Bank liquidity and credit frictions

Jonathan Swarbrick

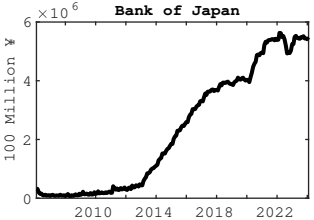
University of St Andrews

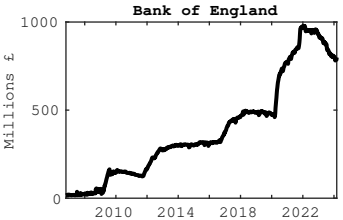
jms48@st-andrews.ac.uk — www.jonathanswarbrick.uk

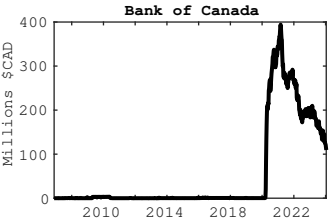
University of Southampton

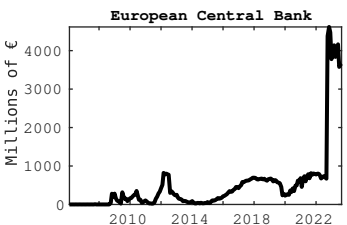
12 June 2024

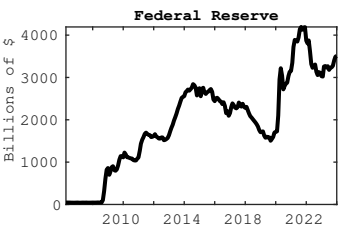
Sky-rocketing banking sector liquidity











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

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

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

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 ↑ while lending standards were tightened (source: SLOOS)
- 2010–2012 lots of liquidity in eurozone banking sector without increasing lending in stressed economies

Some evidence on liquidity and lending 1/2

Evidence:

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

- Kashyap & Stein (2000) find monetary policy transmission stronger for banks with less liquid balance sheets
  - Banks with more liquid assets smooth lending following tightening (see also Ivashina & Scharfstein 2010, Cornett, McNutt, Strahan & Tehranian 2011)

However:

- Acharya, Eisert, Eufinger & Hirsch (2019) find in the euroarea, increased liquidity driven by balance sheet policies led to banks holding more cash and low interest assets, but did not increase loans
  - See also Gambacorta & Marques-Ibanez (2011), Joyce, Tong & Woods (2011), Loutskina (2011), Disyatat (2011), Iyer et al. (2014)

Some evidence on liquidity and lending 2/2

The usual mechanism is more liquidity $\Rightarrow$ more lending

But 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)

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'

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
- Small business lending frictions

Aim of Paper

Build a model to rationalise some of this evidence

- The ambiguous link between liquidity and lending
- Small business lending frictions

Use this to study:

- Role of monetary policy (interest rates 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)

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

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

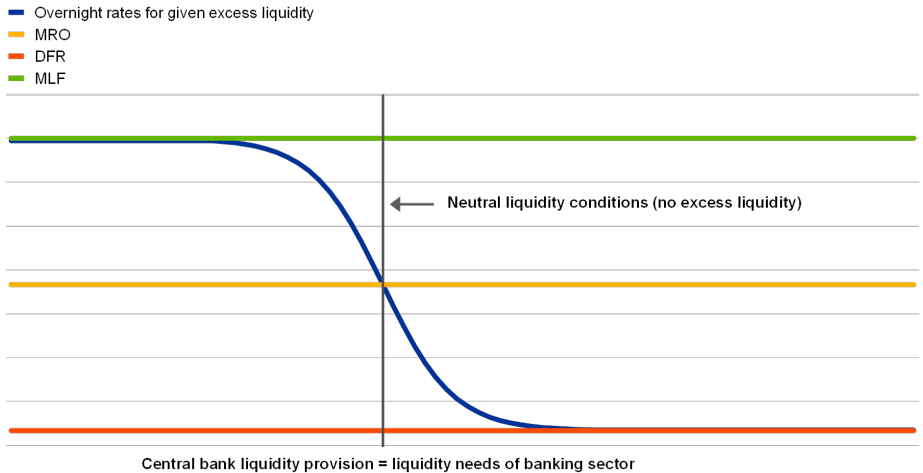


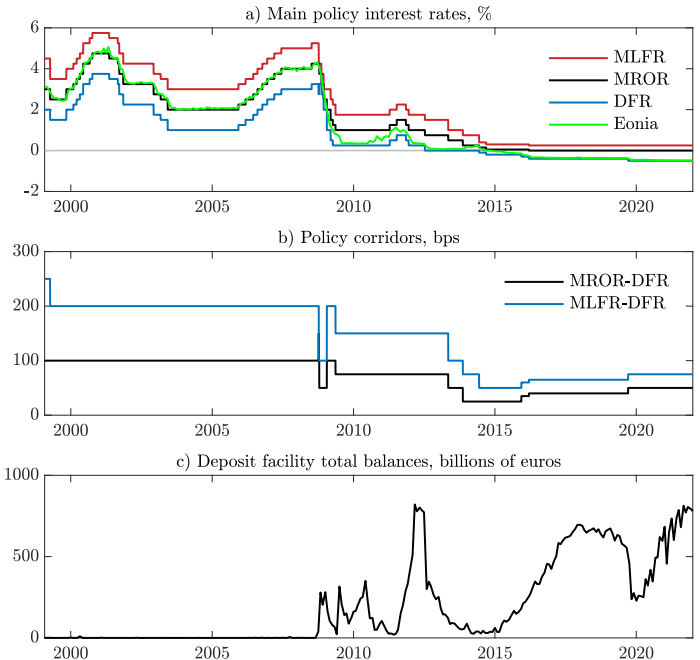
Figure: From Eisenschmidt, Kedan & Tietz (2018) (ECB Economic Bulletin 2018(5))

Corridor system 2/2

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

- High reserve balances → 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 very early stage – 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

Snapshot of results: model and credit friction

New Keynesian model with:

- risky bank lending with adverse selection and credit rationing
- bank liquidity risk (not shown today)

Snapshot of results: model and credit friction

New Keynesian model with:

- risky bank lending with adverse selection and credit rationing
- bank liquidity risk (not shown today)

Main mechanism:

- Central bank deposit facility is an outside option for banks
- When adverse selection is bad (e.g., high risk), banks can ration credit
- CB deposit rate (IoR) affects incentives
- If IoR relatively high, banks ration credit more

Snapshot of results: initial results

Provisional results:

