

Macroeconomic Effects of Bank Recapitalizations

— work-in-progress —

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OUTLINE

1 Introduction

2 Model

3 Our setup

4 Government capital injection

MOTIVATION

Governments' capital injections to the banking system is an important tool during financial crises:

- In 43 crisis episodes over 1970–2008 (Laeven and Valencia, 2012, IMF database)
 - capital injections in 33 episodes
 - average size **8 per cent** of annual GDP
- Current crisis
 - by 2009: 5+ % in the US and the UK, 2.5 % in the euro area
 - Spain requested 100 bill. € EU funding to banks (close to 10 % of the GDP).
 - Gigantic interventions in Iceland (at some stage 30 % of the GDP), Ireland, Cyprus.

AIM

We develop a DSGE model with financial frictions

- where the *balance sheets* of both *banks* and *non-financial corporations* (NFC) matter for macro-financial linkages
- and banks' balance sheets are more important for macroeconomic dynamics than those of the NFCs.
- we use this model to study macroeconomic implications of government's *capital injection* to banks.

KEY POLICY MESSAGE

Capital injections

- + beneficial as shock cushion
- counterproductive if terms are too harsh.
- + *ex ante* positive
- *ex post* negative
- + particularly useful in uncertain times!

BACKGROUND

Until recently: frictions in the investment financing

- builds on agency problems
- balance sheet of non-financial corporations
- financial accelerator: Bernanke et al. (1999)
- collateral constraints: Kiyotaki and Moore (1997)

Lately: financial intermediation and banks' balance sheet

- affects external finance premium of banks
- and its lending
- Gertler and Karadi (2011), Gertler and Kiyotaki (2010)
- abstracts from agency problem in investment financing

OUR APPROACH

We combine

- entrepreneurial wealth
- to banks' capital

by embedding Holmström and Tirole (1997) into
New-Keynesian framework

OUR EXTENSIONS

We extend Holmström and Tirole (1997) in

- ① endogenising monitoring activity
→ banks' capital is scarce
- ② bank consists of bankers
→ unlimited liability of bankers
→ depositors are hedged
- ③ aggregate uncertainty and investment shocks
→ risk-factors play important role

HOLMSTRÖM AND TIROLE (1997)

- Workhorse model in corporate finance literature
- Only a few papers have applied it within macroeconomic framework: Chen (2001, JME), Meh and Moran (2010, JEDC), Aikman and Paustian (2006, BoE WP), Faia (2011, ECB WP), Christensen, Meh and Moran (2011)

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DUAL MORAL HAZARD IN HOLMSTRÖM AND TIROLE (1997)

First moral hazard with **banks** and **entrepreneurs**

Depositors

Cannot observe *ex ante* if banks monitor

Banks

Monitor with the cost $c \times i$.

Entrepreneurs

Choose between Good, Bad and Ugly projects that produce $R \times i$.

Second moral hazard with **depositors** and **banks**

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THE FIRST MORAL HAZARD: ENTREPRENEUR AND BANKS

Entrepreneurs invest and *want to increase the size* of a project by borrowing.

Moral hazard between entrepreneurs and lenders

- Entrepreneurs face incentives to choose a socially non-optimal pet project.
- The pet project has a lower success rate p_L than the socially optimal rate p_H ,
- but it offers the entrepreneurs some private benefits.

Banks' **monitoring prevents most outrageous pet projects.**

→ gives a role for banks.

ALTERNATIVE PROJECTS IN HOLMSTRÖM AND TIROLE (1997)

Three alternative projects that produce $R \times i$ units of capital
 success probability private benefit

Good	p_H	—
Bad	$p_L < p_H$	b
Ugly	p_L	$B > b$

Monitoring by banks — with the cost $c \times i$ — detects the **Ugly** project

→ less costly for the entrepreneur to choose the good project.

THE SECOND MORAL HAZARD: BANKS AND DEPOSITORS

Banks, too, want to **borrow** (from depositors) to increase the size of a project.

