Interest rates, bank liquidity and credit frictions

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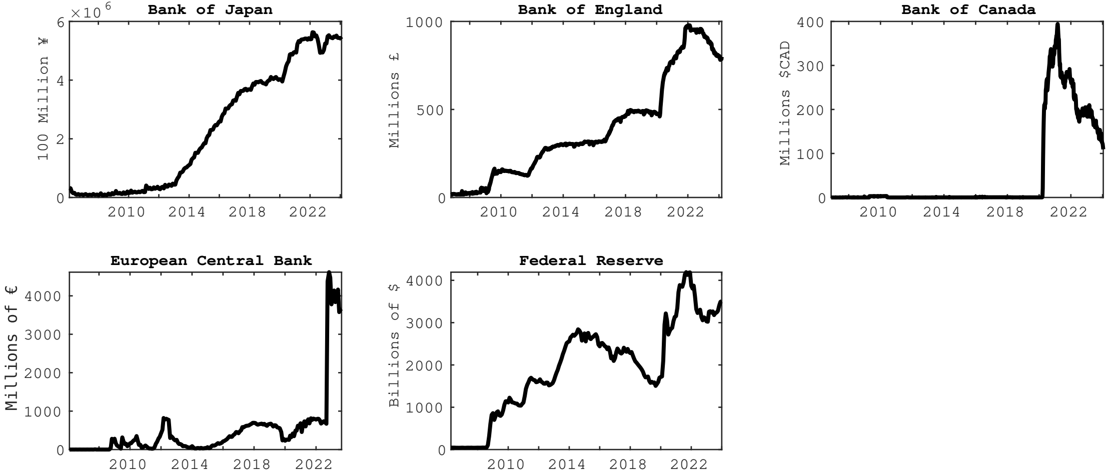
Sky-rocketing banking sector liquidity



Shows central bank reserve balances / deposit facility use

Monetary policy implementation has evolved since the Great Moderation

Expanded toolkit – balance sheet policies, more prominent role for forward guidance, credit easing policies etc

Implementation of ‘conventional’ monetary policy also shifted, e.g.:

- ECB – fixed allotment auction $\longrightarrow$ fixed rate, full allotment
- US: interest on reserve balances
- Negative interest rates

These policies contributed to a big increase in banking sector excess reserves

Bank liquidity and the credit channel

Increasing banking sector liquidity and UMPs have had an unclear affect on bank lending

Central banks injected huge amounts of liquidity, but banks often increase excess reserves rather than increase lending:

- 2008–2009 excess reserves in US $\uparrow$ while lending standards were tightened (source: SLOOS)
- 2010–2012 lots of liquidity in eurozone banking sector without increasing lending in stressed economies

Bank liquidity and lending

- More (less) liquidity tends to increase (decrease) lending: Kashyap, Rajan & Stein (2002) (see also Adrian & Shin 2010, Carpenter, Demiralp & Eisenschmidt 2014)

- Sometimes the impact of liquidity is ambiguous, it depends on:
  - balance sheet of banks (Berger & Bouwman 2009, Disyatat 2011, Cornett et al. 2011, Gambacorta & Marques-Ibanez 2011)
  - profitability of lending (Disyatat 2011)
  - risk in the economy (Joyce, Tong & Woods 2011, Gambacorta & Marques-Ibanez 2011)

- Acharya, Eisert, Eufinger & Hirsch (2019) find in the EZ, increased liquidity (via balance sheet policies) $\rightarrow$ banks help more cash and low interest assets, but <u>did not increase loans</u>
  - See also Gambacorta & Marques-Ibanez (2011), Joyce, Tong & Woods (2011), Loutskina (2011), Disyatat (2011), Iyer et al. (2014)

Lending to SMEs

Lending to SMEs seized up in eurozone

- Continued despite easing of sovereign debt crisis
- Despite easy monetary conditions
- Driven by credit supply rather than demand (Holton, Lawless & McCann 2013)
- Iyer, Peydró, da Rocha-Lopes & Schoar (2014) find 'no overall positive effects of central bank liquidity but instead higher hoarding of liquidity'

Plenty of evidence QE boosted activity at the ZLB (Gambacorta, Hofmann & Peersman 2014)

- An important channel was an increase in lending (Rodnyansky & Darmouni 2017, Ferrando, Popov & Udell 2019)
- But evidence that smaller firms remained credit constrained (Acharya, Eisert, Eufinger & Hirsch 2019, Finnegan & Kapoor 2023)

Aim of Paper

Build a model to rationalise some of this evidence

- The ambiguous link between liquidity and lending
- The role of interest rate corridors
- Small business lending frictions

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Use this to study:

- Role of monetary policy (interest rates, interest rate corridors, and UMPs)
- Interaction between liquidity and credit frictions

Credit channel of monetary policy

There is a huge literature on credit channel of monetary policy:

- Starting point: Bernanke & Blinder (1988) shows how increased reserves translate to higher lending in IS/LM model
- Bernanke & Gertler (1995) highlight two distinct channels: *bank-lending* channel and *balance-sheet* channel
- Balance sheet channel: e.g., Bernanke & Gertler (1989), Gertler & Gilchrist (1994), Bernanke, Gertler & Gilchrist (1999), Iacoviello (2005)
- Bank lending channel: e.g., Gertler & Kiyotaki (2010), Cúrdia & Woodford (2010), Brunnermeier & Sannikov (2014), Holden, Levine & Swarbrick (2020)

I build on a literature that studies the impact of information frictions in bank lending (see, e.g, Diamond 1984, Kiyotaki & Moore 1997, Ioannidou et al. 2022)

- In particular, adverse selection and credit rationing: Stiglitz & Weiss (1981), Eisfeldt (2004), Bolton, Santos & Scheinkman (2011), Martin & Taddei (2013), Kurlat (2013), Benhabib, Dong & Wang (2018), Bigio (2015) Chang (2018), Ikeda (2020)

Interest rate corridors and liquidity management

Traditionally, central banks could implement monetary policy via:

- OMOs
- setting reserve requirements
- setting interest rates on standing facilities in corridor system

With abundant liquidity, the corridor system became more important

- ECB already has corridor system in place
- Fed began paying IoER during GFC, moving towards corridor system
- As liquidity rose, many central banks moved to a floor system

See Bindseil (2000) (theory of bank liquidity management), Whitesell (2006) (corridor system), and Goodfriend (2002) (comparison of frameworks: RR vs corridors)

