Money and Capital in a persistent Liquidity Trap

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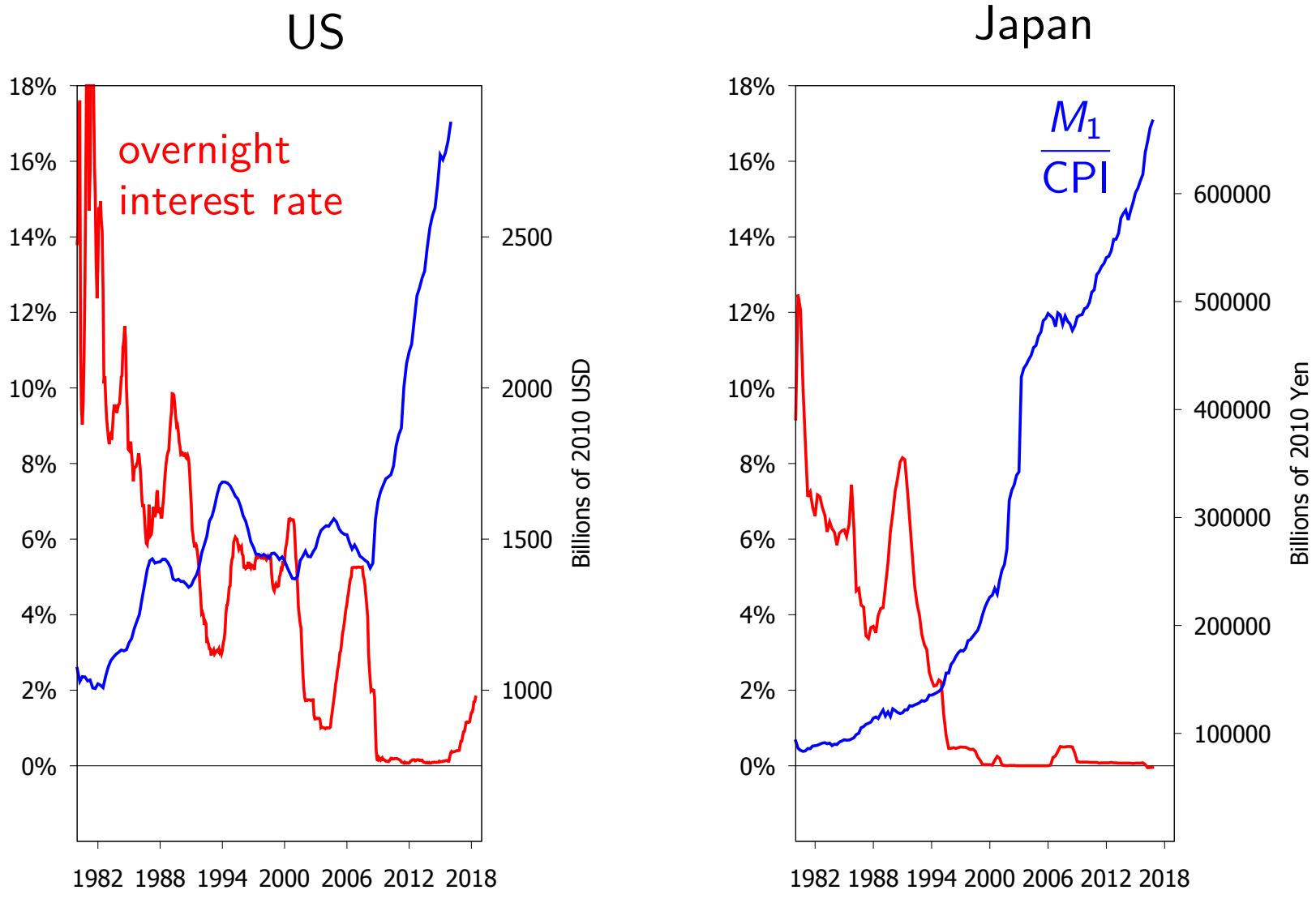
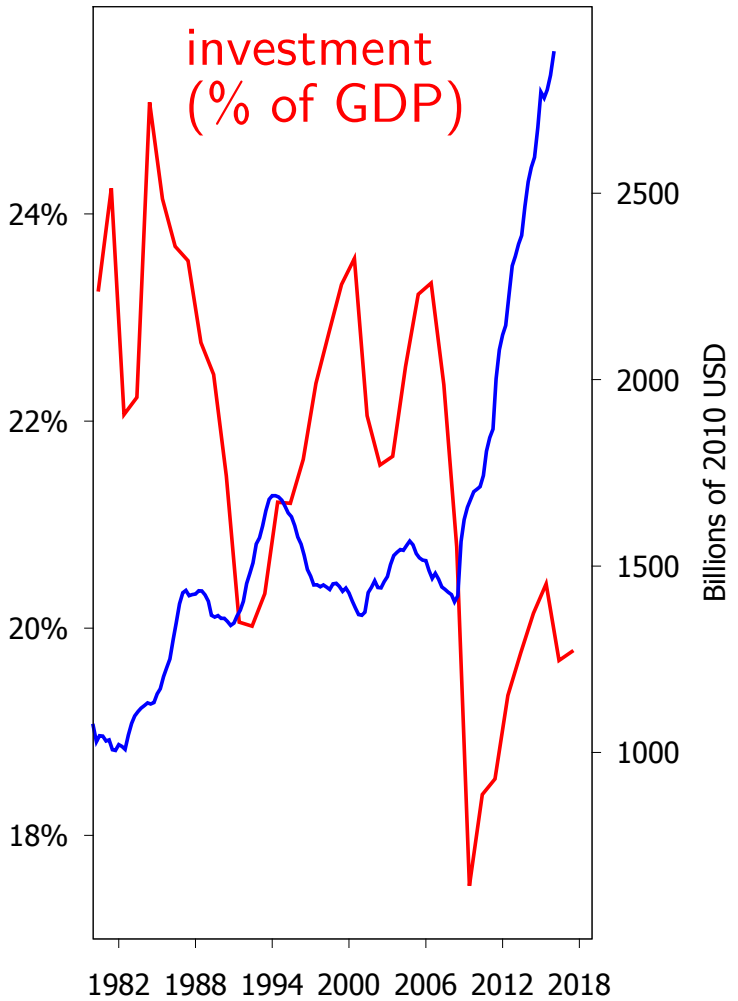
Persistent liquidity traps