Monitoring is costly

⇒ **the second moral hazard** → banks have to be given proper incentives to monitor

Three party contract among

- 1 entrepreneur (insider)
- 2 bank (another insider)
- 3 outside investor (=depositor=household)

CONTRACT FEATURES IN HOLMSTRÖM AND TIROLE (1997)

- How much each party invests to the project
- How to divide the proceeds of the project
 - to behave, the entrepreneur and the bank have to receive (at least) a certain minimum share
 - the smaller the share of the insiders (entrepreneurs+banks), the larger share is given to the outsiders
- The more outsiders get, the more they contribute
 - the larger the investment project
 - the higher the leverage

PROBLEMS IN HOLMSTRÖM AND TIROLE (1997)

- 1 In macroeconomic applications, only *aggregate informed* capital stock matters for macroeconomic dynamics

$$\text{Informed capital} = \text{Bank capital} + \text{firm capital}$$

→ **no distinct roles** for bank balance sheets and firm balance sheets at macroeconomic level. (Exception: Christensen, Meh and Moran (2011) has similar structure as we have.)

- 2 Perfect correlation of returns in the banks' lending portfolio.
- 3 Banks' monitoring decision is binary.

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PLUGGING INTO DSGE

Features of the DSGE

- Standard New-Keynesian sticky price
- Capital
- Representative household
 - three members: (1) consumer-worker, (2) entrepreneur, (3) banker
 - perfect insurance within household

HOUSEHOLDS

Family of three "occupations":

① Worker

- Supply labour
- Returns the wage to household
- Makes deposits

② Banker

- Manages a financial intermediary
- (An i.i.d.) exit probability $1 - \lambda^b$ (average survival time $= 1/(1 - \lambda^b)$).
- Upon exiting, a banker transfers retained earnings to the household and becomes a worker.
- Each period a same share of workers convert to bankers and receive a "start up" transfer from the family. Share stays constant.

HOUSEHOLDS...

③ Entrepreneur

- Runs an investment project.
- Otherwise a similar structure as the banker but with exit probability $1 - \lambda^e$.

Perfect consumption insurance within family.

HOUSEHOLDS.....

Other issues

- Bank deposits are intra-period deposits (Carlstrom and Fuerst (1997)
 - ⇒ can be excluded from the intertemporal budget constraint.
 - ⇒ facilitates comparison with the standard New-Keynesian model.
- Capital accumulation

$$K_{t+1} = (1 - \delta)K_t + p_H R I_t.$$

TIMING OF EVENTS

- 1 Contracts are designed and signed
- 2 The banks decide how much to monitor, the entrepreneurs choose the project (in equilibrium they always choose the good project)
- 3 The projects are carried out
- 4 The projects are completed, and the capital goods are sold (to capital rental firms) at price q_t
- 5 The proceeds are divided between the entrepreneur, the bank and the outside investors (depositors)
- 6 **Investment shock:** The quality of some of the capital goods is not appropriate. The capital rental firms (that have bought the defective capital goods) are reimbursed by the entrepreneurs and the bankers (but not by the depositors/outside investors) .

PRODUCTION OF CAPITAL

- Produced by entrepreneurs
- Entrepreneurs borrow from other households.
- Successful project transform i units of final goods to Ri units ($R > 1$) of capital goods.
- Probability of a "good" project: p_H .
Continuum of "bad" projects with probability $p_L < p_H$
differing amount of non-verifiable revenues bi ($b \in (0, \bar{b}]$).
Divisible and transferable (unlike in original HT).

PRODUCTION OF CAPITAL...

We need to ensure that the good project

- 1 has a positive rate of return, and
- 2 it is preferable to all bad projects from the households point of view

$$q_t p_H R > \max \left\{ 1 + r_t^d, q_t p_L R + \bar{b} \right\}$$

PRODUCTION OF CAPITAL.....

Monitoring

- By monitoring intensity c
- bank eliminates all bad projects $b \geq b(c)$ from the entrepreneurs choice set. Diminishing returns.
 - bankers will never want to eliminate all bad projects.
 - entrepreneurs must be provided incentives to choose the good project.
- Monitoring requires real resources: bank pays ci units of final goods to workers of its household.
 - the more monitoring, the smaller ability to lend.