Corridor system 1/2

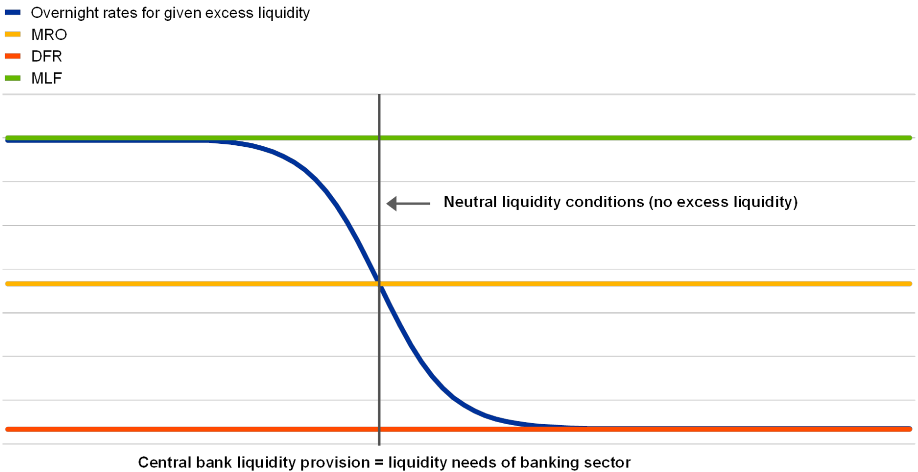


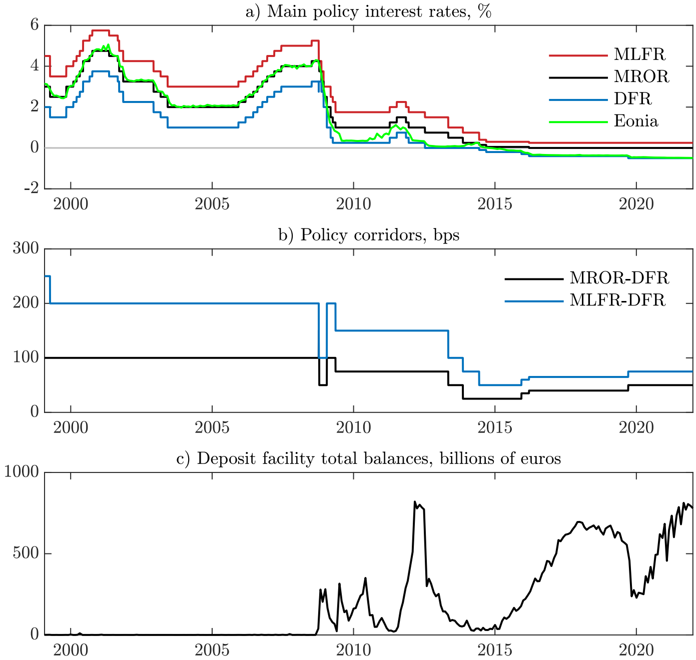
Figure: From Eisenschmidt, Kedan & Tietz (2018) (ECB Economic Bulletin 2018(5))

Corridor system 2/2

- Width of interest rate corridor to manage the volatility of overnight rate (Bindseil & Jabłecki 2011)
  - Narrow corridor $\rightarrow$ low volatility
  - Wide corridor $\rightarrow$ high interbank market volumes

- High reserve balances $\rightarrow$ floor becomes more important
  - Floor (CB deposit rate) becomes main policy interest rate
  - Deposit rate lowered to incentivize increased lending to real economy
  - Draghi (2015): "cuts in the rate on the deposit facility vastly improve the transmission of our monetary policy"

ECB interest rates



This paper

It is an early stage project – comments very welcome!

This paper:

- presents a model with endogenous excess reserves
- the interest on reserves affects banks incentives
- we'll see that liquidity injections impact lending conditions via:
  - affecting bank profitability
  - altering the incentive structure when banks face adverse selection
- it is not the volume of liquidity that matters, it is bank profitability, and the interaction with information frictions
- QE can have a positive or negative impact on lending
- always positive at the ZLB

Model Overview

New Keynesian (Calvo) model + frictional bank lending + bank liquidity risk:

- Households are standard
- Follow Swarbrick (2023) – Stiglitz & Weiss (1981) information problem (see also, e.g., Ikeda 2020)
- Some firms have private information
- Each period draw either risky/safe projects (risk of productivity ω^i)
- Expected productivity the same $\rightarrow$ $1 = \omega_t^s = p_t \omega_t^r$
- Banks can separate borrowers using loan approval
- When risk is high, banks can ration credit and hold excess reserves (paying CB deposit rate)

Firms

Want to focus on bank lending channel/credit friction affecting **SMBs**

- Assume some projects verifiable safe, some unverifiable safe / risky
- Small firms characterised as being unable to i) diversity risk, ii) having unverifiable information
- All require 1 unit of external finance
- Refer to firms with private information **small firms**, others are **large firms**
- Firm entry costs – firm entry until firm value = costs
- Cobb-Douglas production function

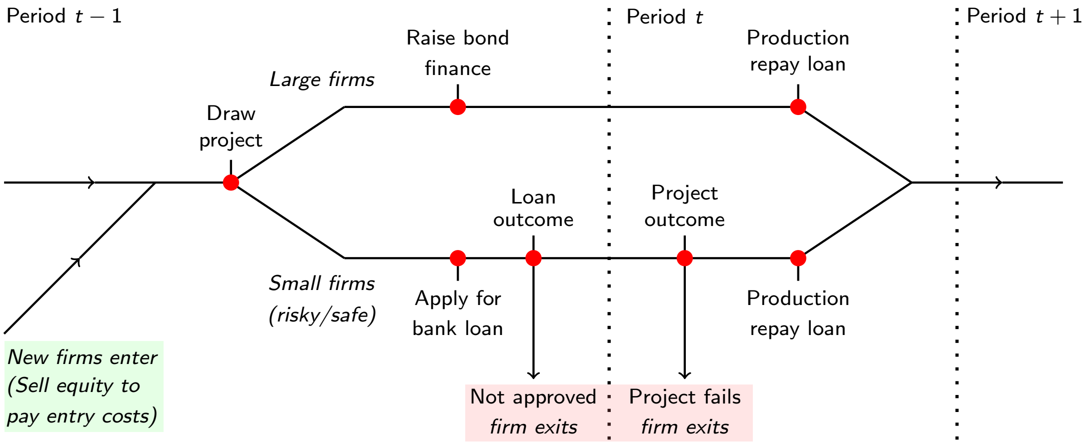
Large firms:

- No information problem, so raise finance in bond market

Small firms:

- Banks do a better job screening borrowers

Firm dynamics



Banks

To fix ideas, it is useful to separate liquidity demand and loan supply:

1. Bank demand liquidity — liquidity demand satisfies free entry condition
2. Banks post lending contracts (**frictional lending**)
3. Banks face risk in matching to firms (**liquidity risk**)

We can ignore the liquidity risk for now

Banks and lending 1/2

- Separate borrowers using loan approval
  - Abstract from collateral and loan size
  - Loan terms are repayment rate τ_t^i and approval rate x_t^i

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$$R_{t+1}^s - \tau_t^s \geq 0 \tag{1}$$

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- Risky **incentive compatibility** (IC) constraint binds

$$\underbrace{x_t^r p_{t+1}\left(R_{t+1}^r - \tau_t^r\right)}_{\text{Surplus choosing risky loan}} \geq \underbrace{x_t^s p_{t+1}\left(R_{t+1}^r - \tau_t^s\right)}_{\text{Surplus choosing safe loan}} \tag{2}$$