Increased real cash holdings in persistent liquidity traps

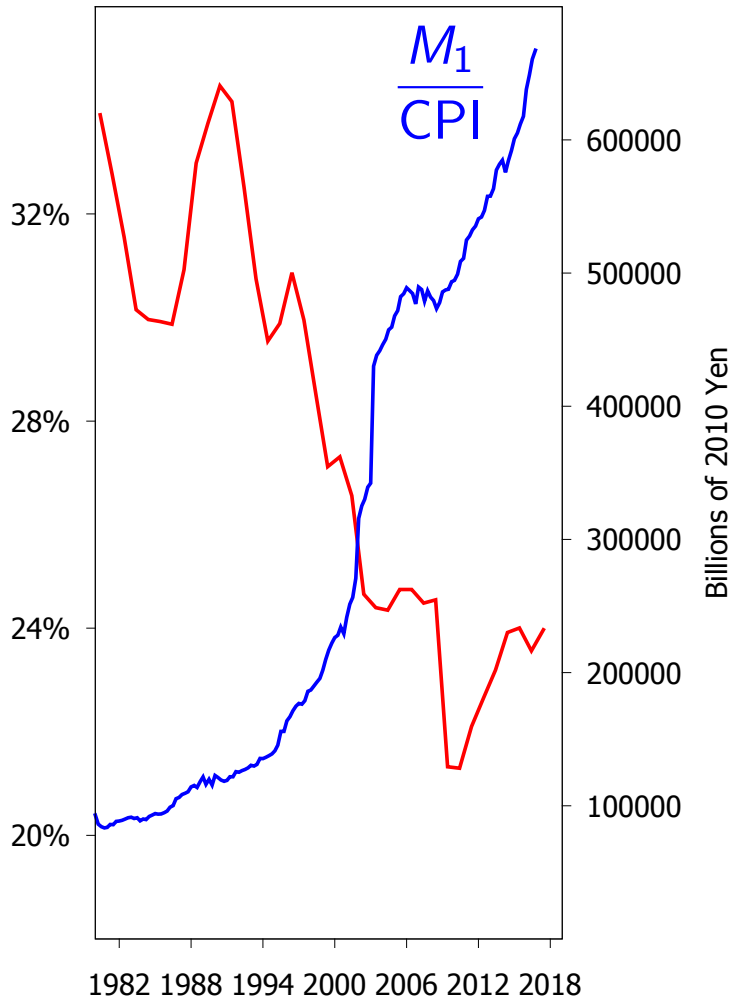


Investment slowdown in persistent liquidity traps

US



Japan



negative impact on potential output

Can increased real money holdings crowd out physical capital?

Can increased real money holdings crowd out physical capital?

Standard models

- no
- money holdings have no real effects
- usually kept out of the model

This paper

- outside ZLB: no
- at ZLB: investors hold cash as a saving instrument
- cash has low return: leads to low investment and output in the medium term

medium term supply-side effect of persistent liquidity trap

A model of scarce assets with money

model of scarce assets

- credit-constrained investors hold assets to finance investment
- deleveraging: borrowing constraint reduces supply of assets
- w/o money: arbitrarily low equilibrium interest rate (shadow rate)

introduce money explicitly

- sets ZLB and creates gap between effective and shadow rate
- outside ZLB: only provides transaction services
- at ZLB: used as saving instrument

medium term analysis

- first study flexible price steady states (after prices have adjusted)
- supply-side view ($\neq$ usual demand-side analyses)
- also look at transition dynamics with short-run nominal rigidities

Main results

Consider a deleveraging shock that reduces net supply of assets

outside ZLB	• interest rate decline: stimulates the supply of assets • deleveraging shock need not affect capital and output
at ZLB	• interest rate gap widens & investors increase money holdings • medium-term decline of capital and output • why? low return of money & real balance effect
policy implications	• exit the trap: decrease effective rate or increase shadow rate • higher Gov't debt helps exiting ZLB but can lead to lower output • QE widens interest rate gap and can extend the liquidity trap

Relation to the literature

Persistent liquidity traps in standard NK models: insufficient demand

- persistently negative output gap $\Leftrightarrow$ persistent nominal rigidities
- Schmitt-Grohé-Uribe 2013, Eggertsson and Mehrotra 2014, Caballero-Farhi 2015, Benigno-Fornaro 2015, Michau 2015

Supply-side effects at the ZLB

- Buera-Nicolini 2014, Guerrieri-Lorenzoni 2015, Ragot 2016

Money and liquidity

- fiat money as a saving instrument: OLG model of Samuelson 1958, turnpike model of Townends 1980
- external liquidity (public debt) and investment: Woodford 1990, Holmström-Tirole 1997, Kiyotaki-Moore 2008, Kocherlakota 2009, Farhi-Tirole 2012, Benhima-Bacchetta 2015

Real balance effect

- the Pigou effect: Pigou 1943, Patinkin 1956
- which also obtains in non-ricardian heterogenous-agent models: Weil 1991, Ireland 2005, Benassy 2008, Devereux 2011

Outline

1. A model with scarce assets and money

Main assumptions

One-good economy with nominal bonds and money

Two types of agents: investors and workers

Investors have a demand for assets

- they save, waiting for investment opportunities
  (as in Woodford, 1990)
- investing phase: issue bonds to finance investment
  but subject to borrowing constraint
- Bonds dominate money as a saving vehicle, except at ZLB

Workers need money for transactions

Baseline model: perfect foresight & flexible prices

Investors

Maximize $U_t = \sum_{s=0}^{\infty} \beta^s \log(c_{t+s})$

Alternate between investing and saving phase

gross real interest rate $= \frac{i_{t+1} P_t}{P_{t+1}}$

Investing phase in t: $c_t^I + k_{t+1} = a_t + \frac{M_t^S}{P_t} + \frac{b_{t+1}}{r_{t+1}}$

Saving phase in t: $c_t^S + \frac{a_{t+1}}{r_{t+1}} + \frac{M_{t+1}^S}{P_t} = \rho_t k_t - b_t$

Borrowing constraint (relevant for investing phase)

$$b_{t+1} \leq \phi_t \rho_{t+1} k_{t+1}$$

deleveraging shock: $\phi \downarrow$

Capital rented to firms with production function $y_t = k_t^{\alpha} h_t^{1-\alpha}$

- $\rho_t k_t = \alpha y_t$ (full depreciation in benchmark model)

Supply of assets by other agents

Workers

Cash-in-advance constraint:

$$M^w_{t+1} = \text{wage bill} = (1-\alpha)P_t y_t$$

Exogenous real debt limit I^w

Government

Budget constraint:

$$\frac{M_{t+1}}{P_t} - \frac{M_t}{P_t} + \frac{I^g_{t+1}}{r_{t+1}} = \frac{T^w}{P_t} + I^g_t$$

Fiscal policy sets real debt I^g

Monetary policy:

$$M_{t+1}/M_t = \theta \geq 1$$

(pins down long-term inflation)

Solving the model

Analytical results in benchmark model

- perfect foresight
- permanent shocks on ϕ

  (proxy very persistent shocks)
- steady state equilibria

  (give asymptotic response)
- flexible prices and wages

(+ full K depreciation)

Simulate transition dynamics in extended model

- uncertainty
- leverage $\phi \in (\phi^H, \phi^L)$

  deleveraging: ϕ drops from ϕ^H to ϕ^L

  with prob π of switching back to ϕ^H
- downward wage rigidity

  $W_t = \max\{\gamma W_{t-1}, W_t^*\}$

  W^* is market-clearing wage

(+ partial K depreciation)

