact of Negative Capital Shock(2)



Investors lose from banks' bail-out.

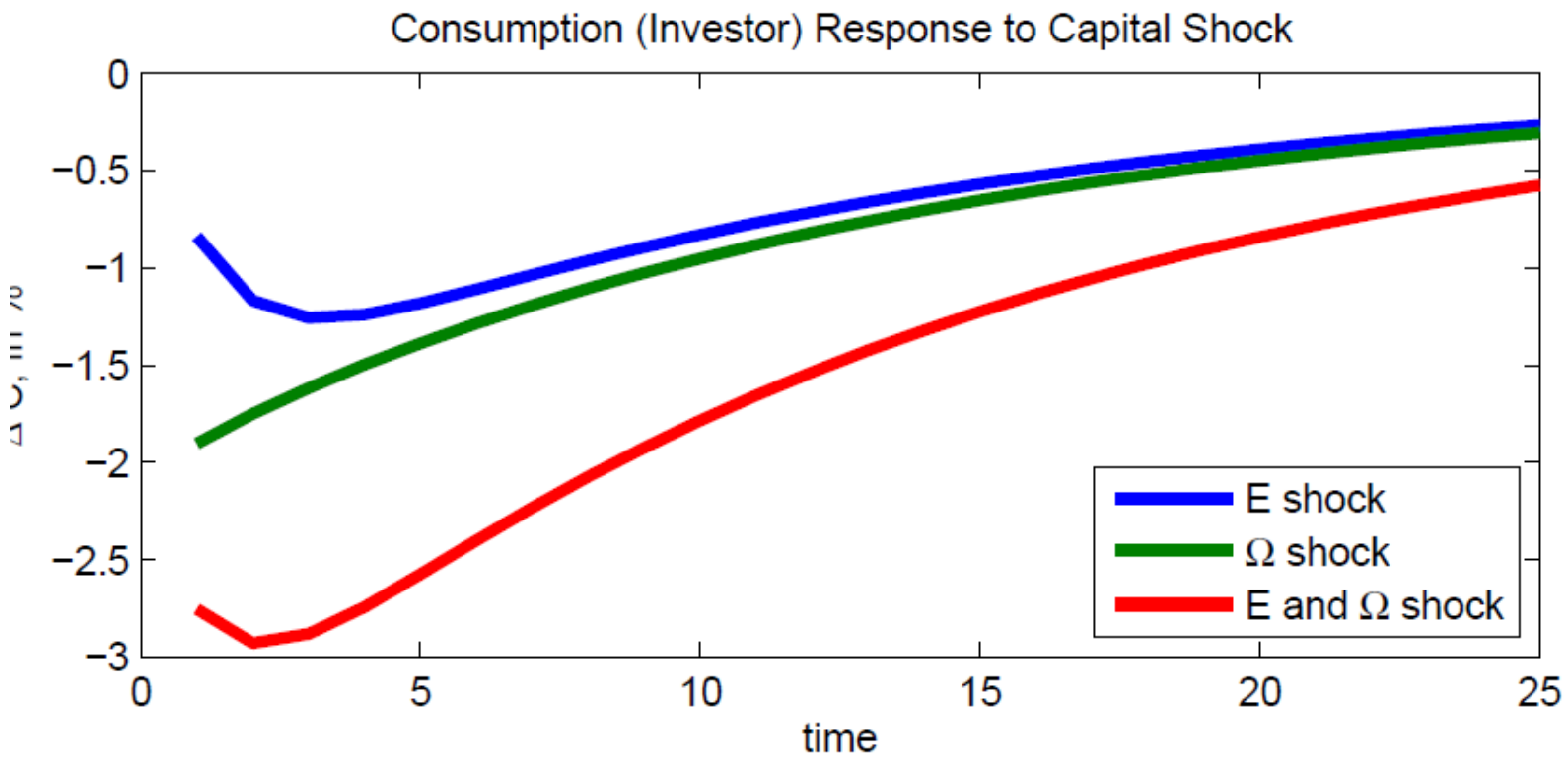
Recovery takes time.

Impact of Negative Capital Shock(3)

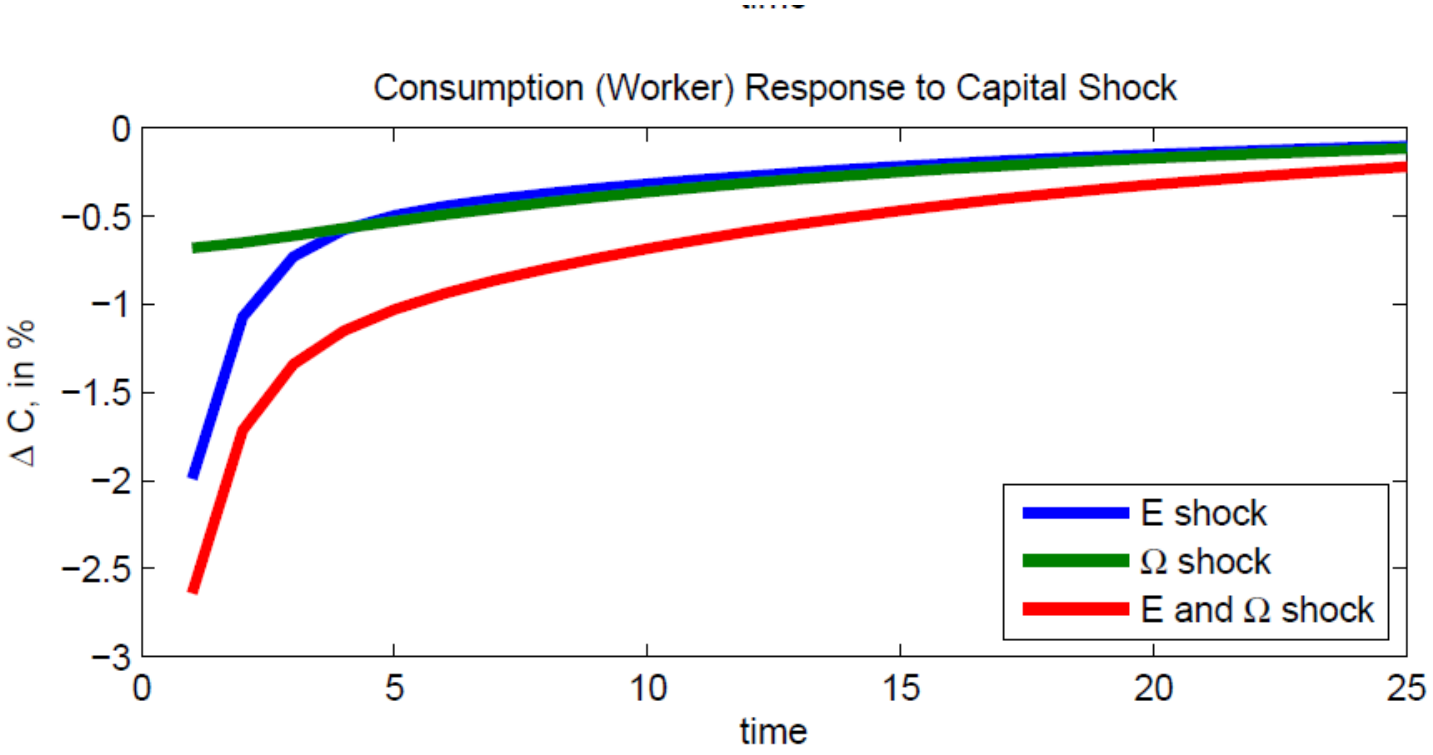


Banks' bail out limits output losses.