- If ZLB squeezes corridor $\rightarrow$ more credit rationing
  - additional cost of ZLB
  - importance of negative rates
- QE can be used as an additional tool
  - Can shift monetary policy towards a floor system
- Away from ZLB, two main channels:
  - lowers overnight rate compared to main policy target rate – usual demand channel expansion $\uparrow$
  - increases incentive to ration credit contraction $\downarrow$
  - Which effect dominates depends on financial conditions (firm risk)
- At the ZLB, I find QE can always help

Model details: households and final good sector

New Keynesian (Calvo) model with frictional bank lending

- Follow Swarbrick (2023) – Stiglitz & Weiss (1981) information problem (see also, e.g., Ikeda 2020)
- Standard representative household:
  - Consumes; provides labour; saves in bank, bonds, or equity
- Monopolistic competitive retailers
  - Purchase homogenous wholesale good, sell differentiated final good
  - Set retail price s.t., Calvo frictions
  - Leads to NK Phillips curve

Intermediate goods firms

We assume there are 'small firms' and 'large firms' (proportion exogenous, firm type random)

- To focus on bank lending channel/credit friction affecting **SMBs**
- Small firms characterised as being unable to i) diversity risk, ii) having unverifiable information
- All require 1 unit of external finance (firm size not about size!)
- The number of firms determines aggregate production
- Firm entry costs – firm entry until firm value = costs
- Cobb-Douglas production function

Intermediate goods firms

We assume there are 'small firms' and 'large firms' (proportion exogenous, firm type random)

- To focus on bank lending channel/credit friction affecting **SMBs**
- Small firms characterised as being unable to i) diversity risk, ii) having unverifiable information
- All require 1 unit of external finance (firm size not about size!)
- The number of firms determines aggregate production
- Firm entry costs – firm entry until firm value = costs
- Cobb-Douglas production function

Large firms:

- No information problem, so raise finance in bond market

Intermediate goods firms

We assume there are 'small firms' and 'large firms' (proportion exogenous, firm type random)

- To focus on bank lending channel/credit friction affecting **SMBs**
- Small firms characterised as being unable to i) diversity risk, ii) having unverifiable information
- All require 1 unit of external finance (firm size not about size!)
- The number of firms determines aggregate production
- Firm entry costs – firm entry until firm value = costs
- Cobb-Douglas production function

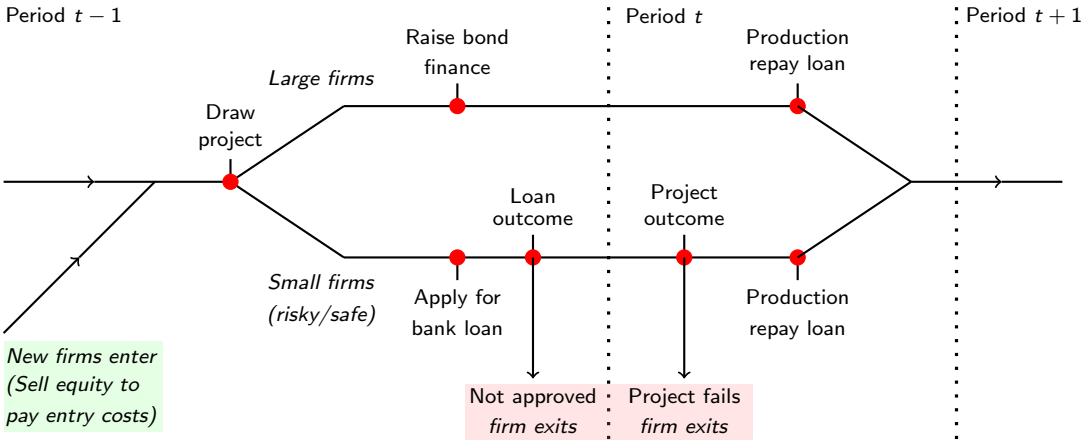
Large firms:

- No information problem, so raise finance in bond market

Small firms:

- Each period, firms draw a project, either risky or safe – but expected return the same
- Project type is private information

Firm dynamics



Banks and lending

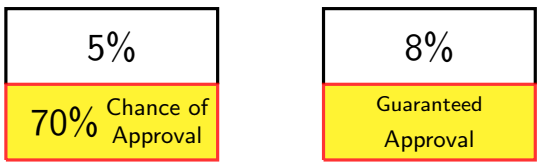
Banks provide a role of screening SMBs

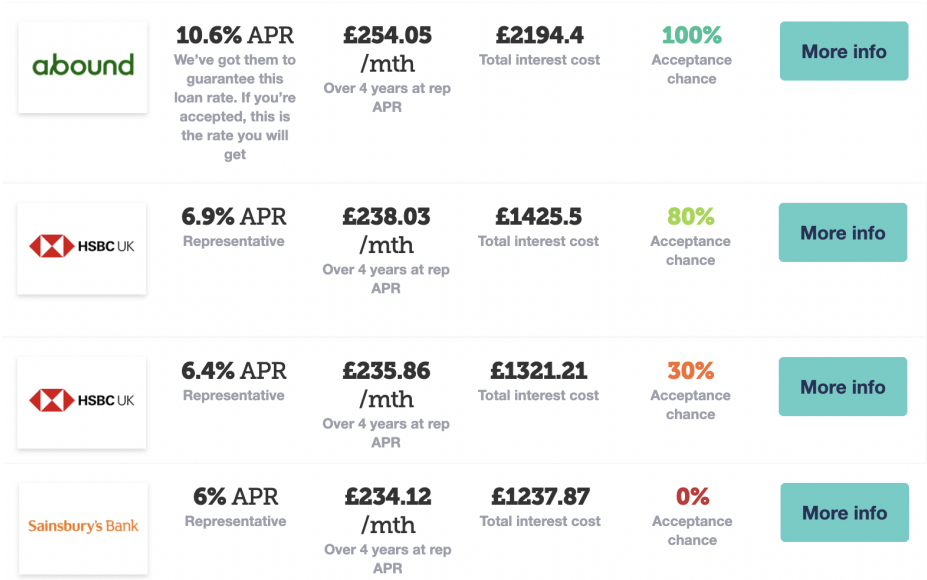
- Separate borrowers using loan approval
  - Abstract from collateral and loan size
  - Loan terms are repayment rate and approval rate

Banks and lending

Banks provide a role of screening SMBs

- Separate borrowers using loan approval
  - Abstract from collateral and loan size
  - Loan terms are repayment rate and approval rate
  - Illustration:

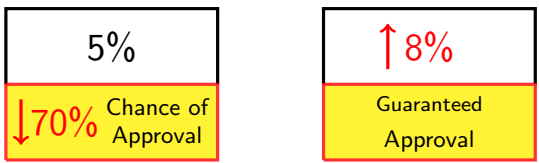



abound
10.6% APR
We've got them to guarantee this loan rate. If you're accepted, this is the rate you will get
£254.05 /mth
Over 4 years at rep APR
£2194.4
Total interest cost
100%
Acceptance chance
More info
HSBC UK
6.9% APR
Representative
£238.03 /mth
Over 4 years at rep APR
£1425.5
Total interest 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

Banks provide a role of screening SMBs

- Separate borrowers using loan approval
  - Abstract from collateral and loan size
  - Loan terms are repayment rate and approval rate
  - Illustration:



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

Banks

Using central banks liquidity and HH deposits:

- banks post loan contracts specifying **interest rate** τ_t^i and **approval probability** x_t^i

Banks

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 solve:

$$\max_{\substack{x_t^s, x_t^r \\ \tau_t^s, \tau_t^r}} \mathbb{E}_t \left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}} \left(\lambda x_t^s \left(\tau_t^s - R_t^* \right) + (1-\lambda) x_t^r \left(p_{t+1}^r \tau_t^r - R_t^* \right) \right) \right] \tag{1}$$

$$\text{s.t.} \quad \text{IC \& IR constraints} \tag{2}$$

$$\lambda x_t^s + (1-\lambda) x_t^r \leq \bar{x}_t \tag{3}$$

$$0 \leq x_t^s \leq x_t^r \leq 1 \tag{4}$$

- IR constraint binds for safe firms (no expected profits)
- IC constraint binds for risky firms (earn expected profits to reveal type)
- IC, IR also $\Rightarrow \tau_t^r \geq \tau_t^s$, $x_t^r \geq x_t^s$
- R_t^* is opportunity cost of funds (e.g., interest on reserve balances)

Banks first-order conditions

Solution to the problem yeilds:

$$\mathbb{E}_t\left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}}\left(p_{t+1}R^r_{t+1}-R^*_t\right)\right]=\varrho_t-\psi_t\frac{1}{1-\lambda}+\varphi^r_t\frac{1}{1-\lambda} \tag{5}$$

$$\mathbb{E}_t\left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}}\left(\left(\lambda+(1-\lambda)\,p_{t+1}\right)R^s_{t+1}-R^*_t\right)\right]=\varrho_t+\varphi^r_t-\varphi^s_t \tag{6}$$

And

$$\varphi^s_t,\varphi^r_t,\varrho_t,\psi_t\geq 0 \tag{7}$$

$$\lambda x^s_t+(1-\lambda)\,x^r_t\leq \bar{x}_t \tag{8}$$

$$0\leq x^s_t\leq x^r_t\leq 1 \tag{9}$$

$$\varphi^s_t x^s_t=\varphi^r_t\left(1-x^r_t\right)=\varrho_t\left(\bar{x}_t-\lambda x^s_t-(1-\lambda)\,x^r_t\right)=0 \tag{10}$$

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

Investment wedge and credit rationing

The investment wedge stems the information rents

- Paid to risky firms
- Higher the risk, the higher the spread

Investment wedge and credit rationing

The investment wedge stems the information rents

- Paid to risky firms
- Higher the risk, the higher the spread

If the risk increases enough, banks will ration credit

- Low interest rate loans face lower approval probability
- This allows banks to raise interest rates on risky loans
- I.e., lending standards tighten
- Banks earn a lower interest on reserves than loans, so the spread rises even higher

Investment wedge and credit rationing

The investment wedge stems the information rents

- Paid to risky firms
- Higher the risk, the higher the spread

If the risk increases enough, banks will ration credit

- Low interest rate loans face lower approval probability
- This allows banks to raise interest rates on risky loans
- I.e., lending standards tighten
- Banks earn a lower interest on reserves than loans, so the spread rises even higher

An important identity will by value of lending $\varrho_t \geq 0$ (ψ is multiplier on $x_t^r \geq x_t^s$ constraint):

$$\text{Shadow value of lending } = \varrho_t = \mathbb{E}_t \left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}} \left(\left(1 - \frac{1-\lambda}{\lambda} \left(1 - p_{t+1} \right) \right) R_{t+1}^s - R_t^* \right) \right] - \psi_t \qquad (12)$$

Investment wedge and credit rationing

The investment wedge stems the information rents

- Paid to risky firms
- Higher the risk, the higher the spread

If the risk increases enough, banks will ration credit

- Low interest rate loans face lower approval probability
- This allows banks to raise interest rates on risky loans
- I.e., lending standards tighten
- Banks earn a lower interest on reserves than loans, so the spread rises even higher

An important identity will by value of lending $\varrho_t \geq 0$ (ψ is multiplier on $x_t^r \geq x_t^s$ constraint):

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

Monetary policy

Standard Taylor rule

$$r_t^{mro} = \bar{r} + \gamma_\pi \left(\pi_{t-1,t} - \pi^*\right) + \gamma_y \left(y_t - \bar{y}\right) \tag{13}$$

- 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}

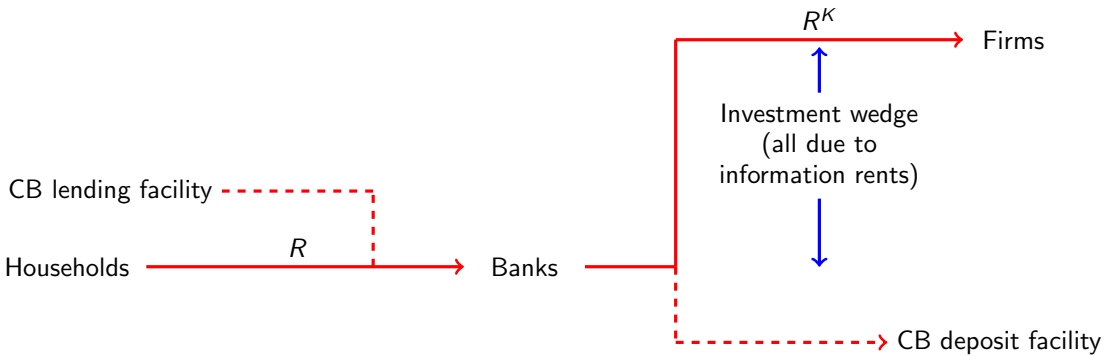
We also allow the bank to conduct QE through purchasing assets from HHs — more on this if time