THE FINANCING CONTRACT

Features

- Three-party contract: depositors (workers), entrepreneurs, bankers.
- Limited liability
- Inter-period anonymity → no reputation issues.
- Entrepreneurs invest all their own wealth n_t to the project
- Stipulates how much of i_t comes from banks a_t and depositors d_t .
- How the return R in the case of success is distributed among the entrepreneur R_t^e , her bankers R_t^b and depositor R_t^w .
- Banker, given his share of the cake, maximizes the banks' profits by choosing monitoring intensity c_t .
- Assume that banks behave competitively.

THE FINANCING CONTRACT...

Optimal financing contract solves the following program:

$$\max_{\{i_t, a_t, d_t, R_t^e, R_t^b, R_t^w, c_t\}} q_t p_H R_t^e i_t$$

subject to the entrepreneur's and her banker's incentive constraints

$$q_t p_H R_t^e i_t \geq q_t p_L R_t^e i_t + b(c_t) i_t, \quad (1)$$

$$q_t p_H R_t^b i_t \geq q_t p_L R_t^b i_t + (1 + r_t^d) c_t i_t, \quad (2)$$

THE FINANCING CONTRACT.....

the depositors' and the banker's participation constraints

$$q_t p_H R_t^w i_t \geq (1 + r_t^d) d_t, \quad (3)$$

$$q_t p_H R_t^b i_t \geq (1 + r_t^a) a_t, \quad (4)$$

and the resource constraints for the investment inputs and outputs

$$a_t + d_t - c_t i_t \geq i_t - n_t, \quad (5)$$

$$R \geq R_t^e + R_t^b + R_t^w. \quad (6)$$

THE FINANCING CONTRACT.....

- (5) implies that the aggregate supply of investment funds must satisfy their aggregate demand and
- (6) that the total returns must be enough to cover the total payments.
- All constraints bind in equilibrium.

INVESTMENTS AND LEVERAGE

Solving the problem for i_t gives

$$i_t = \frac{n_t}{g(r_t^a, r_t^d, q_t, c_t)} \quad (7)$$

where

$$g(r_t^a, r_t^d, q_t, c_t) = \frac{p_H b(c_t)}{\Delta p (1 + r_t^d)} + \left[1 + \frac{p_H}{\Delta p} \left(1 - \frac{1 + r_t^d}{1 + r_t^a} \right) \right] c_t - \rho_t \quad (8)$$

is the **inverse of degree of leverage**.

INVESTMENTS AND LEVERAGE

- The first term: larger possibilities to extract private revenues decrease leverage by discouraging participation of outside investors.
- This effect can be reduced by increasing monitoring.
- The second term: more intense monitoring also has two negative effects on leverage
 - consumes resources that could have otherwise been invested in the project, and
 - makes it harder to satisfy the banker's incentive constraint.
- $\rho_t \equiv \frac{p_H q_t R}{1+r_t^d} - 1 > 0$ denotes the net rate of return on the good investment project. The larger the rate of return the easier to attract outside funding.

MONITORING CHOICE

Optimal level of monitoring solves

$$\max_{c_t \geq 0} \frac{b(c_t)}{g(r_t^a, r_t^d, q_t, c_t)}. \quad (9)$$

where the functional form for $b(c_t)$ is

$$b(c_t) = \begin{cases} \Gamma c_t^{-\frac{\gamma}{1-\gamma}} & \text{if } c_t > \underline{c} \\ \bar{b} & \text{if } c_t \leq \underline{c} \end{cases}, \quad (10)$$

where $\Gamma > 0$, $\bar{b} > 0$, $\gamma \in (0, 1)$, and $\underline{c} \geq 1$. The second row implies that there is a minimum efficient scale for monitoring investments or an upper bound for the private revenues.

AGGREGATION

Assume

- all projects will be monitored with the same intensity and
- all entrepreneurs have the same capital structure.

→ straightforward aggregation.