Equilibrium

Shortage of assets

Equilibrium on the bond market

$$\underbrace{b_{t+1}}_{\leq \phi_t \alpha y_{t+1}} + \underbrace{I^w_{t+1} + I^g_{t+1}}_{\equiv I_{t+1}} = a_{t+1}$$

net supply of bonds to investors

Asset-scarce equilibrium

if ϕ and I low

borrowing constraints are binding

$r < 1/\beta$ in the steady state

Assume "autarkic" investors

I is net position of investors

case $I = 0$ is actually realistic

implies $b = a$

Euler equation of savers

$$\underbrace{\beta(1-\phi_{t-1})\alpha y_t}_{\text{demand for saving instruments}} = \underbrace{\frac{1}{r_{t+1}}\left(\phi_t \alpha y_{t+1} + \frac{M^S_{t+1}}{P_{t+1}}\right)}_{\text{supply of saving instruments}} \qquad (1)$$

Normal equilibrium

$i_{t+1} > 1$

then $M^S = 0$

- r adjusts

Liquidity trap (ZLB)

$i_{t+1} = 1$

then $r_{t+1} = P_t/P_{t+1}$

- $M^S/P > 0$ adjusts

define shadow rate r^S that would obtain without ZLB

Aggregate budget constraint of investors

$$k_{t+1} = \beta\alpha y_t - \frac{P_{t+1}}{P_t}\frac{M^S_{t+1}}{P_{t+1}} + \beta\frac{M^S_t}{P_t} \tag{2}$$

price of liquidity

crowding-out effect

liquidity effect

Equilibrium on money market

$$M_{t+1} = \underbrace{(1-\alpha)P_t y_t}_{\text{transaction (workers)}} + \underbrace{M^S_{t+1}}_{\text{saving (investors)}} \tag{3}$$

price P adjusts to accommodate demand for money

(with nominal rigidities: y temporarily adjusts downward)

2. The effect of deleveraging

Asymptotic response to long-lasting deleveraging (steady state analysis)

Deleveraging shock: $\phi \searrow$

Euler equation

$$\beta(1-\phi)\alpha y = \frac{1}{r}(\phi\alpha y + m^S)$$

Aggregate budget constraint

$$k = \beta\alpha y - (\theta - \beta)m^s$$

with $m_t^S = M_t^S / P_t$

normal equil.

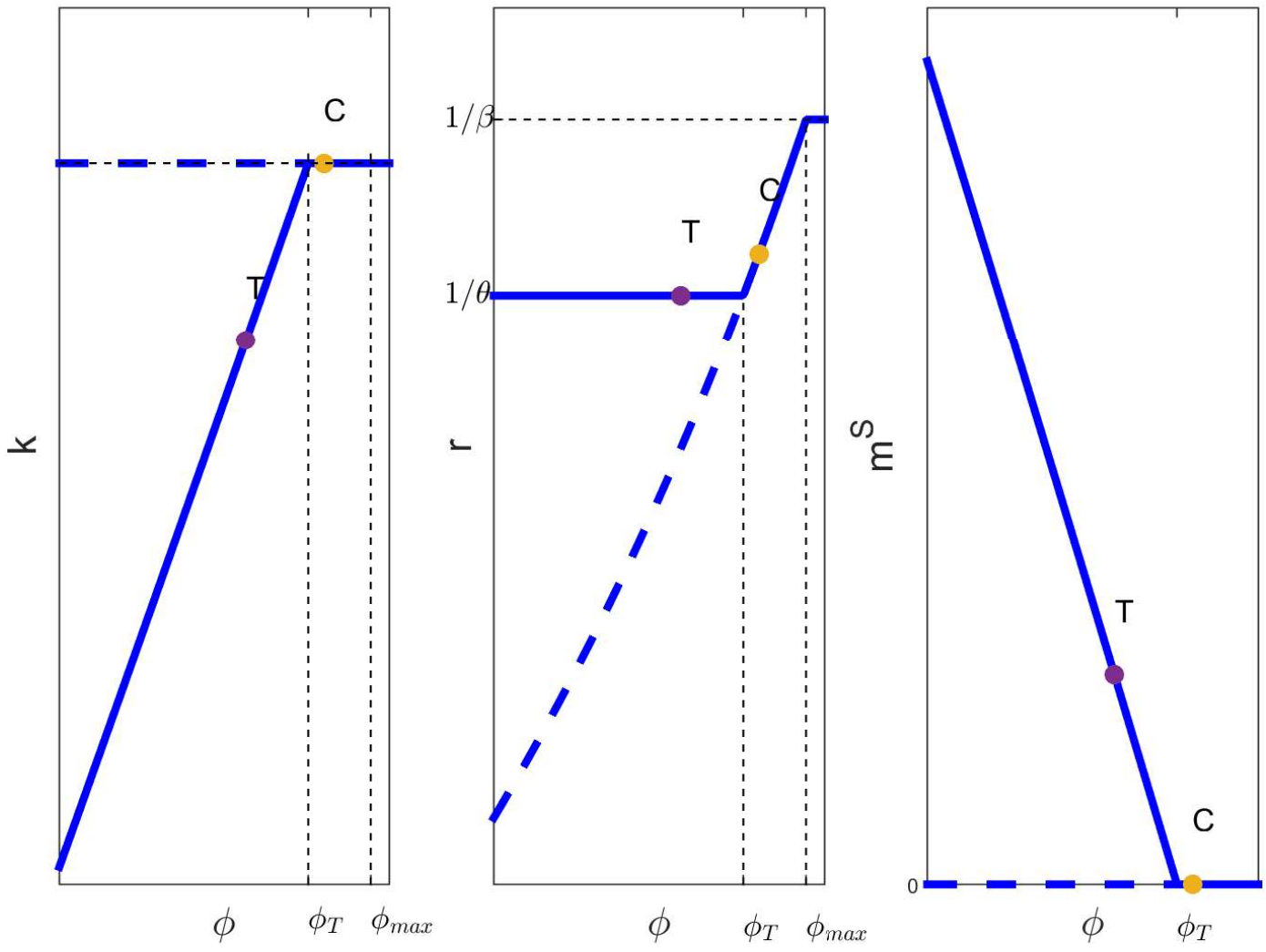
- $m^s = 0$
- $r = r^S = \dfrac{\phi}{\beta(1-\phi)} \searrow$
- $k = \beta\alpha y$ doesn't depend on ϕ

liquidity trap

- $r - r^S = \dfrac{1}{\theta} - \dfrac{\phi}{\beta(1-\phi)} \nearrow$
- $m^S = \alpha \underbrace{\left[(1-\phi)\dfrac{\beta}{\theta} - \phi\right]}_{\propto(r-r^S)} y \nearrow$
- $k = \beta\alpha y - (\theta - \beta)m^S \searrow$