Interest rates

Benchmark – efficient financial markets

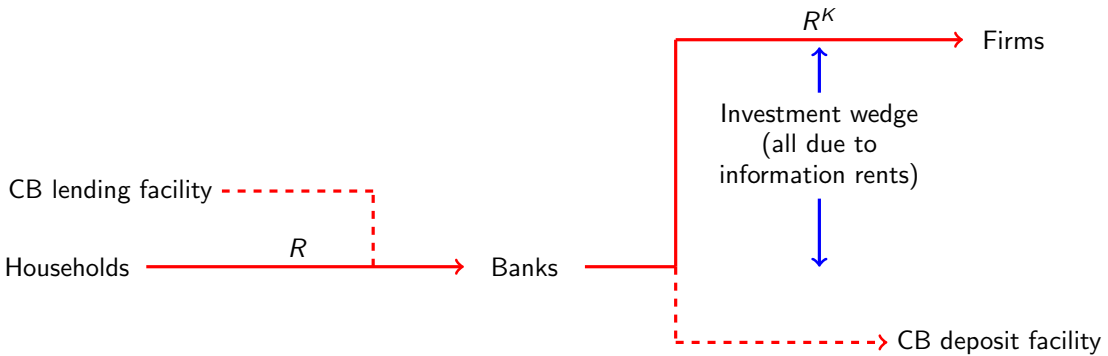
Interest rates

Benchmark – credit frictions, no excess liquidity



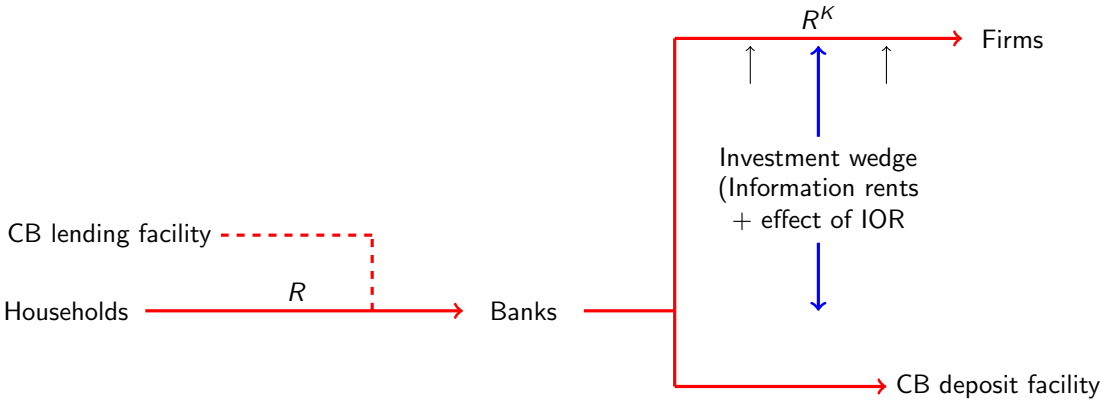
Interest rates

Benchmark – credit frictions, no excess liquidity



Interest rates

Benchmark – credit frictions, with excess liquidity



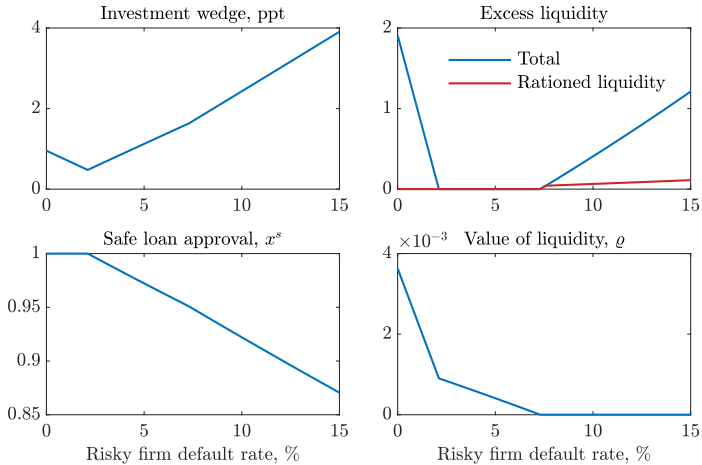
Note: interest rate corridor only matters when banks hold excess reserves

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

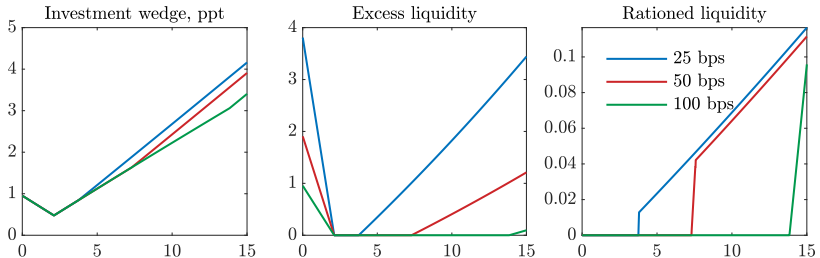
2. Banks ration credit due to high level of risk
   - To raise risky loan interest rates, banks must lower approval of safe loans
   - I.e., cannot only tighten standards on high-interest rate loans
   - Safe borrowers rationed
   - Banks hold excess reserves instead

Comparative statics – effect of risk



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

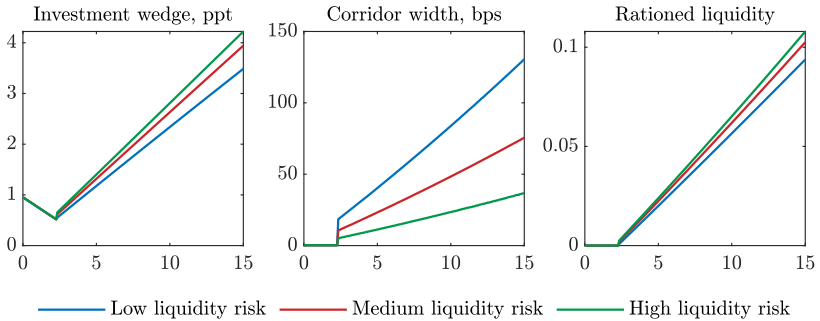
Comparative statics – role of corridor



Result: changes in deposit rate only affect economy through the effect on credit rationing.

x axis is risky firm default rate.

Provisional results – optimal corridor width



x axis is risky firm default rate.

