Sticky Deposits, Leverage Relief, and Bank Lending*

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Abstract

I study how bank lending responds to temporary leverage relief when deposits are sticky. Methodologically, I embed deposit stickiness in a euro-area-calibrated general equilibrium model with heterogeneously capitalized banks that face idiosyncratic loan and deposit shocks, a leverage ratio requirement, and equity issuance costs. Leverage relief temporarily excludes reserves from the leverage ratio. Leverage relief raises lending through two channels. Through a leverage channel, less-capitalized banks lend more because losses no longer force them to issue equity while the relief lasts. Through a deferred issuance channel, banks that avoid issuance accumulate less equity, which counterintuitively also boosts lending. As an undercapitalized bank loses equity, issuance at the end of the relief becomes near-certain. A loss then raises the amount issued as much as a gain lowers it, so the bank weighs gains and losses equally. As undercapitalized banks supply more loans, returns to lending fall and better-capitalized banks lend less. Four quarters of leverage relief increase bank lending by up to 0.9% above steady state, but lending falls to 0.6% below steady state once the relief ends, because banks hold less equity. Lastly, after a deposit inflow into the banking system, leverage relief raises lending more during the relief but is followed by a deeper contraction.

Keywords: banking, lending, dynamics

JEL Codes: E58, G21

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1 Introduction

Depositors rarely switch banks for better interest rates or service quality (Egan, Hortaçsu, Kaplan, Sunderam, & Yao, 2025; Basten & Juelsrud, 2026). At the same time, payments between depositors move deposits between banks, generating deposit shocks (Li & Li, 2024). Because depositors are insensitive to interest rates, banks cannot use deposit pricing to offset these shocks. Deposit stickiness makes deposits an attractive funding source for banks but limits their control over liabilities.

Bolton, Li, Wang, & Yang (2025) show that when banks face sticky deposits, deposit shocks, costly equity issuance, and a leverage ratio (LR) requirement, deposit inflows can hurt the value of less-capitalized banks. When a bank with little equity relative to deposits receives a deposit, it also receives an asset. This asset increases unweighted leverage, which has to satisfy the LR requirement. When leverage rises too much, a bank has to issue costly equity. The threat of costly issuance also causes what the authors term "endogenous risk aversion": risk-neutral bankers make portfolio decisions as if they were risk-averse and choose to hold fewer risky assets, i.e. loans. This paper extends their model of the bank to general equilibrium and uses it to study how leverage relief affects lending.

My contribution is threefold. First, I show how deposit stickiness can be implemented in a micro-founded infinite-horizon general equilibrium model. Second, I explain in a simple model why these frictions change banks' lending decisions. Third, I show how deposit stickiness provides a new explanation for why leverage relief expands bank lending, with novel policy implications.

In the model, banks fund risky loans and risk-free reserves with sticky deposits, rate-sensitive wholesale funding, and equity. Depositors choose a bank with competitive terms when they open an account, staying with that bank until exogenous exit. Banks compete upfront for deposits by offering incentives to open an account. Depositors pay other depositors, which causes deposits to move between banks, generating idiosyncratic changes in the balance-sheet size of banks. Together with idiosyncratic shocks to the value of loans generating changes in the equity of banks, these deposit shocks generate dispersion in banks' capitalization. As both adjusting deposits and issuing equity are costly, banks do not fully undo these shocks, which yields heterogeneously capitalized banks. Besides an LR requirement, banks have to meet a risk-weighted capital requirement, which limits their lending. I calibrate the model to the euro area over the period in which the LR requirement has been in force, approximately matching the consolidated bank balance sheet and the median buffer over the LR requirement.

While banks differ in both equity E and deposits D, the problem is set up such that only the level of capitalization, equity-over-deposits $e = E/D$, matters for their scaled decisions. As banks' capitalization falls, banks reduce both wholesale funding and lending; when capitalization is sufficiently low, they use no wholesale funding. When deposit inflows or loan losses push these banks' capitalization e below a threshold $\underline{e}$, equity can become insufficient to meet the LR requirement. Banks then have to issue equity. Note here the role of stickiness: if instant adjustment of deposits were costless, deposits would be adjusted instead of equity. Because issuing equity is costly, banks lend less and take fewer deposits as their capitalization approaches $\underline{e}$.

I model leverage relief as an unexpected exemption of reserves from the leverage ratio for an announced duration. That is, the leverage ratio goes from $\frac{\text{Unweighted Assets}}{\text{Equity}}$ to $\frac{\text{Unweighted Assets}-\text{Reserves}}{\text{Equity}}$. During the relief, banks are no longer forced to issue equity if capitalization e falls below $\underline{e}$: these banks can take the additional deposits and hold reserves on the asset side, keeping their leverage ratio below the LR requirement. They meet the LR requirement by shifting their assets from loans to reserves instead. This lets undercapitalized banks—banks with $e < \underline{e}$—defer equity issuance until the relief ends. In turn, less-capitalized banks lend more as temporary violations of the LR requirement are more likely to go unpunished, in line with empirical findings that the banks closest to the LR requirement increase lending (Koont & Walz, 2021).

Traditional view of leverage relief. The Fed and the ECB both implemented leverage relief in 2020 with the explicit aim of supporting lending.[1] Where a rationale was given, it was static: how much slack leverage relief creates under the LR requirement. Acosta-Smith, Grill, & Lang (2024) formalize the static logic of how an LR requirement would affect lending: both the capital requirement and the LR requirement play the same role. Risk-neutral banks expand their balance sheets—funding and risky assets—until a leverage constraint binds. Depending on a bank's business model, either the LR requirement or the capital requirement binds. In this world, relaxing the binding requirement, e.g. by exempting reserves, would expand lending by the banks for which it binds. The static logic cannot explain why banks that still have some distance to the requirement would be affected.

Leverage relief with sticky deposits. Leverage relief affects banks' lending directly in two ways: through a leverage channel and a deferred issuance channel. First, as loan losses are less

[1]The Fed exempted reserves from April 2020 to March 2021 (Board of Governors of the Federal Reserve System, 2020); the ECB from September 2020 to March 2022 (ECB, 2021). The Board of Governors of the Federal Reserve System (2020) stated it did so to "increase banking organizations' ability to provide credit to households and businesses" in its press release. The ECB did not state any specific purpose, but the Dutch central bank did so in its press release (De Nederlandsche Bank, 2021): "The decision frees up capital, which increases banks' capacity for lending."

likely to lead to issuance, banks are more willing to take risk. Second, as banks no longer have to issue equity when capitalization is too low, banks accumulate less equity. Banks are also indirectly affected: as other banks change their lending and deposit-taking, market prices change, and with them other banks' profits and incentives to lend and take deposits. In particular, the loan spread falls, making banks with non-binding capital requirements lend less immediately, while the better-capitalized banks with binding capital requirements lend less over time as their profits fall.

The **leverage channel** is straightforward. Less-capitalized banks—those previously at risk of having to issue equity during the leverage relief—lend more as they have time to recover equity after losses without issuance. Over time, this leverage channel becomes less potent for banks that are not undercapitalized: the likelihood that they become undercapitalized before the end of the leverage relief falls. In turn, these banks lend less as the end of the leverage relief draws closer. However, for undercapitalized banks the opposite holds: these banks start lending more as the end of the leverage relief draws closer and issuance becomes unavoidable.

Section 2 lays out a two-period model of the bank with the same frictions to explain why banks' lending decisions change as they do in the full model. A bank issues equity in the second period when deposit inflows or loan losses push its capitalization below the minimum implied by the LR requirement. Loans either return a gain or a loss. The bank trades off the expected return on loans against the marginal increase in expected equity issuance costs when deciding how much to lend. The marginal change in expected issuance costs is conditional on the realization of deposits. When second-period deposits are low, the bank meets the LR requirement regardless of the loan shock: no issuance. When deposits are high, the bank violates the LR requirement regardless of the loan shock: unconditional issuance. When deposits are in the middle, the bank violates the LR requirement after a loss, but not after a gain: conditional issuance.

When conditional issuance is more likely, banks are more risk-averse as losses increase issuance costs, while gains do not reduce issuance costs. Generally, as banks' equity falls, conditional issuance becomes more likely, as less of a deposit inflow is needed to trigger it, decreasing the willingness of banks to lend. However, as banks become undercapitalized, this reverses: when banks lose more equity, it becomes increasingly unlikely that gains avoid issuance, raising the probability of unconditional issuance. In this case, gains reduce issuance costs as much as losses increase them, making banks more risk-neutral. As the end of the leverage relief draws closer, loan gains or outflows large enough to restore capitalization become increasingly unlikely for undercapitalized banks as less time remains for such shocks to accumulate, so issuance is all but certain, and these banks act

as if risk-neutral again.

The **deferred issuance channel**—the effect of banks holding less equity due to deferred equity issuance—surprisingly increases lending during the relief. The banks that lose equity relative to no leverage relief—mainly less-capitalized banks that avoid issuance—lend more after losing equity. Without leverage relief, banks lend more when they have more equity: the marginal propensity to lend (MPL) is positive, as is common in heterogeneous bank models.[2] During the leverage relief, less-capitalized and undercapitalized banks lend more when they have less equity: around $e = \underline{e}$, these banks have a negative MPL. As their equity falls, unconditional issuance becomes more likely, making these banks act more risk-neutral and lend more. Negative MPLs become more tightly concentrated around $\underline{e}$ and increase in absolute size as the end of the leverage relief draws closer, making the impact of equity on lending bigger around the LR requirement. Towards the end of the leverage relief, almost all of the increase in lending is driven by undercapitalized banks. After the relief, undercapitalized banks issue equity up to the requirement, but equity remains below its steady-state level. Part of the deferred issuance becomes avoided issuance, as some banks have recovered the equity shortfall with profits earned during the relief period. As MPLs turn positive again, lending falls below its steady-state level.

Negative MPLs at low capitalization resemble gambling for resurrection, where less-capitalized banks take excessive lending risk because limited liability lets them shift potential losses to depositors or the government (Rochet, 1992; Hellmann et al., 2000). The mechanism here is different. Banks bear losses in full, so there is no risk shifting: lending more reduces the expected equity shortfall at the end of the leverage relief because loans earn a positive expected return. Undercapitalized banks act on this more strongly because issuance becomes all but certain, which lowers their endogenous risk aversion.