Investors' consumption after a shock

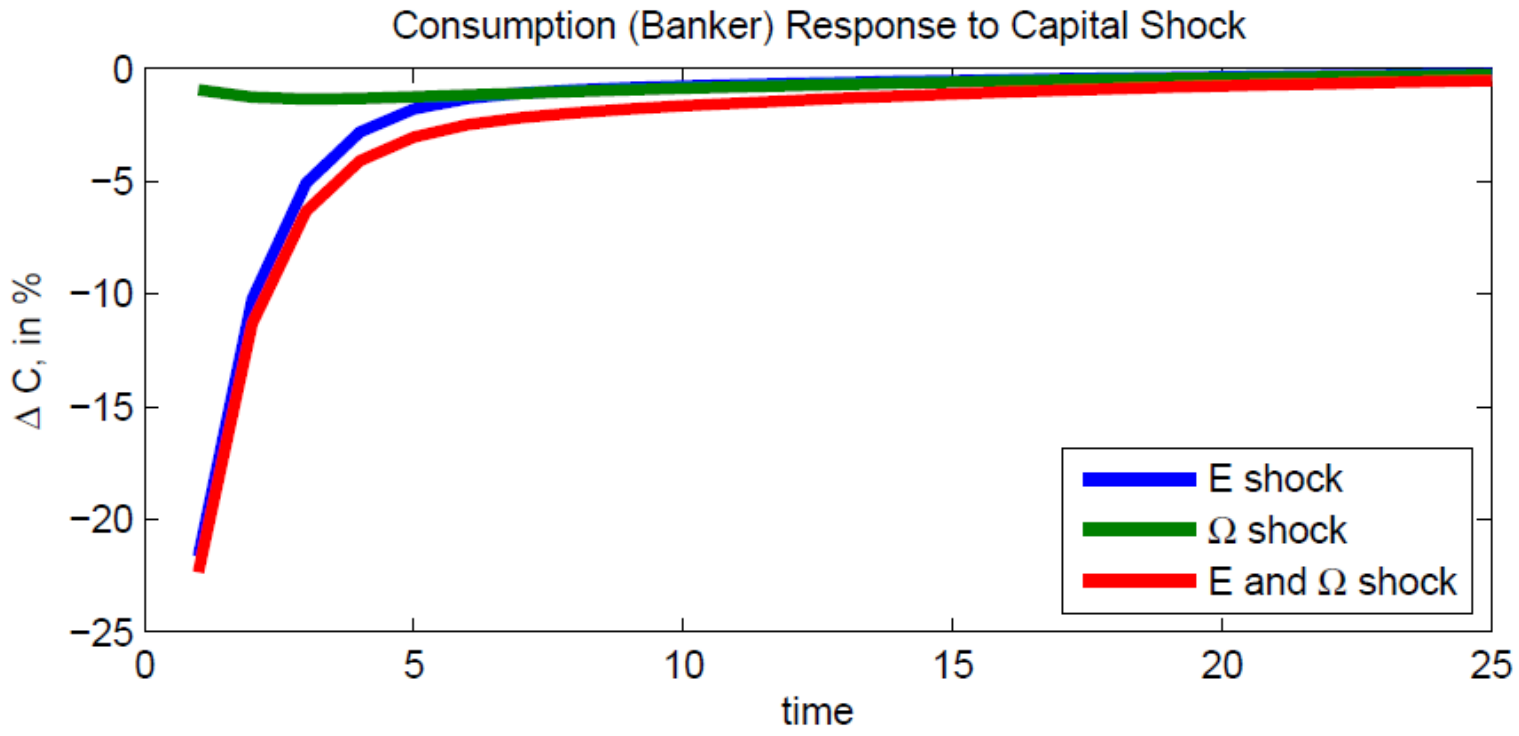


Workers' consumption after a shock



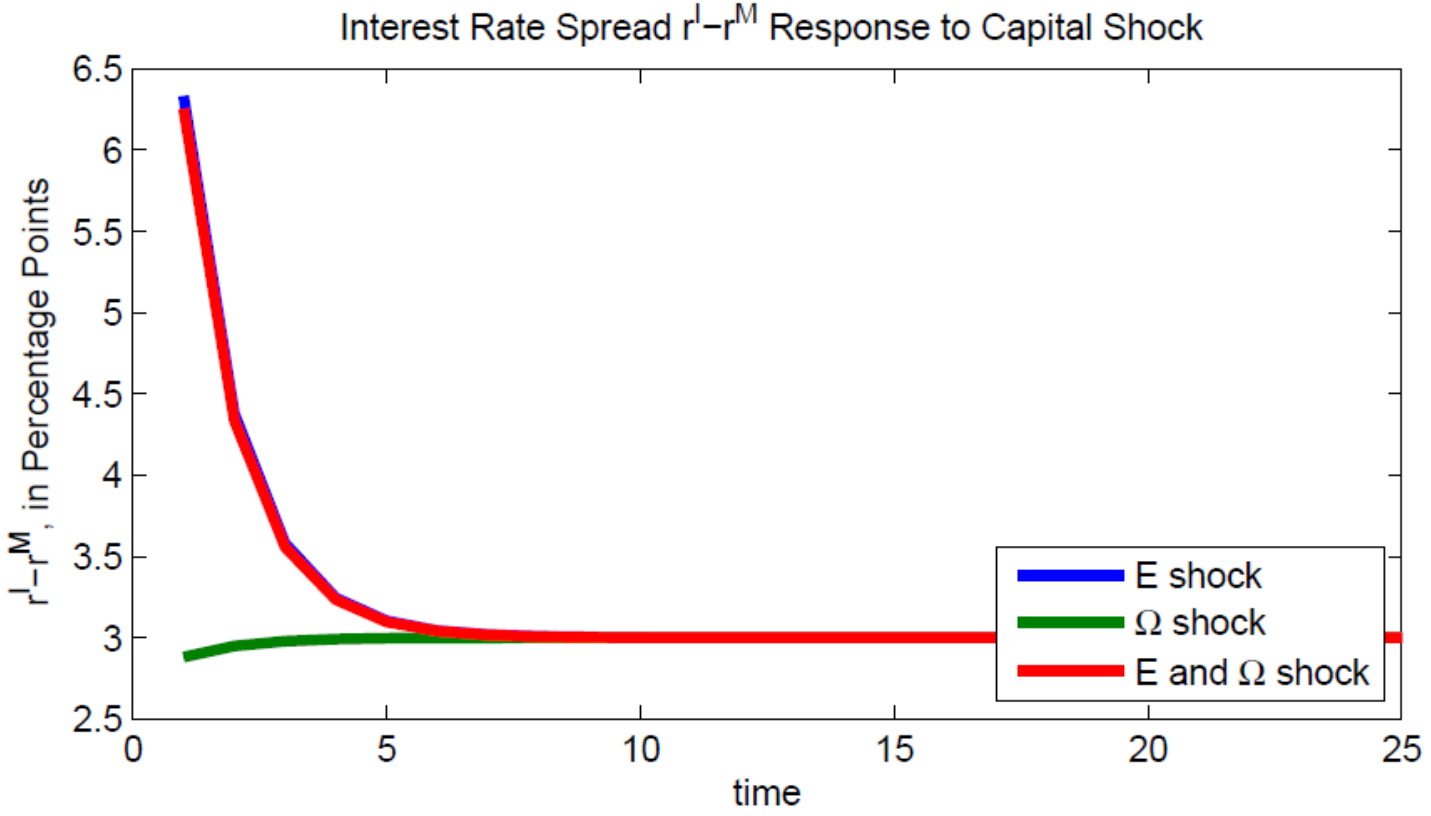
Workers benefit from banks'bail outs.