Dynamics

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

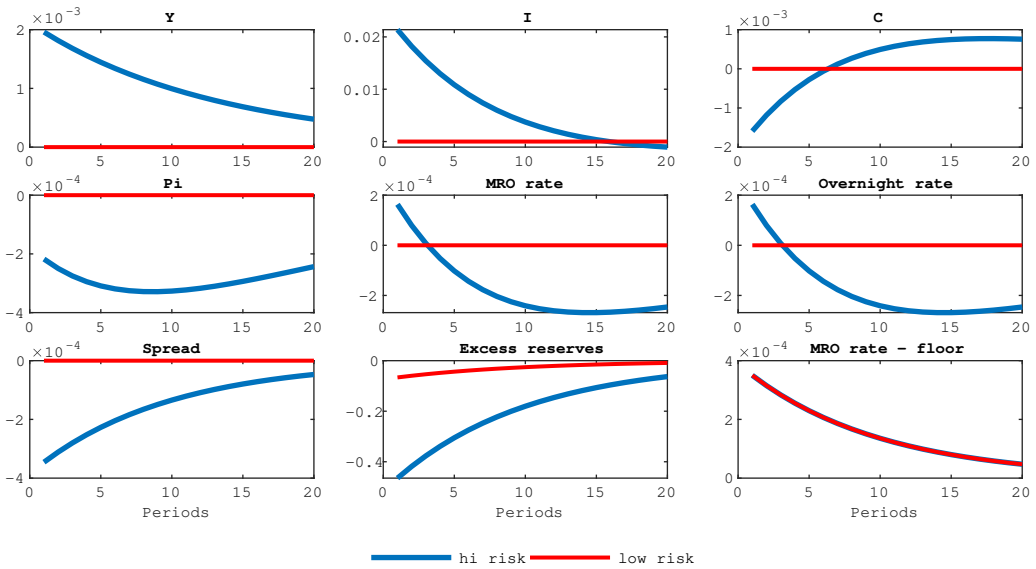
- To temporary widening of the corridor
  - Interest on reserves falls
  - No impact in low-risk economy (no holding excess reserves)
  - Increased lending in high-risk economy (banks holding excess reserves)

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



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

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

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):

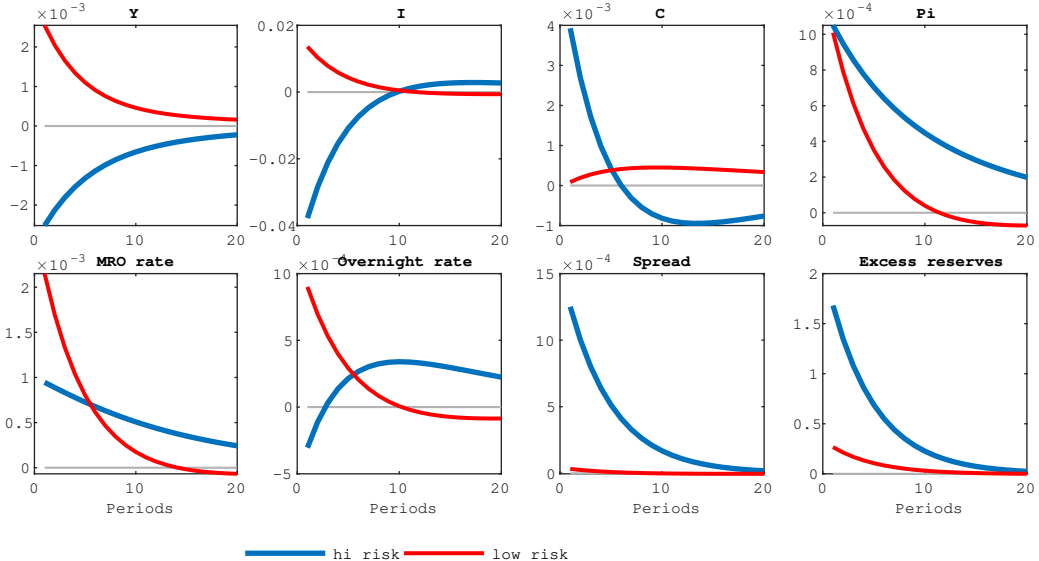
$$1 = \mathbb{E}_t \left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}} \left(\underbrace{\left[\lambda x_t^s + (1-\lambda)\left(1-(1-p_{t+1})\, x_t^s \right) \right] R_t^s \frac{L_t}{S_t}}_{\text{Return on lending}} + \underbrace{\left(1 - \left(\lambda x_t^s + (1-\lambda) \right) \frac{L_t}{S_t} \right) R_t^*}_{\text{Return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