Surviving banker receive

- the proceed $\lambda^b p_H R_t^b I_t$ (entrepreneur similarly), and
- (note that the production of investment goods is at the end of the period. Hence bankers and entrepreneurs park their wealth to capital rental firms.)
- the capital rental income r_t^K and
- the unit of undepreciated capital good at the period $t + 1$, ie $(1 - \delta)q_{t+1}$.

DYNAMICS OF CAPITAL

Accumulation of bank and entrepreneurial capital is slow!

Bank's capital

Entrepreneurial capital

$$A_{t+1} = A_t \lambda^b (1 + r_t^a) \times \left[\frac{r_{t+1}^K + (1 - \delta) q_{t+1}}{q_t} \right],$$

$$N_{t+1} = N_t \lambda^e (1 + r_t^e) \times \left[\frac{(r_{t+1}^K + (1 - \delta) q_{t+1})}{q_t} \right],$$

where

$$1 + r_t^a \equiv q_t p_H R_t^a I_t / A_t$$

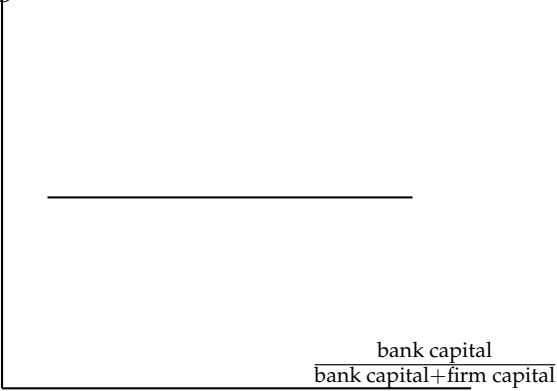
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AGGREGATE INVESTMENTS AND COMPOSITION OF INFORMED CAPITAL

Without endogenous monitoring

aggregate investments



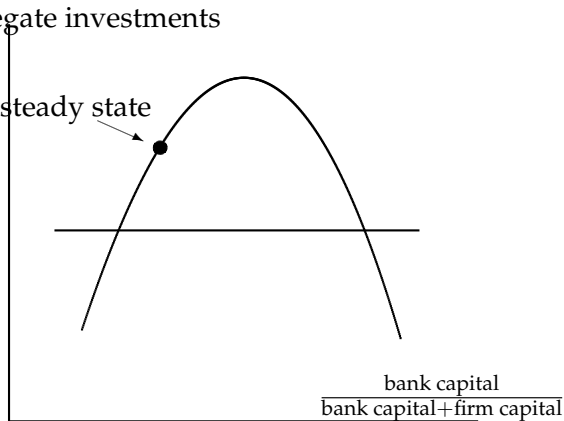
$\frac{\text{bank capital}}{\text{bank capital} + \text{firm capital}}$

AGGREGATE INVESTMENTS AND COMPOSITION OF INFORMED CAPITAL

With endogenous monitoring

aggregate investments

steady state



SCARCITY OF BANKS' CAPITAL RESULTS FROM THE REAL MONITORING COSTS

Real monitoring costs result in scarcity

The more intensive monitoring the less resources can be invested in the projects.

Another angle to the scarcity:

- maximizing leverage implies intensive monitoring (by banks)
- and banks should invest more of their own capital to limit moral hazard
- but this implies low yield (less scarce capital)
- that makes it difficult to sustain large bank capital stock.

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BANKERS AND BANKS: HEDGING DEPOSITORS

Bank is a balance sheet entity which *pays to the depositors*

$$\text{bank} = \left\{ \begin{array}{c} \text{banker} \\ \vdots \\ \text{banker} \end{array} \right\}$$

A banker manages a project. His/her pay off depends on the success of the project.

→ **depositors are hedged** against success/failure of individual bankers

→ failure of larger number of projects does not harm depositor but reduces bank capital

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AGGREGATE INVESTMENT SHOCKS

In the standard New-Keynesian (or RBC) model

$$K_{t+1} = (1 - \delta)K_t + I_t(1 + \varepsilon_t^I)$$

We adjust the success probability of a project:

$$\tilde{p}_H = p_H(1 + \varepsilon_t^I)$$

$$\tilde{p}_L = p_L(1 + \varepsilon_t^I)$$

$E_t \varepsilon_t^I = 0$, shock occur at the *end of period*.