Bankers' consumption after a shock



Obviously, bankers also benefit from bail outs.

Impact of shocks on spreads



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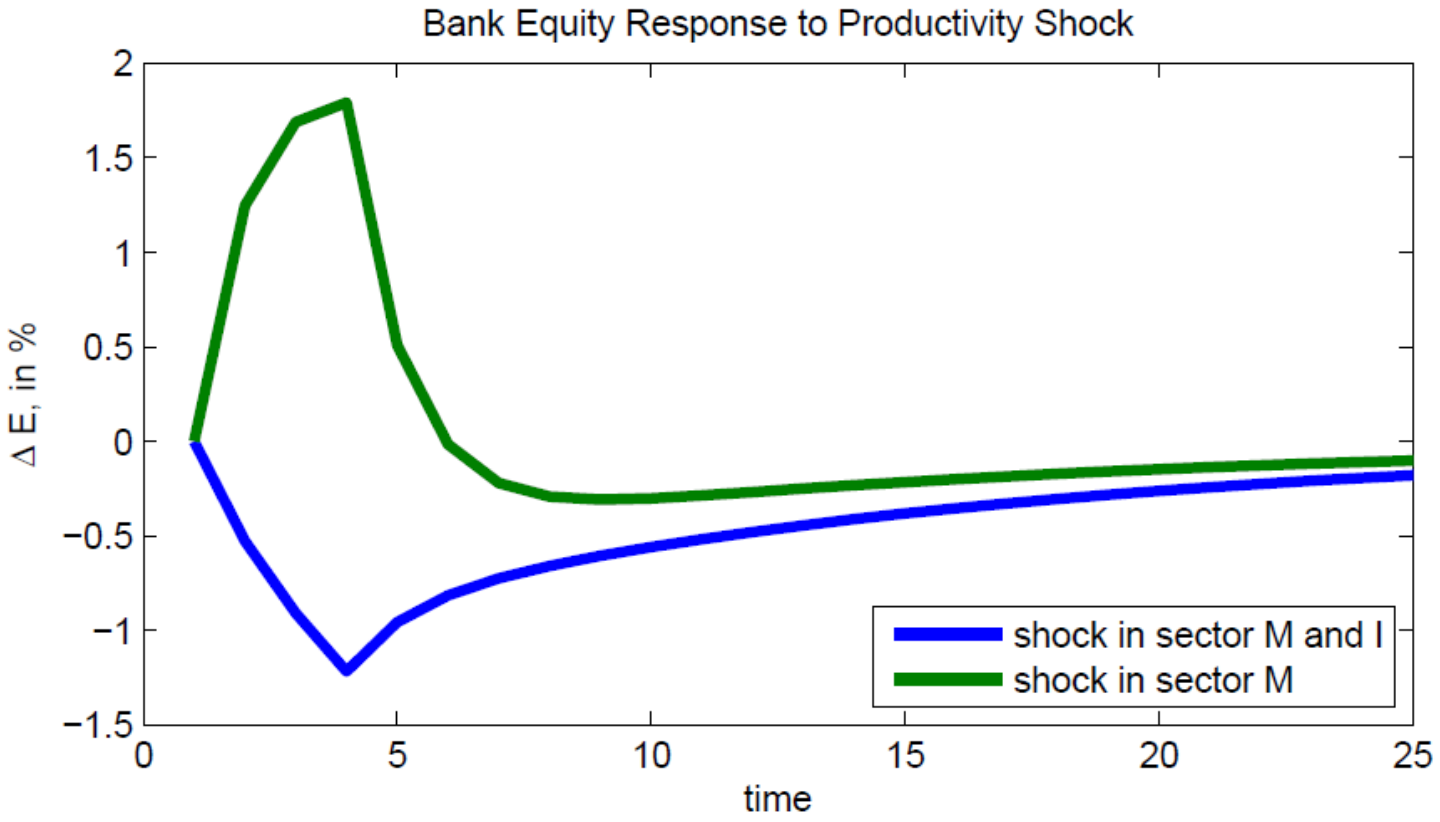
IMPACT OF REAL SHOCKS

We now simulate the impact of negative productivity shocks (3% decrease in productivity during three periods):