General-equilibrium effects play a large role in the total effect of leverage relief on lending. As both direct effects expand lending, competition for loans pushes down the loan spread and reduces the lending of better-capitalized banks. This happens partly because lower lending profits push down their capitalization, making future issuance more likely and tightening capital requirements, and partly because lower returns to lending make it less attractive for these banks to lend. In my calibration, four quarters of leverage relief raise lending by up to 0.93% above steady state, about half of the 2% increase that would occur if prices did not adjust. In the real world, undercapitalized banks crowding out the lending done by better-capitalized banks could have unmodelled financial

[2] E.g., Bellifemine et al. (2025); Abad et al. (2026)

stability consequences.

Competition for deposits generates further general-equilibrium effects: during the relief, less-capitalized banks are willing to take in more deposits, making it more costly for all banks to attract deposits. In principle, such deposit competition could decrease profits materially, lowering lending through lower equity, a concern raised by the ECB (Grodzicki et al., 2023). This concern applies without deposit stickiness, but not with it. With sticky deposits, banks take few additional deposits, as attracting deposits is costly and new deposits stay after the relief ends. Lower deposit profits then reduce equity by only 0.07% of steady-state equity by the start of the relief's last quarter, against a total drop of 1.5%. As a result, changes in the deposit price have little effect on lending.

In contrast, I show in Section 6 that in a counterfactual model where deposits are flexible—depositors always choose the bank with the highest return on deposits—banks expand deposit-taking during the relief until the deposit spread is zero. Lower deposit profits alone reduce equity by 1.6% of steady-state equity by the start of the relief's last quarter. As all banks have binding capital requirements without deposit stickiness, loans fall one-for-one with equity.

Policy takeaway. This model generates an intertemporal trade-off for a policymaker trying to increase lending, which is missing from the static logic. The loss of equity that increases lending during the leverage relief decreases lending after the leverage relief ends: loans fall to 0.61% below steady state after four quarters of relief, as less-capitalized banks are more at risk of equity issuance after loan losses. Moreover, there are potential financial stability effects associated with less-capitalized banks crowding out the lending of better-capitalized banks during the relief.

Length of the leverage relief. Longer leverage relief causes banks to lend more during the relief, as banks have more time to recover their equity after potential losses: six quarters of leverage relief raise lending by up to 1.86%, against 0.93% for four quarters. However, as banks do not issue equity for longer, equity falls by 2.6% instead of 1.5%, and loans fall to 1.10% below steady state after the relief ends, against 0.61%. Potential financial stability effects from less-capitalized banks crowding out the lending of better-capitalized banks would also be stronger.

State-dependent effects: leverage relief after large deposit inflows. Lastly, I consider leverage relief implemented after a large deposit inflow into the banking system. Between December 2019 and the announcement of leverage relief in September 2020, the euro area saw an 8% inflow of sticky deposits, while banks' equity barely moved. I show that after such an inflow, i.e. when relatively many banks are close to or over the LR requirement, effects on lending are 50% larger compared to normal times. At the peak of the relief, loans rise by 1.40%, against 0.93% without the

inflow, while the fall after the relief deepens from 0.61% to 0.92%. The intuition is that as many banks are near the LR requirement after such an inflow, banks are more responsive to the relief in how much they lend. However, because more banks near the LR requirement would issue equity without the relief, more banks defer issuance, which lowers equity and lending in the medium term.

Equilibrium definition & numerical method. As bank-level deposits follow a geometric Brownian motion, their cross-sectional distribution has no steady state. Because the bank's problem is homogeneous of degree one in deposits, I define the equilibrium in terms of the aggregate level of deposits and deposit-weighted distribution of bank capitalization—the distribution one obtains when drawing random deposits and looking up the banks' capitalization. In the model and Appendix B, I show how the evolution of this distribution can be derived. Moreover, in Appendix C I show how to solve for equilibrium numerically.

1.1 Literature

The paper is part of the recent literature on bank lending in general equilibrium with heterogeneously capitalized banks. Jamilov & Monacelli (2026) investigate to what extent cross-sectional differences in size and profitability matter for how changes in bank equity transmit to lending. Bellifemine, Jamilov, & Monacelli (2025) nest these banks in a New-Keynesian model to investigate the impact of size and profit heterogeneity on the effectiveness of monetary policy and its interaction with microprudential policy. Abad, Bigio, Garcia-Villegas, Marbet, & Nuño (2026) consider banks issuing long-term loans and compare economies with fixed interest rates to economies with variable interest rates. Dempsey (2026) considers the effect of capital regulation on macroeconomic aggregates and bank stability with competition between banks and non-banks in an economy with heterogeneously capitalized banks. This paper contributes to this literature by also considering deposit stickiness and leverage relief.

The paper also contributes to the literature on banks with sticky deposits in the macroeconomy. Jermann & Xiang (2023) investigate the implications of deposit stickiness for banks' bankruptcy risk. Jermann & Xiang (2025) investigate the implications of deposit stickiness for optimal capital regulation. This paper abstracts away from bankruptcy risk and endogenous maturity of deposits, but adds an endogenous lending choice, which makes it possible to study the impact of stickiness on lending. More generally, the paper builds on the literature on how deposit stickiness affects bank choices, started by Flannery (1982); recent examples include Blickle, Li, Lu, & Ma (2025); Lu & Wu (2026) and Egan et al. (2025).

The banks in the paper follow the literature on dynamic capital structure with costly equity issuance, started by Hennessy & Whited (2005). In this literature, two papers report that firms take on more risk when their cash holdings are low. Rochet & Villeneuve (2011) show that firms with fixed equity issuance costs and low cash on hand stop insuring large risks. Bolton et al. (2013) show that when equity issuance is cheaper than normal, firms with low cash on hand invest more in capital to trigger issuance sooner. Both effects are caused by local convexity of the value function: some firms turn risk-seeking. The mechanism in this paper is slightly different; banks' endogenous risk aversion only starts increasing at low capitalization, but banks remain risk-averse at all times.

The paper contributes to the literature on the LR requirement and leverage relief. Acosta-Smith et al. (2024) investigate theoretically how, in a static setting, a leverage ratio might affect bankruptcy and lending. Most research on the effects of leverage relief is empirical and generally does not focus on lending. He, Nagel, & Song (2022) attribute a drop in Treasury inconvenience yields to the Fed's leverage relief, but they abstract away from the rest of broker-dealers' balance sheets. Breckenfelder & Ivashina (2023) show that European corporate bond funds lost more value during COVID when they were intermediated by European broker-dealers closer to the LR requirement. Rahman & Warusawitharana (2023) show that leverage relief in the US increased bank valuations, a result the calibrated model reproduces. Koont & Walz (2021) focus on how banks' broader balance sheets, including loans, are affected by leverage relief.

The paper adds LR requirements and their interaction with deposit stickiness to the large literature on how capital requirements affect banks' dynamic decisions in general equilibrium (e.g., Gertler & Kiyotaki, 2010; Corbae & D'Erasmo, 2021; Bianchi & Bigio, 2022; Wang, 2025; Jamilov & Monacelli, 2026; Begenau et al., 2026; Dempsey, 2026). Bianchi & Bigio (2022) have both an LR requirement and within-period deposit flows. However, the mechanism there works the other way: a within-period deposit outflow leads to a costly shortage of reserves. In their paper, a deposit inflow cannot impose equity issuance costs as it does in this paper, as the LR requirement only has to hold after banks choose their deposits between periods.

Methodologically, the paper combines two literatures. The first solves general-equilibrium heterogeneous-agent models; Achdou et al. (2022) show how to solve for equilibrium in continuous time without aggregate risk when a steady-state distribution of all state variables exists. The second studies firms, also in continuous time, whose problem is homogeneous of degree one in size, so that it reduces to a single ratio state (Fischer, Heinkel, & Zechner, 1989; Goldstein, Ju, & Leland, 2001; Bolton, Chen, & Wang, 2011, 2013; Décamps, Gryglewicz, Morellec, & Villeneuve, 2017);

Bolton et al. (2025) apply such a structure to banks. This paper extends the method of Achdou et al. (2022) to these problems while keeping the reduction in dimensionality by working with a size-weighted distribution. This makes it possible to nest the firms of the corporate finance literature in general equilibrium with idiosyncratic risk.

2 Simple model: how does leverage relief affect lending?

This section considers a simpler two-period version of a bank's problem to explain why undercapitalized banks lend much more during leverage relief and increase lending as the end of the leverage relief gets closer.

There are two dates, $t \in \{0, 1\}$. At $t = 0$, the banker is endowed with 1 deposit and E_0 equity. It is a real model with quantities denoted in terms of a consumption good. The banker makes a portfolio decision: the bank invests the deposit, potential wholesale funding B, and E_0 equity in risk-free reserves R and risky loans L. Between $t = 0$ and $t = 1$, deposits change with a deposit shock: depositors make or receive payments, changing the amount of deposits in the bank. This does not affect equity. Moreover, between the periods, stochastic lending returns are realized, changing equity. At $t = 1$, the banker has to issue equity if the leverage ratio (LR) requirement is violated, incurring issuance costs. At the end of $t = 1$, the banker consumes their equity. The banker has full information and rational expectations.

Later, date $t = 1$ is interpreted as the date that leverage relief ends.

2.1 Mathematical problem

The bank at $t = 1$ has to issue equity to ensure that the LR requirement[3]

$$\frac{E_1 + D_1}{E_1} \leq \xi_L$$

is not violated, where E_1 is equity at $t = 1$ after issuance and D_1 is deposits in period 1. Let F denote equity issuance. A bank maximizes expected $t = 1$ equity post-issuance net of issuance costs $(1 + \psi)F$, where $\psi > 0$. The objective of the bank is

$$\mathbb{E}\left[E_1 - (1 + \psi)F\right].$$

[3]This is after substituting out wholesale funding and reserves as before.

