When Banks Hold Back:

Credit and Liquidity Provision

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This paper in summary

- **Motivating Evidence. Tension between:**
  - Banks' tendency to **overextend** and occasionally fuel financial booms that end badly (*Rajan (2006), Lorenzoni (2008), Shleifer and Vishny (2009), Stein (2012) and Acharya and Rajan (2022)*)
  - Their revealed **reluctance** to borrow from the central bank to originate more credit (*Brunner and Meltzer (1964), Meltzer (1976 and 2003), Friedman and Schwartz (1963), Peristiani (1998), Bernanke (2009), Armantier et al (2015), Rostagno et al (2021)*)

- **Results**
  - In a stigma-free model of banking (modified version of *Stein (2012)*), we show that **parsimonious borrowing** and **under-provision of credit** can result even when banks have an underlying incentive to overissue deposits and overextend credit
  - Why? **The central bank sees potential collective gains from disintermediating the market for emergency liquidity** in a bad state, which **banks individually don't internalise**. So, even when a LOLR operation is in place to supply backstop liquidity, **banks borrow less and originate less credit than would be desirable** from a social welfare perspective
  - **Credit Easing and QE** can repair the broken nexus between liquidity provision and credit
  - We find **no empirical connection between loans and borrowed reserves** obtained from conventional refinancing facilities. In contrast, there is a **robust connection between loans and reserves borrowed under a CE program or non-borrowed**, i.e. acquired from a QE injection

Outline

- **A model of reluctant banks**

- **Empirical Analysis**

  - A liquidity preference shock urges banks to tap central bank liquidity, but borrowings don't support lending

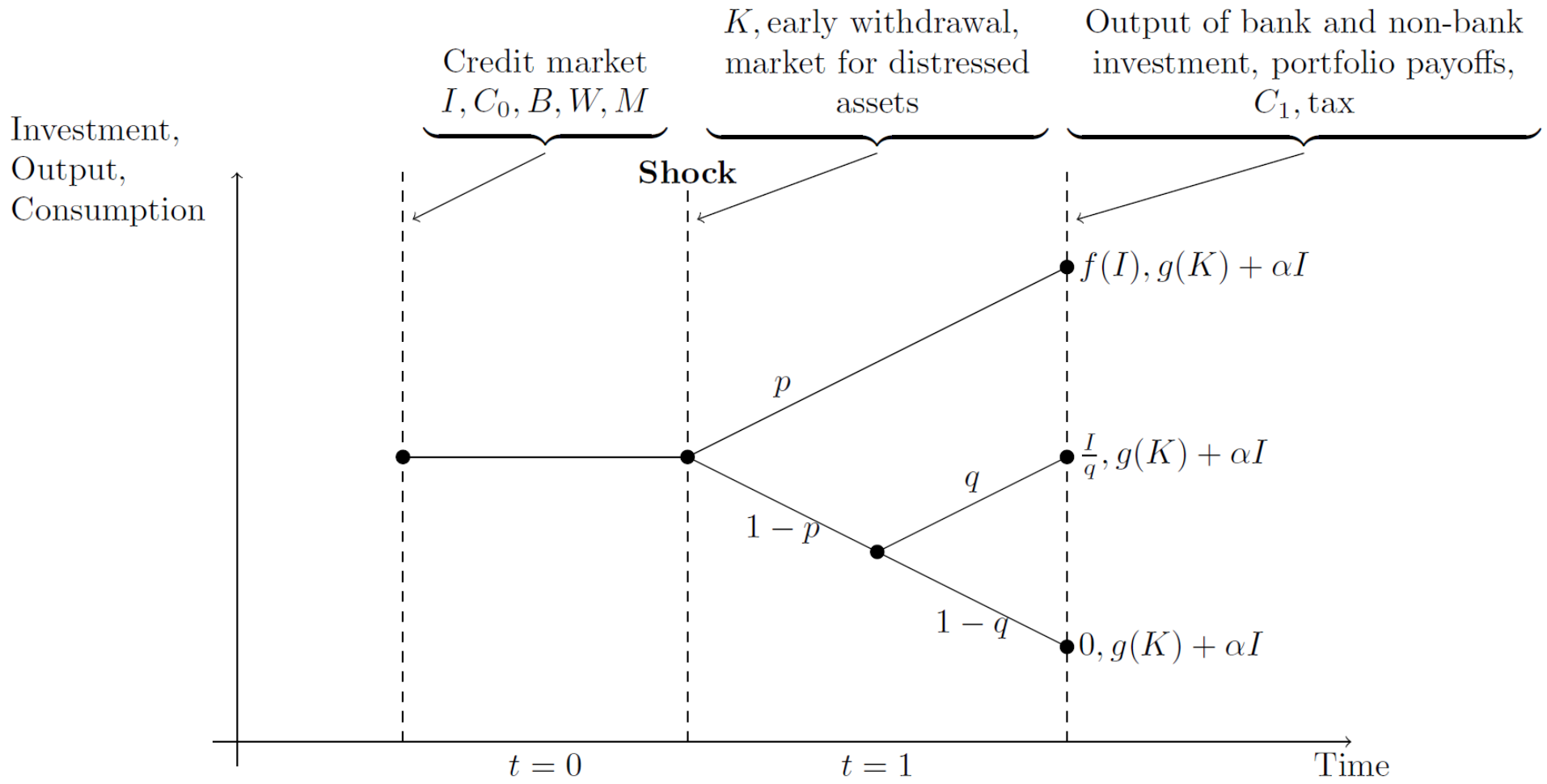
  - Bank credit is uncorrelated with backup liquidity but tightly connected with reserves borrowed under a CE program or non-borrowed (injected via QE)

  - Robust effects of liquidity provision through CE and QE on the real economy

- **Conclusions**

A model of reluctant banks

A variant of Stein (QJE, 2012): Two-period economy, four sectors: households, bank-financed manufacturing sector ("banks" in short), non-bank-financed manufacturing sector ("non-banks"), and a policy authority. Policy authority can advance liquidity to the banks



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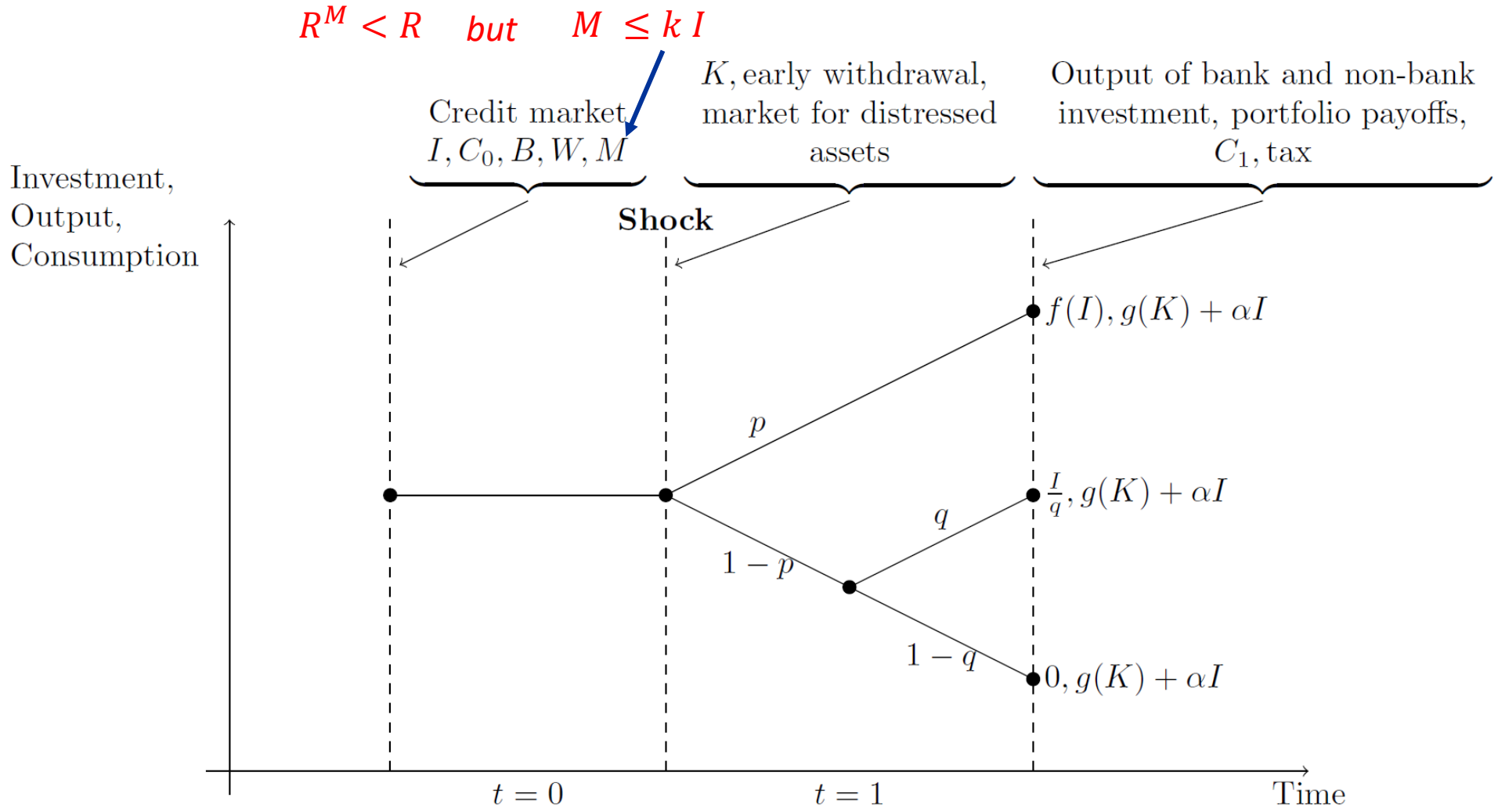

Banks' borrowing shortfall and under-investment

❑ Stein's non-interventionist (*NI*) equilibrium

- Here, if the bad state hits and depositors withdraw *M* before maturity, the only source of emergency liquidity for banks to make good on their deposit liabilities is fire-sale asset liquidation. Non-banks won't take the buying side of the distressed asset market unless at a unit price $k = \frac{1}{g'(K)} \leq 1$, $K = W - M$, that makes them indifferent between investing *W* in their own technology or in purchases of distressed assets.
- Despite the expected loss of asset value in the bad state, banks' cost of deposit funding, $R^{NI} = [1 + (1-p)\frac{1-k}{k}]\, R^M < R,$ is less than the cost of securities funding (R) because $R^M < R.$ So, **banks have an incentive to over-issue deposits and credit**, which gives rise to a negative externality
- But notice that the **diversion of funds by non-banks from own physical investment to purchases of banks' distressed assets comes at the deadweight cost**: non-bank sector production in the bad state is only *g(W−M) < g(W)*

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❑ A Lender of Last Resort (*LOLR*) equilibrium

- Here, the central bank stands ready to lend liquidity freely to the banks when a run occurs through over−collateralised refinancing at a rate: $R^{LOLR} = [1 + (1-p)\frac{1-x}{x}]\, R^M < R$, where $1 - x = 1 - k$ is the haircut that is applied to the bank's pledged assets at the liquidity window
- While the cost of deposit funding to the bank mirrors market conditions, in *LOLR* the central bank disintermediates the market for emergency liquidity and non−banks are forced to invest the entire amount of borrowed funds *W* into their production technology: *g(W)*
- **From an aggregate welfare perspective, foreclosing the possibility for non-banks to divert part of their borrowed funds to the bank asset market is preferable, as it boosts aggregate consumption. So, *LOLR* improves over *NI***
- But, in a *LOLR* equilibrium banks only internalise the expected cost of overcollateralization $(1-p)\frac{1-k}{k}$; they don't see the collective gains from the central bank bypassing non-banks as emergency liquidity provider. So, **in a *LOLR* equilibrium, banks borrow less than would be socially desirable, there is a loan deficit and the economy suffers from under-investment**