- **Only in sector M**
- **In both sectors**

Bank Capital after a real shock



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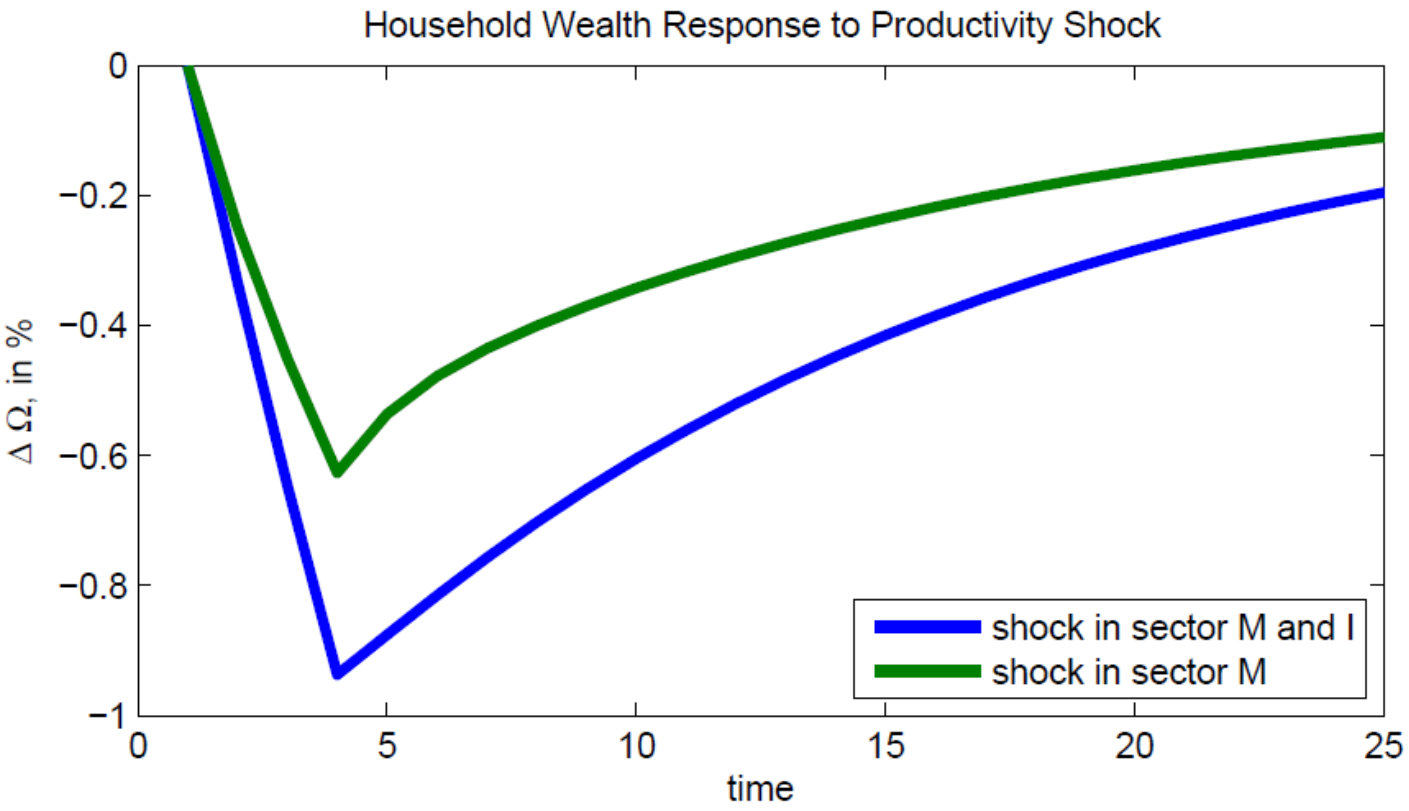
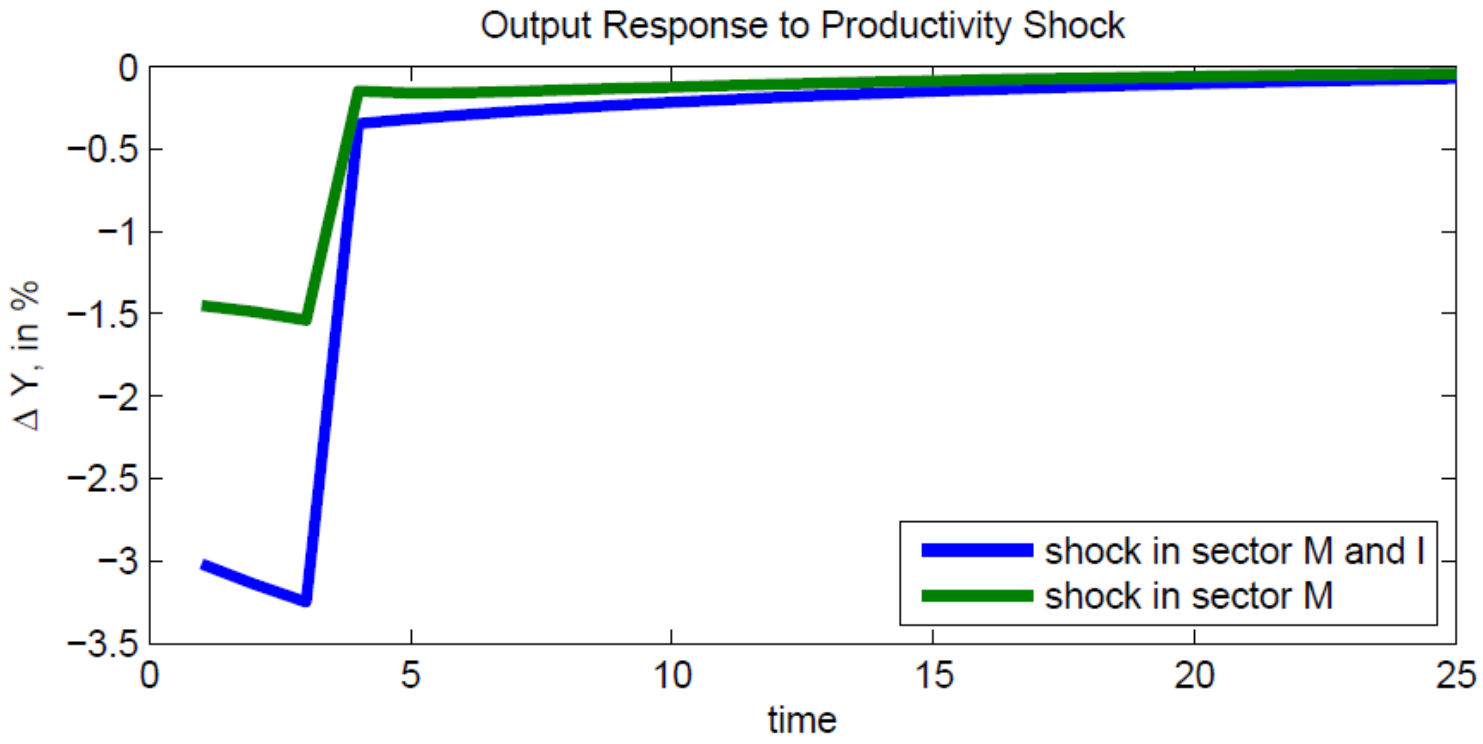
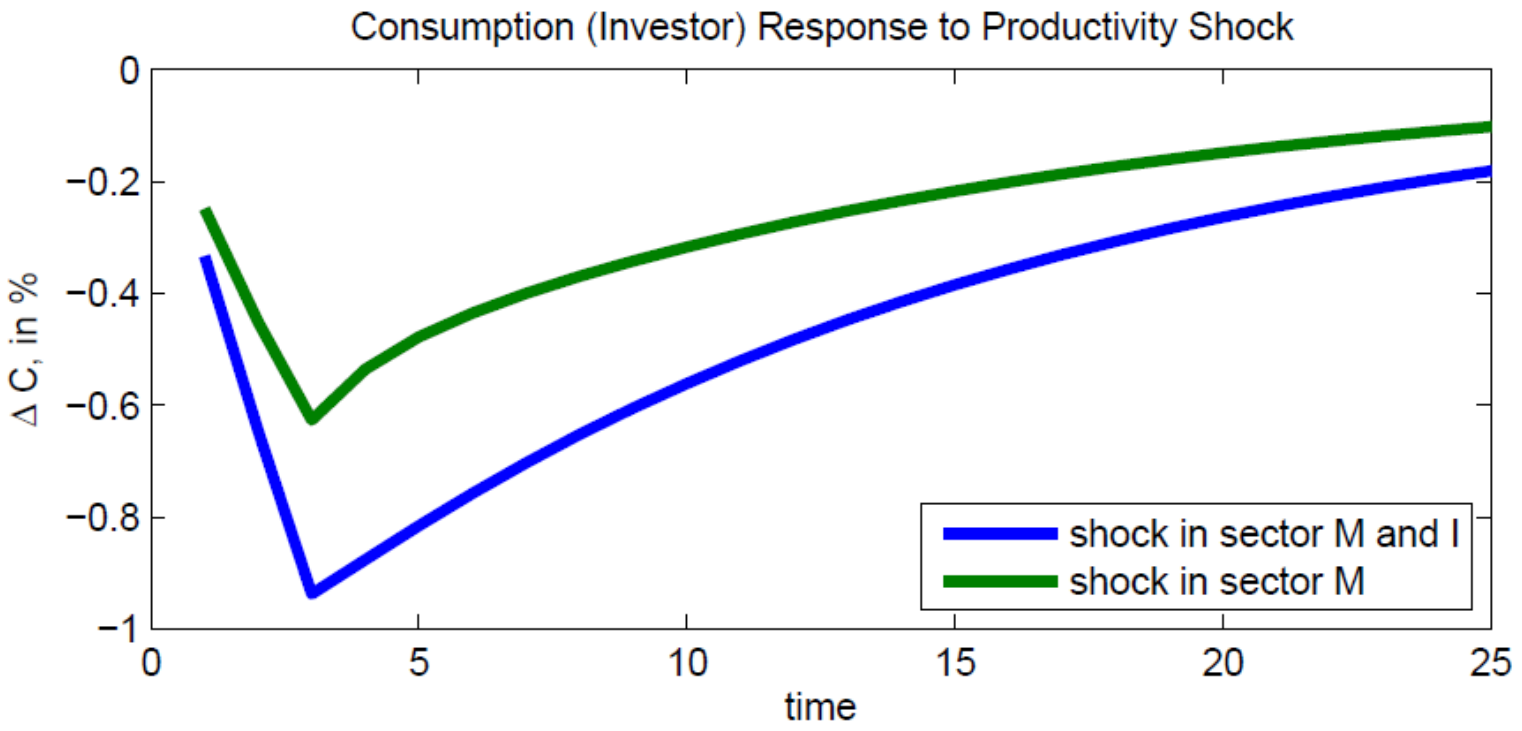
Household wealth after a real shock