low return ($\theta > \beta$) takes away resources from investment

Investors' deleveraging



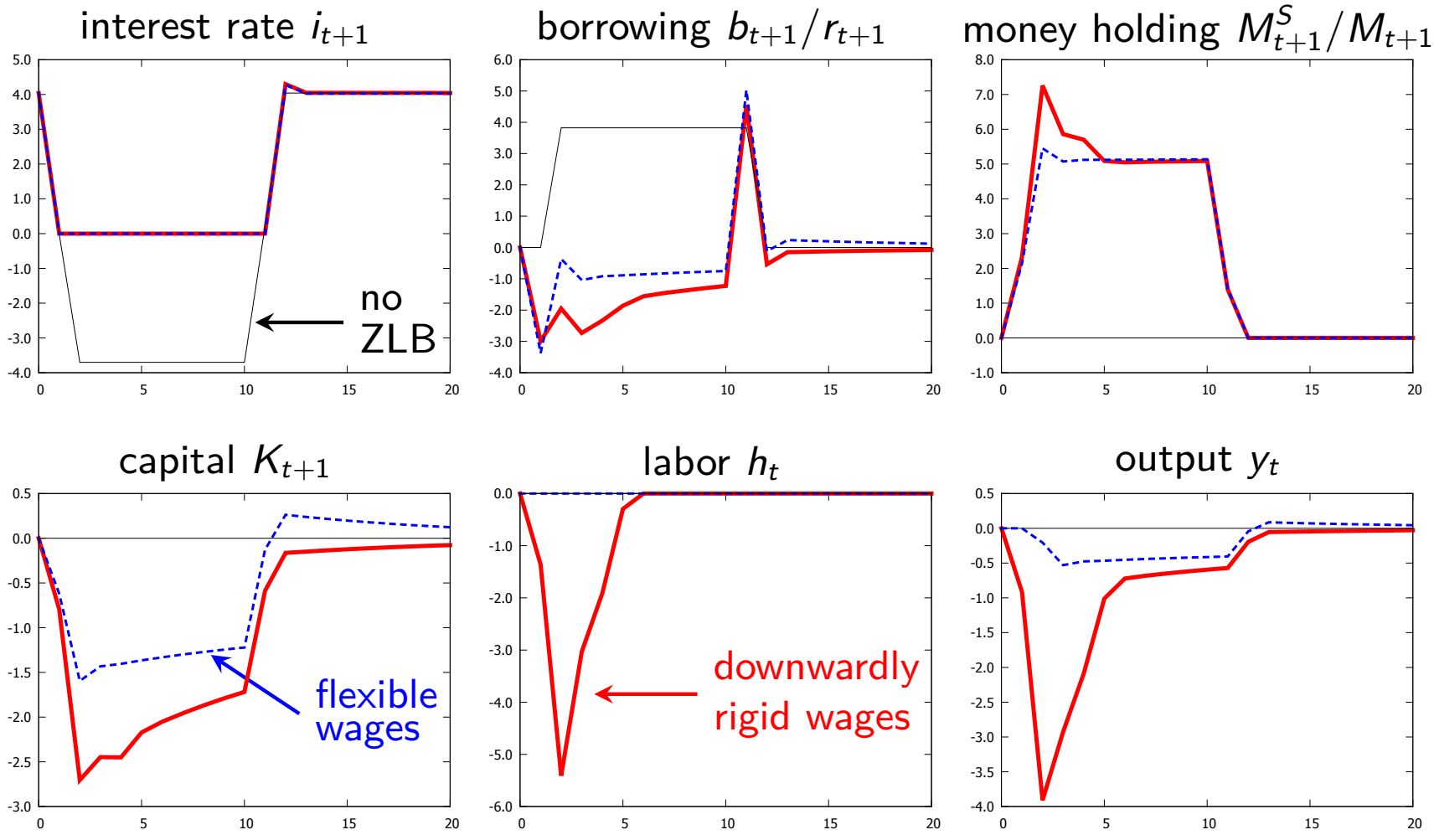
Dashed line = shadow variables

Transition dynamics during transitory deleveraging

Calibration: US economy pre-crisis

Parameter	Value	Target
Time period = 1 year		
Balance sheet parameters		
I^g	0	Gov't supply of assets, net of RoW demand (Flow of Funds 2006)
I^w	0	Autarkic investors
Rates of return		
β	0.96	4% real return on capital
ϕ^H	0.495	2% real interest rate
Deleveraging parameters		
$\phi^L/\phi^H - 1$	-3.9%	20% peak-to-trough non-resid. investment
γ	1.005	5.5 pp increase civilian unemployment
π	0.10	10% probability of exit each year
Conventional parameters		
α	0.33	
δ	0.10	
θ	1.02	

Response to a 10 year deleveraging shock

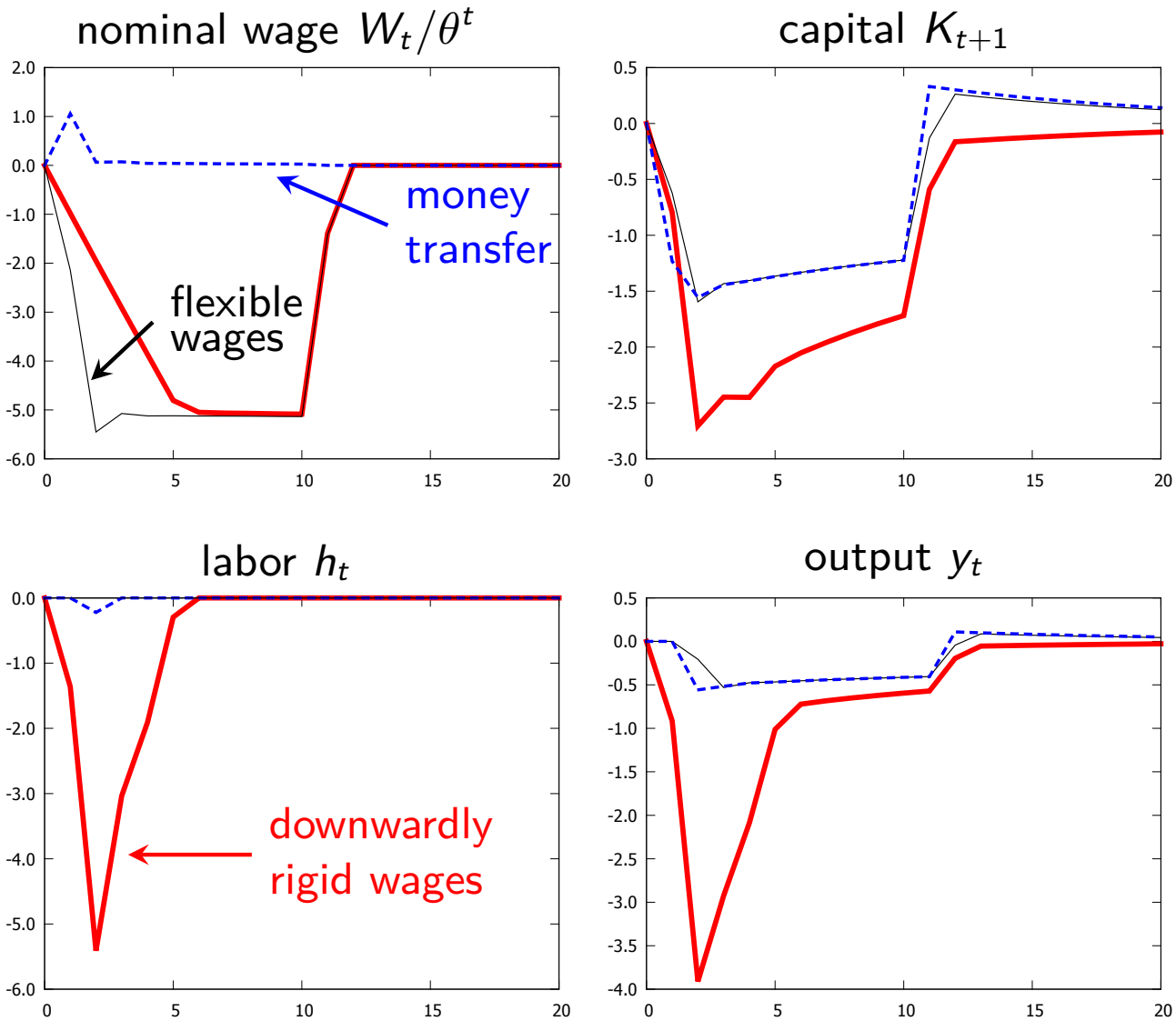


- strong keynesian demand-side effects in short run
- supply-side effects remain after wages have adjusted