At $t = 0$, the bank invests its assets in risky loans L and risk-free reserves R, subject to the balance sheet constraint

$$R + L = 1 + B + E_0.$$

Between $t = 0$ and $t = 1$, the return on lending and the deposit inflow become known. Reserves get a net return of r, while wholesale funding B costs r, and loans have a net return of $r+\alpha^L+\varepsilon$, where $\alpha^L > 0$ is the loan spread and ε is the loan shock, with $\mathbb{E}(\varepsilon) = 0$. Note that lending yields a positive NPV. For simplicity I assume binary risk. With probability p, $\varepsilon = \varepsilon_H > 0$, while with probability $1 - p$, $\varepsilon = \varepsilon_L < -\alpha^L$. Deposits at time $t = 1$, D_1, are drawn from a continuous distribution G, independently of the loan shock, with support in $(0, \infty)$ and $\mathbb{E}(D_1) = 1$. The bank's equity at $t = 1$ is

$$E_1 = \big((1 + r)(R - B) + (1 + r + \alpha^L + \varepsilon)L\big) + F = (1 + r)E_0 + r + (\alpha^L + \varepsilon)L + F,$$

where the last equation substitutes out the balance sheet constraint. To simplify later expressions, I write

$$E_1 = NLE_1 + (\alpha^L + \varepsilon)L + F, \quad NLE_1 := (1 + r)E_0 + r,$$

where NLE_1 is $t = 1$ equity before issuance if a bank does not lend. Rewriting the LR requirement gives

$$E_1 \geq \underline{e}D_1, \quad \underline{e} := (\xi_L - 1)^{-1}.$$

2.2 Solution

The bank always issues the minimum amount required to meet the LR requirement, as additional issuance gives 1 additional unit of equity but incurs $1 + \psi > 1$ issuance costs:

$$F = \max\left\{\underline{e}D_1 - \left(NLE_1 + (\alpha^L + \varepsilon)L\right), 0\right\}$$

Substituting this in the objective function and taking the derivative with respect to L gives the first-order condition

$$\mathbb{E}[\underbrace{(\alpha^L + \varepsilon)}_{\text{ER loans}}\underbrace{(1 + \psi 1_{F>0})}_{MU}] = 0,$$

where $1_{F>0}$ is an indicator function that is 1 if there is issuance: $F > 0$, and 0 otherwise. The bank issues loans until the marginal utility from more loans is zero. The first term in the product is the excess return on loans ("ER loans"), while the second term is the marginal utility of a unit

of profit: 1 if there is no issuance and $1+\psi$ if there is.

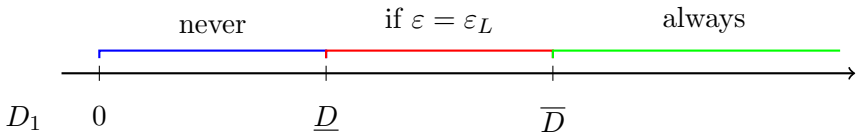
As $\varepsilon \in \{\varepsilon_L, \varepsilon_H\}$, the stochastic variable $(\alpha^L+\varepsilon)(1+\psi 1_{F>0})$ has four distinct possible realizations: either there is issuance or not, and either lending returns are high or low.

Conditional on the loan shock and the amount of loans L, there is a level of deposits such that if deposits exceed that level, issuance occurs. When lending returns are high ($\varepsilon = \varepsilon_H$), call this level $\overline{D}$. When lending returns are low, call this level $\underline{D}$. Note that

$$\underline{D} = \frac{NLE_1 + (\alpha^L + \varepsilon_L)L}{\underline{e}} < \overline{D} = \frac{NLE_1 + (\alpha^L + \varepsilon_H)L}{\underline{e}}.$$

Whether issuance occurs for each possible realization of D_1 is summarized in Figure 1. When $D_1 < \underline{D}$, in the blue segment, issuance never occurs regardless of lending, "no issuance". If $\underline{D} < D_1 < \overline{D}$, in the red segment, issuance occurs only if lending has a bad return, which I call "conditional issuance". Lastly, if $D_1 > \overline{D}$, in the green segment, issuance occurs regardless of lending returns, which I refer to as "unconditional issuance".

Figure 1: When issuance occurs conditional on the realization of D_1.



To simplify later expressions, I henceforth assume that

$$\alpha^L + \varepsilon_L = -1,$$

which implies that if a bad lending outcome occurs, only the interest rate r times the amount lent is recovered.

Table 1 contains the likelihood of each line segment for this case, as well as the conditional expectation of the excess return of lending times the marginal utility of a profit of lending. The FOC can be written as the sum of the products of these quantities:

$$\mathbb{E}\left((\alpha^L + \varepsilon)(1 + \psi 1_{F>0})\right) = \sum_{i=1}^{3} p_i \mathbb{E}((\alpha^L + \varepsilon)(1 + \psi 1_{F>0}) \big| D_1 \in \text{segment}_i) = 0,$$

where i refers to all three line segments and p_i is the probability of being in segment i.

Note that these conditional expectations depend only on the parameters; the FOC changes only

because the probabilities p_i change.

Table 1: The probability and conditional expected marginal utility of lending of different segments

	no issuance	conditional issuance	unconditional issuance
probability	$G(\underline{D})$	$G(\overline{D}) - G(\underline{D})$	$1 - G(\overline{D})$
$\mathbb{E}((\alpha^L + \varepsilon)(1 + \psi 1_{F>0}) \big\vert D_1 \in \text{segment})$	α^L	$\alpha^L - (1-p)\psi$	$\alpha^L(1+\psi)$

I will restrict myself to analysing the case where

$$0 < \alpha^L < (1-p)\psi.$$

This restriction implies that when issuance is conditional on the lending outcome, the marginal expected benefit from lending is negative: the bank would prefer less lending. This restriction is natural as otherwise banks would want to lend an infinite amount, pushing the loan spread α^L down. This condition is necessary and sufficient for the problem to have a unique amount of loans L as a solution, as shown in Proposition 1. The intuition is as follows: if $L = 0$, the influence of lending on profits is 0, thus $\underline{D} = \overline{D}$ and the conditional issuance segment has 0 length. As L increases, good lending returns mean that the bank can take in more deposits, while bad returns imply faster issuance. $\underline{D}$ falls while $\overline{D}$ increases. In the extreme case that $L \to \infty$, $\underline{D} \to 0$ and $\overline{D} \to \infty$. In this case, there is conditional issuance regardless of D. As conditional issuance implies a negative incentive for lending, while unconditional or no issuance implies positive incentives for lending, there exists an optimal interior L.

Proposition 1. *This problem has a unique solution with finite L if and only if $\alpha^L < (1-p)\psi$.*

Proof. See Appendix F. □

The conditional expectations on each segment always have the same sign, regardless of the parameters: on the segment where issuance does not occur or occurs unconditionally, the conditional expectations are positive. The intuition is that a marginal unit of lending in these cases increases the expected payoff, as lending has positive NPV and, in these regions, it is uncorrelated with issuance. If these cases are more likely, the bank is more willing to lend. In the unconditional issuance case, the bank has stronger incentives to lend: the profit on lending means less issuance on average.

2.3 Varying the length of leverage relief in the simple model

Let one period last T years.[4] In what follows, I will denote annualized variables with a tilde. Interest and spreads accrue at a constant rate per unit of time, so they scale linearly with the length of the period:

$$r = T\tilde{r}, \qquad \alpha^L = T\tilde{\alpha}^L.$$

Deposit shocks accumulate as sums of independent increments, so their variances are proportional to the length of the period: $D_1 = 1 + \sqrt{T}\eta$, where the annual deposit shock η has distribution $\tilde{G}$ with mean zero, variance $\tilde{\sigma}_D^2$, and support in $(-1, \infty)$, so that deposits always remain positive as long as $T < 1$.

For loan losses, I still assume binary risk, but the size of the gains and losses scales with the square root of the duration: $\varepsilon_H = \sqrt{T}\tilde{\varepsilon}_H$ and $\varepsilon_L = \sqrt{T}\tilde{\varepsilon}_L$. This way the variance of losses ε equals $T\tilde{\sigma}_\varepsilon^2$, where $\tilde{\sigma}_\varepsilon^2$ is the variance when $T = 1$, as it does with Brownian risk.The issuance cost ψ and the requirement ξ_L, and hence $\underline{e}$, are properties of the regulatory environment and issuance technology rather than of the horizon, and are thus held fixed.

Now consider an undercapitalized bank: $e < \underline{e}$. As the end of leverage relief draws near, $T \to 0$, the probability of a large change in capitalization goes to 0 as the variance of both loan losses and deposit inflows goes to 0 fast. This means that for an arbitrary level of loans, all probability mass is concentrated in the unconditional-issuance region when a bank's capitalization e is below $\underline{e}$. As a result, banks start lending more and more as their first-order condition requires them to have some conditional issuance. As a result, this bank's lending goes to infinity.

Similarly, overcapitalized banks with $e > \underline{e}$ will always remain in the no-issuance region for an arbitrary amount of loans, giving banks incentives to lend in this simple model.However, this case does not generalize to either the baseline model or different kinds of risk. This logic does not generalize to an infinite-horizon model, as these banks would face potential equity issuance in later periods with a binding LR requirement with an infinite horizon, giving them incentives to limit lending. Moreover, this is perhaps less relevant for the real world, as this logic does not generalize to the case with Poisson risk: where the probability of a loss goes to 0, while the size of potential losses stays the same. In this case there is always conditional issuance for a finite large amount of

[4]This drops the normalization $\alpha^L + \varepsilon_L = -1$, as it cannot hold for every period length. The normalization only simplifies expressions and does not affect the results. The assumption needed for existence changes to $0 < \alpha^L < -(1-p)\psi(\alpha^L + \varepsilon_L)$. This is still natural, as otherwise banks would always lend an infinite amount.

lending, which these banks trade off against an increasingly small loan spread.[5]

Proposition 2 in Appendix F formalizes this logic and shows at what rate lending diverges. In particular, it implies Corollary 1.

Corollary 1. *As $T \to 0$, lending $L_T \to \infty$ if the bank is not at the LR requirement, $e \neq \underline{e}$, and $L_T \to 0$ if $e = \underline{e}$.*

Proof. This follows directly from Proposition 2, as $\sqrt{T}L_T$ converges to a positive limit if $e \neq \underline{e}$, and $L_T/\sqrt{T}$ converges to a finite limit if $e = \underline{e}$. □

Note that this corollary necessarily implies a decrease in lending as $T \to 0$, as, for positive period lengths, the existence result implies that loans are finite.

3 Model: banks with sticky deposits

This section presents an infinite-horizon economy, where time $t \geq 0$ is continuous, and there is a single good. Banks intermediate funds between households and firms. On the asset side, banks can hold short-term risk-free bonds, "reserves", or make loans to borrowers. On the liability side, banks can issue short-term bonds, "wholesale funding", or rate-insensitive sticky deposits. Households can save in deposits or bonds. Deposits provide liquidity services relative to bonds. Households discount the future at a constant rate r, which pins the interest rate on bonds at r at all times, while the rates on loans and cash bonuses for new deposits adjust endogenously.

Deposit stickiness means that banks compete for deposits by offering cash bonuses at the start of a depositor-bank relationship, and only limited interest payments thereafter. The risk of breaching an LR requirement ties deposit-taking and lending together. A banking regulator can implement leverage relief, temporarily exempting reserves from the LR requirement and removing this risk in the near future.