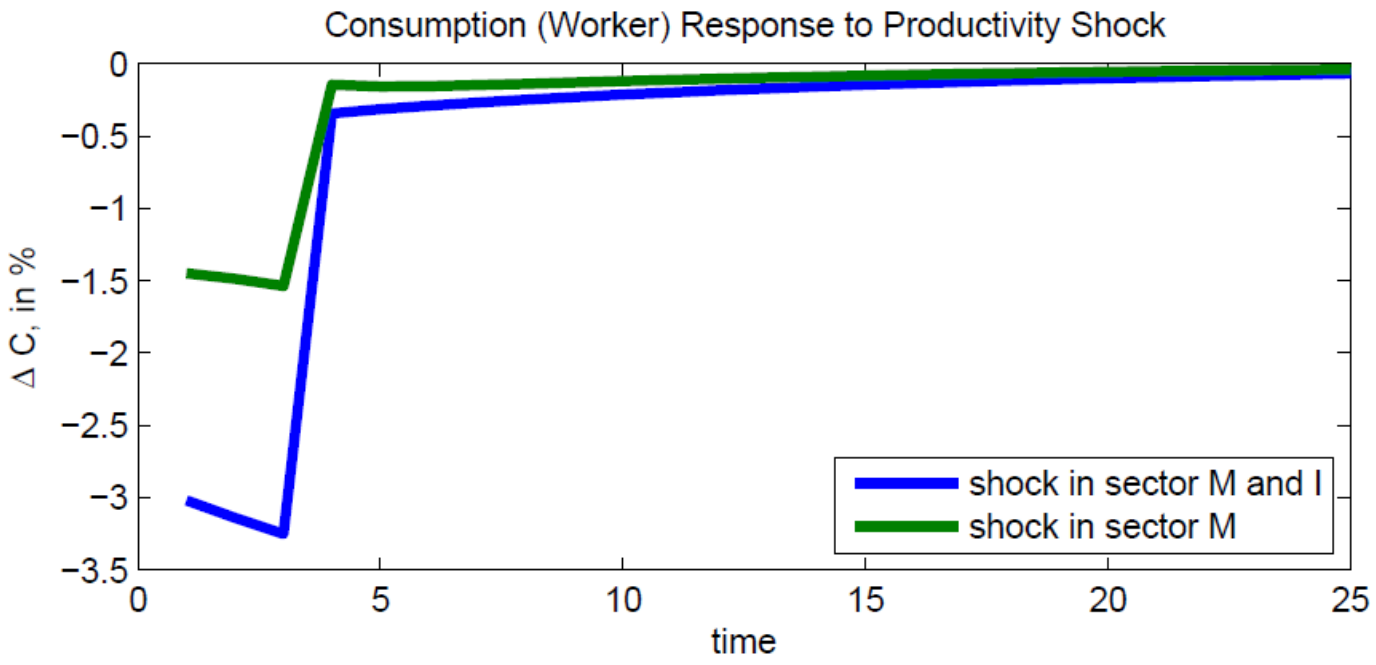


Output response to real shock

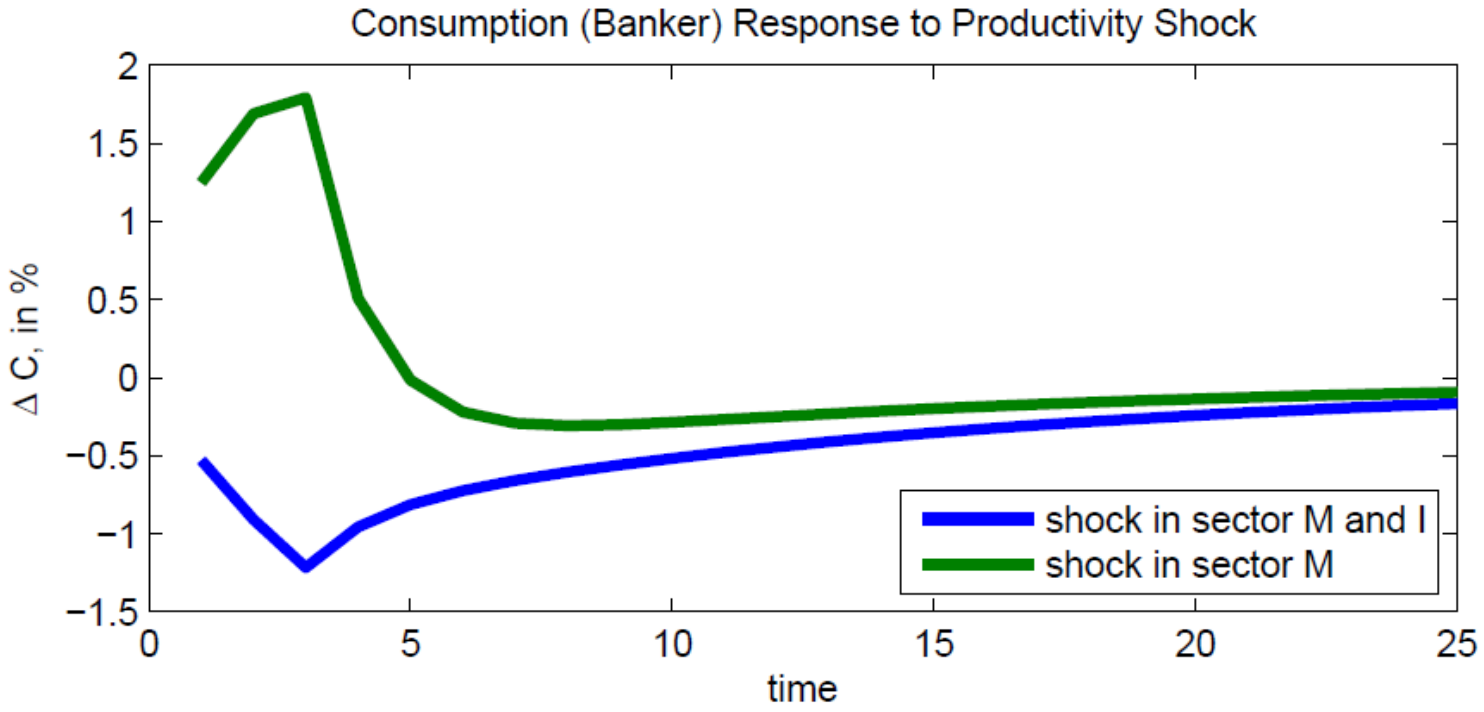


Investors' consumption after a real shock

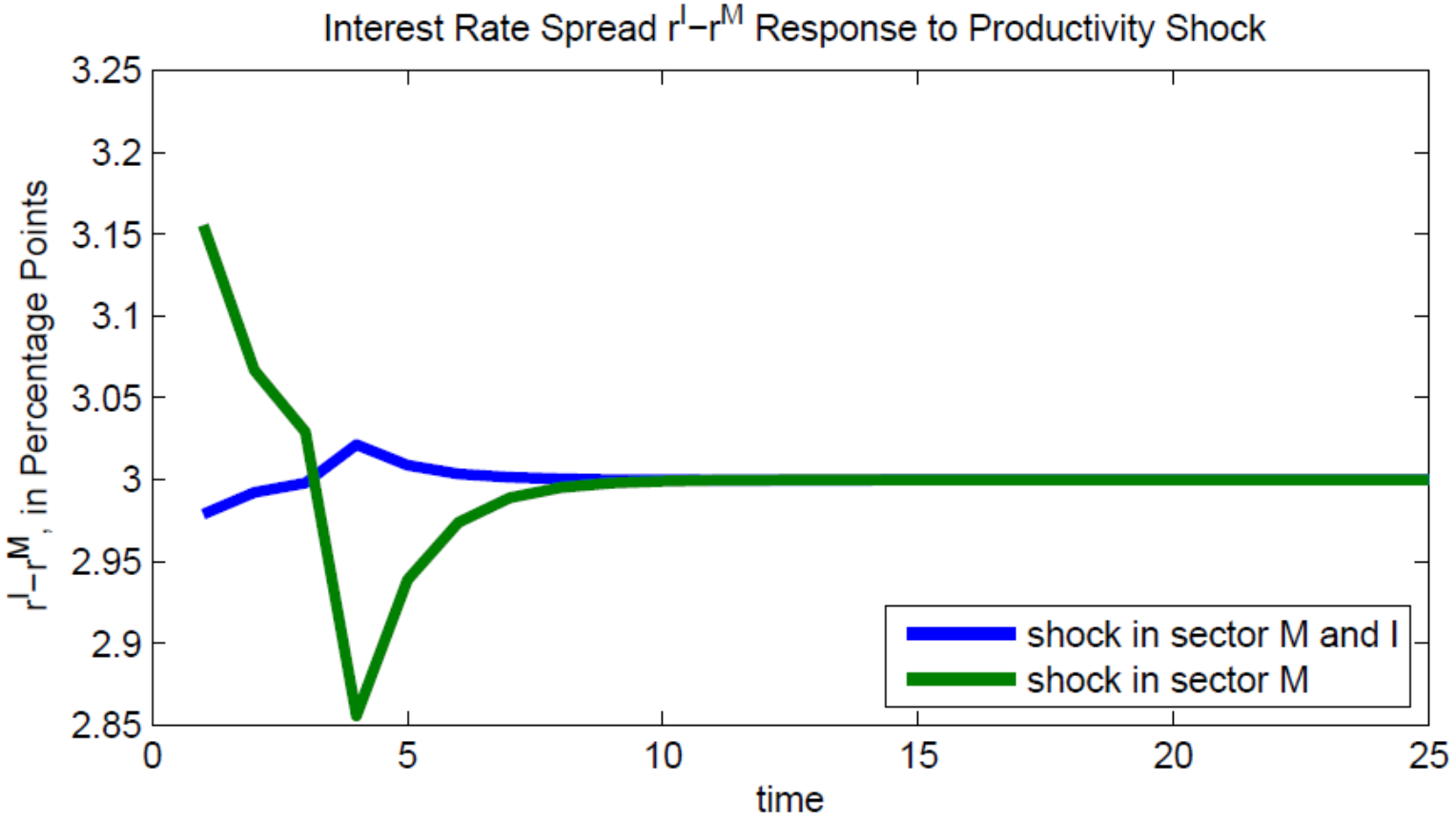



Consumption (Worker) Response to Productivity Shock
0
−0.5
−1
−1.5
−2
−2.5
−3
−3.5
Δ C, in %
0
5
10
15
20
25
time
shock in sector M and I
shock in sector M