3. Policies in a liquidity trap

Addressing short-run keynesian unemployment

Helicopter money can mimic flexible wages



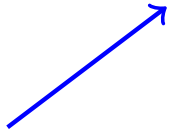
- in the following, focus on flexible wages

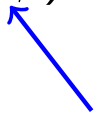
Exiting the liquidity trap

Exiting the liquidity trap

Requires closing the interest rate gap

$$r - r^S = \frac{i}{\theta} - \frac{\phi + (I^w + I^g)/(\alpha y)}{\beta(1-\phi)}$$





Decrease effective rate

- higher inflation θ
- negative nominal rate i

Increase shadow rate

- increase public debt I^g = public supply of liquidity
- QE = decrease shadow rate and deepens liquidity trap

What is the effect on capital and output?

Scarce-asset setting: low rates are inefficient
(impair consumption smoothing and in some cases lead to capital overaccumulation)

Decrease effective rate

Large enough decrease: exit ZLB

- higher capital and output

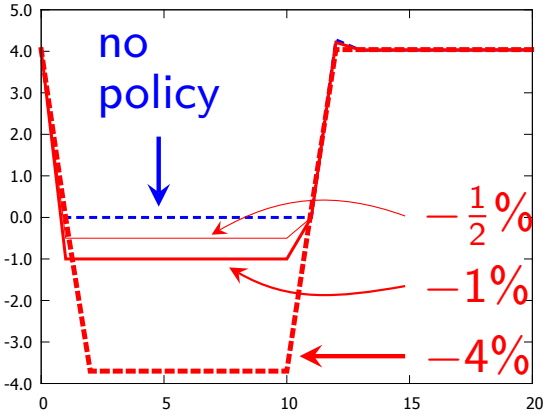
But timid decrease has ambiguous impact on capital and output

- low real rate decreases the demand for money
  (b/c relaxes borrowing constraint)
- but also decreases real return on money

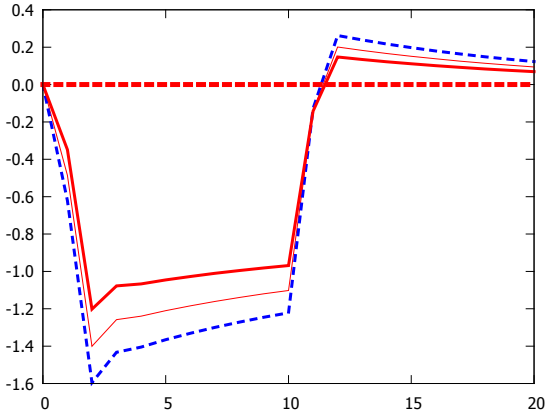
Negative interest rate

Baseline deleveraging shock (4%, with $\pi = 1/10$)

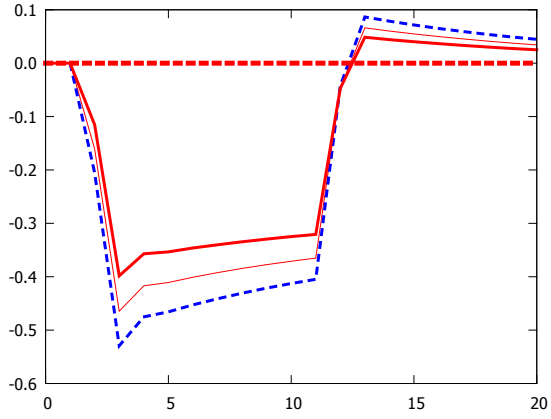
interest rate i_{t+1}



capital K_{t+1}

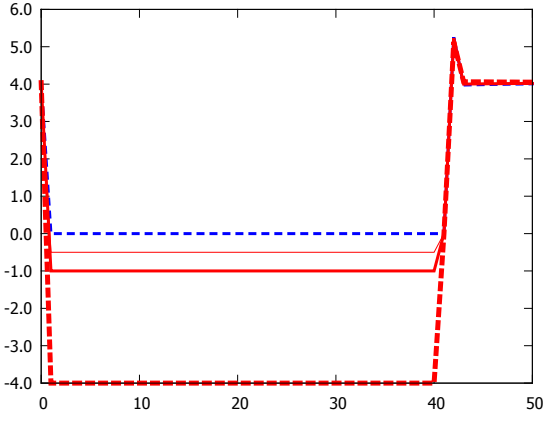


output y_t

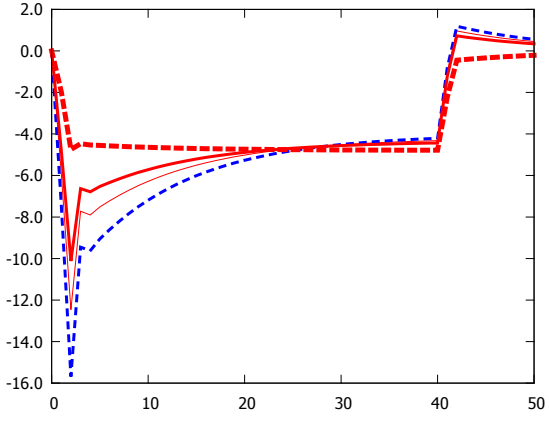


Stronger deleveraging shock (9%, with $\pi = 1/20$)

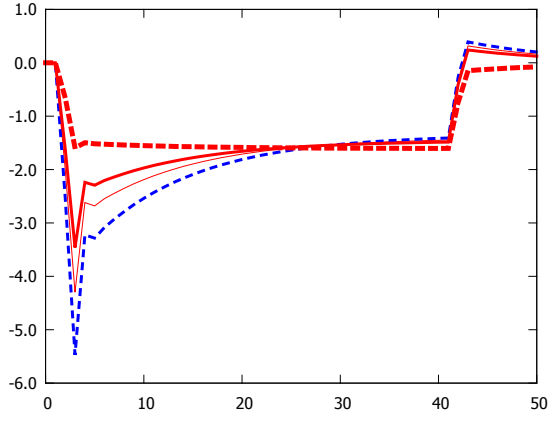
interest rate i_{t+1}



capital K_{t+1}



output y_t



Increase shadow rate

Large enough increase of public debt: exit ZLB

- small increase offset by $\downarrow m^S$

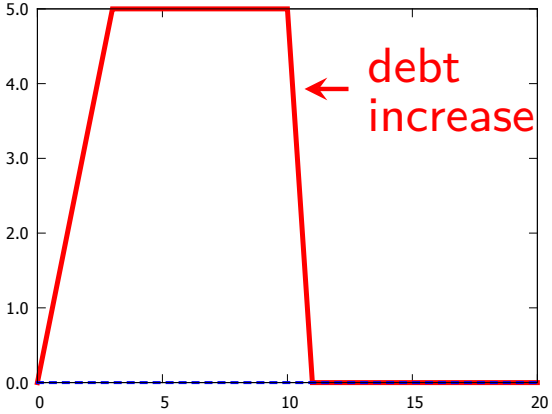
When exiting the liquidity trap

- possible negative impact on capital and output for small increase in I^g
- positive impact if large enough increase in I^g