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❖ **Banks are generally reluctant to borrow from standard conventionally-priced backup facilities**

❖ **When a liquidity preference shock forces banks to tap a *LOLR* liquidity facility, their borrowings don't support lending**

Credit easing and quantitative easing repair the broken nexus between liquidity and credit

❑ A Credit easing (*CE*) equilibrium

- As in *LOLR*, but with the refinancing facility for banks priced attractively. In *CE*, the asset discount for loan collateralization, $1 - x$, which uniquely pins down R^{CE} is itself a choice variable in the policy selection process.
- We show that $R^{CE} = R^{M}$: in *CE* it's optimal to set the asset discount for loan collateralization to zero, or $x = 1$
- By providing liquidity assistance at an interest rate equal to the "lower bound" rate paid on deposits, R^{M}, ***CE* brings private allocations into complete alignment with those prescribed by the social optimum**, so eliminates under-investment

❑ A Quantitative easing (*QE*) equilibrium

- The CE result is not robust to one-way production externalities from the bank-intermediated production sector to non-bank intermediated production sector: *g(W) + α I,* with $\alpha > 0$
- If $\alpha > 0$, the central bank in a *QE* program can push the economy to the *CE* optimum by offering to purchase a pre-set amount of bank assets M^{QE} equal to M^{CE} in the event of a bank run at a price $P^{QE} \geq 1$
- In late 2014, after implementing a first round of TLTROs (ECB's version of *CE*) with disappointing take-up, the ECB decided to set a target for the size of its monetary policy assets and implement the target through asset purchases. The November 2014 post-meeting statement: "*Together with the series of TLTROs to be conducted until June 2016,* [our] *asset purchases will have a sizeable impact on our balance sheet, which is expected to move towards the dimensions it had at the beginning of 2012*"

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❖ **CE and QE – changing the nature of liquidity provision into something cheaper and more persistent – can nudge banks towards expanding their intermediation activity**

❖ **The extra credit spurred by CE and QE is productive: it's conducive to more investment and income**

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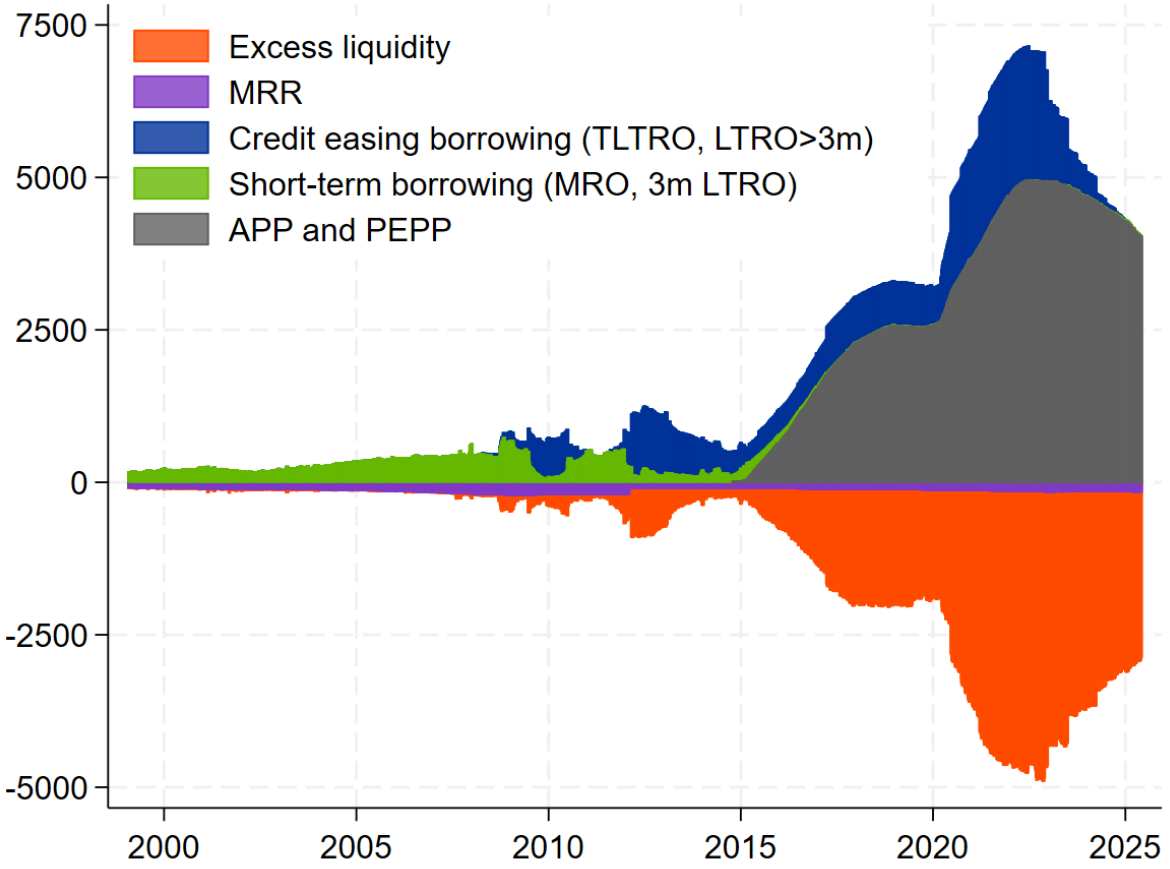
Borrowed Reserves, Credit Easing Reserves and Non-borrowed Reserves

Eurosystem Borrowing



Glossary

- **Excess liquidity/reserves**: liquidity that credit institutions hold on their central bank's accounts in excess of minimum requirements
- **Borrowed reserves:** liquidity that banks borrow directly from the short-term central bank facilities, e.g. through central bank liquidity-providing operations (MRO + LTRO up to 3m)
- **Credit easing reserves:** funds obtained by borrowing under Targeted longer-term refinancing operations (TLTROs) and non-standard LTRO (maturity >3m)
- **Non-borrowed reserves:** reserves banks receive, directly or indirectly, as a result of an ongoing central bank bond purchase program

Notes: Excess liquidity is the sum of reserves held in the current account and deposit facility in excess of reserve requirements, which are shown as MRR. "Credit easing borrowing" refers to borrowing by banks from the TLTROs and LTROs with maturity above 3 months. Short-term borrowing refers to banks' participation in the one-week main refinancing operations (MRO) and LTROs with maturity of up to 3 months. APP and PEPP holdings are shown in amortised book value (APP: EUR 2.5tn; PEPP: EUR 1.5tn as of 30 May 2025).
Latest observation: 30 May 2025.

A liquidity preference shock may force banks to tap a LOLR facility, but not to support lending

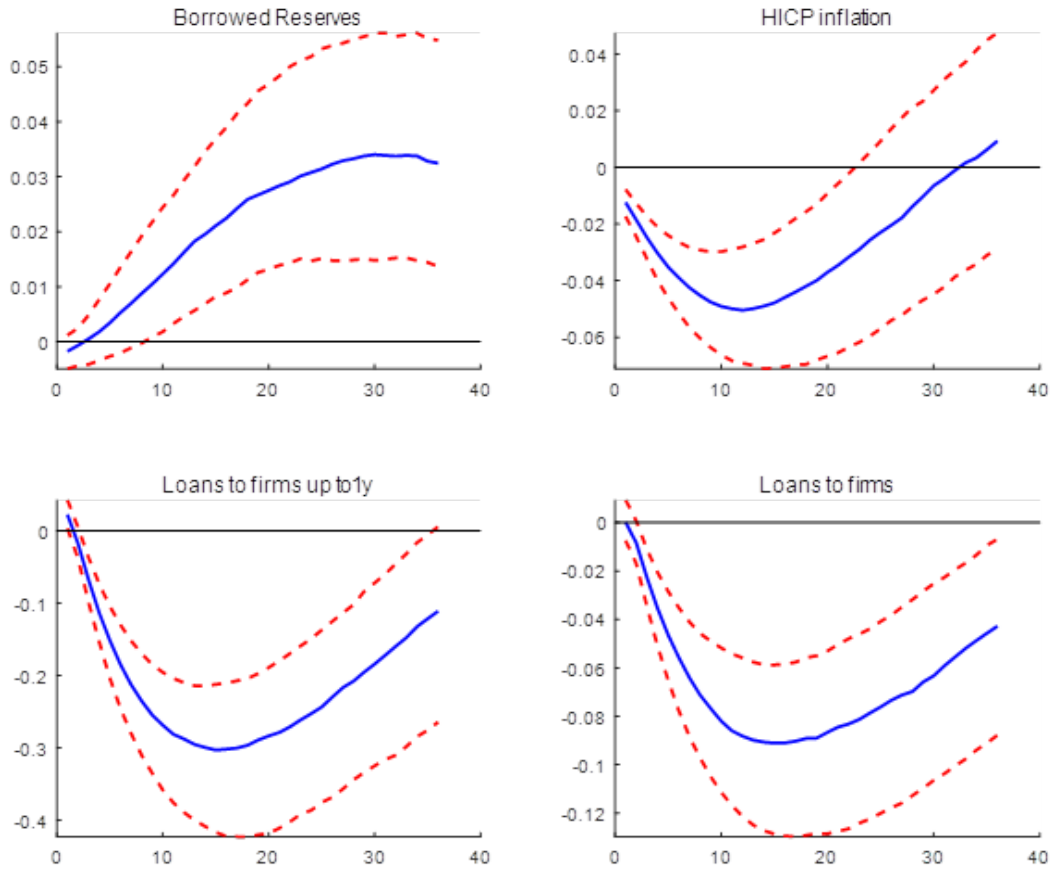
BVAR:

$$\begin{pmatrix} I & 0 \\ A_{0,yz} & I \end{pmatrix} \begin{pmatrix} z_{,t} \\ y_t \end{pmatrix} = A(L) \begin{pmatrix} z_{t-1} \\ y_{t-1} \end{pmatrix} + \begin{pmatrix} e_{,t} \\ u_t \end{pmatrix}$$

$$Y = \begin{bmatrix} \text{Industrial Production} \\ \text{Borrowed reserves} \\ \text{Overnight interest rate} \\ \text{Inflation} \\ \text{Loans to firms} \\ \text{Bank capital ratio} \\ \text{Security over asstes} \end{bmatrix}$$

Sample: July 2007-July 2024

An increase in borrowing to address an adverse shock will not result in higher loan origination



Note: The figure presents the response of the variables to an unanticipated temporary shock that decreases industrial production by 1 pp and leaves the policy rate unchanged over the entire simulation horizon. The solid line is the median, the red dotted lines represent the 16th and 84th percentiles of the posterior distribution.