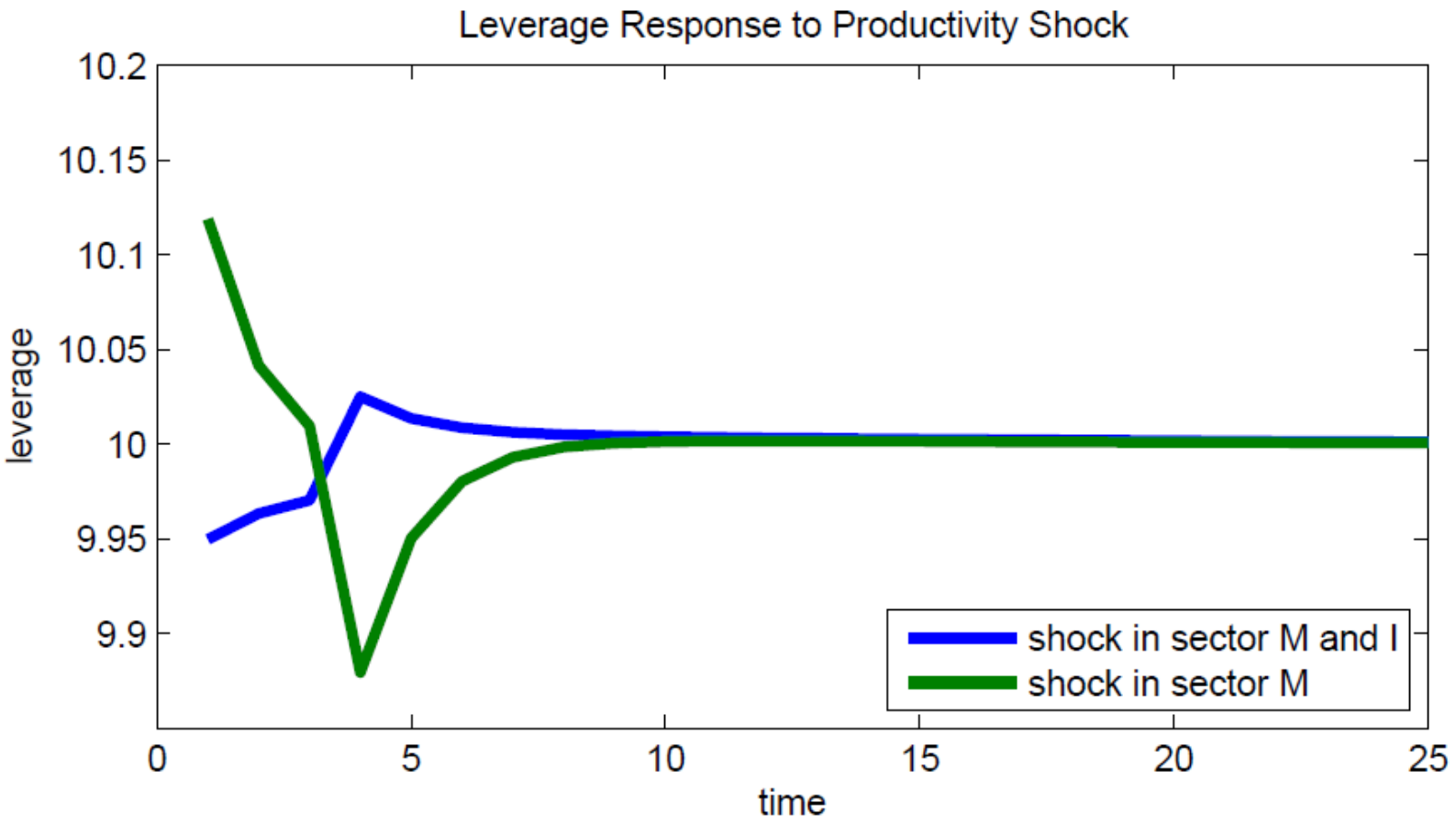
Bankers' consumption after a real shock



Impact of real shocks on spreads



Impact of real shock on leverage



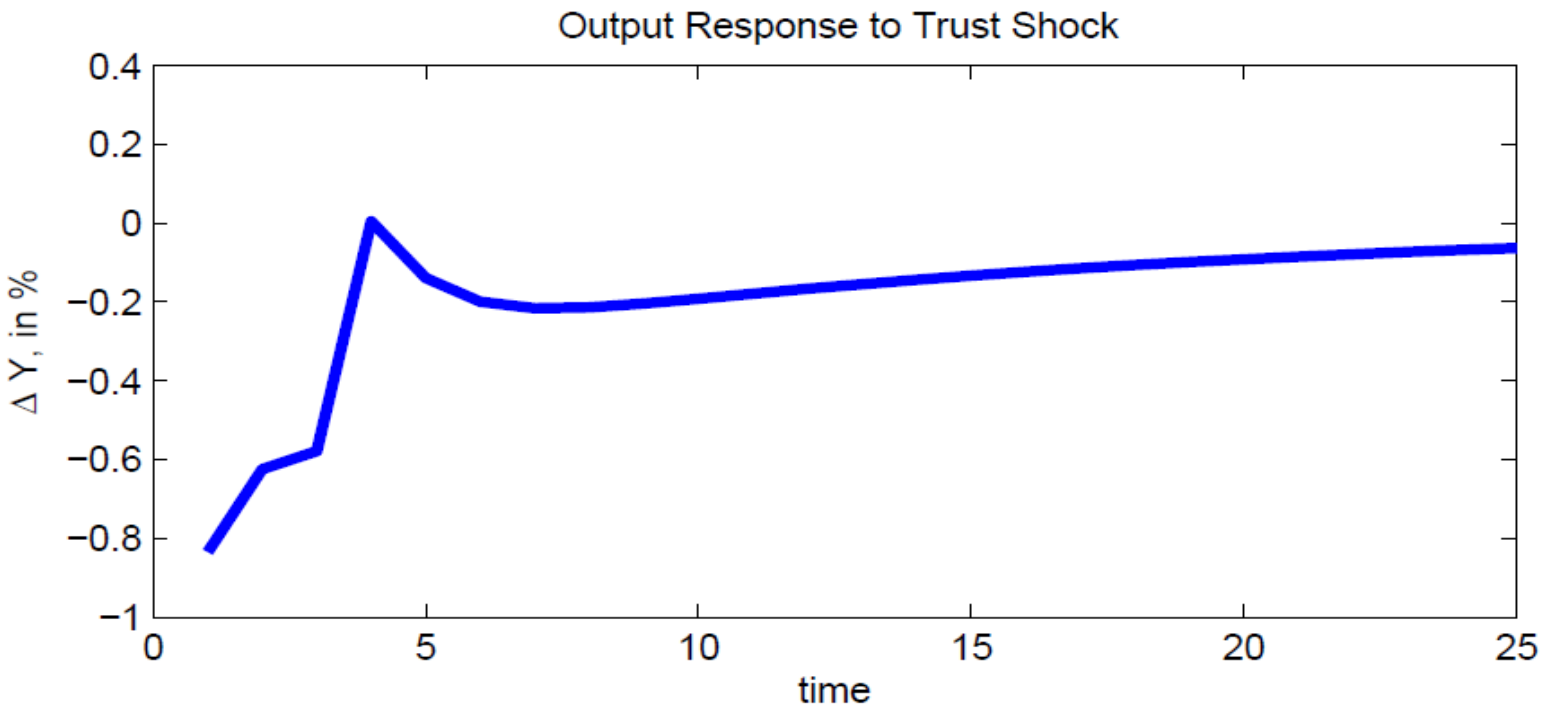
IMPACT ON WELFARE

Table 3: Welfare Effects

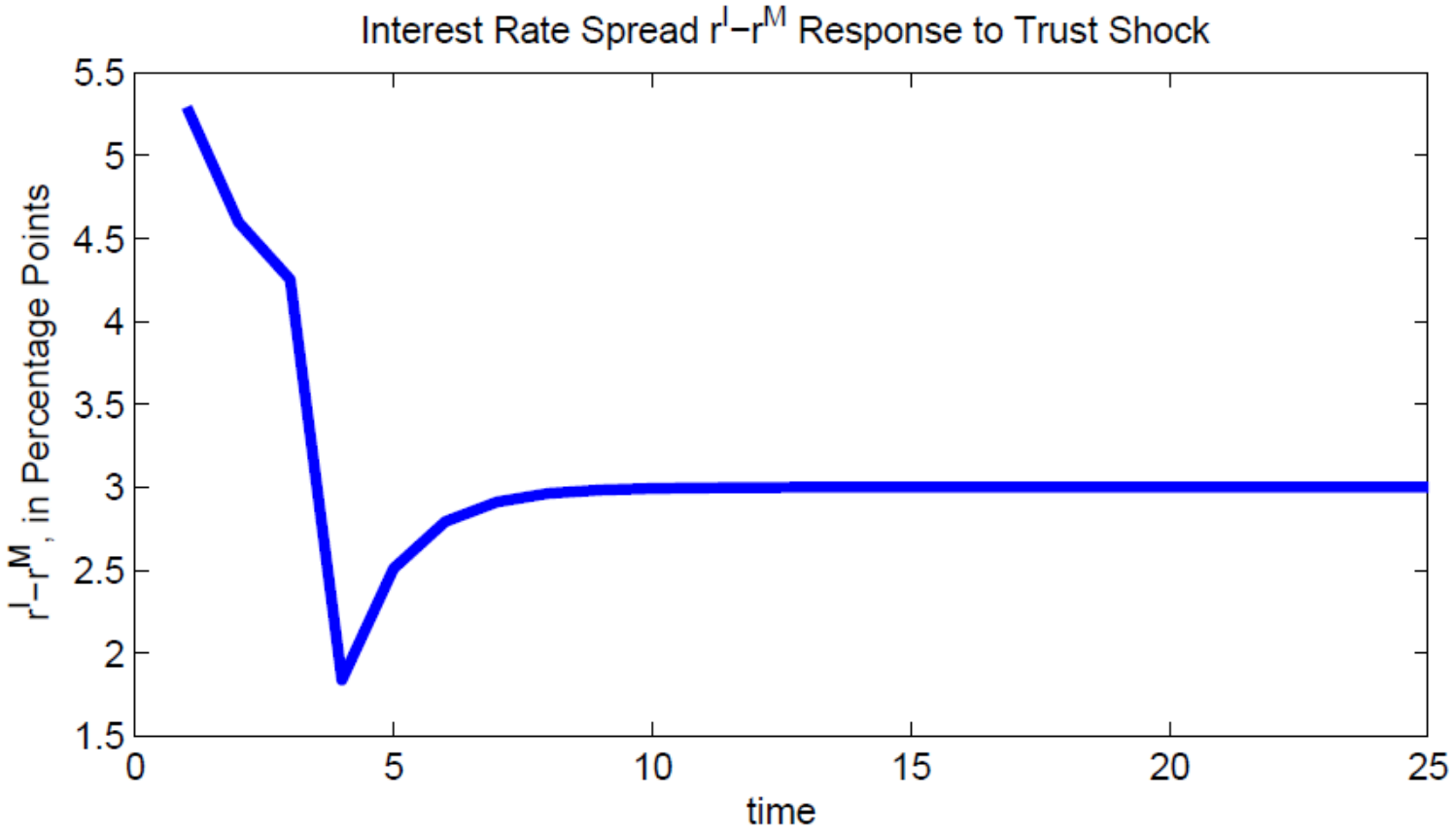
parameter	welfare effects		
	investor	worker	banker
Shock to Productivity for 3 Periods: $z^M = 0.97z^M$, $z^I = 0.97z^I$	-0.3360	-0.4432	-0.5820
Shock to Productivity for 3 Periods: $z^I = 0.97z^I$	-0.1344	-0.2234	-1.2323
Shock to Productivity for 3 Periods: $z^M = 0.97z^M$	-0.2007	-0.2160	0.6549

IMPACT OF TRUST SHOCKS

Finally we look at the impact of a decrease in "trust" (30% increase in θ for three periods)



Impact of a trust shock on spreads



POLICY IMPLICATIONS

- Banking crises have much bigger impact on output and welfare than financial crises of the same absolute magnitude.
- Implies than bank bailouts financed by taxes paid by investors reduce dramatically the welfare cost of banking crises.
- However recovery slowed down by bankers’”impatience”: too high dividends paid by banks

POLICY IMPLICATIONS(2)

- In our model without default, imposing bank capital regulations (in excess of market imposed leverage constraint) would be counterproductive.
- However, imposing dividend restrictions on banks allows to accumulate bank capital faster.
- The optimal intervention seems to be a combination of bail out and dividend restrictions.

CONCLUSION

- Parsimonious model of capital accumulation where both bank credit and bonds are used by firms.
- Generates endogenous pro-cyclical leverage as in Adrian Shin (2008) without default risk.
- Suggests that bail outs financed by taxes combined with dividend restrictions seem to me the optimal way to manage banking crises.