AGGREGATE INVESTMENT SHOCKS. . .

Aggregate (negative) investment shock:

→ *levered* impact on aggregate bank capital

leverage proportional to $\frac{\text{deposits}}{\text{banks' aggregate capital}}$

→ *BUT* no levered impact on the firms' capital *due to limited liability*.

⇒ all next period investments smaller.

MARGINAL VALUE OF CAPITAL

Investment shock occur at the *end of period*: $E_t \varepsilon_t^I = 0$

→ banks' and entrepreneurs' **capital risky!**

Negative investment shock $\varepsilon_t^I \downarrow$

→ wipes out banker and entrepreneurial capital, $A, N \downarrow$

→ marginal value of bank and (often) entrepreneurial capital rise, $v^e, v^b \uparrow$

→ marginal value of banks' capital even higher (due to banker/bank structure), $v^b \uparrow\uparrow$.

Pro-cyclicality of banks' capital generates high premium that affects incentives:

→ banks ask larger share of the cake; deposits smaller

→ projects are smaller

Just like in equity premium but **high bank leverage amplifies the channel!**

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(Stochastic) marginal value of bankers capital v_t^b :

$$v_t^b = \underbrace{(1 - \lambda^b)}_{\text{converts}} + \lambda^b \beta E_t \underbrace{\left\{ \Lambda_{t,t+1} \overbrace{\frac{r_{t+1}^K + (1 - \delta)q_{t+1}}{q_t} (1 + \tilde{r}_{t+1}^b)}^{\text{return, } r} v_{t+1}^b \right\}}_{\text{stays}}$$

If banker *converts*, she consumes the wealth

↔ marginal value of capital is unity.

If banker *stays* as an entrepreneur, she earns *expected return, r* .

Entrepreneur's problem analogous

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AGENCY PROBLEM AND VOLATILITY

The more volatile (macro) environment

- the higher risk premium and
- the higher the banks' share

→ the more serious agency problem and

→ the lower the depositors share.

And the lower is the output!

CALIBRATION

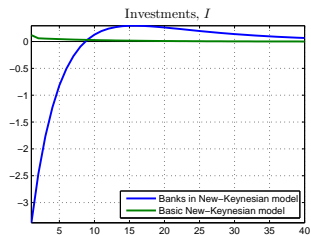
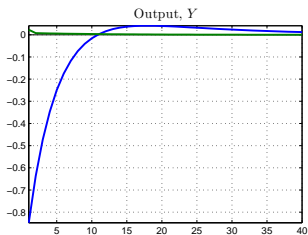
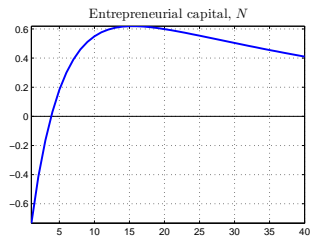
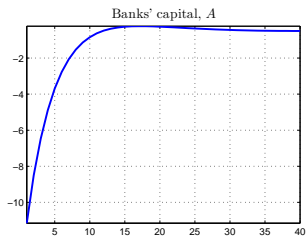
Standard RBC – New Keynesian calibration

Financial block is based on the following statistics

- Riskless real rate 2 % per annum
- Excess (real) return on banks capital 13 %
- Excess return on firm capital 6.5 %
- Firms' capital investment ratio 45 %
- Banks' capital ratio 4 %
- Banks (annual) monitoring costs relative to assets 0.6 %

We use `dynare++` to compute our simulations: **3rd order approximation of the nonlinear decision rules.**

NEGATIVE INVESTMENT SHOCK



SHOCK PROPAGATION

Basic New-Keynesian

Less (than expected) capital available due to negative investment shock

→ more investments needed in subsequent periods

Financial frictions

Due to banks' leverage investment shock has large impact on banks' capital.