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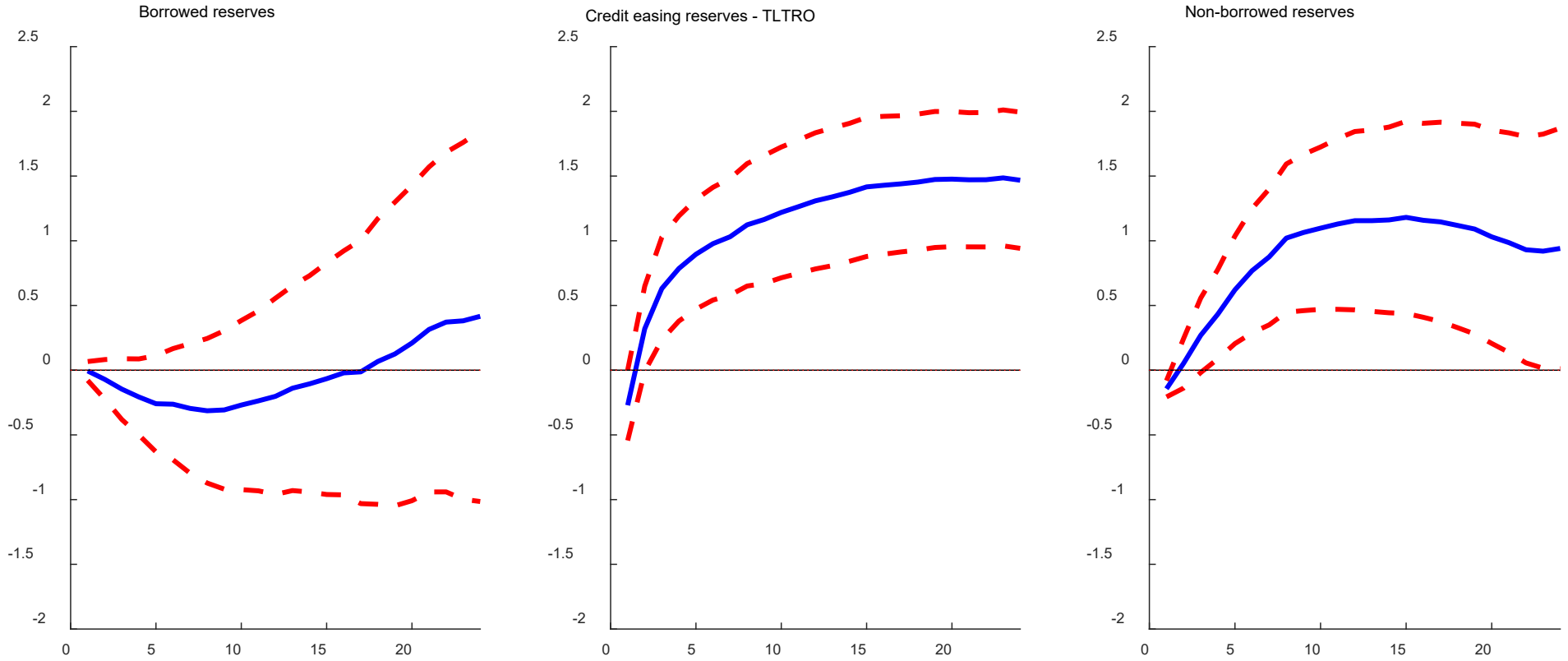
Bank lending and liquidity provision under different regimes

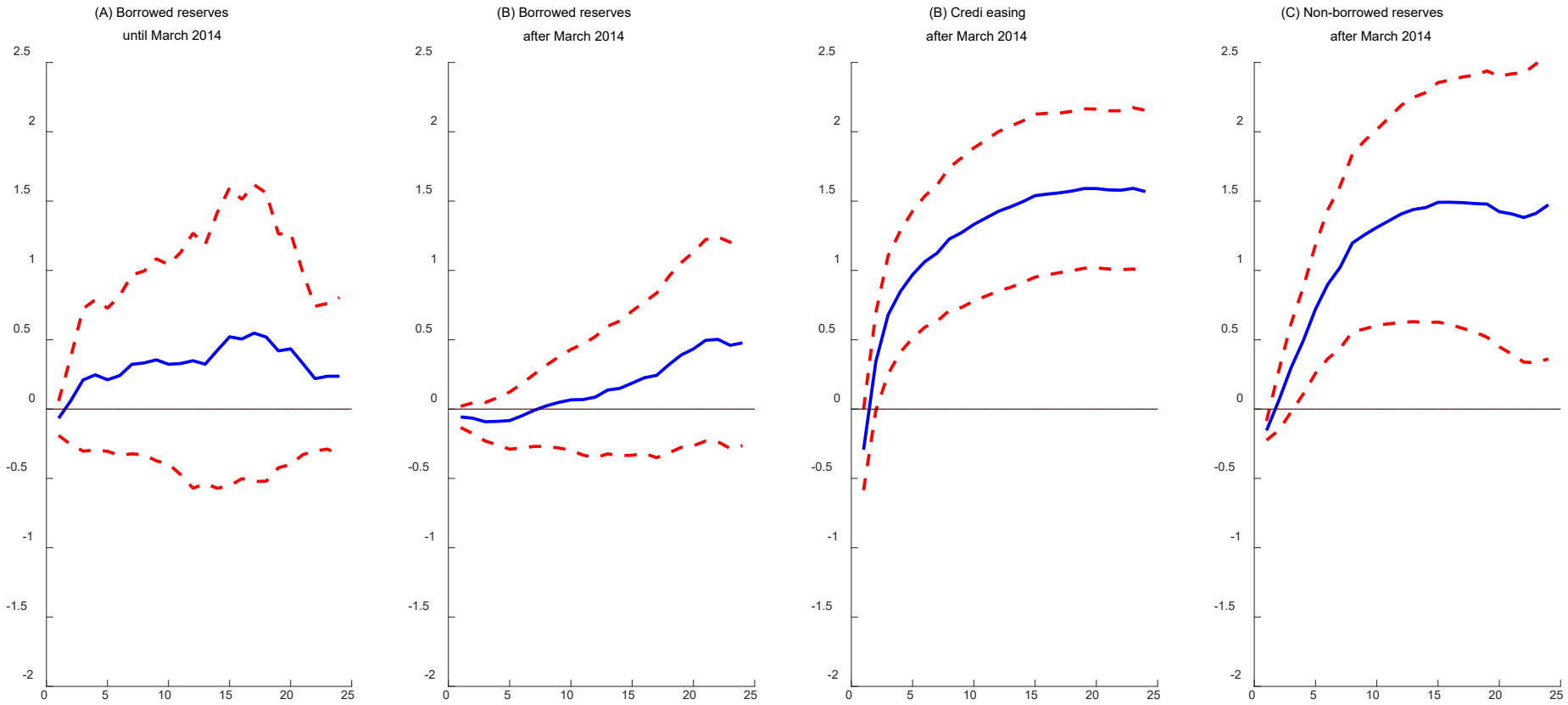
$$\Delta L_{i,t+h} = \alpha_{i,h} + \beta_h \Delta NBR_{i,t} + \delta_h \Delta BR_{i,t} + \lambda_h \Delta \mathrm{CE}R_{i,t} + \Gamma_\mathrm{h} X_{i,t-1} + \epsilon_{i,t+h} \;\; for\; h = 1, \dots, 24$$



Note: The figure reports the cumulated response of banks' loan growth up to time *t+h* to an increase in borrowed, TLTRO and non-borrowed reserves ratio at time t. The solid line are retrieved from the coefficients β_h, δ_h, and λ_h from the regression $\Delta L_{i,t+h} = \alpha_{i,h} + \beta_h \Delta NBR_{i,t} + \delta_h \Delta BR_{i,t} + \lambda_h \Delta \mathrm{CE}R_{i,t} + \Gamma_\mathrm{h} X_{i,t-1} + \epsilon_{i,t+h}$, $h = 1, \dots, 24$. $\Delta L_{i,t+h}$ is the cumulated change in loans to firms of bank *i* between *t* and *t + h*; the variable $\Delta NBR_{i,t}$ and $\Delta BR_{i,t}$ represents the change in the ratio of borrowed and non-borrowed reserves over assets. $\Delta \mathrm{CE}R_{i,t}$ is instead the ratio of credit easing reserves, i.e. TLTRO funds, over assets. $X_{i,t-1}$ includes the non-performing loan ratio, the return on assets, bank-specific credit demand conditions from the BLS, the share of government of government and corporate securities in the bank's assets, the level of excess liquidity over assets and the share of deposit of assets. The dashed lines report the 95% confidence intervals for each horizon *h* with standard errors clustered at the country*time and bank level.

Response of bank loans before and after the unconventional monetary measures

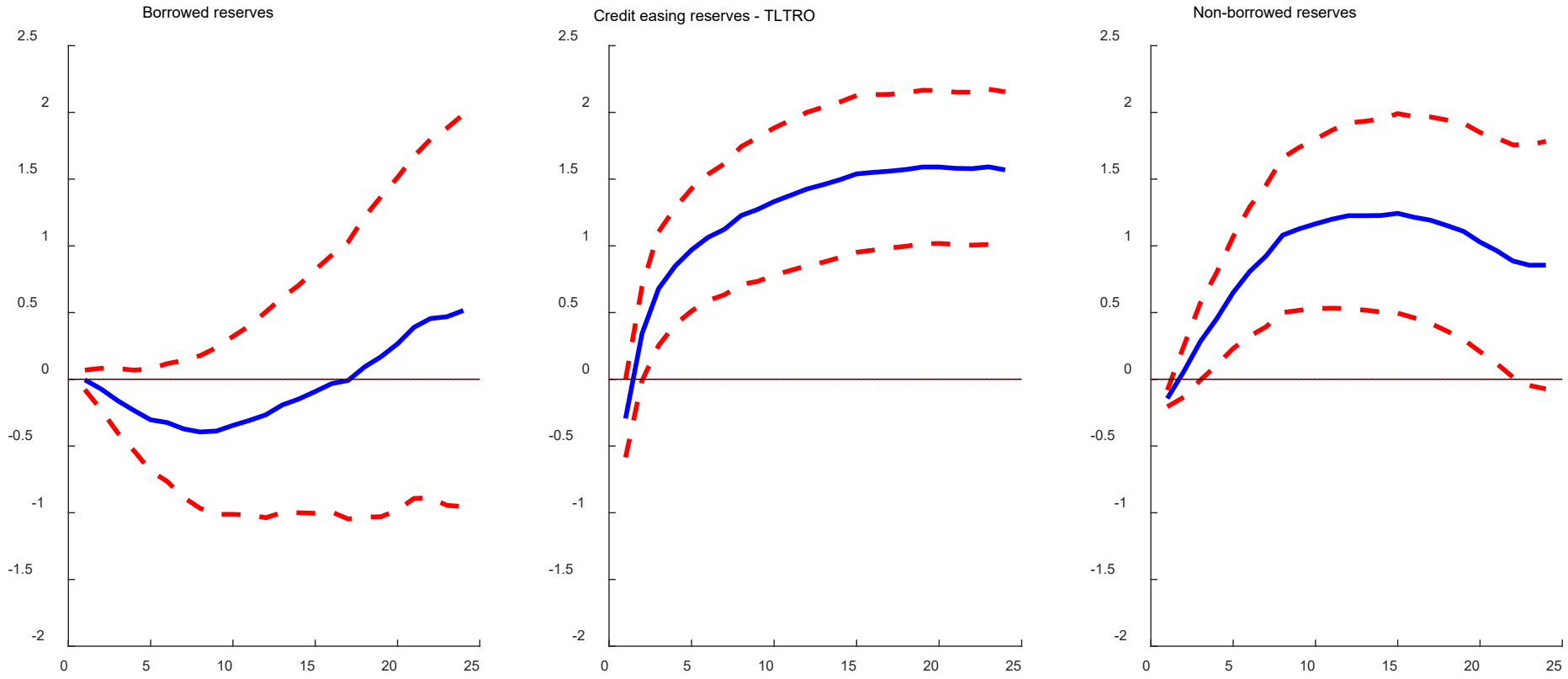
Response of bank loans over subsamples



Note: The figure reports the cumulated response of banks' loan growth up to time *t+h* to a drop in non-borrowed and borrowed reserves ratio at time t The solid line are retrieved from the coefficients β_h and δ_h from the regression of the regression $\Delta L_{i,t+h} = \alpha_{i,h} + \beta_h \Delta NBR_{i,t} + \delta_h \Delta BR_{i,t} + \Gamma_h X_{i,t-1} + \epsilon_{i,t+h}, for\ h = 1, \dots, 24$. $\Delta L_{i,t+h}$ is the cumulated change in loans to firms of bank *i* between *t* and *t + h*; the variable $\Delta BR_{i,t}$and $\Delta NBR_{i,t}$represents the change in the ratio of borrowed and non-borrowed reserves over assets; We control for a host of lagged observable characteristics at the bank level $X_{i,t-1}$, which include the non-performing loans (NPL) ratio, the return on assets (ROA), the share of government and corporate securities in the bank's assets, bank-specific credit demand conditions from the BLS, and bank fixed effects $\alpha_{i,h}$. In addition to the benchmark specification, we also control for the level of excess liquidity over asses and the share of deposit of assets. The shaded areas report the 68% and 95% confidence intervals for each horizon *h* with standard errors clustered at the country*time and bank level.