Banks and lending 2/2

- Consider IR and IC with no aggregate uncertainty (and using $p_t R_t^r = R_t^s$):

$$
\begin{aligned}
\tau_t^s &= R_{t+1}^s && (3)\\
x_t^r p_{t+1}\left(R_{t+1}^r - \tau_t^r\right) &= x_t^s p_{t+1}\left(R_{t+1}^r - \tau_t^s\right) \\
\Rightarrow \quad \tau_t^r &= R_{t+1}^r - \frac{x_t^s}{x_t^r}\left(1 - p_{t+1}\right) R_{t+1}^r && (4)
\end{aligned}
$$

Banks and lending 2/2

- Consider IR and IC with no aggregate uncertainty (and using $p_t R^r_t = R^s_t$):

$$\tau^s_t = R^s_{t+1} \tag{3}$$

$$x^r_t p_{t+1} \left(R^r_{t+1} - \tau^r_t \right) = x^s_t p_{t+1} \left(R^r_{t+1} - \tau^s_t \right)$$

$$\Rightarrow \quad \tau^r_t = R^r_{t+1} - \frac{x^s_t}{x^r_t} \left(1 - p_{t+1} \right) R^r_{t+1} \tag{4}$$

- Illustrative numbers:

Loan 1	Loan 2
5%	8%
70% Chance of Approval	Guaranteed Approval

abound	**10.6% APR** We've got them to guarantee this loan rate. If you're accepted, this is the rate you will get	**£254.05 /mth** Over 4 years at rep APR	**£2194.4** Total interest cost	**100%** Acceptance chance	More info
HSBC UK	**6.9% APR** Representative	**£238.03 /mth** Over 4 years at rep APR	**£1425.5** Total interest cost	**80%** Acceptance chance	More info
HSBC UK	**6.4% APR** Representative	**£235.86 /mth** Over 4 years at rep APR	**£1321.21** Total interest cost	**30%** Acceptance chance	More info
Sainsbury's Bank	**6% APR** Representative	**£234.12 /mth** Over 4 years at rep APR	**£1237.87** Total interest cost	**0%** Acceptance chance	More info

Banks and lending 2/2

- Consider IR and IC with no aggregate uncertainty (and using $p_t R_t^r = R_t^s$):

$$\tau_t^s = R_{t+1}^s \tag{3}$$

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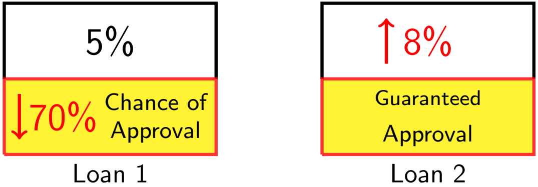

- When risk is high, banks can ration credit and hold excess reserves (paying CB deposit rate)

Bank lending problem 1/2

Bank j period t profits:

$$\left[\lambda x^s_{t-1}\tau^s_{t+1} + (1-\lambda)\, x^r_{t-1} p^r_t \tau^r_t\right] L_{t-1}(j) + \Big(S_{t-1} - \left(\lambda x^s_{t-1} + (1-\lambda)\, x^r_{t-1}\right) L_{t-1}(j)\Big)\, R^X_t(j) - R_{t-1} S_{t-1}$$

- $L_t(j)$ is loan demand (matched firms) – this is s.t. risk
- S_t is sources of liquidity (central bank liquidity, household deposits). Same for all banks by symmetry

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We have:

- Return on loans
- Cost of/return on surplus liquidity – could be positive/negative by choice or liquidity risk
- Cost of funds

Bank lending problem 1/2

Bank j period t profits:

$$\left[\lambda x_{t-1}^{s}\tau_{t+1}^{s} + (1-\lambda)\, x_{t-1}^{r} p_{t}^{r}\tau_{t}^{r}\right] L_{t-1}(j) + \left(S_{t-1} - \left(\lambda x_{t-1}^{s} + (1-\lambda)\, x_{t-1}^{r}\right) L_{t-1}(j)\right) R_{t-1}^{X}(j) - R_{t-1}S_{t-1}$$

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R_t^X depends on interbank market rate and standing facilities

Bank lending problem 2/2

Using central banks liquidity and HH deposits:

- banks post loan contracts specifying **interest rate** τ_t^i and **approval probability** x_t^i
- τ_t^i and x_t^i chosen to maximize expected discounted profits subject to:

$$\text{IC \& IR constraints} \tag{5}$$

$$0 \leq x_t^s \leq x_t^r \leq 1 \tag{6}$$

- IR constraint binds for safe firms (no expected profits)
- IC constraint binds for risky firms (earn expected profits to reveal type)
- IC, IR also $\Rightarrow \tau_t^r \geq \tau_t^s$, $x_t^r \geq x_t^s$

Banks first-order conditions

Solution to the problem yields:

$$\mathbb{E}_t\left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}}\left(p_{t+1}R^r_{t+1}-R^*_t\right)\right]=\varphi^r_t\frac{1}{1-\lambda}-\psi_t\frac{1}{1-\lambda} \tag{7}$$

$$\mathbb{E}_t\left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}}\left(\left(\lambda+(1-\lambda)\,p_{t+1}\right)R^s_{t+1}-R^*_t\right)\right]=\varphi^r_t-\varphi^s_t \tag{8}$$

And

$$\varphi^s_t,\varphi^r_t,\psi_t\geq 0 \tag{9}$$

$$0\leq x^s_t\leq x^r_t\leq 1 \tag{10}$$

$$\varphi^s_t x^s_t \;=\; \varphi^r_t\left(1-x^r_t\right)\;=\;\psi_t\left(x^r_t-x^s_t\right)=0 \tag{11}$$

R^*_t is opportunity cost of funds (depends on interbank rate, interest on reserve balances etc)

Credit rationing

Consider the equilibrium with $\varphi_t^s = 0$ ($x_t^s > 0$) and $\varphi_t^r > 0$ ($x_t^r = 1$)

- Credit rationing can occur if $\psi_t = 0$ (no pooling), so $x_t^s < 1$
- First-order conditions become

$$\psi_t = \mathbb{E}_t \left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}} \left(\left[\lambda - (1 - \lambda)(1 - p_{t+1}) \right] R_{t+1}^s - \lambda R_t^* \right) \right] \geq 0 \tag{12}$$

Credit rationing more likely if:

- More risk $1 - p_{t+1} \uparrow$
- Lower return on capital $R_{t+1}^s \downarrow$
- Higher opportunity cost of funds $R_t^* \uparrow$

Implies thresholds beyond which banks ration credit

Monetary policy

Standard Taylor rule

$$r_t^{mro} = \bar{r} + \gamma_\pi \left(\pi_{t-1,t} - \pi^*\right) + \gamma_y \left(y_t - \bar{y}\right) \tag{14}$$

- Think of this as the central bank setting the main refinancing rate at regular full -allotment auctions
- Interest rate on HH deposits $R_t = R_t^{mro}$ in equilbrium

Central bank also has two standing facilities

- Deposit facility paying R_t^{df} (excess reserves)
- Lending facility charging R_t^{lf}

We also allow the bank to conduct QE through purchasing assets from HHs — more on this if time