3.1 Households and deposit supply

Setup and preferences. The economy is populated by a unit mass of perpetual-youth households in the tradition of Blanchard (1985). They consume, hold deposits, hold and issue bonds, and own

[5]Poisson risk is not a problem for undercapitalized banks, as these banks still get positive NPV from lending and issuance remains unavoidable - it just becomes a lot with some small probability.

all firms and banks. Households derive utility from holding deposits, making them accept a lower interest rate on deposits than on bonds. Flow utility takes the quasi-linear form

$$C_t^d + x(D^d),$$

where C_t^d is the household's consumption and x is an increasing, concave function giving the flow utility from the liquidity services of its deposit holdings D^d. Households have a constant discount rate r. Households may consume positive and negative amounts, and utility is linear. This ensures that households lend and borrow perfectly elastically through bonds at the constant rate r, as in Brunnermeier & Sannikov (2014). Households are born and die at the rate λ^D: a household's death is what makes an existing depositor leave its bank. Newborn households fund their deposits through negative consumption and cannot adjust their holdings thereafter; a household whose bank exits faces the same problem as a newborn household. Appendix E presents the full problem and my chosen functional form for x in detail. It is shown that the amount of deposits and bonds bought does not depend on household wealth, so I do not specify how wealth is distributed across households.

The deposit contract. When a household opens a bank account, the bank issues deposits at a discount: for each new deposit, the household pays the bank q_t, implying that the household receives $1 - q_t$ as a cash bonus. Households take the deposit price q_t as given; it is the price at which banks issue deposits. Banks pay interest on the book value of existing deposits at a rate of βr, where $\beta < 1$ is exogenous and r is the interest rate on bonds. This interest is paid directly to the household and not reinvested in deposits. Bank-depositor relationships are broken at a rate $\lambda := \lambda^D + \lambda^B$, where λ^D is the rate at which households die and λ^B is the exogenous rate at which banks cease operations, specified later. When the relationship ends, depositors are returned 1 good per deposit. This gives rise to the following return on deposits.

Lemma 1 (Return on deposits)**.** *A deposit yields the expected return*

$$r_t^D = \frac{\beta r}{q_t} + \frac{\lambda(1 - q_t)}{q_t}. \tag{1}$$

The deposit return varies over time only through the deposit price q_t.

Proof. Appendix E. □

The first term reflects interest payments; the second reflects the expected capital gain $1 - q_t$

from relationship termination at rate λ.

Deposit supply. A household that opens a new deposit account chooses to supply D_t^* deposits. In the appendix, I show that this new deposit supply is a downward-sloping function of $q_t(r - r_t^D)$, the deposit price times the deposit spread. For my functional form of utility, a new depositor supplies

$$D_t^*\left(q_t(r - r_t^D)\right) = \bar{D}\left(q_t(r - r_t^D)\right)^{-1/\gamma^D} \tag{2}$$

deposits. The parameters $\frac{1}{\gamma^D}$ and $\bar{D}$ determine the elasticity of deposit supply and the level of deposits, respectively.

Integrating over all households, aggregate deposit supply D_t^s changes as new deposit accounts open and existing deposit accounts close. Recall that relationships break at rate λ, so a fraction λdt of households open new deposit accounts and deposit D^*, while a fraction λdt of deposit accounts close, holding D_t^s deposits on average. Aggregate deposit supply D_t^s then changes by

$$dD_t^s(q_t, D_t^s) = \lambda(D_t^*(q_t(r - r_t^D)) - D_t^s)dt. \tag{3}$$

3.2 Firms

Firms are treated in reduced form. Non-financial firms borrow to finance investment and produce the final consumption good. These firm decisions give rise to an aggregate loan demand L_t^d. Aggregate loan demand is static, falls with the interest rate on loans, and takes the CES form

$$L^d(r + \alpha_t^L) = \Theta^L(1 + r + \alpha_t^L)^{\varepsilon^L}, \tag{4}$$

where α_t^L is the loan spread over bonds and $\varepsilon^L < 0$ governs the interest-rate elasticity of demand. Bianchi & Bigio (2022) show how this loan demand can be micro-founded.

3.3 Banks

The banking sector consists of a continuum of ex-ante identical perfectly competitive banks indexed by j. Initially there is a unit mass of banks, which shrinks as banks exit. Banks maximize shareholder value, where the shareholders are the households. Banks are largely modelled as in Bolton et al. (2025).

Liabilities. Banks fund their assets with rate-insensitive deposits D_{jt}, rate-sensitive bonds B_{jt}—

referred to as "wholesale funding" when on the liabilities side of the balance sheet—and equity E_{jt}. Some real-world deposits are rate-sensitive (Blickle et al., 2025). These deposits map to wholesale funding in the model. Deposits evolve according to

$$dD_{jt} = D_{jt}\left(\mu_{jt}^{D}dt + \sigma_{D}d\mathcal{W}_{jt}^{D}\right), \tag{5}$$

where μ_{jt}^{D} is the bank's expected net deposit growth rate and $\mathcal{W}_{jt}^{D}$ is a standard Brownian motion. Deposit account closures cause a bank's deposits to fall by $D_{jt}\lambda^{D}dt$ on average, so a bank that attracts no new depositors has $\mu_{jt}^{D} = -\lambda^{D}$. Moreover, a key function of deposits is to serve as a means of payment. Payment activities generate deposit shocks. When a bank's depositors pay depositors in other banks, money flows out, $\sigma_{D}d\mathcal{W}_{jt}^{D} < 0$. When a bank's depositors receive payments from depositors of other banks, money flows in, $\sigma_{D}d\mathcal{W}_{jt}^{D} > 0$. These deposit shocks are assumed to be independent between banks.

Banks also choose how many new deposits $(\mu_{jt}^{D} + \lambda^{D})D_{jt}$ to attract. Banks pay $1 - q_t$ to attract a new deposit; a bank's spending on new deposits is thus $(1 - q_t)(\mu_{jt}^{D} + \lambda^{D})D_{jt}dt$. A bank that lets its deposit base shrink faster than depositors leave of their own accord, $\mu_{jt}^{D} < -\lambda^{D}$, buys a negative number of new deposits and so receives $1 - q_t$ per deposit shed. As banks pay depositors an exogenous fraction $\beta < 1$ of the bond rate r in interest, their deposit interest expense is $D_{jt}\beta r dt$.

Wholesale funding B_{jt} consists of risk-free bonds that are issued at time t and mature at time $t + dt$. The bank pays the risk-free rate r on wholesale funding, giving wholesale interest expense $rB_{jt}dt$.

Assets. Banks invest in risk-free reserves R_{jt} and risky loans L_{jt}. Reserves are bonds held on the asset side of the balance sheet and thus pay the interest rate on bonds r, giving an interest income $rdtR_{jt}$. Reserves and wholesale funding are two sides of the same risk-free bond. The bank holds bonds as reserves on the asset side ($R_{jt} > 0$, $B_{jt} = 0$) or issues bonds as wholesale funding on the liability side ($B_{jt} > 0$, $R_{jt} = 0$).

Risky loans L_{jt} earn a return equal to $(r + \alpha_t^{L})dt + \sigma_{L}d\mathcal{W}_{jt}^{L}$, where α_t^{L} is the loan spread between the average return on loans and the interest rate on bonds, σ_L is the volatility of the value of loans and $\mathcal{W}_{jt}^{L}$ is a Brownian motion representing idiosyncratic loan shocks—unexpected charge-offs or recoveries on the loan book. These Brownian motions are assumed to be mutually uncorrelated between banks and uncorrelated with the Brownian motion representing deposit shocks $d\mathcal{W}_{jt}^{D}$.

The evolution of equity and balance sheet. Banks gain equity by retaining profits and issuing

equity. The law of motion of the book value of bank equity is given by

$$dE_{jt} = \underbrace{(R_{jt}rdt + L_{jt}\left((r+\alpha_t^L)dt + \sigma_L d\mathcal{W}_{jt}^L\right))}_{\text{income}} - \underbrace{(B_{jt}rdt + D_{jt}\left(\beta r + (1-q_t)(\mu_{jt}^D + \lambda^D) + \frac{\theta}{\kappa}\left|\mu_{jt}^D\right|^\kappa\right)dt)}_{\text{expenses}} + \underbrace{dF_{jt}}_{\text{issuance}}. \tag{6}$$

The bank cannot choose to pay out equity before exiting and thus retains all profits. Profits consist of the return on reserves and loans net of interest paid on wholesale funding and on deposits, cash bonuses for new depositors, and convex adjustment costs of changing the deposit base $D_{jt}\frac{\theta}{\kappa}\left|\mu_{jt}^D\right|^\kappa dt$, with $\theta > 0$ governing the level and $\kappa > 1$ the curvature. The bank can issue equity; F_{jt} denotes a bank's cumulative equity issuance up to time t. Deposit shocks do not affect bank equity, as these reflect payments between depositors. When a depositor pays a depositor in another bank, the bank loses a deposit but also has to pay a reserve to the receiving bank, changing assets and liabilities by the same amount.

The balance sheet constraint of a bank reads

$$E_{jt} + D_{jt} + B_{jt} = L_{jt} + R_{jt}. \tag{7}$$

Regulation. Banks are subject to two regulatory constraints. For the risk-weighted capital requirement, I assume that loans have a risk weight of 1 and reserves of 0. The capital requirement $\frac{\text{Risk-weighted Assets}}{Equity} \leq \xi_K$ then limits risky lending:

$$\frac{L_{jt}}{E_{jt}} \leq \xi_K. \tag{8}$$

The non-risk-based LR requirement $\frac{\text{Unweighted Assets}}{\text{Equity}} \leq \xi_L$ limits the total size of the balance sheet:

$$\frac{L_{jt} + R_{jt}}{E_{jt}} \leq \xi_L. \tag{9}$$

I assume that the capital requirement is more stringent, such that it may bind:

Assumption 1. $\xi_K < \xi_L$.

This obtains for the euro area, as shown when choosing these parameters.

As the capital requirement is more stringent, the LR requirement can only bind when reserves R_{jt} are positive. When $R_{jt} = 0$, both ratios are $\frac{L_{jt}}{E_{jt}}$, so the capital requirement binds before the LR requirement can bind. As the LR requirement only binds when reserves are positive, it can only

bind if $B_{jt} = 0$. Using the balance sheet constraint (7) and substituting in that $B_{jt} = 0$, the LR requirement can be rewritten as

$$\frac{E_{jt} + D_{jt}}{E_{jt}} \leq \xi_L \iff D_{jt} \leq (\xi_L - 1)E_{jt}. \tag{10}$$

The non-risk-based LR requirement limits deposit-taking: when banks are constrained in the amount of reserves they can hold, they are constrained in the number of deposits they can take.