What about NIRP?

Response of bank loans controlling for NIRP



Note: The figure reports the cumulated response of banks' loan growth up to time *t+h* to an increase in TLTRO, non-borrowed and borrowed reserves ratio at time *t*. The solid line are retrieved from the coefficients β_h, δ_h, and $\lambda_h$from the regression $\Delta L_{i,t+h} = \alpha_{i,h} + \beta_h \Delta NBR_{i,t} + \delta_h \Delta BR_{i,t} + \lambda_h \Delta \mathrm{CER}_{i,t} + \Gamma_h X_{i,t-1} + \epsilon_{i,t+h}$, $h = 1, \ldots, 24$. $\Delta L_{i,t+h}$ is the cumulated change in loans to firms of bank i between *t* and *t + h*; the variable $\Delta NBR_{i,t}$ and $\Delta BR_{i,t}$represents the change in the ratio of borrowed and non-borrowed reserves over assets. $\Delta \mathrm{CER}_{i,t}$is instead the ratio of credit easing reserves, i.e. TLTRO funds, over assets. $X_{i,t-1}$includes the non-performing loan ratio, the return on assets, bank-specific credit demand conditions from the BLS, the share of government of government and corporate securities in the bank's assets, the level of excess liquidity over asses and the share of deposit of assets. In addition to the benchmark specification, we also control for the level of excess liquidity over asses and the share of deposit of assets. The dashed lines report the 95% confidence intervals for each horizon h with standard errors clustered at the country*time and bank level.

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Real effects of liquidity regimes

$$\Delta Y_{f,t} = \alpha^{FE} + \Phi_{\mathrm{R}} \Delta R_{f,t-1} + \lambda PD_{f,t-1} + \Omega_{\mathrm{R}} \left(\Delta R_{f,t-1} \times PD_{f,t-1} \right) + \Gamma_h X_{f,t-1} + \epsilon_{i,f,t}$$

Y = {Sales, Employment, Investment} R_f = {*BR, CER, NBR*} X = {Age, Size, Leverage}

	Sales			Employment			Investment		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$\Delta BR_{f,t-1}$	3.450***	-0.122	-0.0825	0.597***	0.0233	0.0394	0.0277	-0.00437	-0.0249
	(0.198)	(0.194)	(0.195)	(0.140)	(0.141)	(0.141)	(0.287)	(0.290)	(0.291)
$\Delta CER_{f,t-1}$	0.0931***	0.0752***	0.0587**	0.105***	0.0407**	0.0458**	0.0580***	0.0832***	0.0834***
	(0.0117)	(0.0255)	(0.0256)	(0.00830)	(0.0177)	(0.0178)	(0.0140)	(0.0300)	(0.0301)
$\Delta NBR_{f,t-1}$	2.057***	0.438***	0.417***	0.586***	0.319***	0.315***	0.140***	0.354***	0.356***
	(0.0219)	(0.0261)	(0.0262)	(0.0148)	(0.0179)	(0.0180)	(0.0249)	(0.0307)	(0.0308)
$PD_{f,t-1}$	-0.0184	-0.0285**	-0.0446**	-0.0920***	-0.101***	-0.0986***	-0.272***	-0.267***	-0.266***
	(0.0217)	(0.0130)	(0.0213)	(0.0142)	(0.0142)	(0.0142)	(0.0217)	(0.0217)	(0.0217)
$PD_{f,t-1} \times \Delta BR_{f,t-1}$	0.0177	0.00323	0.00622	-0.0266	-0.0301	-0.0296	-0.0271	-0.0261	-0.0276
	(0.0318)	(0.0310)	(0.0311)	(0.0192)	(0.0192)	(0.0192)	(0.0300)	(0.0301)	(0.0301)
$PD_{f,t-1} \times \Delta CER_{f,t-1}$	0.00259*	0.00499***	0.00474***	0.0000556	0.000302	0.000282	0.0112***	0.0109***	0.0109***
	(0.00157)	(0.00154)	(0.00154)	(0.000967)	(0.000965)	(0.000966)	(0.00142)	(0.00142)	(0.00142)
$PD_{f,t-1} \times \Delta NBR_{f,t-1}$	0.0189***	0.0254***	0.0251***	0.00526***	0.00638***	0.00639***	0.00689***	0.00636***	0.00626***
	(0.00249)	(0.00242)	(0.00243)	(0.00152)	(0.00151)	(0.00152)	(0.00224)	(0.00225)	(0.00225)
Fixed Effects:									
Firm	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time	-	Yes	Yes	-	Yes	Yes	-	Yes	Yes
ILS	-	-	Yes	-	-	Yes	-	-	Yes
Observations	2000021	2000021	1999864	2000021	2000021	1999864	1928872	1928872	1928715
R-squared	0.290	0.343	0.345	0.288	0.291	0.293	0.360	0.360	0.362

Isn't banks' increased tolerance for risk translating into zombie lending?

	Sales			Employment			Investment		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$\Delta BR_{f,t-1}$	2.869***	-0.165	-0.0839	0.163	-0.273**	-0.243**	-0.395	-0.430*	-0.470
	(0.167)	(0.166)	(0.166)	(0.122)	(0.123)	(0.124)	(0.247)	(0.250)	(0.350)
$\Delta CER_{f,t-1}$	0.0159**	0.0192**	0.0197**	0.154***	0.0693***	0.0702***	0.0242**	0.153***	0.148***
	(0.00809)	(0.00974)	(0.01001)	(0.00708)	(0.0144)	(0.0145)	(0.0123)	(0.0250)	(0.0251)
$\Delta NBR_{f,t-1}$	1.774***	0.361***	0.365***	0.459***	0.214***	0.214***	0.126***	0.283***	0.275***
	(0.0179)	(0.0203)	(0.0203)	(0.0119)	(0.0139)	(0.0139)	(0.0209)	(0.0246)	(0.0247)
$Zombie_{f,t-1}$	-16.79***	-13.19***	-12.93***	-4.966***	-4.262***	-4.163***	-6.221***	-6.540***	-6.628***
	(1.640)	(1.576)	(1.580)	(0.960)	(0.958)	(0.959)	(1.444)	(1.445)	(1.448)
$Zombie_{f,t-1} \times \Delta BR_{f,t-1}$	0.277	0.457	0.540	-1.350	-1.319	-1.357	3.164	3.154	3.344
	(2.908)	(2.866)	(2.874)	(1.150)	(1.150)	(1.153)	(2.264)	(2.264)	(2.267)
$Zombie_{f,t-1} \times \Delta CER_{f,t-1}$	0.119	-0.0772	-0.0757	0.0723	0.0322	0.0316	0.253	0.280	0.283
	(0.108)	(0.105)	(0.106)	(0.0651)	(0.0650)	(0.0650)	(0.251)	(0.251)	(0.255)
$Zombie_{f,t-1} \times \Delta NBR_{f,t-1}$	-0.303	1.453	1.581	0.170**	0.103	0.110	0.0950	0.115	0.132
	(2.315)	(2.285)	(2.286)	(0.0860)	(0.0857)	(0.0864)	(0.130)	(0.130)	(0.129)
Fixed Effects:									
Firm	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time	-	Yes	Yes	-	Yes	Yes	-	Yes	Yes
ILS	-	-	Yes	-	-	Yes	-	-	Yes
Observations	2427517	2427517	2427365	2427517	2427517	2427365	2261077	2261077	2260911
R-squared	0.283	0.331	0.335	0.288	0.292	0.294	0.360	0.360	0.362

Note: The variable Zombie is a dummy variable that takes value 1 if a firm has an interest coverage ratio persistently below 1 over three previous years and has been operating in the market for at least a decade. The model includes other control variables, including firm age, leverage and size, as well as the set of fixed effects as reported in the table. ILS stands for industry-location-size fixed effects and capture credit demand components common across firms belonging to the same 2-digit industry, the same geographical location (city) and same decile of the size distribution of firms. Standard errors are clustered at firm and time level. * p<.1, ** p<.05, *** p<.01.

Exposure to central bank liquidity, risk-taking and firm outcomes

1. Firms with greater exposure to banks borrowing in a CE program or holding larger volumes of non-borrowed reserves increase employment, sales, and investment.

2. Zombie firms exhibit poorer economic performance.

$$Zombie = \begin{cases} 1 & if\ ICR < 1\ for\ 3y\ and\ Age > 10y \\ 0 & otherwise \end{cases}$$

3. Zombie firms' exposure to banks with higher non-borrowed reserves does not influence this outcome. This aligns with the notion that the increase in bank credit supply followed by a rise in central bank reserves is not associated with excessive risk-taking or zombie lending.

Outline

- **A model of reluctant banks**
- **Empirical Analysis**
  - A liquidity preference shock urges banks to tap central bank liquidity, but borrowings don't support lending
  - Bank credit is uncorrelated with backup liquidity but tightly connected with reserves borrowed under a CE program or non-borrowed (injected via QE)
  - Robust effect of liquidity provision through CE and QE on the real economy
- **Conclusions**

Conclusions

❑ Model

- **LOLR:** If a standard, conventionally-priced refinancing operation (LOLR) is the only source of liquidity, banks are reluctant to borrow from regular short-term liquidity-providing operations and, when they do so, they don't use the borrowed liquidity to back up their lending to the broader economy
- **CE**: Liquidity offered in a refinancing operation on concessionary terms (Credit Easing, CE) can bring the economy to the social optimum in the absence of production externalities across sectors
- **QE**: With production externalities, Quantitative Easing (QE) can bring the economy to the CE social optimum

❑ Empirics

- **Banks are not indifferent to the origin of their liquidity endowments**, whether obtained through short-term loans from the central bank, from credit easing interventions or outright transactions
- **LOLR:** lack of connection between borrowed reserves and loans
- **CE and QE:** Robust connection between loans and TLTRO-borrowed reserves or non-borrowed
- **Real effects:** Credit spurred by CE and QE is productive and conducive to more investment

Thank you

Literature

Bank credit cycles and unstable banking

- Bernanke and Gertler (1989), Kiyotaki and Moore (1997), Rajan (2006), Adrian and Shin (2008), Lorenzoni (2008), Shleifer and Vishny (2009), Stein (2012) and Acharya and Rajan (2022).

Banks' reluctance to borrow central bank funds

- Bernanke (2009): "In August 2007,.. banks were reluctant to rely on discount window credit to address their funding needs"
- Peristiani (1998), ReStat; Furfine (2001), EL; Armantier, Ghysels, Sarkar, Shrader (2015), JFE; Anbil (2018), JFE

Central bank reserves and bank lending

- Banks that increased their reserve holdings, following the FED QE3, **increased lending** (Rodnyansky and Darmouni, 2017; Kandrac and Schlusche, 2021).
- Banks with higher excess reserve holdings **grant more credit lines** and take more risk (Acharya et al. 2023; Acharya and Rajan, 2022).
- The reallocation of central bank reserves towards banks with higher liquidity needs **fosters credit supply** (Altavilla, Boucinha, Burlon, Giannetti, and Schumacher, 2022)
- Reserve-rich banks' credit **supply is less sensitive** to the monetary policy tightening compared to other banks (Fricke, Greppmair, and Paludkiewicz, 2023)
- An increase in excess reserve holdings **crowds out bank lending** (Diamond, Jiang and Ma, 2023)
- Liquidity factors contribution to the decline in credit (Bianchi and Bigio, 2022)

Banks' reluctance to borrow

Already in the 1920s, Federal Reserve (Fed) economists Riefler and Burgess noticed that banks' reluctance to borrow from the discount window gave the Fed's open market operations an extra leverage over credit conditions, especially in a tightening phase (Brunner and Meltzer, 1964; and Meltzer, 1976 and 2003).