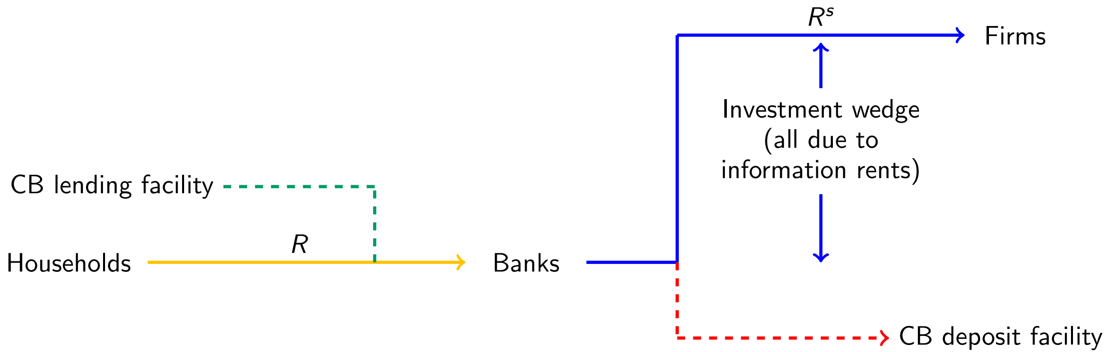
Interest rates

Benchmark – no liquidity risk, efficient financial markets

$$\text{Households} \xrightarrow{R} \text{Banks} \xrightarrow{R^s} \text{Firms}$$

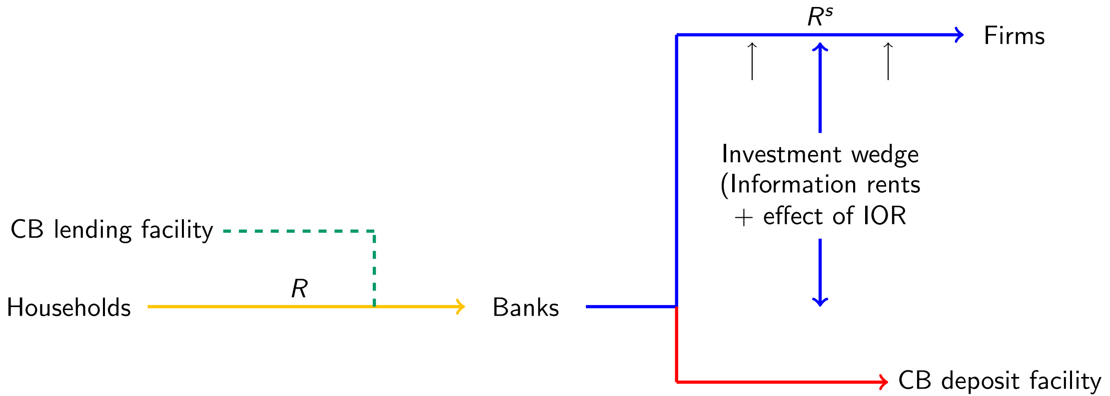
Interest rates

Benchmark – credit frictions, no liquidity risk, no excess liquidity



Interest rates

Benchmark – credit frictions, with excess liquidity, no liquidity risk

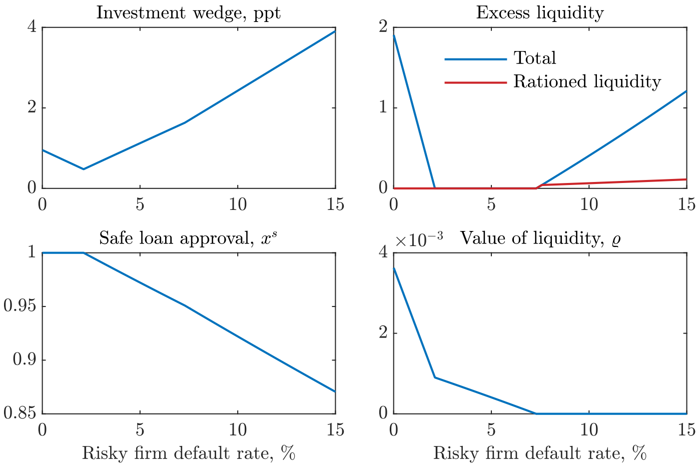


Note: interest rate corridor only matters when banks hold excess reserves

Excess liquidity can arise from two sources

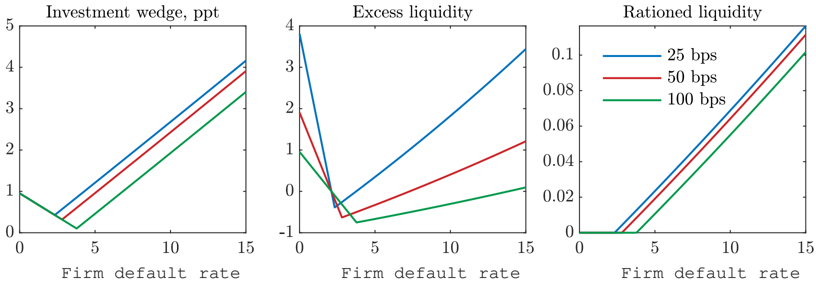
1. More liquidity available than firms looking for loans at equilibrium interest rates
   - Depends on risk and entry costs
   - Lower risk $\rightarrow$ lower firm profits
   - Low profits + high entry costs = few firms
   - Fewer firms $\rightarrow$ less investment $\rightarrow$ higher marginal return on capital
   - Excess liquidity in banking sector and positive spread
2. Banks ration credit due to high level of risk
   - To raise risky loan interest rates, banks must lower approval of safe loans
   - I.e., cannot only tighten standards on high-interest rate loans
   - Safe borrowers rationed
   - Banks hold excess reserves instead

Comparative statics – effect of risk



Result: large region with no excess reserves – the interest rate corridor has no role

Comparative statics – role of corridor



Result: changes in interest on reserves only affect economy through the effect on credit rationing.

Constraint on lending

Liquidity risk and the interbank market

We now consider the impact of liquidity risk

- Suppose banks do not know the number of firms they will match with
- No aggregate risk
- Banks can borrow/lend on interbank market subject to search frictions
- Interbank market rate will depend on banking sector liquidity and policy interest rates

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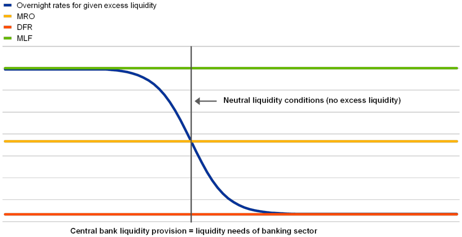


Liquidity risk 1/2

- L_t is average number of firms matched to a bank, S_t is total bank liquidity
- Banks post lending contracts under uncertainty of the number of firm matches
- Specifically, the number of firms matched to bank j is subject to shock ε_t:

$$L_t(j) = L_t \exp\left(\varepsilon_t\left(j\right)\right) \qquad \varepsilon_t \sim \mathcal{N}\left(-\frac{\sigma^2}{2}, \sigma^2\right) \tag{15}$$

  so $\mathbb{E}\left[\exp\left(\varepsilon_t\left(j\right)\right)\right] = 1$ (no aggregate liquidity risk)
- $L_t\left(\lambda x_t^s + (1-\lambda)x_t^r\right)$ is the total loans granted
- we can define a measure of bank liquidity surplus $\phi_t \equiv S_t / L_t$