These two constraints play different roles. Banks can perfectly control loans, so the capital requirement (8) holds at every instant and simply caps lending. As banks cannot perfectly control deposits, the LR requirement (10) cannot always be met. As in Bolton et al. (2025), this LR requirement determines when banks are forced to issue equity.

When reserves are exempted during leverage relief, the left-hand side of (9) becomes $\frac{L_{jt}}{E_{jt}}$, which is the capital ratio. Since the capital requirement is the more stringent of the two, (10) is then slack at any deposit level: the bank can take unlimited deposits while leverage relief lasts, holding the corresponding assets as reserves.

Exit & payouts. Following Gertler & Kiyotaki (2010), banks exit at a rate λ^B. When a bank exits, it pays out all its equity to the households and stops operations. The depositors leave the bank and search for a new bank. Typically, these models assume that new banks replace exiting banks to keep the mass of banks constant. To avoid having to allocate sticky deposits to entrant banks, I assume no new banks enter.

Issuance & objective. Shareholders incur equity issuance costs when a bank issues equity. Let H_{jt} denote the cumulative costs of equity issuance up to time t. These costs are proportional to the amount issued, $dH_{jt} = \psi dF_{jt}$. A bank's problem can be written as the maximization of shareholder value

$$V_{j0} = \max_{\{R,B,\mu^D,L,F\}} \mathbb{E}\left(\int_{t=0}^{\tau_j^B} \exp(-rt)(dU_{jt} - dF_{jt} - dH_{jt})\right) \tag{11}$$

subject to balance sheet constraint (7), capital requirement (8), and LR requirement (10). Here τ_j^B denotes the stochastic stopping time when the bank exits. As the bank pays out when it exits, its change in payouts upon exit is $dU_{j\tau_j^B} = E_{j\tau_j^B}$. At all other times, $dU_{jt} = 0$. The bank chooses its bond position, deposit growth, lending, and issuance; payouts are mechanical. Since exit arrives at

rate λ^B, substituting out dU_{jt} gives

$$V_{j0} = \max_{\{R,B,\mu^D,L,F\}} \mathbb{E}\left(\int_{t=0}^{\infty} \exp(-(r+\lambda^B)t)\left(\lambda^B E_{jt}dt - dF_{jt} - dH_{jt}\right)\right). \tag{12}$$

3.4 The distribution of banks

A key feature of the model is that banks' optimal policies exhibit size independence. Because returns, costs, and constraints all scale with deposits, policy functions can be expressed independently of the current level of deposits. Specifically, capitalization $e_{jt} := E_{jt}/D_{jt}$ is the sole relevant state variable for bank decisions.

Lemma 2 (Size Independence)**.** *The banks' value function, which solves* (11)*, is linear in deposits:* $V_t(D,E) = Dv_t(E/D)$*, where* $v_t(e) := V_t(1,e)$ *is the value of a bank with one deposit and equity-to-deposits ratio* e*.*

Proof. See Appendix A, follows the logic of Bolton et al. (2025). □

This homogeneity arises because interest income, funding costs, adjustment costs, equity issuance costs, and constraints all scale linearly with the balance sheet. Consequently, bank profits and deposit growth rates depend on normalized policy functions and idiosyncratic shocks, not scale. The normalized policy functions are the net deposit growth rate $\mu_t^D(e)$ and loans-per-deposit $l_t(e) := L_{jt}/D_{jt}$ for a bank j with capitalization e. Appendix A states the HJB for v and presents the first-order conditions.

This size independence means that the state of the banking system can be summarized by two objects: the distribution $h_t(e)$ of banks over capitalization e weighted by their deposits, and the aggregate level of deposits D_t. I define my equilibrium in terms of these objects. Appendix B shows how this deposit-weighted distribution of bank capitalization evolves over time theoretically, and Appendix C shows how it is solved for numerically.

3.5 Banking regulator

A banking regulator can choose to implement leverage relief: temporarily exempt reserves from the leverage ratio calculation, essentially suspending the LR requirement. Reserves are exempt for T^{relief} periods after the announcement. In subsequent analysis, this is an MIT shock: it is announced at time $t = 0$, and banks do not anticipate it.

3.6 Market clearing and equilibrium

To close the model, I impose market-clearing conditions. Appendix B shows that the aggregate supply of loans and bonds by banks and the demand for new deposits can be written in terms of the deposit-weighted distribution of bank capitalization $h_t(e)$. The loan market clears when

$$L_t = \int L_{jt} dj = D_t \int l_t(e) h_t(e) de, \tag{13}$$

where L_t is aggregate loans. The market for new deposits clears when the growth in deposit demand from banks equals the growth in deposit supply from households. This growth in deposit demand equals the average bank-level growth in deposits of surviving banks $D_t \int \mu_t^D(e) h_t(e) de dt$ net of deposits in exiting banks $D_t \lambda^B dt$. New deposit market clearing requires

$$dD_t = D_t \int \mu_t^D(e) h_t(e) de dt - D_t \lambda^B dt. \tag{14}$$

In the bond market, banks have an aggregate net long position of $\int ((1+e) - l(e)) h(e) de$. As households have quasi-linear utility, market clearing in the bond market implies that the interest rate on bonds equals households' constant discount rate r at every date. If this obtains, households will take an offsetting position. Otherwise, their position is positive or negative infinity.

The goods market clears by Walras' law.

Definition 1 (Equilibrium)**.** Given an initial deposit-weighted distribution of banks $h_0(e)$, initial aggregate deposits D_0, decisions on when leverage relief applies, and depositors' constant discount rate r, a recursive competitive equilibrium consists of the law of motion of the banks' distribution $\{h_t(e)\}_{t \geq 0}$, bank value and policy functions $\{v_t(e), \mu_t^D(e), l_t(e)\}_{t \geq 0}$, quantities $\{D_t, L_t\}_{t \geq 0}$, and prices $\{q_t, \alpha_t^L\}_{t \geq 0}$ such that (i) bank value and policy functions solve the banks' problem, (ii) the change in aggregate deposits dD_t is consistent with household supply (2), (iii) aggregate loans are consistent with firm demand (4), (iv) the distribution of banks is consistent with the evolution equations given the policy functions in Appendix B, (v) the interest rate on bonds is r, and (vi) markets clear.

A steady-state equilibrium is defined as an equilibrium where all equilibrium objects are constant over time. In particular, the deposit-weighted distribution of banks $h_t(e)$ and aggregate deposits D_t do not move over time. I refer to steady-state values by dropping the time subscript.

3.7 Discussion of main assumptions

Why not compete on deposit rates? Most papers assume that banks set interest rates to attract new deposits, including those set in discrete time with sticky deposits (e.g., Egan et al., 2025). The issue is that banks generally do not commit to an interest rate on checking and overnight savings accounts. A higher deposit rate benefits existing depositors, but new depositors that face switching costs care not about the current interest rate but about the average deposit rate during the period that they have a bank account. Raising current deposit rates thus does nothing to attract new depositors, but costs banks as they need to pay existing depositors. In discrete time, banks can convince new depositors to join by adjusting the deposit rate, as banks can commit to an interest rate for one period.

Cash bonuses. I assume that banks pay depositors cash bonuses upfront to open new bank accounts. This is in line with how banks operate. The extent to which banks spend on attracting new depositors varies with macroeconomic circumstances. Flannery (1982) already noted that banks pay part of the informational cost of opening a new bank account: through advertising and by making account opening more convenient. I take this logic a step further and assume that banks compete on how much they offer new depositors. I call them cash bonuses, but this can be more broadly interpreted as any upfront spending to convince a potential depositor to join the bank: advertising, new branch openings, and promotional interest rates. Benetton et al. (2025) document that banks in the US regularly offer cash bonuses, and that advertisements of these bonuses—lowering households' information-gathering costs—covary more with the Fed Funds rate than interest rates on bank accounts, providing evidence that banks adjust this margin in response to macroeconomic circumstances. Begenau & Stafford (2023) find that new bank branches receive a disproportionate amount of deposit growth. Moreover, branch openings also covary with the Fed Funds rate and tend to be concentrated in counties where competition for deposits is high. That banks choose to expand in regions where there is already competition for deposits supports the assumption of perfect competition for new deposits.

Why would banks pay interest at all? In the model, it is optimal for banks to pay depositors as little interest as possible. Without interest on deposits, $\beta = 0$, the results go through qualitatively. However, I have banks pay interest, as in reality they do pay interest to rate-insensitive depositors, even if only very little. This could potentially be micro-founded by assuming that depositors do switch if the gain from switching is higher than the adjustment cost. Depositors weigh switching costs against their outside options—bond returns and new-depositor incentives at other banks—

which rise with the interest rate on bonds. Banks would pay just enough interest to ensure depositors are indifferent between staying with the bank and leaving.

Form of credit risk. The model only considers continuous Brownian lending risks. In reality, sudden events can also cause loan losses. This could be modelled as a Poisson process, as i.a. Hugonnier & Morellec (2017) do. Modelling credit risk this way would affect the shape of lending in normal times, if fixed issuance costs were also introduced; Rochet & Villeneuve (2011) show that fixed issuance costs mean that for $e < \underline{e}$ the value function is (close to) constant, making the value function locally convex, meaning that banks near the LR requirement would lend more. However, it would not change the later implications for lending of undercapitalized banks during the leverage relief.

Perfect information. The model abstracts from adverse selection of consumers into certain banks: those searching for new banks are more likely to be less sticky, giving banks less incentive to compete for new deposits and lowering equilibrium yields (see Benetton et al., 2025). Abstracting from these frictions means that banks pay too much for new deposits.

No financial distress. The model abstracts from the effects of financial instability arising from the consequences of bank default, as considered by Hugonnier & Morellec (2017); Bellifemine et al. (2025); Abad et al. (2026) and others. Banks would not default even if they could: under limited liability, shareholders default only when the bank's value falls below zero, but $v_t(e) > 0$ at every capitalization e, in steady state and throughout the relief. However, for different parameterizations or with additional frictions, undercapitalized banks could choose to declare bankruptcy, imposing bankruptcy costs on the economy.

3.8 Discussion: differences in how banks are modelled relative to Bolton et al. (2025)

Mathematically, how banks are modelled is almost nested in the framework of Bolton et al. (2025). There are three mathematical changes: no zero lower bound, exogenous payouts due to exit, and interest payments on deposits. In their model, a zero lower bound limits how fast deposits can go down. In this model, it would naturally map to a bank being unable to get rid of existing depositors: $\mu^D \geq -\lambda^D$. I omit the constraint to ease the exposition, since adjustment costs are high enough that it is almost never binding. Exogenous payouts due to exit are a simplification made to be in

line with the macro-banking literature.[6] The no-interest case is nested in my model: set $\beta = 0$.