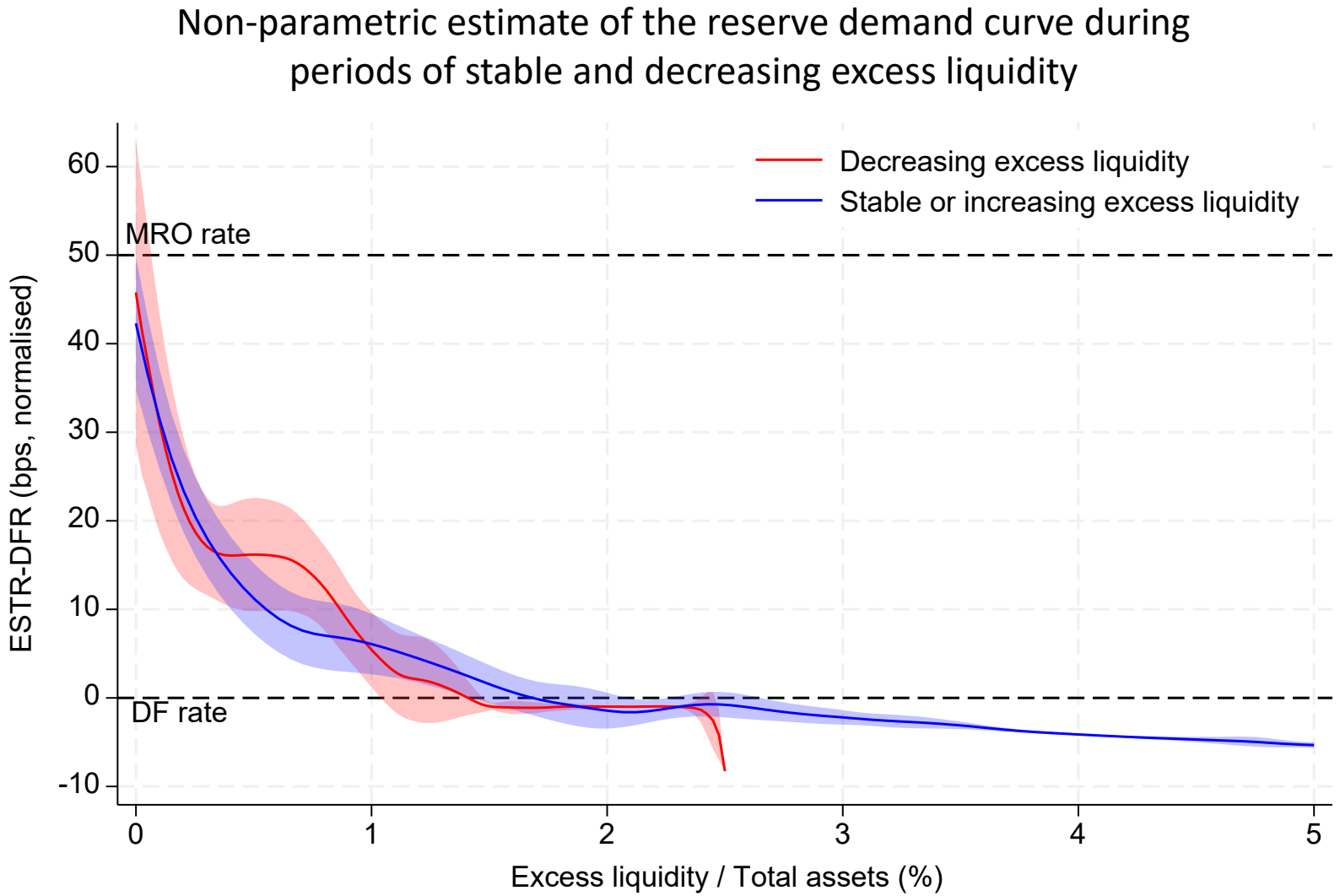
Great Financial Crisis (GFC): many banks faced with a drain of cash would often eschew refinancing with the central bank and rather refuse to make markets, dump assets at deep discounts and cut back credit to restock their liquidity reservoirs (Bernanke, 2009; Armantier *et al 2015*).

Great Depression. Banks remained hesitant to borrow from the discount window (Friedman and Schwartz, 1963).

2013-2014: banks' widescale reimbursement of central bank liquidity in the euro area came into conflict with the central bank's objective to kickstart lending and reflate the economy (Rostagno *et al.*, 2021).

After 1982, the unwillingness of banks to borrow when borrowed reserves were used as an operating target by FOMC weakened interest rate control to the point that the Fed saw a return to an interest-rate-targeting framework as desirable (Meulendyke, 1998, Peristiani, 1998)

Banks' reluctance to borrow in the data



Note: The chart shows the fitted values from a non-parametric estimate of the relationship between the ESTR-DFR spread (normalised to a 50bps corridor widths to account for changes in the spread between the policy rates over time) and the banking system's excess liquidity holdings (defined as a ratio of total assets and adjusted for the averaging of minimum reserve requirements over a maintenance period), distinguishing between the sample period from June to December 2010 and January 2013 to December 2014 as the "decreasing excess liquidity regime" (red line), and the remainder of the sample period as the "stable or increasing excess liquidity regime" (blue line). The overall sample begins in October 2008, when the ECB's liquidity provision in regular refinancing operations changed to a policy of full allotment.

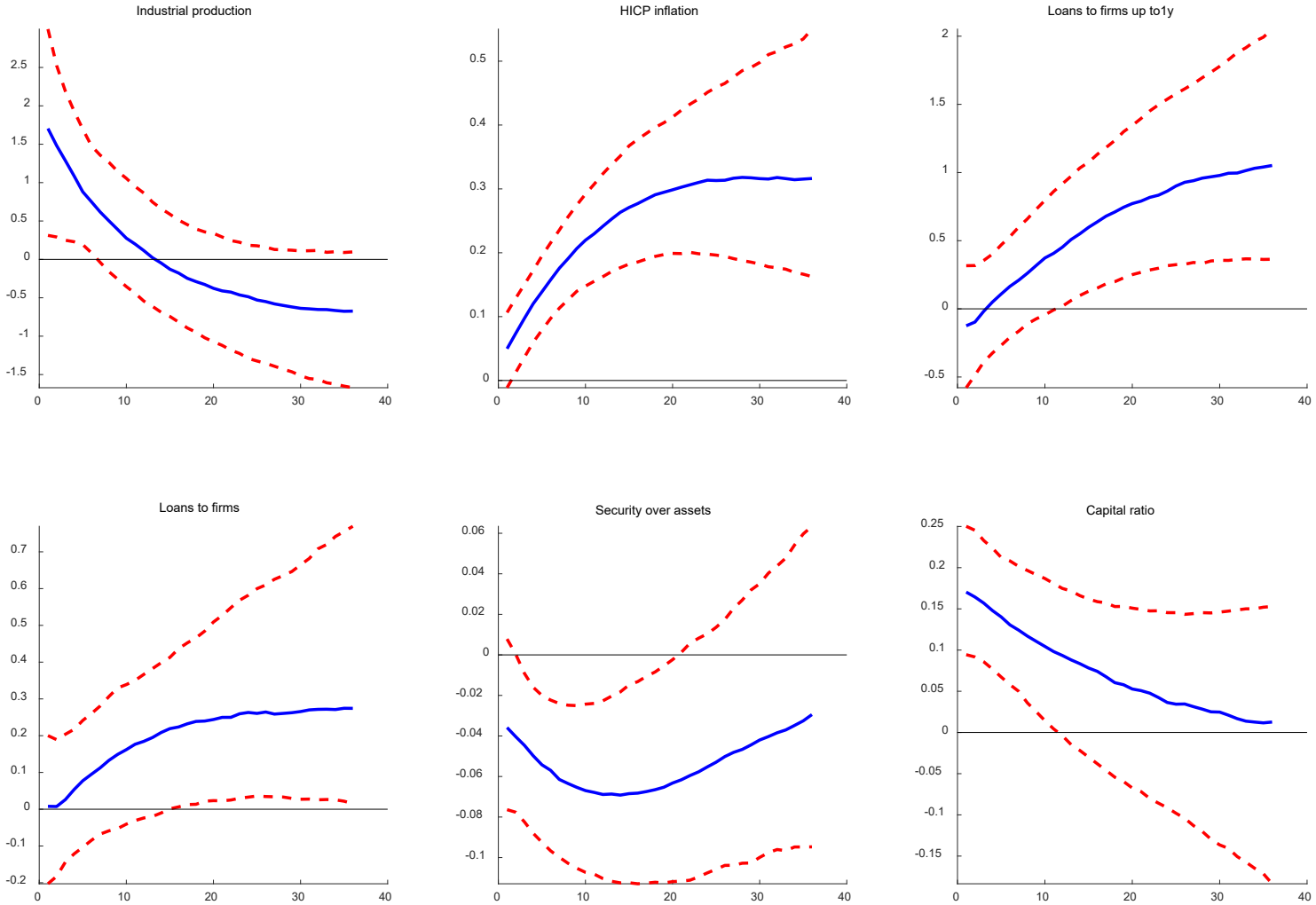
Bank lending and liquidity provision

BVAR:

$$\begin{pmatrix} I & 0 \\ A_{0,yz} & I \end{pmatrix} \begin{pmatrix} z_{,t} \\ y_t \end{pmatrix} = A(L) \begin{pmatrix} z_{t-1} \\ y_{t-1} \end{pmatrix} + \begin{pmatrix} e_{,t} \\ u_t \end{pmatrix}$$

$$Y = \begin{bmatrix} \text{Excess Liquidity} \\ \text{Interest rate} \\ \text{Loans to firms} \\ \text{Bank capital ratio} \\ \text{Security over asstes} \\ \text{Inflation} \\ \text{Industrial Production} \end{bmatrix}$$

Sample: July 2007-July 2024



Note: Response to an unanticipated shock that increases the excess liquidity over assets by 1 pp and leaves the policy rate unchanged over the entire simulation horizon. The solid line is the median, the red dotted lines represent the 16th and 84th percentiles of the posterior distribution.

Bank lending and liquidity provision in a LOLR regime

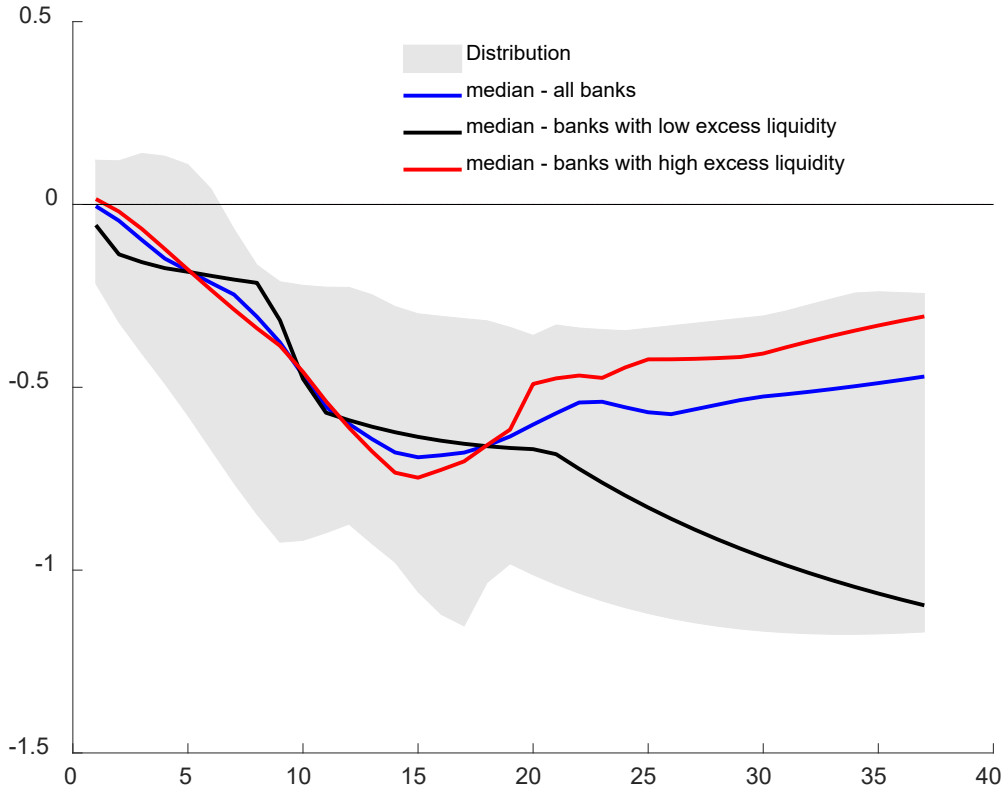
P-BVAR:

$$\begin{pmatrix} I & 0 \\ A_{0,yz} & I \end{pmatrix} \begin{pmatrix} z_{i,j,t} \\ y_{i,j,t} \end{pmatrix} = A(L) \begin{pmatrix} z_{i,j,t-1} \\ y_{i,j,t-1} \end{pmatrix} + \begin{pmatrix} e_{,i,j,t} \\ u_{i,j,t} \end{pmatrix}$$

$$Y = \begin{bmatrix} \text{Industrial Production} \\ \text{Borrowed reserves} \\ \text{Interest rate} \\ \text{Inflation} \\ \text{Loans to firms} \\ \text{Bank capital ratio} \\ \text{Security over asstes} \end{bmatrix}$$

Sample: July 2007-July 2024

Lending growth responses to liquidity shocks



Note: Response to an unanticipated shock that increases liquidity (borrowed, non-borrowed and TLTRO) over assets by 1 pp and leaves the policy rate unchanged over the entire simulation horizon. The solid line is the median, the red dotted lines represent the 16th and 84th percentiles of the posterior distribution.