Since banks' capital is scarce, the impact is even larger to investments.

Due to reduced bank capital, there is less monitoring.

Due to less monitoring, firms need to have a higher stake, ie more capital.

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GOVERNMENT CAPITAL

Government sits on the table and asks a piece of cake with the same cream as the banker's piece.

Assumption (Terms of injection)

The government capital has equal terms with banks' capital.

Government injects capital to banks

- from entrepreneurs' perspective it is like any banks' capital:
very costly
- it does not help banks to borrow from depositors

CHANNELS

Incentives

Ex post capitalization **dilutes banker's payoff to monitoring:**

- government eats part of the cake
- less monitoring
- more difficult to borrow from depositors
- smaller investment projects
- less bank capital accumulation
- bank involvement becomes more costly to the entrepreneurs.

Terms of recapitalizations play important role.

CHANNELS...

Equity cushion

Ex ante capitalization increases total capital

$$\text{leverage} = \frac{\text{deposits}}{\underbrace{\text{banks' capital} + \text{gov. injection}}_{=\text{total capital}}}$$

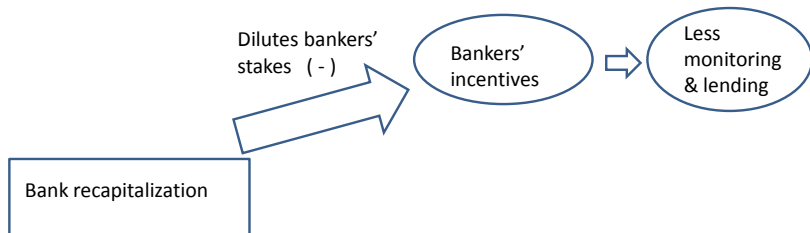
and helps in taking the hit of an investment shock.

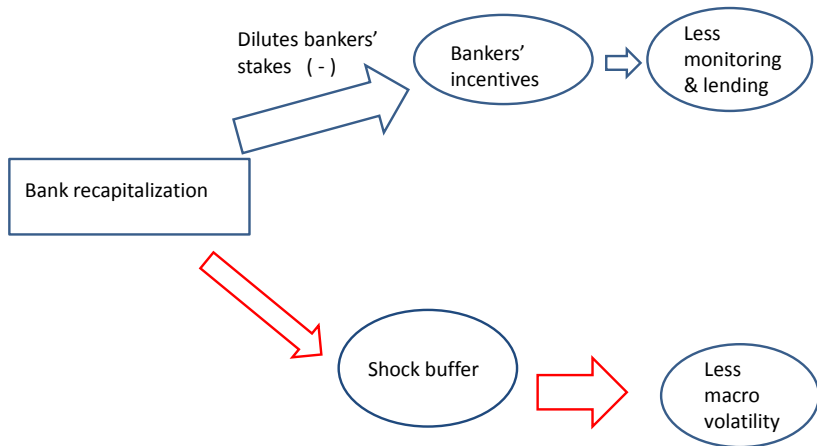
CHANNELS.....

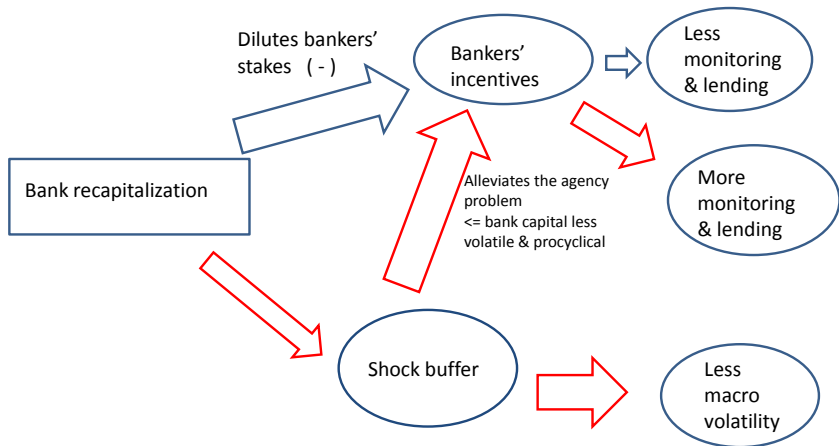
Uncertainty

In a volatile economy equity cushion interacts with incentives:

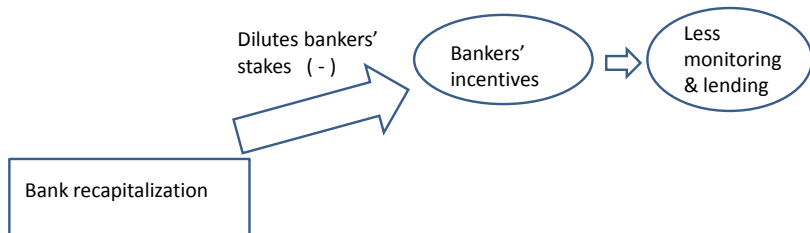
- government capital takes part of the negative hit
- banks' capital less pro-cyclical and less volatile
- smaller risk premium
- banks' share is smaller and depositors' larger
- projects are larger, investments higher



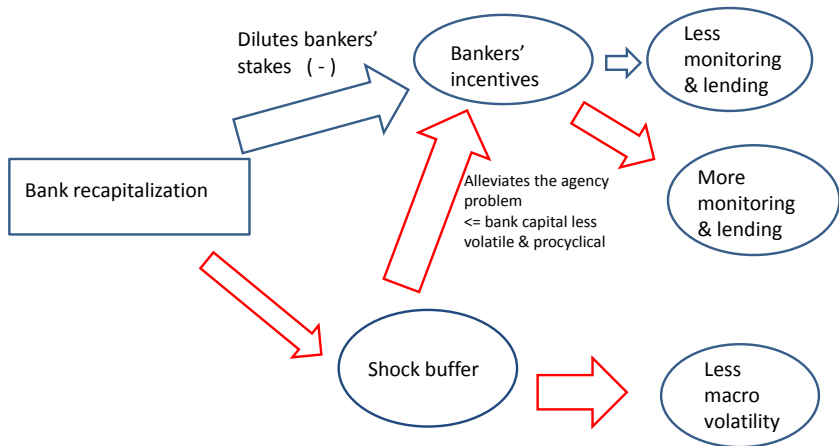




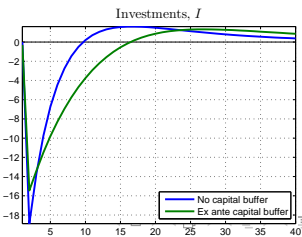
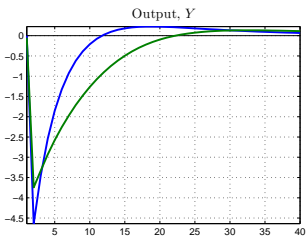
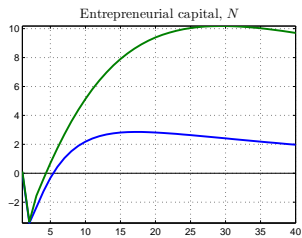
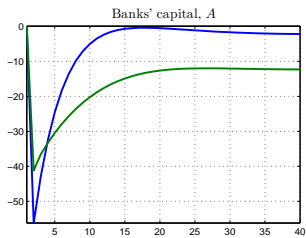
"Normal times"



Turbulent times



Ex ante CAPITALIZATION (50%) AND NEGATIVE INVESTMENT SHOCK (-0.05)



CONCLUSIONS

- A macro-finance model, where both banks' and firms' balance sheets matter: Holmström and Tirole (1997) with endogenous monitoring intensity and aggregate investment shocks.
- In equilibrium, bank capital tends to be scarce, compared to firm capital
- Due to bank leverage, bank capital is vulnerable to (negative) investment shocks
→ Bank capital plays a crucial role in the propagation of (certain) shocks
- Capital injections from the government to banks
 - useful as a shock cushion
 - may be counter-productive if the aim is to avoid deleveraging and boost investment
 - attractive in volatile economic environment.

THANK YOU!

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