Conceptually, the deposit market is presented differently. Bolton et al. (2025) use a deposit supply function where the growth rate of deposits increases when the contemporaneous interest rate on deposits increases, while in my model new depositors respond to cash bonuses. This does not matter for the trade-off the bank faces; it needs to pay money now to have sticky deposits later. In my paper, banks set the growth rate of deposits (quantity) directly, while in their paper, banks choose the interest rate (price), which maps one-to-one to a quantity. Due to this one-to-one mapping, the solution is the same in both settings. Lastly, I make a more specific assumption on deposit demand: I assume perfect competition, whereas Bolton et al. (2025) only assume that new deposit demand is an increasing function of the interest rate. This is a different choice of functional form rather than a model alteration.

4 Calibration and model fit

In this section, I calibrate the model and inspect its steady-state properties.

4.1 Calibration

I calibrate the model to euro area averages between June 2022 and June 2025. This is the period in which the LR requirement was in force. The unit of time is one year. Where euro area data are unavailable, I use US estimates.

For my own bank-level analysis, I use a semi-annual panel of 69 euro area banks and 457 bank-periods (on average 6.62 out of 7 periods per bank) between June 2022 and June 2025. I select bank-periods that are in the EBA's Transparency Exercise. Banks need to have the sum of household and non-financial corporate deposits are at least 30% of assets over the sample, and have to be ECB-supervised for at least one period in the sample.[7] Most data come from the Transparency Exercise. I obtain data on bank-specific LR requirements from banks' Pillar 3 reports, the details of which are in Appendix G. Argenta (EUR 42.7 billion in deposits, 0.40% of the sample) and Novo Banco (EUR 26.7 billion in deposits, 0.25% of the sample) were held by holding companies that did not have these reports available. They were dropped from the sample, as LR requirements at the subsidiary and holding-company level are generally not comparable. Appendix H contains the

[6] E.g., Gertler & Kiyotaki (2010); Wang (2025); Jamilov & Monacelli (2026); Bellifemine et al. (2025); Abad et al. (2026).

[7] Replacing the ECB supervision requirement with requiring banks to have their headquarters in the euro area adds three banks in June 2022, with collectively EUR 24 billion in deposits (0.23% of the sample aggregate deposits).

distribution of banks across headquarters country and a list of all the banks in the sample and their sizes.

The externally calibrated parameters are in Table 2 and the internally calibrated ones in Table 3. I first discuss the externally calibrated parameters.

Table 2: Externally calibrated parameters

Parameter	Description	Value	Source
r	Risk-free rate	2%	Q1 2026 ECB deposit facility rate
β	Deposit beta	0.265	Own estimate, Appendix I
λ^D	Depositor break-up rate	0	Egan et al. (2025)
$1/\gamma^D$	Deposit supply elasticity	0.5	guess
λ^B	Bank exit rate	8.8^{-1}	Gertler & Kiyotaki (2010)
ξ_K	Capital requirement	$(0.1525 \times 0.3695)^{-1} \approx 17.75$	Average ECB requirement
ξ_L	LR requirement	$0.03235^{-1} \approx 30.9$	Average ECB requirement
ψ	Proportional issuance cost	132%	Bolton et al. (2025)
ε^L	Loan demand elasticity	-35	Bianchi & Bigio (2022)
κ	Adjustment cost curvature	2	Bolton et al. (2025)

Table 3: Internally calibrated parameters

Parameter	Description	Value
σ_L	Loan volatility	4.25%
σ_D	Deposit volatility	20%
θ	Deposit adjustment cost	1.40
Θ^L	Loan demand intercept	4.43
$\bar{D}$	Deposit supply scale	0.1195

Notes: These parameters are calibrated jointly. All parameters except $\bar{D}$ are chosen together to match the deposit-weighted median leverage-ratio buffer over the bank-specific requirement and the aggregate balance sheet. $\bar{D}$ is set to normalize steady-state deposits to 1.

Bank exit. I set $\lambda^B = 8.8^{-1}$, making the average bank survive 8.8 years, which is consistent with the exit rate of Gertler & Kiyotaki (2010).

Deposit stickiness. Egan et al. (2025) report that the average US current account remains open 9.5 years, but larger accounts are closed faster. Larger deposit accounts are modelled as multiple deposit accounts; I set $\lambda^D = 0$ such that deposit-bank relationships also last an average of 8.8 years.[8]

[8]In Norway, Basten & Juelsrud (2026) show that after 8 years, a depositor is 70% more likely to have a deposit account with the same bank than with another bank. This would translate into a total break-up rate of $-\log(0.7)/8 \approx 0.0446$ and would imply an average relationship duration of 22.4 years. If anything, this estimate of deposit stickiness is conservative.

The LR requirement. I set $\xi_L = 0.03235^{-1} \approx 30.9$ to match the ECB's minimum leverage ratio requirement of 3% plus an average G-SII surcharge of about 0.2% over the sample, and 0.035% of Pillar 2 requirement and guidance (ECB, 2025).

The capital requirement. Over 2022–2025, the average ECB-supervised bank had to keep a risk-weighted capital ratio of at least 15.25%, including 1.3% Pillar 2 guidance (ECB, 2025). Moreover, as of the end of 2024, the average European corporate loan had a risk weight of 52% and the average mortgage had a risk weight of 17%. I treat these two loan categories as the only relevant ones. As mortgages were 43% of banks' credit exposure in these two categories, the average loan to the private sector had a risk weight of 36.95%.[9] Thus, one unit of capital allows a bank to hold $\xi_K = (0.1525 \times 0.3695)^{-1} \approx 17.75$ times its equity in loans.

Equity issuance costs. Bolton et al. (2025) consider both fixed and variable issuance costs. Their fixed issuance costs equal 0.14% of deposits held at the time of issuance. They do not report how much equity banks issue when they issue equity, but my reproduction of their model shows banks issue equity worth 0.11% of deposits. Adding their proportional issuance cost of 5%, equity issuance costs per unit of equity are $\frac{0.14}{0.11} + 0.05 = 1.32$ in their setting, which I use as my variable issuance costs ψ.

Convexity of adjustment costs. Following Bolton et al. (2025), I set the convexity of deposit adjustment costs $\kappa = 2$ for quadratic adjustment costs.

Deposit beta. In Appendix I I ran a regression of the form

$$\frac{\text{Deposit interest expenditure}_{it}}{\text{Total deposits}_{it}} = \sum_{k=1}^{6} \left(\beta_k \text{ECB dep. rate}_t \times \frac{\text{Type } k \text{ deposits}_{it}}{\text{Total deposits}_{it}} \right) + \varepsilon_{it},$$

where type k refers to either household, non-financial corporate (NFC), central bank, government, other bank or other financial institution deposits. This regression indicates that a bank that funds itself fully with household deposits can expect to have 0.254pp higher deposit interest expenditures when the ECB deposit rate is 1pp higher. Similarly, a bank fully dependent on non-financial corporates is expected to see 0.285pp higher deposit interest expenditures. Other types of deposits are associated with more procyclical deposit interest rates and are thus excluded from the deposit measure. As 34.26% of these deposits come from NFCs, I use $\beta = 0.3426 \times 0.285 + (1 - 0.3426) \times 0.254 = 0.265$.

Deposit supply elasticity. Bianchi & Bigio (2022) set the macro-elasticity of deposit supply

[9] These data can be found at `https://eba.europa.eu/publications-and-media/publications/capital-and-risk-weighted-assets-1`.

at -35 with a reference to the literature, without specifying which. Evidence on this elasticity is scarce, but Chiu et al. (2018) show that aggregate retail deposit supply is inelastic to the rate offered by a bank. In line with their findings, I assume deposit supply is inelastic and take an elasticity of $1/\gamma^D = 0.5$.

Loan demand. Following Bianchi & Bigio (2022), I set the elasticity of loan demand with respect to the gross interest rate at $\varepsilon^L = -35$.

I internally calibrate the volatility of loans σ_L and deposits σ_D, the size of adjustment costs θ, and the intercept of loan demand Θ^L, which decides the size of the equilibrium loan spread. I choose these parameters to approximately match the deposit-weighted median buffer over a bank's requirement which is 2.061pp in the data versus 2.085pp in the calibrated model. Moreover, I calibrate them to the aggregate balance sheet reported in Table 4, where the decomposition largely follows Abad et al. (2026), except I define deposits much more narrowly as household and non-financial corporate deposits, since I find that these are the deposits that are rate-inelastic in Appendix I. Equity is much too low: 5.3% versus 8.6% in the data. However, other funding is rather close. Deposits are only off by 0.3pp, while wholesale funding is only off by 3pp. There are slightly too few loans, 81.9% versus 84.8% in the data.

The calibrated intercept for loan demand Θ^L implies a steady-state loan spread of 24.1bps, slightly higher than the 20bps that Bolton et al. (2025) use. Loans are less volatile, while deposits are more volatile than the values externally calibrated by Bolton et al. (2025).

I set the intercept of deposit supply $\bar{D}$ such that aggregate deposits D^* are normalized to 1 in the steady state.

4.2 Banks in the steady-state cross section

This subsection discusses the policy functions and distributions of banks.

Deposit-taking. Figure 2 shows how net deposit purchases $\mu^D(e)$ change with a bank's capitalization. The left plot displays the policy as a function of equity-per-deposit e. The right plot has the deposit-weighted quantiles H on the horizontal axis instead, showing the policy function across the distribution of e. As in Bolton et al. (2025), banks choose to attract more deposits whenever they are better capitalized. These banks run relatively little risk from deposit inflows pushing them over the LR requirement and thus are willing to attract more depositors.