Does non-random selection of banks introduce a bias into our empirical analysis?

- As there is no proper randomization, the **participation in liquidity operations** (i.e., the treatment) is not independent of the expected outcomes (i.e., lending behaviour).

- The **impact** of a change in liquidity may be **biased downward** if the banks that **borrowed more** from the refinancing operations had **worse lending prospects**.

- To alleviate concerns on potential endogeneity issues related to banks' participation in ECB liquidity operations we use a local projection instrumental variable (LP-IV)

Bartik-like "shift-share" instrument

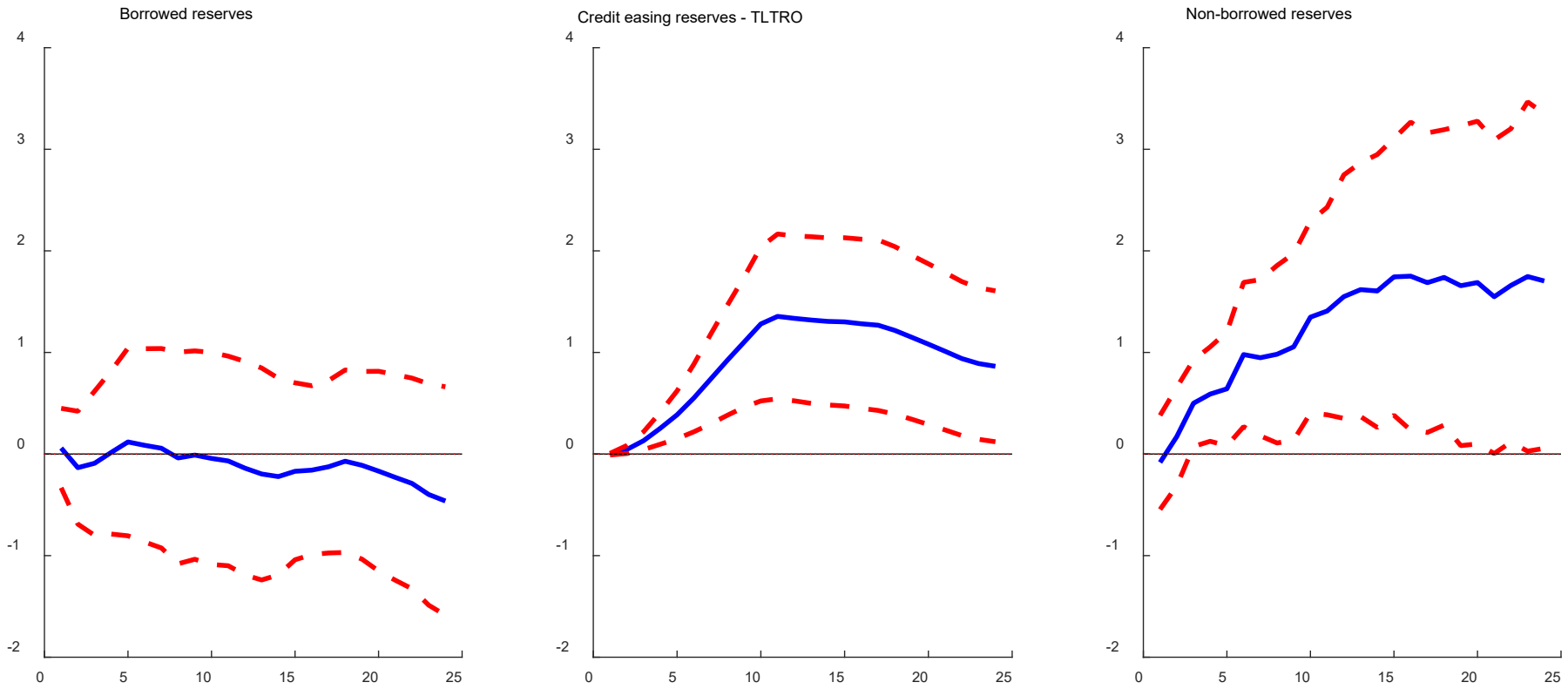
$$Z_{i,t}^{BR} = \underbrace{ln\left(\frac{BR_t}{BR_{t-3}}\right)}_{\textbf{\textit{Shift}}} \times \underbrace{Share_{i,t}^{BR}}_{\textbf{\textit{Share}}}$$

Quarterly growth rate of the aggregate borrowed reserve (BR), i.e. a quantity that an individual bank cannot influence (i.e. the **shift**, or the shock).

Share of each bank's borrowed reserves over the total reserves (i.e. the **share**). To ensure that this second term is less depended on specific events, we take the 12 months average as $\frac{1}{12}\sum_{k=1}^{12} BR_{i,t-k}$.

Bank lending and regimes of liquidity provision

Response of bank loans after a 1pp increase in central bank reserves



Note: The figure reports the cumulated response of banks' loan growth up to time *t+h* to a drop in TLTRO, non-borrowed and borrowed reserves ratio at time t. The solid line are retrieved from the coefficients β_h, δ_h, and λ_h from the regression $\Delta L_{i,t+h} = \alpha_{i,h} + \beta_h \Delta NBR_{i,t} + \delta_h \Delta BR_{i,t} + \delta_h \Delta BR_{i,t} + \lambda_h \Delta \mathrm{TLTRO}_{i,t} + \Gamma_h X_{i,t-1} + \epsilon_{i,t+h}, for\ h = 1, \dots, 24$. $\Delta L_{i,t+h}$ is the cumulated change in loans to firms of bank *i* between *t* and *t + h*; the variable $\Delta NBR_{i,t}$ and $\Delta BR_{i,t}$ represents the change in the ratio of borrowed and non-borrowed reserves over assets. These variables are instrumented. The instrument for the non-borrowed reserves is $Z_{i,t}^{NBR} = ln\left(\frac{NBR_t}{NBR_{t-3}}\right) \times Share_{i,t}^{NBR}$. The instrument for the borrowed reserves is calculated in a similar way. The variable $\Delta TLTRO_{i,t}$ represents the high frequency changes in bank-specific bond yields around TLTRO announcements. Additional lagged observable characteristics at the bank level are included in the vector $X_{i,t-1}$. These variables are the non-performing loan (NPL) ratio, the return on assets (ROA), bank-specific credit demand conditions from the BLS, the share of government of government and corporate securities in the bank's assets, the level of excess liquidity over asses and the share of deposit of assets. The dashed lines report the 95% confidence intervals for each horizon *h* with standard errors clustered at the country*time and bank level.

Loan growth and Reserves – Anacredit bank-firm panel

	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta BR_{b,t-1}$	-0.591	0.213	0.570	0.528	0.200	-0.103
	(0.575)	(0.685)	(0.642)	(0.567)	(0.673)	(0.417)
$\Delta CER_{b,t-1}$	0.441***	1.114***	1.147***	0.674***	0.822***	0.577***
	(0.131)	(0.256)	(0.238)	(0.201)	(0.240)	(0.126)
$\Delta NBR_{b,t-1}$	1.537***	1.027***	1.069***	0.773***	0.990***	0.889***
	(0.276)	(0.319)	(0.296)	(0.221)	(0.316)	(0.191)
Share of securities held$_{b,t-1}$	0.311	0.650**	0.442	0.0385	0.687**	0.312
	(0.325)	(0.314)	(0.293)	(0.257)	(0.329)	(0.295)
$ROA_{b,t-1}$	16.55***	12.36***	11.74***	6.009***	10.72***	6.418***
	(1.927)	(1.785)	(1.635)	(1.067)	(1.720)	(1.054)
$NPL_{b,t-1}$	-0.428	-1.910***	-1.718***	-0.869***	-1.914***	-1.318***
	(0.343)	(0.385)	(0.352)	(0.318)	(0.382)	(0.310)
Fixed effects:						
Bank	Yes	Yes	Yes	Yes	Yes	Yes
Time	-	Yes	Yes	-	Yes	-
ILS	-	-	Yes	-	-	-
ILS*Time	-	-	-	Yes	-	-
Firm	-	-	-	-	Yes	-
Firm*Time	-	-	-	-	-	Yes
Observations	63085929	63085929	63085928	63084924	63007675	40985546
R-squared	0.006	0.008	0.151	0.372	0.384	0.753

1. The coefficient on BR is positive and **NOT** statistically significant across all specifications.

2. The coefficient on CER (TLTRO) is positive and statistically significant across all specifications. In more saturated specifications, the CER coefficient is smaller than the one on NBR.

3. The coefficient on NBR is positive and statistically significant across all specifications.

   - Elasticity of 1 means that an increase in NBR of 350 bn (1% of TA) is associated with an increase in credit by 45 bn (1% of Loans). In other words: the increase of one euro of non-borrowed reserves results in an increase in credit of about 15-cent.

Note: the dependent variable is the annual growth rate of loans to firms f by bank i at time t. The model includes other control variables. Excess liquidity is the change in the excess liquidity (current account + deposit facility - minimum reserve requirements) over main assets. Borrowed reserves represent the change in borrowed reserves (MRO+LTRO) over main assets. Non-borrowed reserves are the change in non-borrowed reserves (excess liquidity-MRO-LTRO) over main assets. The variable TLTRO represents the ratio of TLTRO funds over assets. The model includes share of security held, ROA and NPL ratio as additional control variables as well as the set of fixed effects as reported in the table. ILS stands for industry-location-size fixed effects. Standard errors are clustered at bank and time level. * p<.1, ** p<.05, *** p<.01.