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

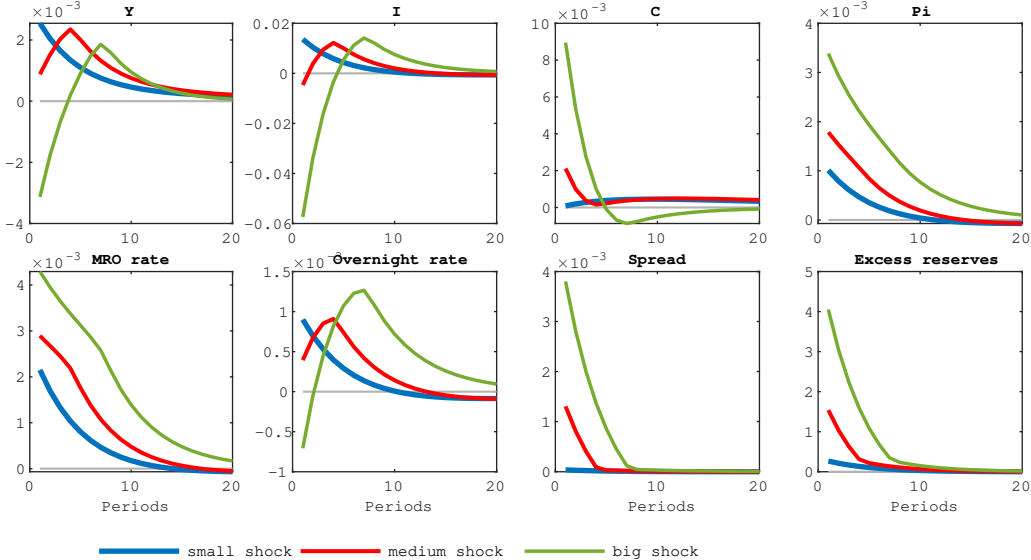
Two competing effects

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

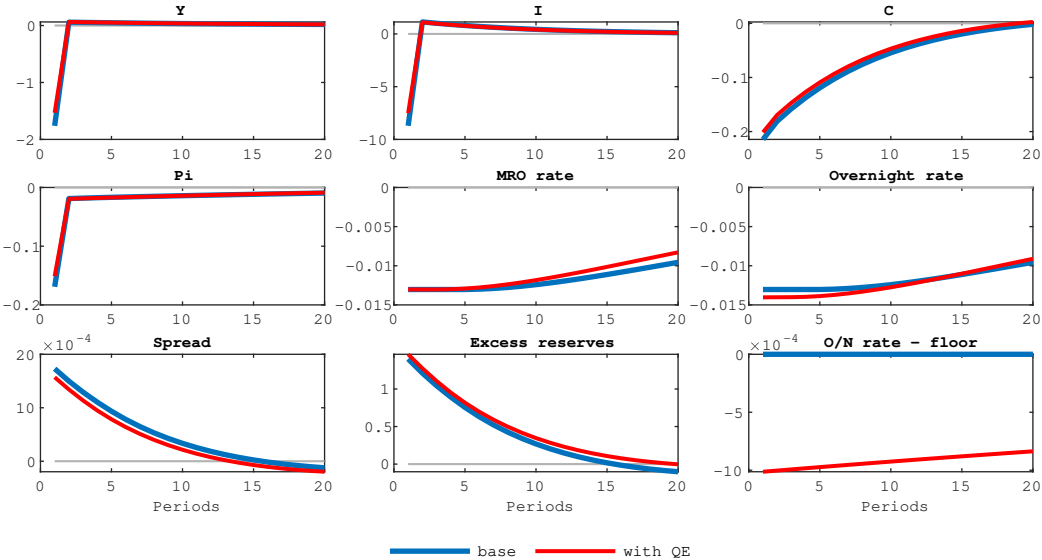
QE programme -- high risk vs. low risk economy



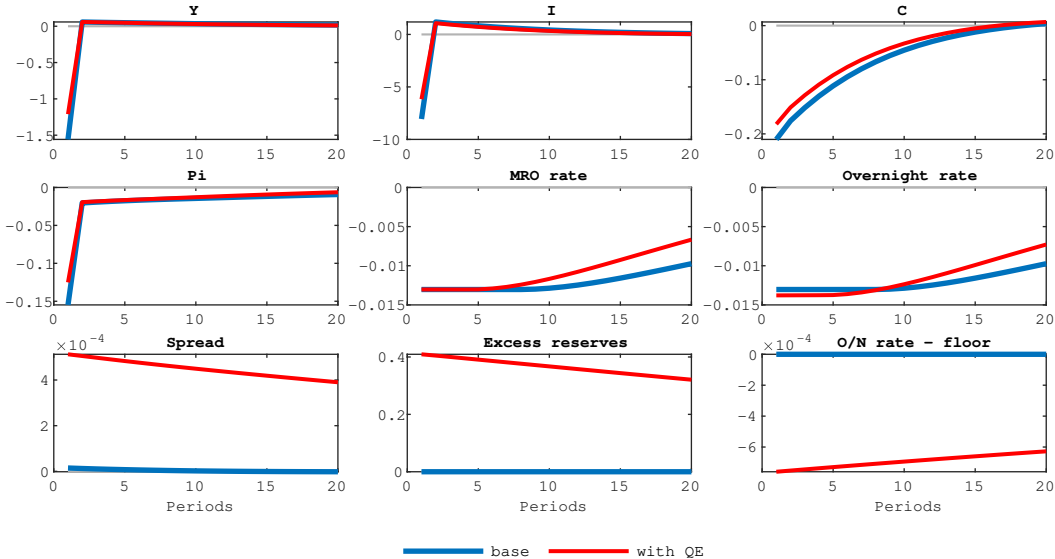
QE -- low risk economy, programme size effect



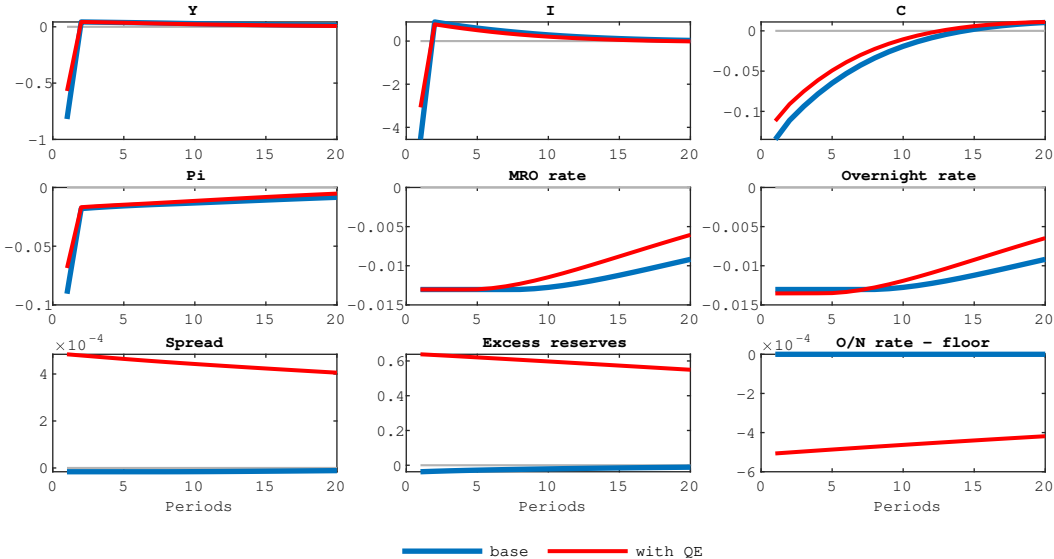
Demand shock with/without QE -- low risk economy



Demand shock with/without QE -- medium risk economy



Demand shock with/without QE -- high risk economy



References I

Acharya, V. V., Eisert, T., Eufinger, C. & Hirsch, C. W. (2019), 'Whatever it takes: The real effects of unconventional monetary policy', *The Review of Financial Studies* **32**(9), 3366–3411.

Adrian, T. & Shin, H. S. (2010), 'Liquidity and leverage', *Journal of Financial Intermediation* **19**(3), 418–437.

Benhabib, J., Dong, F. & Wang, P. (2018), 'Adverse Selection and Self Fulfilling Business Cycles', *Journal of Monetary Economics* **94**, 114–130.

Berger, A. N. & Bouwman, C. H. S. (2009), 'Bank Liquidity Creation', *The Review of Financial Studies* **22**(9), 3779–3837.

Bernanke, B. S. & Blinder, A. S. (1988), 'Credit, money, and aggregate demand', *American Economic Review* **78**(2), 435–439.