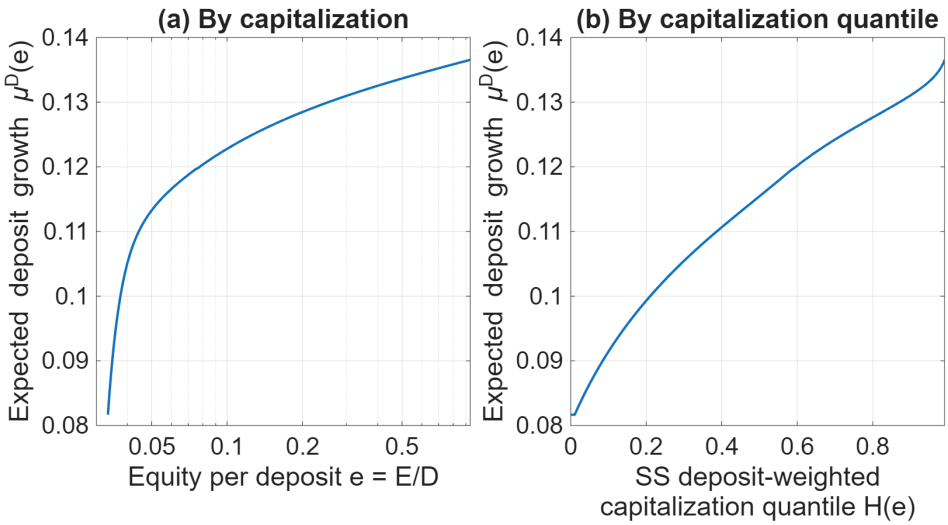
Lending. Figure 3 shows how the loan-to-equity ratio $\frac{l(e)}{e}$ varies with a bank's capitalization. As in Bolton et al. (2025), banks with more equity hold more loans relative to equity. This happens

Table 4: Steady-state consolidated bank balance sheet

Assets			Liabilities		
	Model	Data		Model	Data
Loans	81.9%	84.8%	Deposits	40.1%	39.8%
Reserves and ST securities	18.1%	15.2%	Wholesale funding	54.6%	51.6%
			Equity capital	5.3%	8.6%

Notes: Data are computed from ECB balance sheet items statistics (ECB, 2026a), averaged over the same seven semi-annual periods as the rest of the empirical section (H1 2022–H1 2025), and expressed as percentages of consolidated total assets. The reporting sector is monetary financial institutions excluding the Eurosystem central banks; inter-bank positions are netted from both sides of the balance sheet. Reserves and short-term securities are claims on national central banks and euro area government debt with a maturity shorter than one year. Loans are the domestic residual, so longer-term securities are counted as loans. External assets—loans to and securities issued by non-euro area entities, together with holdings of non-euro cash—and remaining assets are not identified by instrument in the source statistics; they are apportioned between the two categories in proportion to the identified euro area positions. Deposits are euro area household and non-financial corporate deposits. Equity is book equity. Wholesale funding is the residual, so it includes inter-bank and central bank funding, deposits of governments and other financial institutions, deposits placed by non-residents, and debt securities issued. The population differs from the bank-level sample used elsewhere in this section: these statistics cover banks resident in the euro area, whereas the bank-level sample covers euro area headquartered groups consolidated worldwide.

Figure 2: Bank-level net deposit growth

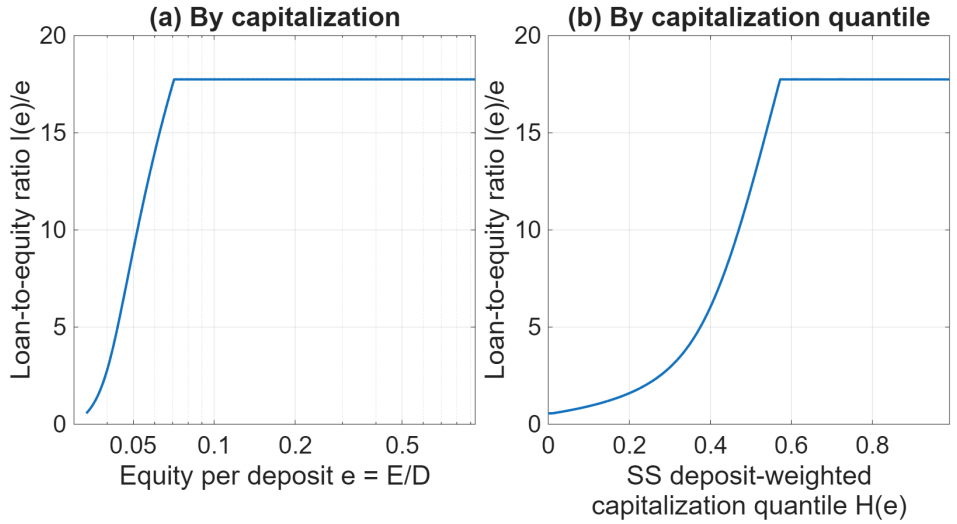


Notes: Panel (a): as a function of e. Panel (b): as a function of steady-state deposit-weighted capitalization quantiles $H(e)$. Plots show the least-capitalized banks holding 99% of deposits.

because for these banks loan losses are less likely to trigger equity issuance. Note that the best-capitalized 42% have a binding capital requirement.

Deposit-weighted distribution. Figure 4 gives the distribution of banks' capitalization. The deposit-weighted CDF $H(e)$ lies above the equally-weighted CDF $G(e)$. This indicates that banks with better capitalization tend to have fewer deposits. There are two opposite forces that create

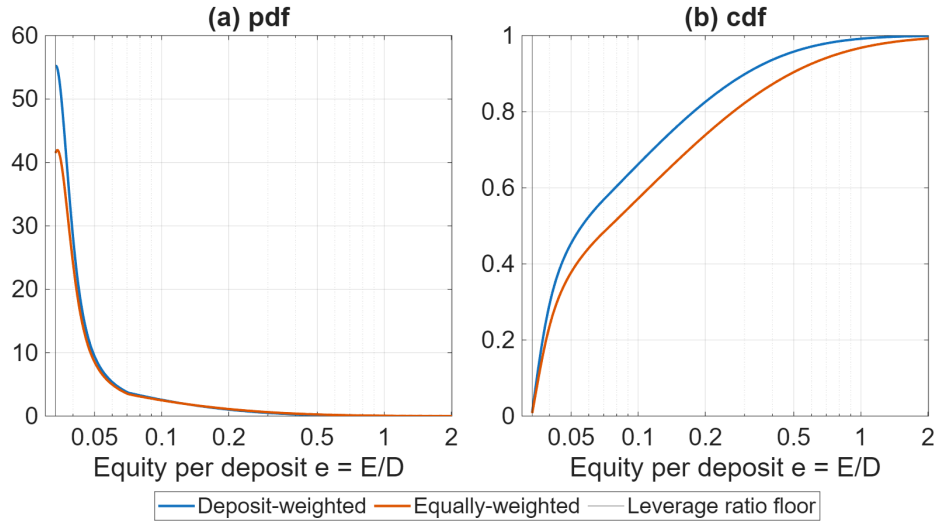
Figure 3: Bank-level loan-to-equity ratio



Notes: Panel (a): as a function of e. Panel (b): as a function of steady-state deposit-weighted capitalization quantiles $H(e)$. Plots show the least-capitalized banks holding 99% of deposits.

a correlation between deposits and capitalization. On the one hand, banks that receive deposit inflows see both an increase in their deposits and a decrease in their capitalization, creating a negative correlation. On the other hand, banks with better capitalization choose to attract more new depositors, creating a positive correlation. In this setting, the former effect dominates as there is more deposit-weighted mass than equally-weighted mass at low capitalization levels.

Figure 4: Steady-state distribution of bank capitalization



Notes: Equally-weighted and deposit-weighted densities g, h and CDFs G, H. Plots show the least-capitalized banks holding 99.9% of deposits.

Data limitations. Data are consolidated at the holding level, meaning that all variables are

for whole banking groups. Some large euro area banks, e.g., Banco Santander, BBVA, and ING, take substantial deposits outside the euro area. As deposit totals are taken at the holding level, these deposits also show up in the data. This blurs the mapping to the model. Still, these deposits are relevant as the binding requirements are set at the holding level. A second limitation is that not all euro area banks are included. The EBA notes that its Transparency Exercise contains 80% of European Economic Area bank assets, but it is unclear why 20% is missing. Smaller banks not under ECB supervision are excluded by my procedure, but they should be relatively unimportant. To get a sense of scale, household and non-financial corporate deposits in the banks in the sample averaged EUR 10.8 trillion (including deposits outside the euro area) during the period, while aggregate euro area household and non-financial corporate deposits averaged EUR 12.8 trillion.

5 Effect of leverage relief

This section analyses quantitatively how leverage relief—a temporary exemption of reserves from the leverage ratio—changes bank lending in the calibrated model, and how that response varies with the length of leverage relief and the distribution of banks' capitalization. In my model, exempting reserves is equivalent to suspending the LR requirement altogether; both allow banks to hold an unlimited amount of deposits, since deposits can be invested in zero-risk-weight reserves. This section shows that the increase in lending during the leverage relief is driven by two channels: the deferred issuance channel—banks losing equity, primarily due to deferred issuance—and the leverage channel—the direct effect of leverage relief on risk-taking.

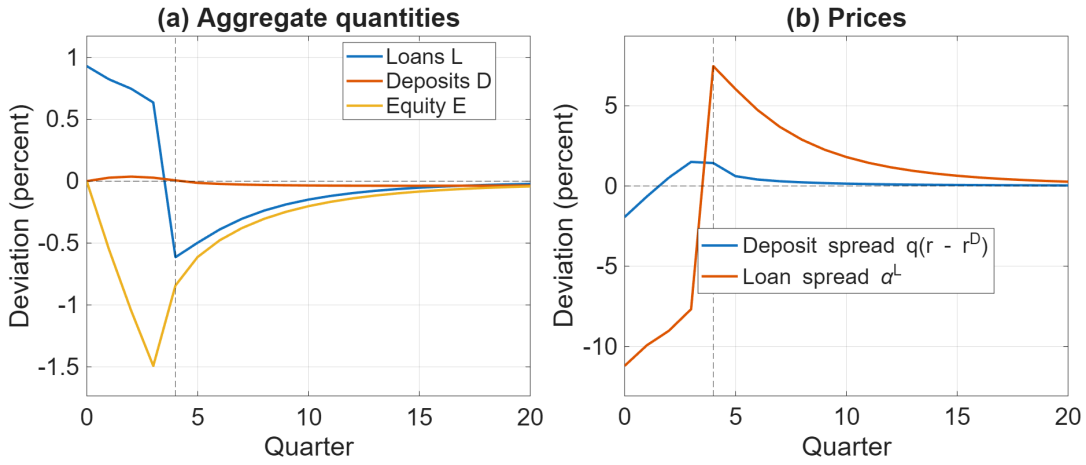
The baseline experiment. Before the leverage relief, the economy is in the steady state[10] with an LR requirement. At $t = 0$, unexpectedly and immediately, the banking regulator exempts reserves from the leverage ratio calculation for $T^{\text{relief}} = 4$ quarters, approximately in line with how long the ECB and the Fed[11] exempted reserves in 2020 and 2021. Leverage relief is modelled as banks no longer having to meet the LR requirement for T^{relief} periods, allowing capitalization e to fall below $\underline{e}$. After leverage relief ends, the LR requirement is fully reinstated and, if needed, banks have to issue equity to ensure that $e \geq \underline{e}$.