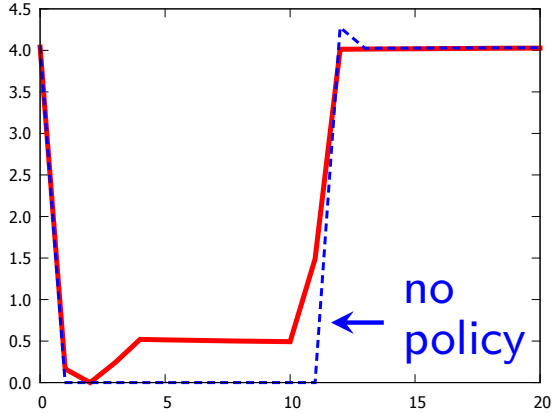
Increase Government debt

Debt increase by 5% of GDP in 2 years
baseline deleveraging shock (4%, with $\pi = 1/10$)

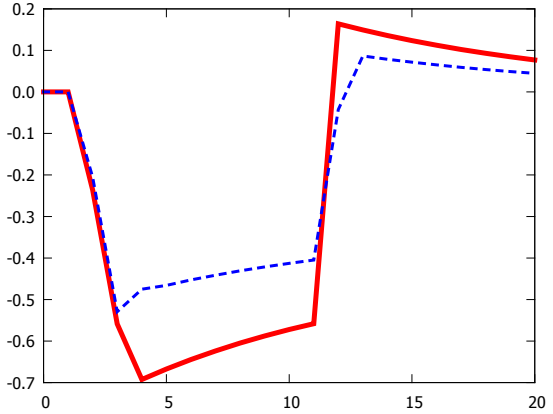
bonds l^g_{t+1}/y_{t+1}



interest rate i_{t+1}

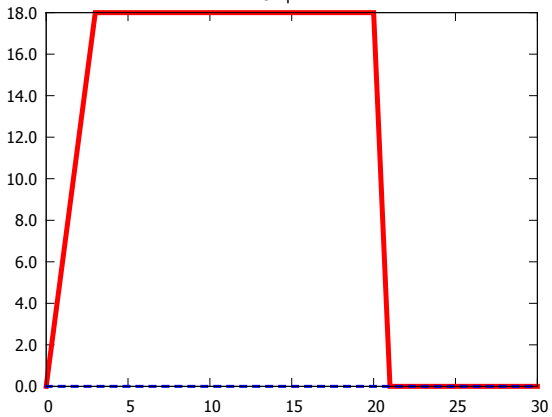


output y_t

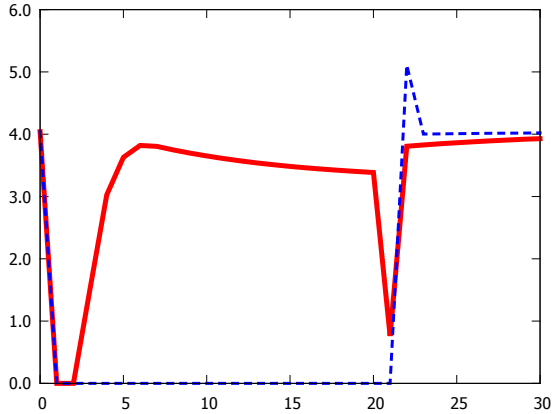


Debt increase by 18% of GDP in 2 years
stronger deleveraging shock (8%, with $\pi = 1/20$)