Liquidity risk 2/2

- The probability a bank will be in surplus is the probability that $\phi \geq \left(\lambda x_t^s + (1-\lambda) x_t^r\right) \exp\left(\varepsilon_t\,(j)\right)$
- Defining excess liquidity

$$e_t \equiv \frac{\phi_t}{\lambda x_t^s + (1-\lambda) x_t^r} \tag{16}$$

we can write the probability a bank will be in surplus as

$$F(e_t) \equiv P\left(e_t > \exp(\varepsilon_t(j))\right) = \int_0^{e_t} f\left(\exp\left[\varepsilon_t\right]\right) \mathrm{d}\exp\left[\varepsilon_t\right] \tag{17}$$

- We can also define probability weighted shock conditional on $e_t > \exp(\varepsilon_t(j))$

$$G(e_t) \equiv \int_0^{e_t} \exp\left[\varepsilon_t\right] \mathrm{d}F(e_t) \tag{18}$$

Interbank market frictions

Without frictions, banks could insure against liquidity risk via the interbank market

- Introduce search frictions so number of matches given by matching function: $M(\theta_t)$
- $\theta_t =$ liquidity demanded/liquidity supplied is interbank market tightness
- Banks match for every dollar, the outside option is to keep searching, value functions for deficit/surplus banks i, j:

$$V_t^d = (1 - q_t^d)R_t^{lf} + q_t^d R_t^{ib} - R_t^{ib}(i,j) \tag{19}$$

$$V_t^s = R_t^{ib}(i,j) - (1 - q_t^s)R_t^{df} - q_t^s R_t^{ib} \tag{20}$$

- The Nash bargaining solution implies:

$$R_t^{ib} = \frac{(1 - q_t^d)R_t^{LF} + (1 - q_t^s)R_t^{DF}}{2 - q_t^s - q_t^d} \tag{21}$$

- R_t^{LF}, R_t^{DF} are standing facility rates
- q_t^s, q_t^d are probability surplus liquidity finds a match, liquidity demand is met respectively

Bank opportunity cost of funds

In the end, bank lending contracts have same functional form

- The opportunity cost of funds becomes:

$$R_t^* = \left(G(e_t) \left[q_t^s R_t^{ib} + (1 - q_t^s) R_t^{df} \right] + \left[1 - G(e_t) \right] \left[q_t^d R_t^{ib} + (1 - q_t^d) R_t^{lf} \right] \right) \tag{22}$$

- replaces $R_t^* = R_t^{DF}$ without liquidity risk
- Therefore R_t^* **higher** with liquidity risk $\longrightarrow$ greater incentive to ration credit
- However, the liquidity risk lowers bank profitability and increases the spread, offsetting this effect

Policy trade-offs

Liquidity risk inefficiency

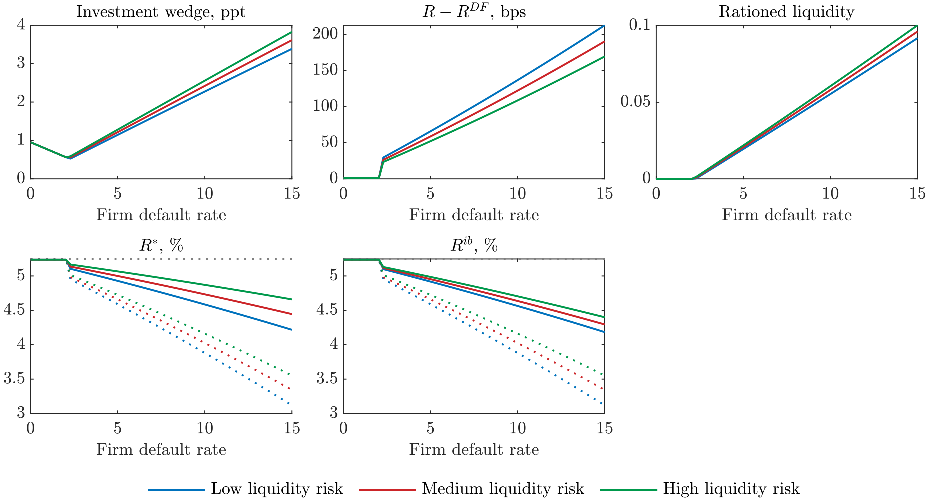
- Higher risk, more chance of using standing facilities, lowering bank profitability
- $\longrightarrow$ increases investment wedge
- A narrower corridor will reduce this inefficiency

But a wider corridor is desired to reduce risk of credit rationing

An asymmetric corridor with $R_t^{LF} = R_t$ and R_t^{DF} very low kills the liquidity shock inefficiency

- Banking sector always illiquid, banks rely fully on central bank lending facility
- Near zero risk of surplus liquidity (excess reserves) and using deposit facility
- The policymaker can set the corridor to ensure liquidity

Optimal corridor width

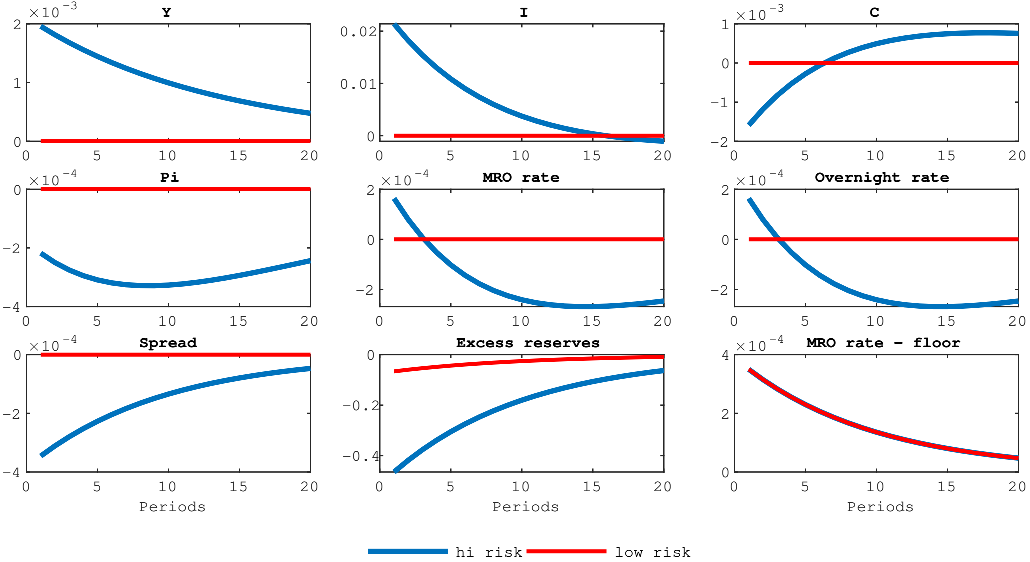


Dynamics

To evaluate the model dynamics, we compute impulse response functions:

- To temporary widening of the corridor
  - Interest on reserves falls
  - No impact in low-risk economy (no holding excess reserves)
  - Increased lending in high-risk economy (banks holding excess reserves)
- QE shock – modeled as a fall in the overnight interest rate below MRO
  - Two possible effects:
  - Standard channel: expansion via lower interest rates
  - Profitability channel: contraction as banks incentive to lend falls, can ratio credit and hold higher reserves

Temporary widening of corridor



Note: shows deviations from SS % or ppt (inflation/interest rates). Excess reserves are reserves/loans ratio

Quantitative Easing

Example implementation:

Central Bank

Liabilities	*Assets*

Bank

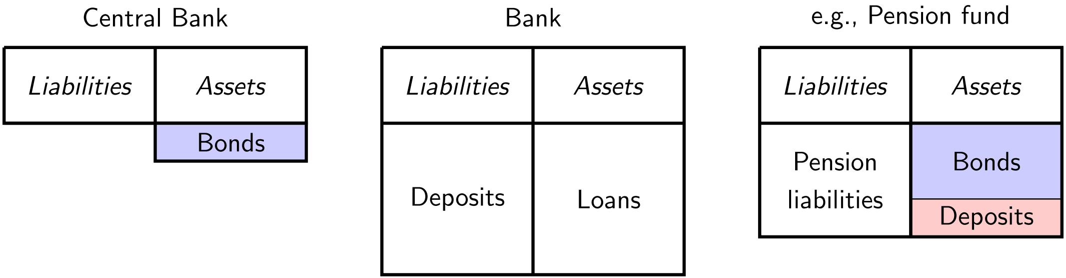
Liabilities	*Assets*
Deposits	Loans

e.g., Pension fund

Liabilities	*Assets*
Pension liabilities	Bonds

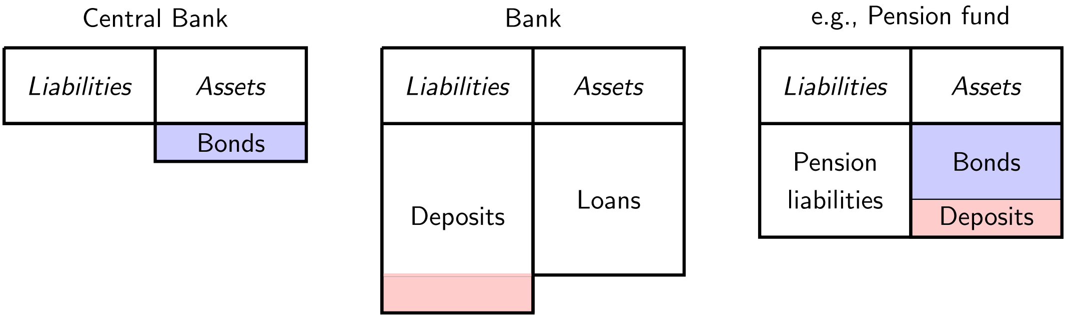
Quantitative Easing

Example implementation:



Quantitative Easing

Example implementation:



Quantitative Easing

Example implementation:

Central Bank

Liabilities	*Assets*
Reserves	Bonds

Bank

Liabilities	*Assets*
Deposits	Loans
	Reserves

e.g., Pension fund

Liabilities	*Assets*
Pension liabilities	Bonds
	Deposits

Quantitative Easing

Example implementation:

Central Bank

Liabilities	*Assets*
Reserves	Bonds

Bank

Liabilities	*Assets*
Deposits	Loans
	Reserves

e.g., Pension fund

Liabilities	*Assets*
Pension liabilities	Bonds
	Deposits

- Lowers the return on bank assets
- $\Rightarrow$ money markets only clear at a lower overnight rate
- Overnight rate moves towards the floor (interest on reserves)

Quantitative Easing

The equilibrium interest rate depends on the volume of banking sector liquidity

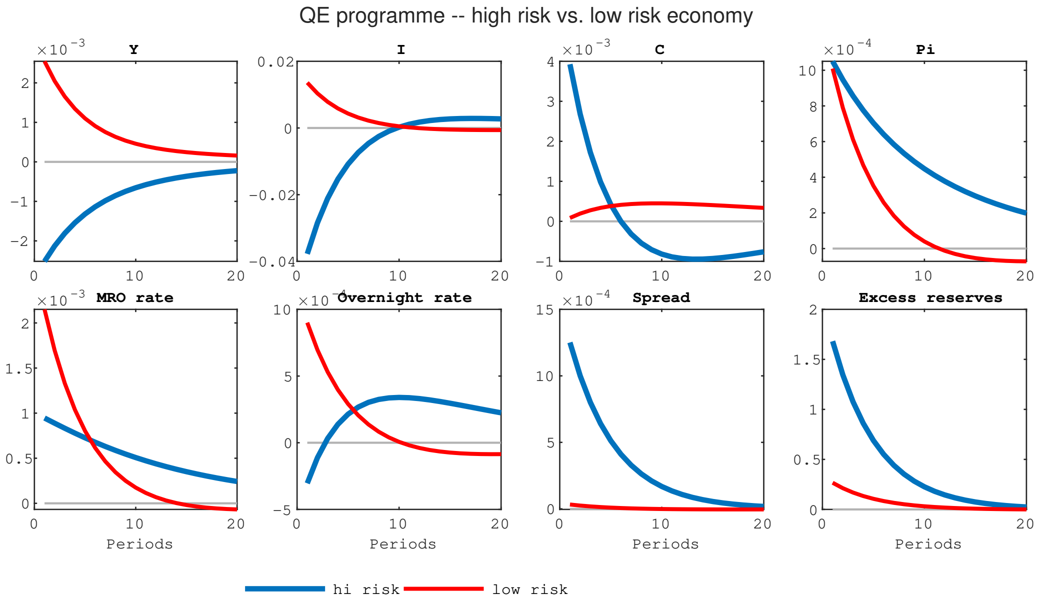
- Suppose the CB purchases assets from HHs or injects bank liquidity directly
- Banks will take liquidity as long as expected return = expected funding cost
- Expected bank return (L_t is loans, S_t is Assets = loans + reserves):

$$1 = \mathbb{E}_t \left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}} \left(\underbrace{\left[\lambda x_t^s + (1-\lambda)\left(1 - (1-p_{t+1})\, x_t^s\right) \right] R_t^s \frac{L_t}{S_t}}_{\text{Return on lending}} + \underbrace{\left(1 - \left(\lambda x_t^s + (1-\lambda) \right) \frac{L_t}{S_t} \right) R_t^*}_{\text{Return on reserves}} \right) \right]$$