Matching AnaCredit bank-level information with firm-level Orbis data

Variable Name	Units	Obs.	Mean	St. Dev.	Median
Sales	yoy	2,818,018	4.528058	54.76027	4.897205
Employment	yoy - No. employees	2,818,018	2.016814	37.03723	0
Investments	yoy	2,818,018	6.297684	65.28107	-2.19092
Firm Age	log - years	2,818,018	2.171098	.7489531	2.397895
Total Assets	log -EUR million	2,818,018	14.05745	1.693925	13.8559
Leverage	% of total assets	2,818,018	0.2435623	0.2313024	0.1946399
Non-borrowed reserves	% of main assets	2,818,018	3.662971	4.259802	2.298898
Borrowed reserves	% of main assets	2,818,018	0.0327158	0.2499879	0
Credit easing reserve	% of main assets	2,818,018	7.465933	6.539388	8.830747
Debtor probability of default (PD)	%	2,818,018	3.80	8.41	1.05%
Zombie	dummy	2,818,018	0.0129	0.1131	0

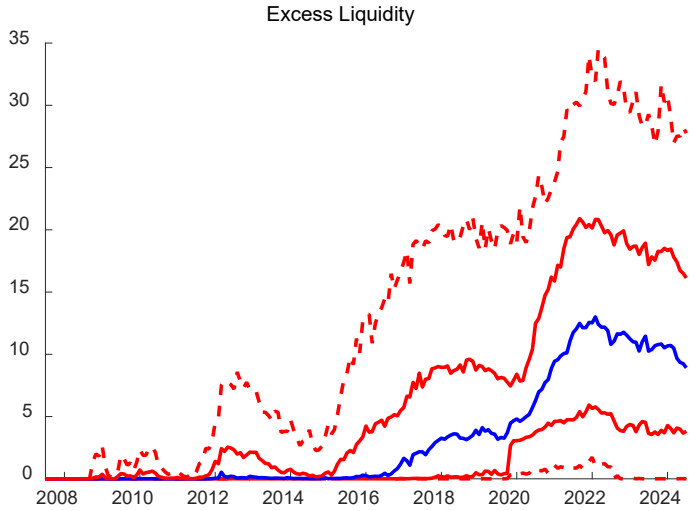
Notes: The unit of observation is the firm. All bank variables are averages across counterpart banks, with bank assets used as weights. To control for outliers, variables are winsorized at the top and bottom 1 percent of the sample. Investment is defined as tangible fixed assets. Debtor probability of default (PD) is the Moody's expected default frequency (EDF). Zombie is a dummy variable that takes value 1 if a firm has experienced an interest coverage ratio persistently below 1 over the three previous years and has been operating in the market for at least a decade. Data from 2018 to 2023.

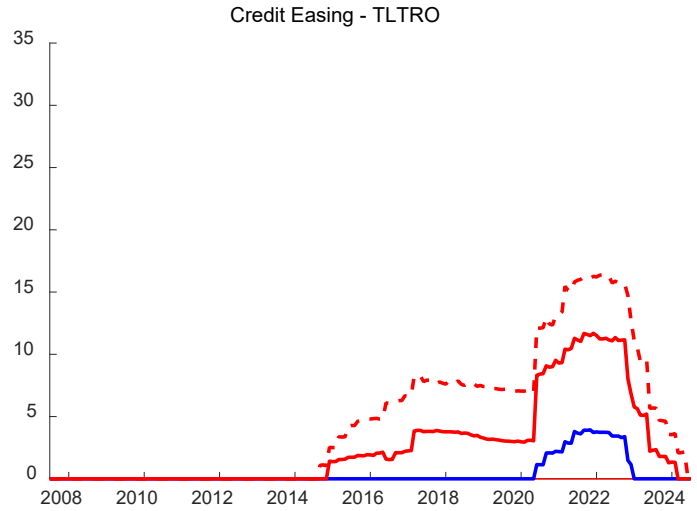
Summary statistics

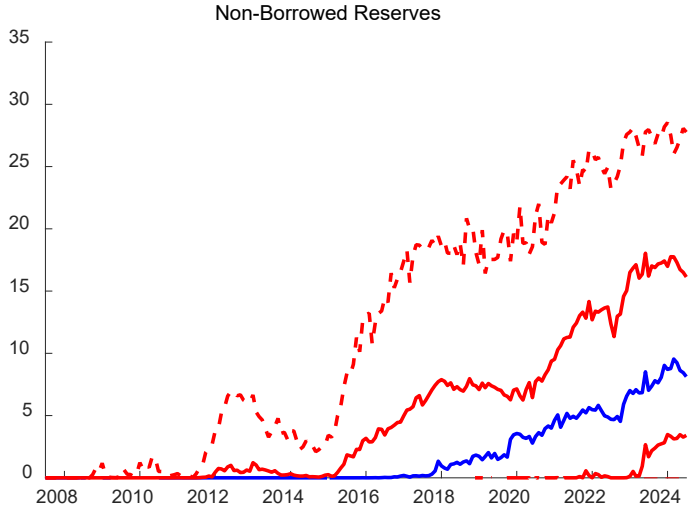
Variable name	Units	Obs.	Mean	St. Dev.
Loan	log(EUR mln)	66,858,446	-2.86	2.32
Excess Liquidity	% of main assets	65,682,715	10.2	5.87
Non-borrowed reserves	% of main assets	65,682,715	3.34	4.33
Borrowed reserves	% of main assets	65,682,715	0.11	0.69
TLTRO	% of main assets	65,682,715	7.97	6.5
Security holdings	% of main assets	65,682,715	8.3	5.5
Return on assets (ROA)	% of main assets	65,682,715	0.36	0.61
Non-performing loans (NPL)	% of loans	65,682,715	4.38	2.77

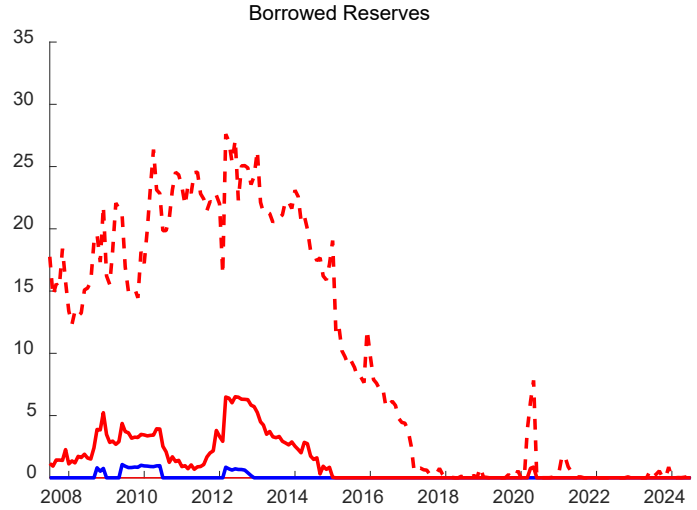
Note: loans (credit lines) are defined as logarithm of outstanding amounts (in EUR million) of loans (credit lines) between a bank and a firm in a given month. Excess liquidity is the ratio of excess liquidity (current account + deposit facility – minimum reserve requirements) over assets. Borrowed reserves are the ratio of borrowed reserve (MRO+LTRO) over main assets. Non-borrowed reserves are the ratio of non-borrowed reserves (excess liquidity-MRO-LTRO-TLTRO) over assets. The variable TLTRO represents the ratio of funds borrowed under TLTROs over assets.

Bank-level data: summary of time series and cross-sectional dispersion





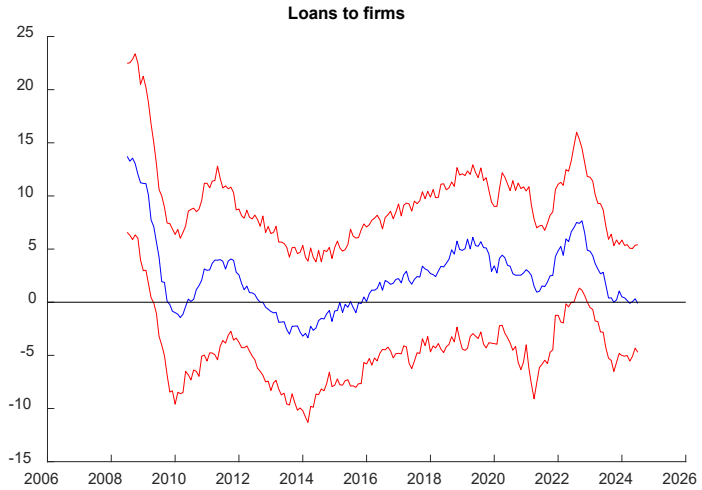


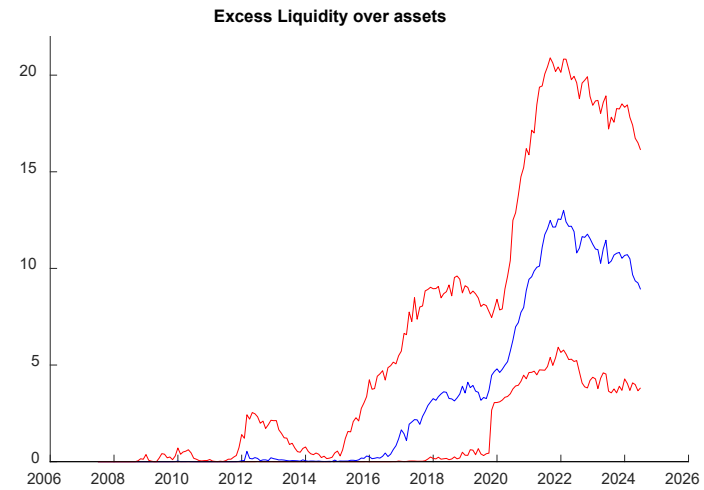


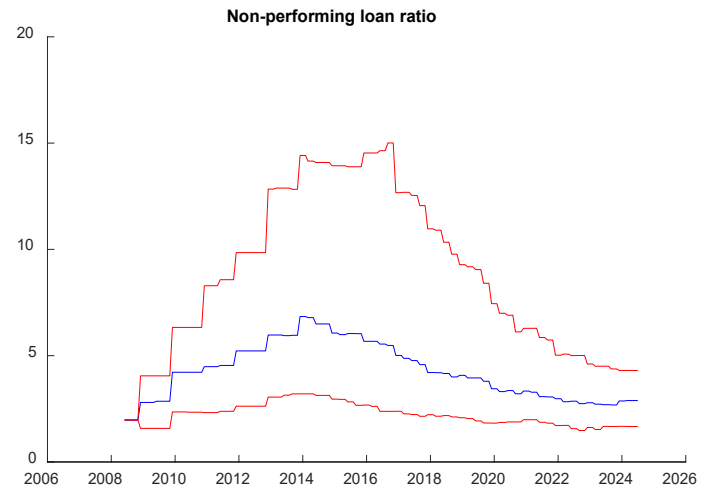
- **Reserves**: deposits from credit institutions with the central bank.
- **Excess reserves**: bank deposits on current accounts with the central bank exceeding the minimum reserve requirements. [CA – MMR], 0%.
- **Excess liquidity**: Sum of excess reserves and deposits in the deposit facility [CA – MMR + DP].
- **Borrowed reserves:** funds that banks borrow directly from the central bank, e.g. through central bank liquidity-providing operations.
- **Credit easing reserves:** Targeted longer-term refinancing operations**.**
- **Non-borrowed reserves:** reserves that banks hold that are not money on loan from a central bank.

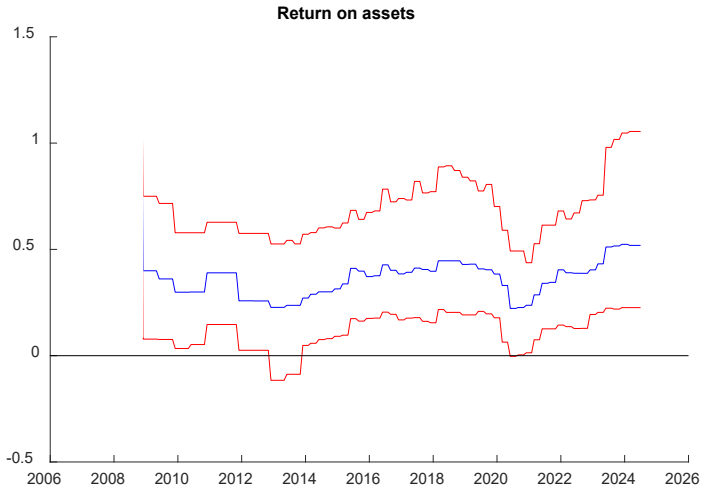
Note: the chart shows for each month in the sample July 2007-July 2024 the median (solid blue line), the interquartile range (solid red lines) and the 10th-90th perc. (dashed red lines) of the individual bank distribution for the main variables employed in the empirical analysis.