Bernanke, B. S. & Gertler, M. (1989), 'Agency costs, net worth, and business fluctuations', *The American Economic Review* **79**(1), 14–31.

Bernanke, B. S. & Gertler, M. (1995), 'Inside the black box: The credit channel of monetary policy transmission', *The Journal of Economic Perspectives* **9**(4), 27–48.

References II

Bernanke, B. S., Gertler, M. & Gilchrist, S. (1999), Chapter 21 the financial accelerator in a quantitative business cycle framework, Vol. 1 of *Handbook of Macroeconomics*, Elsevier, pp. 1341–1393.

Bigio, S. (2015), 'Endogenous liquidity and the business cycle', *American Economic Review* **105**(6), 1883–1927.

Bindseil, U. (2000), 'Towards a theory of central bank liquidity management', *Kredit und Kapital* **3/2000**, 346–376.

Bindseil, U. & Jabłecki, J. (2011), The optimal width of the central bank standing facilities corridor and banks' day-to-day liquidity management, Working Paper Series 1350, European Central Bank.

Bolton, P., Santos, T. & Scheinkman, J. A. (2011), 'Outside and Inside Liquidity', *Quarterly Journal of Economics* **126**(1), 259–321.

Brunnermeier, M. K. & Sannikov, Y. (2014), 'A macroeconomic model with a financial sector', *The American Economic Review* **104**(2), 379–421.

Carpenter, S. B., Demiralp, S. & Eisenschmidt, J. (2014), 'The effectiveness of the non-standard policy measures during the financial crises: The experiences of the federal reserve and the european central bank', *Journal of Economic Dynamics and Control* **43**, 107–129.

References III

Chang, B. (2018), 'Adverse selection and liquidity distortion', *The Review of Economic Studies* **85**(1 (302)), 275–306.

Cornett, M. M., McNutt, J. J., Strahan, P. E. & Tehranian, H. (2011), 'Liquidity risk management and credit supply in the financial crisis', *Journal of Financial Economics* **101**(2), 297–312.

Cúrdia, V. & Woodford, M. (2010), 'Credit spreads and monetary policy', *Journal of Money, Credit and Banking* **42**, 3–35.

Diamond, D. W. (1984), 'Financial intermediation and delegated monitoring', *Review of Economic Studies* **51**(3), 393–414.

Disyatat, P. (2011), 'The bank lending channel revisited', *Journal of Money, Credit and Banking* **43**(4), 711–734.

Draghi, M. (2015), 'Introductory statement to the press conference (with Q&A)'. 3 December 2015, European Central Bank, Frankfurt am Main.
URL: *https://www.ecb.europa.eu/press/pressconf/2015/html/is151203.en.html*

References IV

Eisenschmidt, J., Kedan, D. & Tietz, R. (2018), IMeasuring fragmentation in the euro area unsecured overnight interbank money market: a monetary policy transmission approach, Economic Bulletin (2018), Issue 5, Frankfurt am Main.

Eisfeldt, A. L. (2004), 'Endogenous liquidity in asset markets', *The Journal of Finance* **59**(1), 1–30.

Ferrando, A., Popov, A. & Udell, G. F. (2019), 'Do smes benefit from unconventional monetary policy and how? microevidence from the eurozone', *Journal of Money, Credit and Banking* **51**(4), 895–928.

Finnegan, M. & Kapoor, S. (2023), 'ECB unconventional monetary policy and SME access to finance', *Small Business Economics* **61**(3), 1253–1288.

Gambacorta, L., Hofmann, B. & Peersman, G. (2014), 'The effectiveness of unconventional monetary policy at the zero lower bound: A cross-country analysis', *Journal of Money, Credit and Banking* **46**(4), 615–642.

Gambacorta, L. & Marques-Ibanez, D. (2011), 'The bank lending channel: Lessons from the crisis', *Economic Policy* **26**(66), 135–182.

Gertler, M. & Gilchrist, S. (1994), 'Monetary policy, business cycles, and the behavior of small manufacturing firms', *The Quarterly Journal of Economics* **109**(2), 309–340.

References V

Gertler, M. & Kiyotaki, N. (2010), Chapter 11 - financial intermediation and credit policy in business cycle analysis, Vol. 3 of *Handbook of Monetary Economics*, Elsevier, pp. 547–599.

Goodfriend, M. (2002), 'Interest on reserves and monetary policy', *Federal Reserve Bank of New York Economic Policy Review* **8**(1), 77–84.

Holden, T. D., Levine, P. & Swarbrick, J. M. (2020), 'Credit crunches from occasionally binding bank borrowing constraints', *Journal of Money, Credit and Banking* **52**(2-3), 549–582.

Holton, S., Lawless, M. & McCann, F. (2013), 'Sme financing conditions in europe: Credit crunch or fundamentals?', *National Institute Economic Review* (225), R52–R67.

Iacoviello, M. (2005), 'House prices, borrowing constraints, and monetary policy in the business cycle', *The American Economic Review* **95**(3), 739–764.

Ikeda, D. (2020), 'Adverse selection, lemons shocks and business cycles', *Journal of Monetary Economics* **115**, 94–112.
URL: *https://www.sciencedirect.com/science/article/pii/S0304393219300947*

Ioannidou, V., Pavanini, N. & Peng, Y. (2022), 'Collateral and asymmetric information in lending markets', *Journal of Financial Economics* **144**(1), 93–121.

References VI

Ivashina, V. & Scharfstein, D. (2010), 'Bank lending during the financial crisis of 2008', *Journal of Financial Economics* **97**(3), 319–338.

Iyer, R., Peydró, J.-L., da Rocha-Lopes, S. & Schoar, A. (2014), 'Interbank Liquidity Crunch and the Firm Credit Crunch: Evidence from the 2007–2009 Crisis', *The Review of Financial Studies* **27**(1), 347–372.

Joyce, M. A. S., Tong, M. & Woods, R. (2011), 'The united kingdom's quantitative easing policy: design, operation and impact', *Bank of England Quarterly Bulletin* **51**(3), 200–212.

Kashyap, A. K., Rajan, R. & Stein, J. C. (2002), 'Banks as liquidity providers: An explanation for the coexistence of lending and deposit-taking', *Journal of Finance* **57**(1), 33–73.

Kashyap, A. K. & Stein, J. C. (2000), 'What do a million observations on banks say about the transmission of monetary policy?', *American Economic Review* **90**(3), 407–428.

Kiyotaki, N. & Moore, J. (1997), 'Credit cycles', *Journal of Political Economy* **105**(2), 211–248.