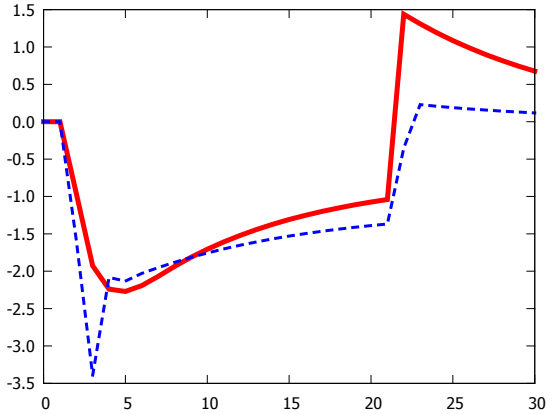
bonds l^g_{t+1}/y_{t+1}



interest rate i_{t+1}

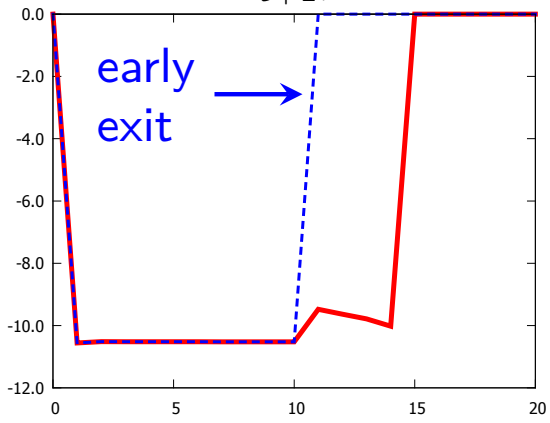


output y_t

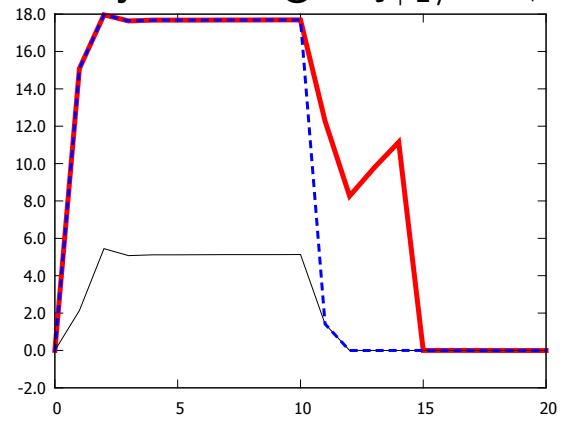


QE with late exit can extend the liquidity trap

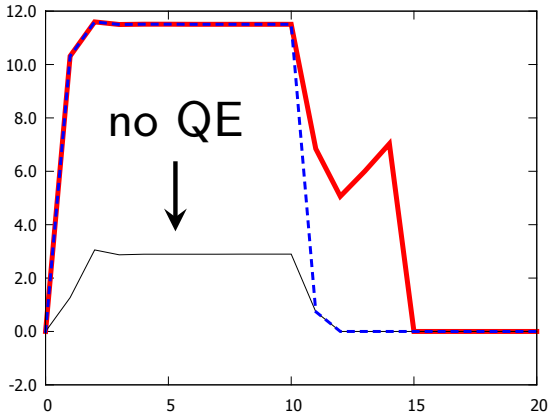
bonds l^g_{t+1}/y_{t+1}



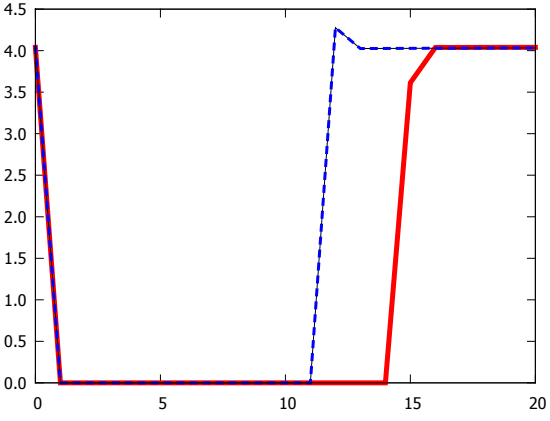
money holding M^S_{t+1}/M_{t+1}



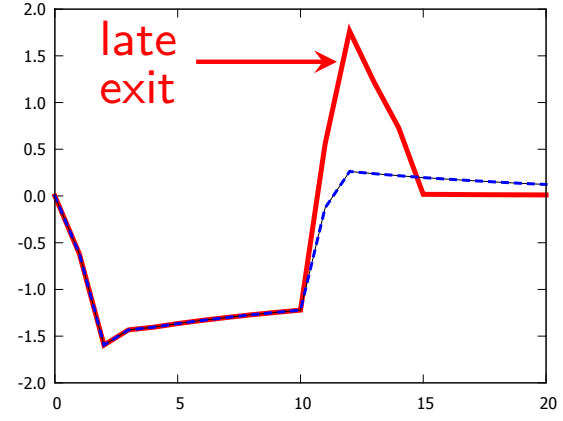
gap Δ_{t+1}



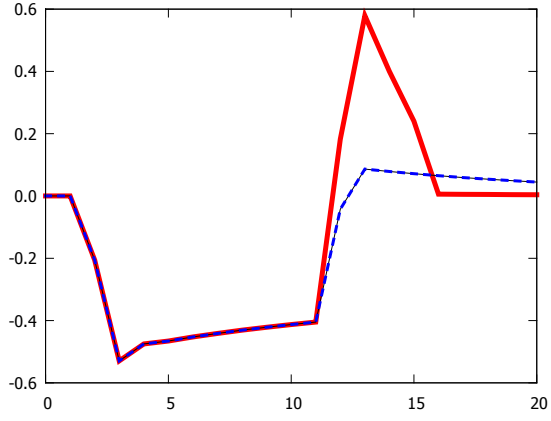
interest rate i_{t+1}



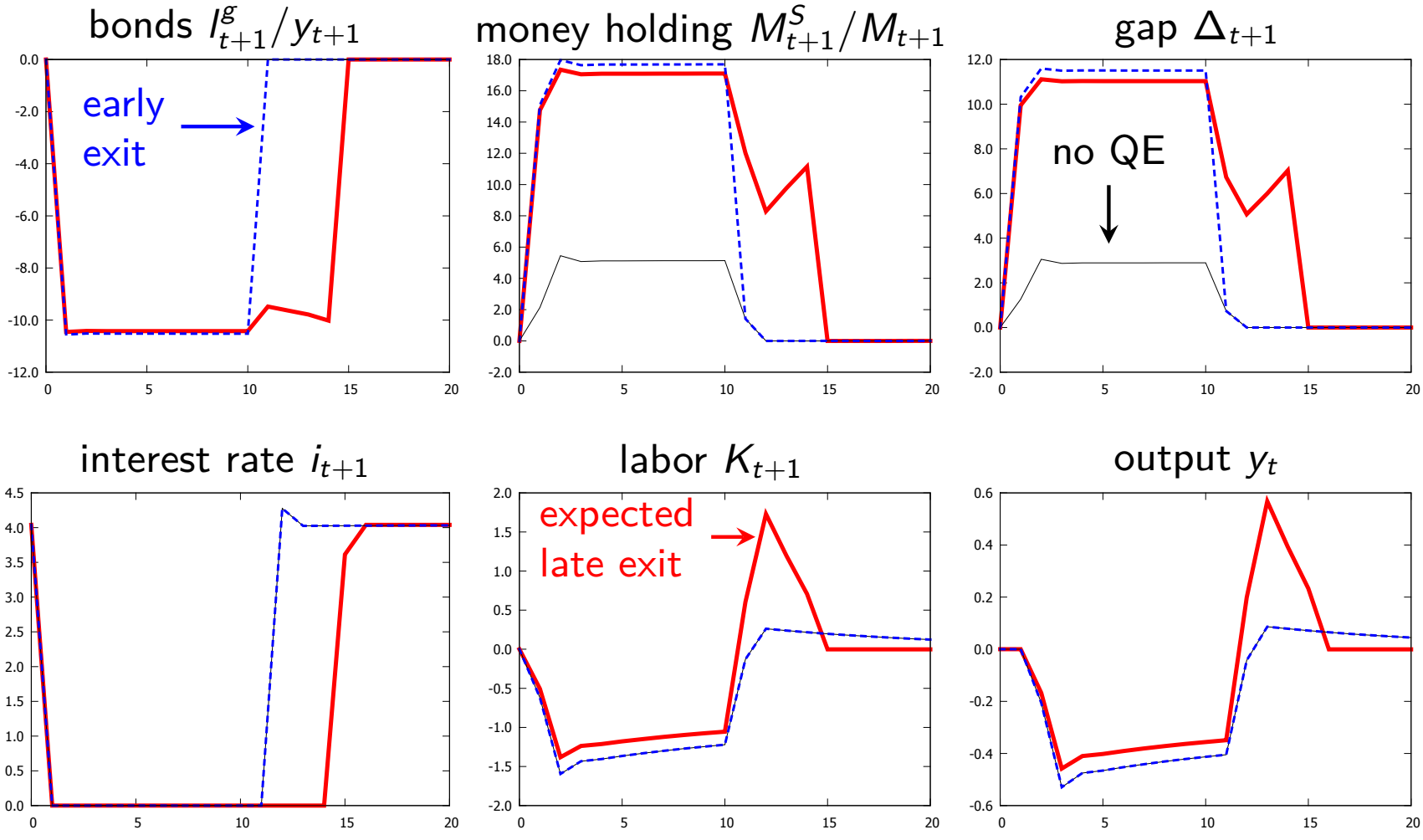
labor K_{t+1}



output y_t



QE with late exit can extend the liquidity trap



- if expected, late exit sustains somewhat output during deleveraging

First best policy

A non-ZLB steady state with high enough public debt is Pareto-efficient

but need to (i) make sure investment is not hurt by higher rates during transition