Bank-level data: summary of time series and cross-sectional dispersion









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- **Excess reserves**: bank deposits on current accounts with the central bank exceeding the minimum reserve requirements. [CA – MMR], 0%.
- **Excess liquidity**: Sum of excess reserves and deposits in the deposit facility [CA – MMR + DP].
- **Borrowed reserves:** funds that banks borrow directly from the central bank, e.g. through central bank liquidity-providing operations.
- **TLTRO:** Targeted longer-term refinancing operations
- **Non-borrowed reserves:** reserves that banks hold that are not money on loan from a central bank.

Note: the chart shows for each month in the sample July 2007-July 2024 the median (blue line) and the interquartile range (red lines) of the individual bank distribution for the main variables employed in the empirical analysis

Do central bank funds incentivize banks to direct credit towards unproductive firms?

	Sales			Employment			Investment		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$\Delta NBR_{f,t-1}$	1.599***	0.242***	0.245***	0.501***	0.214***	0.214***	0.120***	0.194***	0.186***
	(0.0144)	(0.0155)	(0.0155)	(0.00973)	(0.0107)	(0.0107)	(0.0172)	(0.0194)	(0.0194)
$\Delta BR_{f,t-1}$	3.046***	-0.0526	-0.0219	0.811***	-0.0950	-0.0782	-0.571***	-0.779***	-0.765***
	(0.135)	(0.135)	(0.135)	(0.0992)	(0.102)	(0.102)	(0.198)	(0.202)	(0.202)
$Zombie_{f,t-1}$	-12.86***	-11.73***	-11.50***	-3.749***	-3.564***	-3.483***	-2.949***	-2.956***	-2.968***
	(1.109)	(1.063)	(1.064)	(0.606)	(0.605)	(0.606)	(0.933)	(0.933)	(0.933)
$Zombie_{f,t-1}$ x $DNBR_{f,t-1}$	0.488	0.536	0.550	0.107	0.0772	0.0782	0.0950	0.115	0.132
	(0.402)	(0.399)	(0.399)	(0.0796)	(0.0792)	(0.0798)	(0.130)	(0.130)	(0.129)
$Zombie_{f,t-1}$ x $DBR_{f,t-1}$	-0.303	1.453	1.581	-1.183	-0.972	-0.982	1.519	1.330	1.370
	(2.315)	(2.285)	(2.286)	(0.974)	(0.974)	(0.974)	(1.854)	(1.854)	(1.858)
Fixed Effects:									
Firm	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time	-	Yes	Yes	-	Yes	Yes	-	Yes	Yes
ILS	-	-	Yes	-	-	Yes	-	-	Yes
Observations	2427517	2427517	2427365	2427517	2427517	2427365	2335465	2335465	2335314
R-squared	0.287	0.335	0.338	0.286	0.289	0.291	0.355	0.355	0.356

Zombie:
dummy =1 if
1. firm ICR<1 for 3y
2. Age>10y

- First: firms with higher exposure to non-borrowed reserves tend to exhibit better economic performance in terms of employment, sales, and investment
- Second: Although zombie firms generally perform worse economically, their exposure to banks with higher non-borrowed reserves does not influence this outcome. This aligns with the notion that the increase in bank credit supply followed by a rise in central bank reserves is not associated with excessive risk-taking or zombie lending.

Loan growth and Reserves – Bank-firm panel

$$\Delta L_{i,f,t} = \alpha^{FE} + \beta \Delta NBR_{i,f,t} + \delta \Delta BR_{i,f,t} + \Gamma_h X_{i,f,t-1} + \epsilon_{i,f,t}$$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Non-borrowed Reserves$_{b,t-1}$							1.697***	0.956***	0.931***	1.009***	1.051***	0.818***
							(0.326)	(0.349)	(0.312)	(0.222)	(0.336)	(0.215)
Borrowed Reserves$_{b,t-1}$							-1.404*	-0.514	-0.112	0.0948	-0.297	-0.300
							(0.823)	(1.289)	(1.188)	(0.826)	(1.190)	(0.686)
Excess Liquidity$_{b,t-1}$	1.160***	1.679***	1.638***	0.915***	1.398***	0.859***						
	(0.156)	(0.245)	(0.216)	(0.149)	(0.232)	(0.182)						
Fixed effects:												
Bank	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time	-	Yes	Yes	-	Yes	-	-	Yes	Yes	-	Yes	-
ILS	-	-	Yes	-	-	-	-		Yes	-	-	-
ILS*Time	-	-	-	Yes		-	-	-	-	Yes	-	-
Firm	-	-	-	-	Yes	-	-	-	-	-	Yes	-
Firm*Time	-	-	-	-	-	Yes	-	-	-	-	-	Yes
Observations	53258310	53258310	53258308	53257386	53178599	36980542	52986452	52986452	52986450	52985528	52906950	36541542
R-squared	0.007	0.010	0.130	0.158	0.141	0.317	0.007	0.009	0.130	0.158	0.141	0.533

Note: the dependent variable is growth of loans to firms. the annual growth rate of loans to firms f by bank i at time t, where the growth rate is computed as the percentage log difference between time t and t-12. The model includes other control variable. Excess liquidity is the ratio of excess liquidity (current account + deposit facility - minimum reserve requirements) over main assets. Borrowed reserves are the ratio of borrowed reserve (MRO+LTRO) over main assets. Non-borrowed reserves are the ratio of non-borrowed reserves (excess liquidity-MRO-LTRO) over main assets. The model includes share of security held, ROA and NPL ratio as additional control variables. Standard errors are clustered at bank and time level. * p<.1, ** p<.05, *** p<.01.

Do central bank funds incentivize banks to direct credit towards unproductive firms?

	Sales			Employment			Investment		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$\Delta NBR_{f,t-1}$	1.774***	0.361***	0.365***	0.459***	0.214***	0.214***	0.126***	0.283***	0.275***
	(0.0179)	(0.0203)	(0.0203)	(0.0119)	(0.0139)	(0.0139)	(0.0209)	(0.0246)	(0.0247)
$\Delta BR_{f,t-1}$	2.869***	-0.165	-0.0839	0.163	-0.273**	-0.243**	-0.395	-0.430*	-0.470
	(0.167)	(0.166)	(0.166)	(0.122)	(0.123)	(0.124)	(0.247)	(0.250)	(0.350)
$\Delta TLTRO_{f,t-1}$	0.0159**	0.0192**	0.0197**	0.154***	0.0693***	0.0702***	0.0242**	0.153***	0.148***
	(0.00809)	(0.00974)	(0.01001)	(0.00708)	(0.0144)	(0.0145)	(0.0123)	(0.0250)	(0.0251)
$Zombie_{f,t-1}$	-16.79***	-13.19***	-12.93***	-4.966***	-4.262***	-4.163***	-6.221***	-6.540***	-6.628***
	(1.640)	(1.576)	(1.580)	(0.960)	(0.958)	(0.959)	(1.444)	(1.445)	(1.448)
$Zombie_{f,t-1} \times \Delta NBR_{f,t-1}$	-0.303	1.453	1.581	0.170**	0.103	0.110	0.0950	0.115	0.132
	(2.315)	(2.285)	(2.286)	(0.0860)	(0.0857)	(0.0864)	(0.130)	(0.130)	(0.129)
$Zombie_{f,t-1} \times \Delta BR_{f,t-1}$	0.277	0.457	0.540	-1.350	-1.319	-1.357	3.164	3.154	3.344
	(2.908)	(2.866)	(2.874)	(1.150)	(1.150)	(1.153)	(2.264)	(2.264)	(2.267)
$Zombie_{f,t-1} \times \Delta TLTRO_{f,t-1}$	0.119	-0.0772	-0.0757	0.0723	0.0322	0.0316	0.253	0.280	0.283
	(0.108)	(0.105)	(0.106)	(0.0651)	(0.0650)	(0.0650)	(0.251)	(0.251)	(0.255)
Fixed Effects:									
Firm	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time	-	Yes	Yes	-	Yes	Yes	-	Yes	Yes
ILS	-	-	Yes	-	-	Yes	-	-	Yes
Observations	2427517	2427517	2427365	2427517	2427517	2427365	2261077	2261077	2260911
R-squared	0.283	0.331	0.335	0.288	0.292	0.294	0.360	0.360	0.362

Zombie:
dummy =1 if
1. firm ICR<1 for 3y
2. Age>10y

- First: firms with higher exposure to non-borrowed reserves tend to exhibit better economic performance in terms of employment, sales, and investment
- Second: Although zombie firms generally perform worse economically, their exposure to banks with higher non-borrowed reserves does not influence this outcome. This aligns with the notion that the increase in bank credit supply followed by a rise in central bank reserves is not associated with excessive risk-taking or zombie lending.

Reserve availability and bank risk-taking

$$\Delta L_{i,f,t} = \alpha^{FE} + \beta \Delta NBR_{i,f,t} + \delta \Delta BR_{i,f,t} + \lambda PD_{f,t} + \vartheta\left(NBR_{i,f,t} \times PD_{f,t}\right) + \varphi\left(BR_{i,f,t} \times PD_{f,t}\right) + \Gamma_{\mathrm{h}} X_{i,f,t-1} + \epsilon_{i,f,t}$$

	(1)	(2)	(3)	(4)	(5)
$PD_{b,f,t-1}$	-0.358***	-0.507***	-0.536***	-0.674***	-0.673***
	(0.0337)	(0.0311)	(0.0299)	(0.0295)	(0.0233)
$\Delta NBR_{b,f,t-1}$ x $PD_{b,f,t-1}$	0.0343***	0.0153***	0.0160***	0.0193***	0.0337***
	(0.00506)	(0.00519)	(0.00504)	(0.00580)	(0.00418)
$\Delta BR_{b,f,t-1}$ x $PD_{b,f,t-1}$	0.00486	-0.00684	-0.0495	-0.00641	-0.0154
	(0.0520)	(0.0405)	(0.0347)	(0.0515)	(0.0300)
Fixed effects					
Bank*Time	Yes	Yes	Yes	Yes	Yes
ILS	-	Yes	-	-	-
ILS*Time	-	-	Yes	-	-
Firm	-	-	-	Yes	-
Firm*Time	-	-	-	-	Yes
Observations	36678890	36678886	36677930	36584784	28359995
R-squared	0.038	0.155	0.170	0.159	0.583

1. On average, banks are more likely to penalize riskier borrowers by offering less credit to firms with a higher probability of default.

2. The availability of central bank reserves activates a risk-taking channel of monetary policy, mitigating the decline in credit: a greater availability of central bank reserves leads banks to extend more loans. However, this effect is only significant for non-borrowed reserves.

Note: the dependent variable is the annual growth rate of loans to firms f by bank i at time t. $\Delta BR_{i,t-1}$ s represents the change in borrowed reserves (MRO+LTRO) over main assets. $\Delta NBR_{i,t-1}$ denotes the change in non-borrowed reserves (excess liquidity-MRO-LTRO) over main assets. PD is the Moody's firm-specific expected default frequency (EDF). The model includes other control variables as well as the set of fixed effects as reported in the table. ILS stands for industry-location-size fixed effects. Standard errors are clustered at bank and time level. * p<.1, ** p<.05, *** p<.01.

A model of reluctant banks

The first regime we consider is one in which the policy authority announces at the start of time zero that it stands ready to lend to the banks under a lender-of-last-resort (LOLR) facility, at an interest rate

$$R^{LOLR} = [1 + (1-p)\tfrac{1-x}{x}]\, R^M < R$$

In a LOLR regime banks maximise the following profit function with respect to *m* and *I*:

$$(A.1) \quad \mathbb{P}^B = pf(I) + (1-p)\,\lambda I - RI + mI(R - R^M) - (1-p)\frac{1-x}{x} mI R^M,$$

Combining the first order conditions for *m* and *I*, imposing the binding money-issuance constraint and the definition of R^{LOLR}, we obtain:

$$(A.2) \quad pf'(I) + (1-p)\,\lambda - R = -\frac{x\lambda}{R^M}[R - R^{LOLR}]$$