Kurlat, P. (2013), 'Lemons Markets and the Transmission of Aggregate Shocks', *American Economic Review* **103**(4), 1463–1489.

References VII

Loutskina, E. (2011), 'The role of securitization in bank liquidity and funding management', *Journal of Financial Economics* **100**(3), 663–684.

Martin, A. & Taddei, F. (2013), 'International capital flows and credit market imperfections: A tale of two frictions', *Journal of International Economics* **89**(2), 441–452.

Rodnyansky, A. & Darmouni, O. M. (2017), 'The effects of quantitative easing on bank lending behavior', *Review of Financial Studies* **30**(11), 3858–3887.

Stiglitz, J. E. & Weiss, A. (1981), 'Credit Rationing in Markets with Imperfect Information', *American Economic Review* **71**(3), 393–410.

Swarbrick, J. (2023), 'Lending standards, productivity, and credit crunches', *Macroeconomic Dynamics* **27**(2), 456–481.

Whitesell, W. (2006), 'Interest rate corridors and reserves', *Journal of Monetary Economics* **53**(6), 1177–1195.

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
- $\omega_t^s = p_t^s = \omega_t^r p_t^r = 1$, $\omega_t^r > 1, p_t^r < 1$

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
- $\omega_t^s = p_t^s = \omega_t^r p_t^r = 1$, $\omega_t^r > 1, p_t^r < 1$

If funded, choose labour demand to maximise period profits:

$$V_t^i = \max_{h_t\left(\omega_t^i\right)} \left\{ \frac{P_t^W}{P_t} y_t\left(\omega_t^i\right) - \frac{W_t}{P_t} h_t\left(\omega_t^i\right) - \left(\frac{\tau_{t-1}^i}{\Pi_{t-1,t}} q_{t-1} - (1-\delta)\,\omega_t^i q_t \right) k + V_t \right\} \tag{14}$$

where

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

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
- $\omega_t^s = p_t^s = \omega_t^r p_t^r = 1$, $\omega_t^r > 1, p_t^r < 1$

If funded, choose labour demand to maximise period profits:

$$V_t^i = \max_{h_t(\omega_t^i)} \left\{ \frac{P_t^W}{P_t} y_t\left(\omega_t^i\right) - \frac{W_t}{P_t} h_t\left(\omega_t^i\right) - \left(\frac{\tau_{t-1}^i}{\Pi_{t-1,t}} q_{t-1} - (1-\delta)\,\omega_t^i q_t \right) k + V_t \right\} \tag{14}$$

where

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

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

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
- $\omega_t^s = p_t^s = \omega_t^r p_t^r = 1$, $\omega_t^r > 1, p_t^r < 1$

If funded, choose labour demand to maximise period profits:

$$V_t^i = \max_{h_t\left(\omega_t^i\right)} \left\{ \frac{P_t^W}{P_t} y_t\left(\omega_t^i\right) - \frac{W_t}{P_t} h_t\left(\omega_t^i\right) - \left(\frac{\tau_{t-1}^i}{\Pi_{t-1,t}} q_{t-1} - (1-\delta)\,\omega_t^i q_t \right) k + V_t \right\} \tag{14}$$

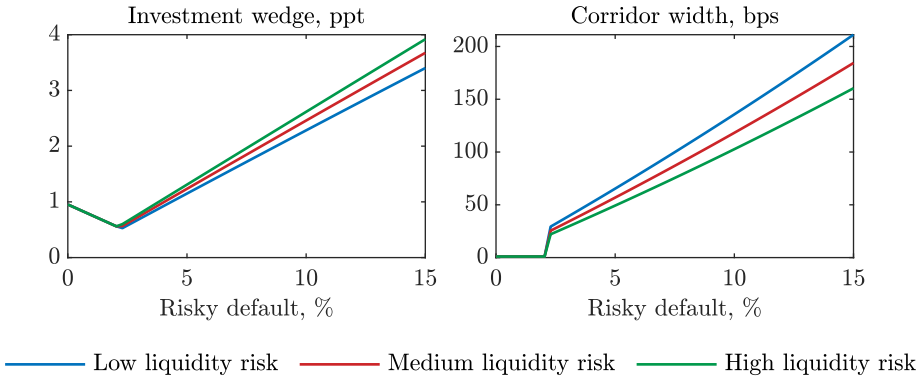
where

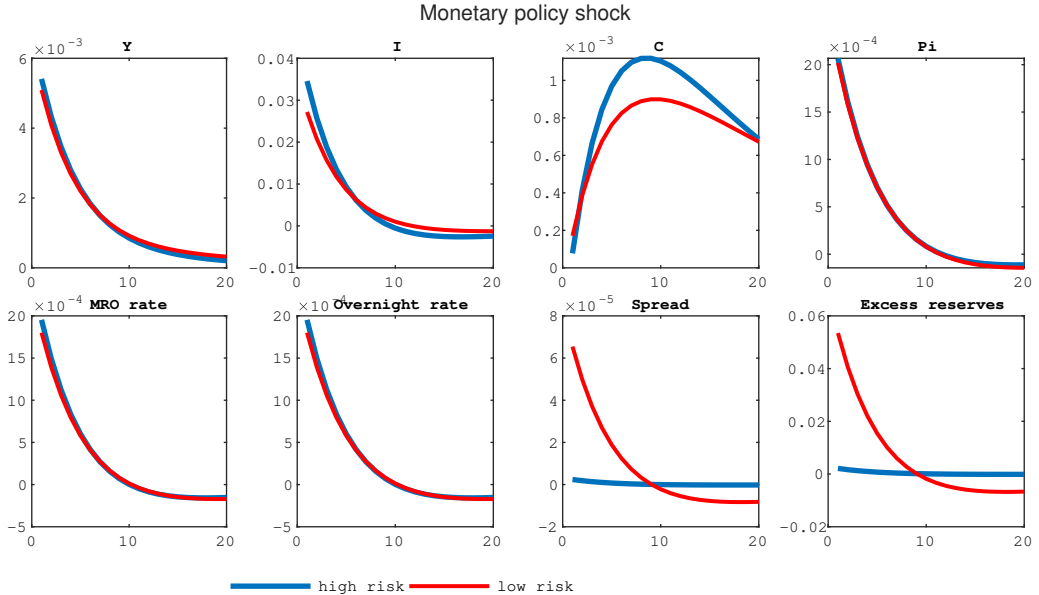
$$y_t\left(\omega_t^i\right) = z_t \left[\omega_t^i k\right]^{\alpha} \left[h_t\left(\omega_t^i\right)\right]^{1-\alpha}$$

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

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

Optimal corridor




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