- capital subsidy

(ii) help investors smooth consumption during transition

- corporate tax

and (iii) make sure no agent is worse off

- consumption tax

4. Extensions

Extensions

workers' deleveraging

- tightening workers' borrowing limit also decreases asset supply
- same effect on interest rate and money holdings
- but positive effect on capital and output [more]

bubbles

- bubble can appear when $r \leq 1$, both at/outside ZLB
- bubble sustains a higher interest rate
- ambiguous effect on capital [more]

preference and growth shocks

- $\uparrow$ in discount factor or $\downarrow$ in productivity growth can lead to ZLB
- but no negative medium-run impact on capital
- because saving increases

other

- financial intermediation, inefficient saving technology, idiosyncratic uncertainty [more]
- similar results

Conclusion

Deleveraging of investors in a liquidity trap can explain both:

- cash hoarding
- persistent slowdown in investment

Persistent liquidity trap has supply-side policy implications

- focus on the supply of assets
- complementary to demand-side policies in the short term

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Appendix

Investors are in autarky in the US data

Balance sheet for Nonfinancial Corporate Business
in Financial Accounts of the US

Simple definition of net position

- Net worth - Nonfinancial Assets
- between -2% of GDP in 2000 and 6% of GDP in 2006

More restricted definition

- Net position in interest bearing assets
- between -9% of GDP in 2000 and -2% of GDP in 2006

[back]

Calibration of balance sheet parameters

Financial Accounts of the US in 2006

Net position of Government (incl. monetary authority) in interest-bearing instruments $\approx$ -40% of GDP

Net position of rest of world in interest-bearing instruments $\approx$ 40% of GDP

- available supply of Governement assets ≈ 0

[back]

Investors' deleveraging with $I \neq 0$

normal equil.

- shadow rate r^S increases with I: $r = \frac{\phi + I/(\alpha y)}{\beta(1-\phi)}$
- $k = \beta\alpha y - (\frac{1}{r} - \beta)I$ now depends on r and ϕ

liquidity trap

- total liquidity $s = m^S + I = \alpha \left[(1-\phi)\frac{\beta}{\theta} - \phi\right] y$ $\nearrow$ when $\phi \searrow$
- $k = \beta\alpha y - (\theta - \beta)s$ $\searrow$ when $\phi \searrow$

Workers' deleveraging

Workers' deleveraging ($l^w \searrow$)

Outside ZLB

similar to investors's deleveraging

- asset shortage: $r \searrow$
- lower r has a positive effect on capital

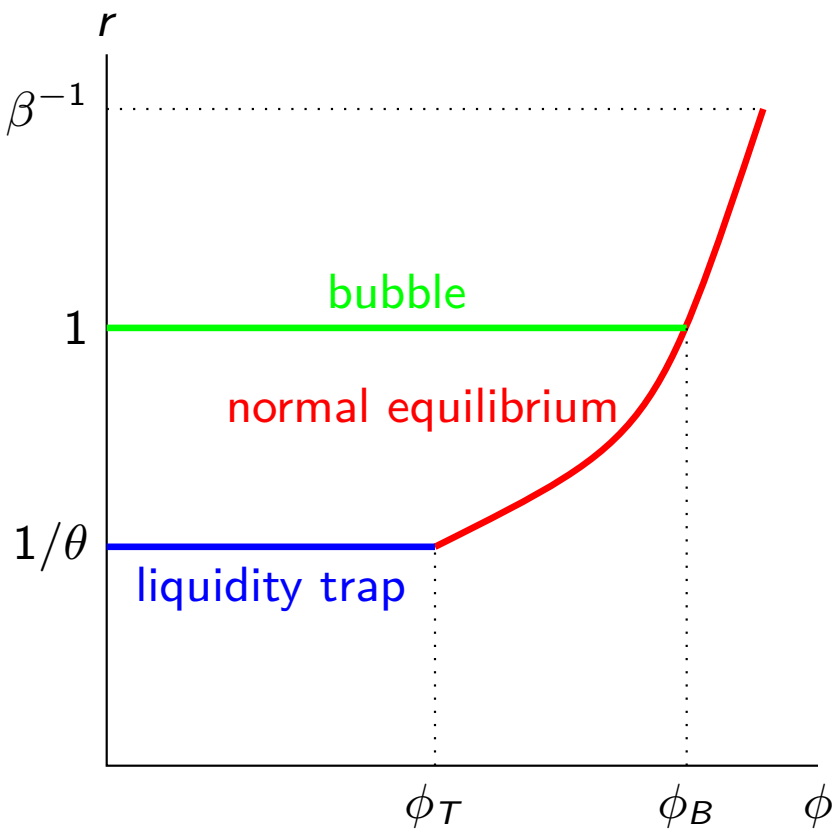
Liquidity trap

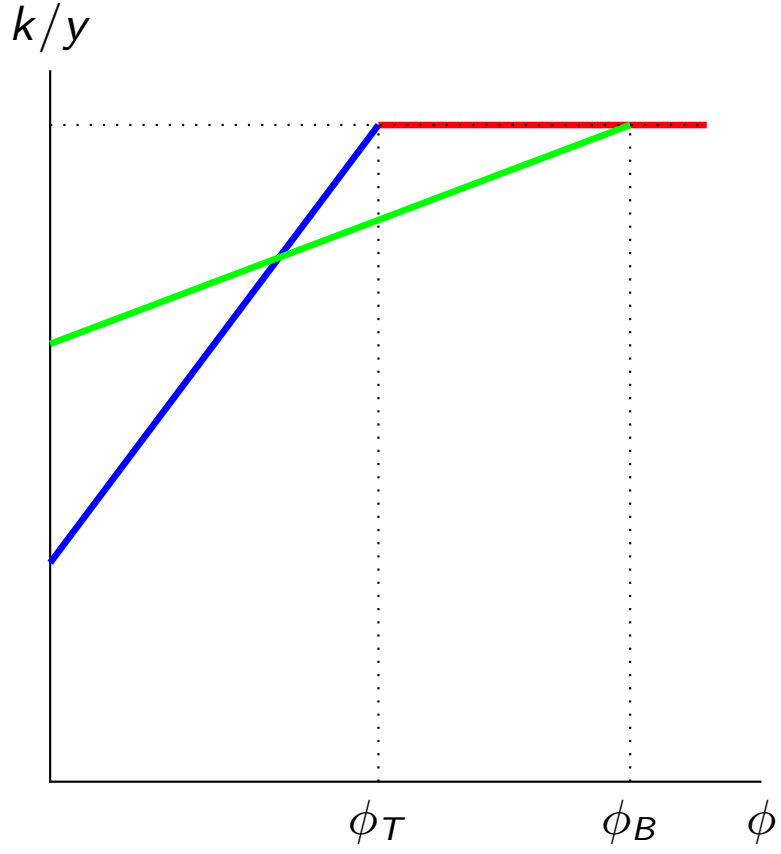
no effect on k

- does not affect investors' asset demand, which is still $\alpha[(1-\phi)\beta/\theta - \phi]y$
- effect on supply of assets to investors $m^S + l$ is fully offset by increase in m^S

[back]

Bubbles





- bubble can appear when $r \leq 1$
- equivalent to money when $\theta = 1$

- intermediate (low) leverage: bubble crowds out (in) capital

[back]

Financial intermediation

- money mainly in bank deposits
- a model with banks is isomorphic to baseline model
- increase in cash holdings by investors at ZLB shows up as an increase in excess bank reserves at the Central Bank

[back]