- This lowers average bank return, so will only clear at lower interest rate

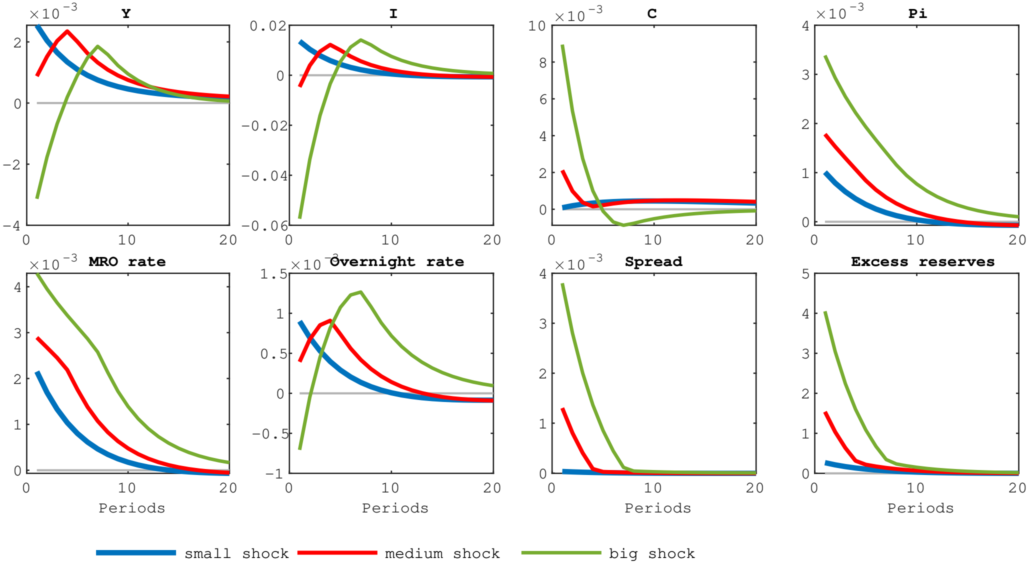
Two competing effects

- With lower interest rates, banks pass on to more favourable lending conditions: lending $\uparrow$
- As equilibrium interest rate $\downarrow$ but CB deposit rate unchanged, incentive to ration credit: lending $\downarrow$

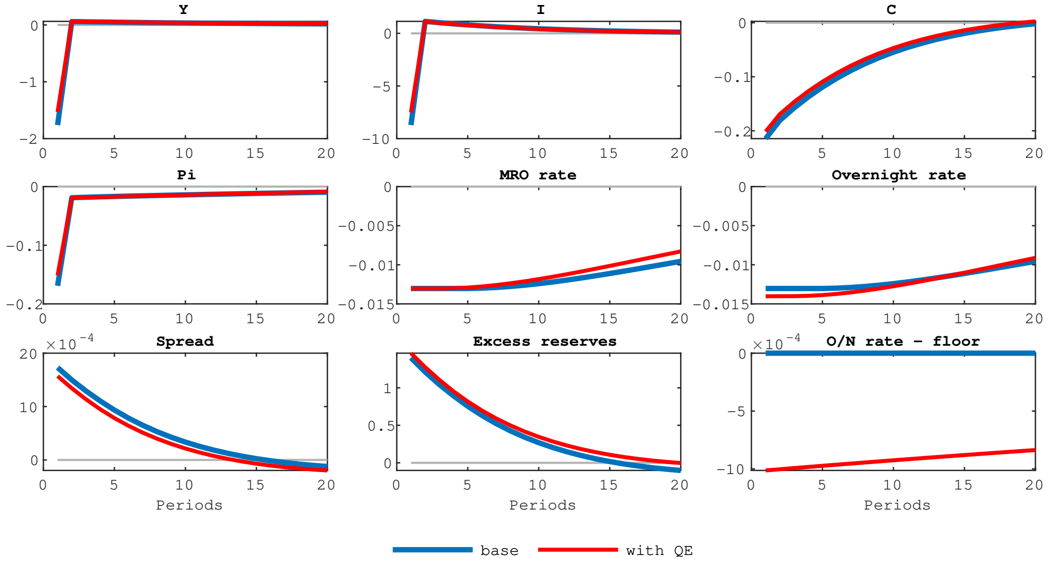


QE programme -- high risk vs. low risk economy
Y
I
C
Pi
MRO rate
Overnight rate
Spread
Excess reserves
Periods
hi risk
low risk

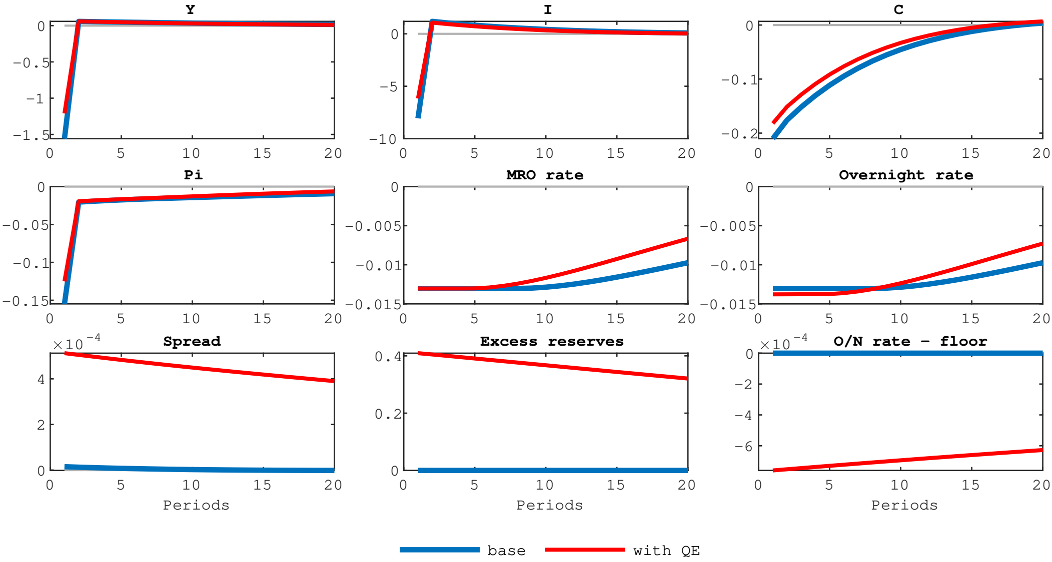
QE -- low risk economy, programme size effect



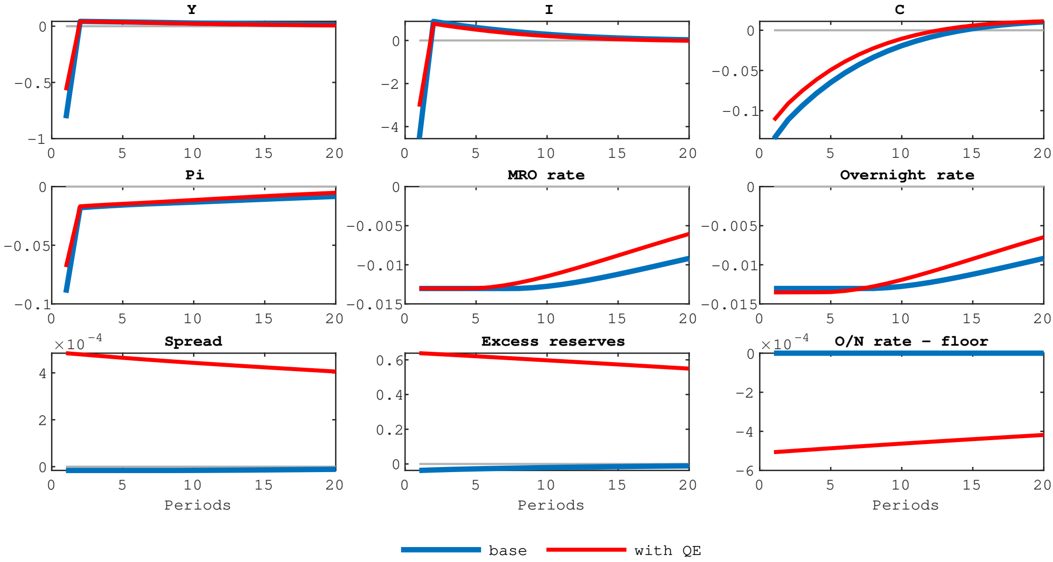
Demand shock with/without QE -- low risk economy



Demand shock with/without QE -- medium risk economy



Demand shock with/without QE -- high risk economy



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Firms: large and small firms

- Differentiate between large (observable projects) and small (unobservable projects) firms
- Every period, firms draw their type (large/small) and a project (risky/safe):
  1. λ are **safe** – known return, no risk of default
  2. $1 - \lambda$ are **risky** – uncertain return, risk of default
- Project type doesn't matter for large firms as we'll assume equal NPV
- Entry costs – new firms raise equity finance to enter $\implies$ claim on future profits
- Firms must raise outside finance for ongoing investment

Small firms

Firms raise k units of outside finance (loans)

- convert to $\omega_t^i k$ units of capital, $i \in \{s, r\}$
- succeed with probability p_{t+1}^i, otherwise yield zero
- $\omega_t^s = p_t^s = \omega_t^r p_t^r = 1$, $\omega_t^r > 1, p_t^r < 1$

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If funded, choose labour demand to maximise period profits:

$$V_t^i = \max_{h_t\left(\omega_t^i\right)} \left\{ \frac{P_t^W}{P_t} y_t\left(\omega_t^i\right) - \frac{W_t}{P_t} h_t\left(\omega_t^i\right) - \left(\frac{\tau_{t-1}^i}{\Pi_{t-1,t}} q_{t-1} - (1-\delta)\,\omega_t^i q_t \right) k + V_t \right\} \tag{23}$$

where

$$y_t\left(\omega_t^i\right) = z_t \left[\omega_t^i k\right]^{\alpha} \left[h_t\left(\omega_t^i\right)\right]^{1-\alpha}$$

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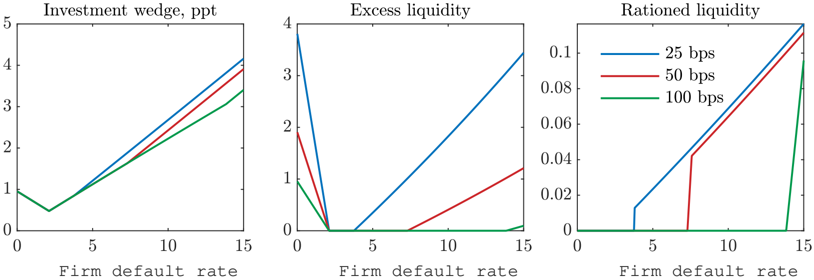
$$V_t = \mathbb{E}_t\left[\Lambda_{t,t+1}\left(\eta V_{t+1}^c + (1-\eta)\left(\lambda x_t^s V_{t+1}^s + (1-\lambda)\, x_t^r p_{t+1}^r V_{t+1}^r\right)\right)\right]$$

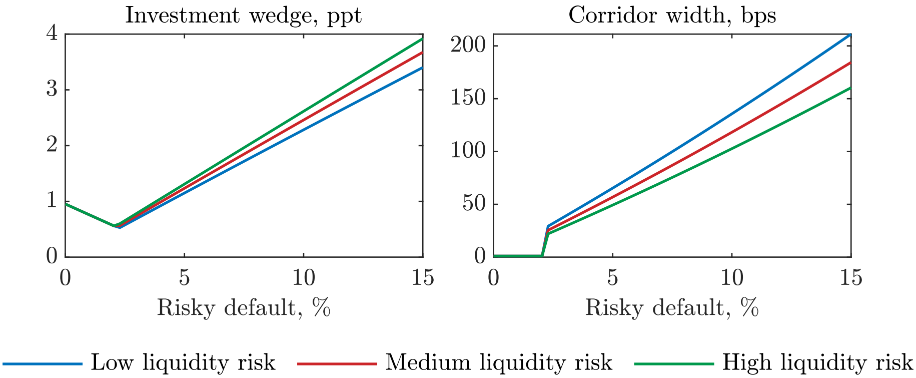
- τ_{t-1}^i is the loan repayment rate

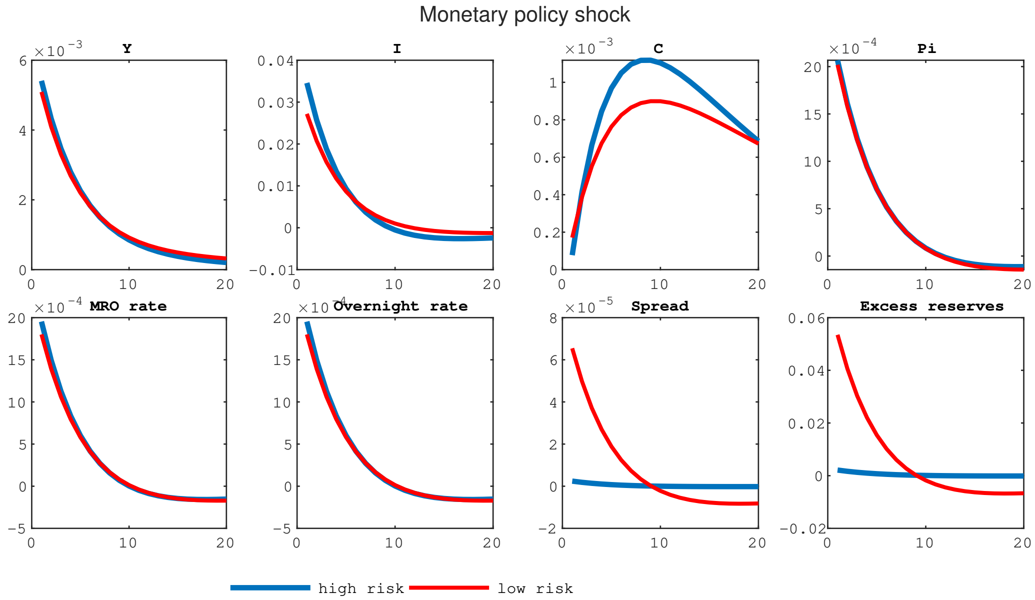
Comparative statics – role of corridor



Return

Optimal corridor




Monetary policy shock
Y
I
C
Pi
MRO rate
Overnight rate
Spread
Excess reserves
high risk
low risk