[10] In the absence of shocks, the economy drifts to the steady state. So these initial conditions should give reasonably close impulse responses even if the economy is not in steady state. Later, I investigate state-dependent effects by also considering this policy after a deposit inflow. The impulse responses are approximately the same.

[11] The Fed exempted reserves (and Treasuries) from the calculation for 4 quarters. Formally, the ECB exempted reserves from the LR calculation for six quarters. However, for the first three of these quarters, banks did not legally have to follow an LR requirement as Basel III was not fully implemented yet; they only had to calculate it. For this reason, I model leverage relief as slightly longer than three quarters; banks had more than three quarters to prepare for issuance.

5.1 Lending response to leverage relief

Figure 5: Aggregate response to four-quarter leverage relief



Notes: Percentage deviations from steady state. Panel (a): loans L, deposits D, and equity E. Panel (b): the mean deposit spread $q_t(r - r_t^D)$ and the loan spread α^L. The dashed vertical line marks the end of the relief.

Figure 5 displays how the economy responds to leverage relief. Panel (a) displays how aggregate quantities adjust to the relief. Panel (b) displays the corresponding impulse response functions for intermediation spreads: the loan spread α^L and the implied deposit spread a new depositor gives up over a new deposit's lifetime $q_t(r - r_t^D)$.

During the leverage relief, banks no longer issue equity when their capitalization e falls too much. As a result, issuance falls, decreasing aggregate equity. Moreover, loan losses or deposit inflows no longer carry near-term issuance risk, and banks take more deposits and loans, leading to an increase in loans and deposits at lower spreads. As banks' capitalization falls, taking deposits becomes more costly; after the LR requirement is reinstated, they are more likely to need to raise equity. In turn, banks take fewer new deposits as the leverage relief lasts longer. At the end of the relief, equity jumps up as undercapitalized banks are forced to issue equity. In spite of this jump in equity, lending and deposit-taking fall as loan losses and deposit inflows now trigger immediate issuance for these banks.

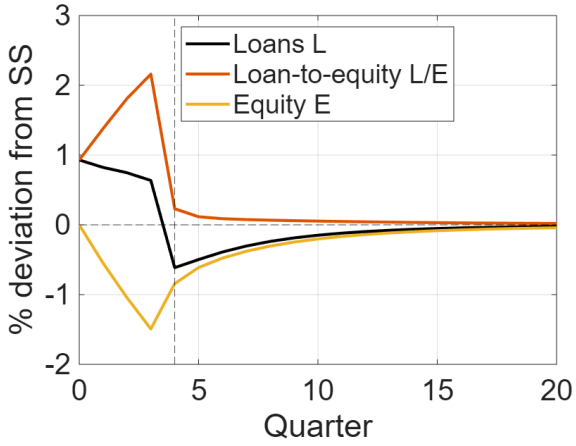
Quantitatively, the effect on loans is sizable: at the peak, loans expand by 0.93% of the steady-state amount, while deposits only expand by 3.7bps. After the relief ends, lower equity levels lead to 0.61% fewer loans and up to 3.7bps fewer deposits compared to steady state at reinstatement. Increased competition yields a drop of 1.9% in the deposit spread when the relief starts, which reverts to a 1.5% higher spread right before the relief ends as deposits are more of a liability then.

The loan spread is the price that changes the most: it falls by 11.2% at the start of the relief and by 7.7% right before the relief ends, and is 7.5% above its steady-state level once the LR requirement is reinstated.

Decomposing the lending changes. I decompose the change in aggregate loans into the proximate causes of these changes: changes in equity and changes in the willingness of banks to lend given their capitalization. In steady state, lower capitalization lowers aggregate lending, either because banks are more at risk of future issuance after loan losses, or because banks with binding capital requirements are forced to reduce their lending. Banks can also choose to change their loan-to-equity ratio $\frac{l(e)}{e}$ due to the leverage relief. I decompose aggregate loans as follows:

$$L_t = \underbrace{\frac{L_t}{E_t}}_{\text{loan-to-equity ratio}} \underbrace{E_t}_{\text{equity}}, \qquad \text{where } \frac{L_t}{E_t} = \frac{\int l_t(e) h_t(e) de}{\int e h_t(e) de}.$$

Figure 6: Decomposing the lending response



Notes: All amounts are percentage deviations from the steady state. The dashed vertical line marks the end of leverage relief.

Figure 6 decomposes the loan change into the changes in the average loan-to-equity ratio and aggregate equity. It shows that as lending expands while equity falls, the average loan-to-equity ratio increases. I now analyse separately why banks' loan-to-equity ratio and equity change.

5.1.1 Why does the loan-to-equity ratio change?

The aggregate loan-to-equity ratio has two time-varying parts: the policy function $l_t(e)$ and the deposit-weighted distribution $h_t(e)$ with which it is weighted. I therefore decompose the change in

the loan-to-equity ratio into

$$\frac{L_t}{E_t} = \underbrace{\frac{L}{E}}_{\text{SS loan-to-equity ratio}} + \underbrace{\frac{\int (l_t(e) - l(e))h(e)de}{\int eh(e)de}}_{\Delta\text{policy}} + \underbrace{\left(\frac{\int l(e)h_t(e)de}{\int eh_t(e)de} - \frac{L}{E}\right)}_{\Delta\text{distribution}} + \text{Residual.}$$

The term Δpolicy captures the change in the loan-to-equity ratio that would arise if the capitalization distribution of banks remained unchanged, but the policy function were to change as it does. The term Δdistribution captures the change in the loan-to-equity ratio that would arise if the capitalization distribution changes as it does, but the policy function were to remain as in steady state. These two terms are the only changes that would occur if the model were linearized.[12] The residual term captures the non-linear effect: the change in the average loan-to-equity ratio that arises because l_t and h_t change jointly; the effect of the distribution moving to a region where the willingness to lend is affected much by leverage relief.

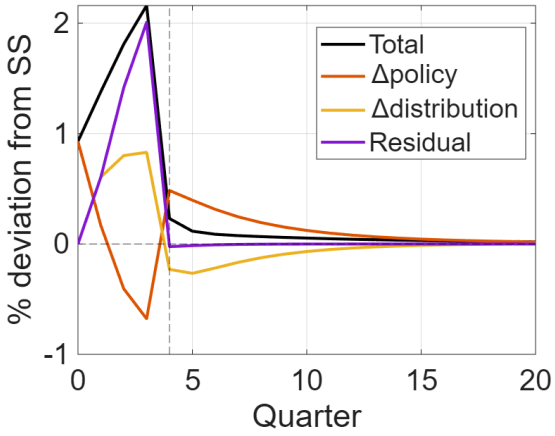
The steady-state policy function $l(e)$ is key to how large Δdistribution is. However, because in steady state all banks have $e \geq \underline{e}$, the steady-state policy function $l(e)$ is ill-defined for $e < \underline{e}$. During the leverage relief, banks can and do reach levels of capitalization lower than $\underline{e}$, so an extension of $l(e)$ is needed. The steady-state policy function $l(e)/e$ increases everywhere, making it natural that $l(e)/e \leq l(\underline{e})/\underline{e}$ for all $e < \underline{e}$. As a counterfactual bank would issue equity up to $\underline{e}$, I extend $l(e)$ such that $l(e)/e = l(\underline{e})/\underline{e}$ for $e < \underline{e}$. That is, the loan-to-equity ratio does not change as banks become undercapitalized.

Figure 7 decomposes the change in the loan-to-equity ratio. It shows that at the start of the leverage relief, changes in the policy function $l_t(e)$ drive the change in the loan-to-equity ratio, while later in the relief most of the increase in the loan-to-equity ratio comes from the residual. It is natural that at the start of the relief all of the change comes from the policy function: the distribution has not yet had time to move. That the residual dominates later means that the probability mass of banks moves to a region where their willingness to lend changes a lot.

Perhaps surprisingly, the loan-to-equity ratio is higher right after the relief ends than in steady state. This is in spite of banks having lower capitalization levels, which would lower the loan-to-equity ratio in partial equilibrium. Indeed, Δdistribution is negative: banks now have capitalization levels at which they lend less in steady state. However, on aggregate, banks lend more per unit of equity as Δpolicy is more positive. Banks with the same capitalization lend more as the loan

[12] Thinking about linearization does not make much sense with this kind of policy; there either is leverage relief or not. For other policies, such as interest rate policies, it makes more sense.

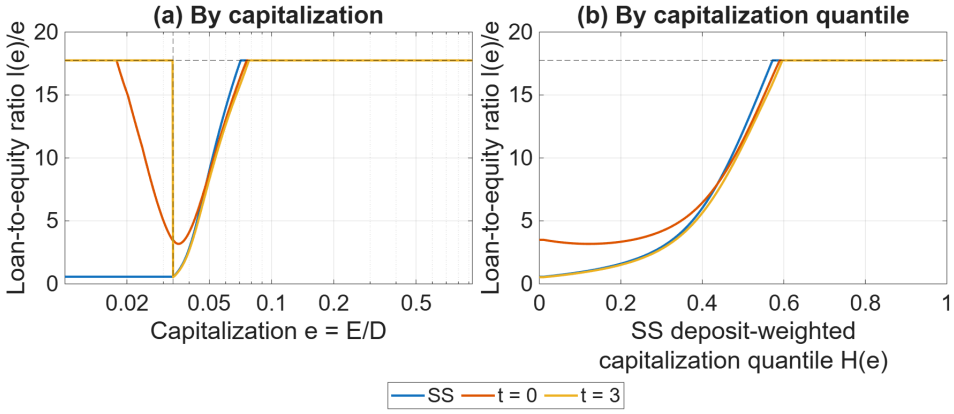
Figure 7: Decomposing the loan-to-equity ratio



Notes: Each term of the decomposition of L_t/E_t is in percent of steady-state L/E; below $\underline{e}$ the steady-state policy is $l(e) = l(\underline{e})e/\underline{e}$. The dashed vertical line marks the end of leverage relief.

spread is higher: lower equity leads to a drop in loan supply, which causes banks to lend more with the equity that they do have as it is now more profitable. The higher loan spread compensates for the fact that lending is more likely to trigger equity issuance for many banks.

Figure 8: Bank-level loan-to-equity ratio during leverage relief



Notes: Panel (a): as a function of e, on a logarithmic scale from $e = 0.01$; below $\underline{e}$ the steady-state line is the assumed $l(\underline{e})/\underline{e}$. Panel (b): as a function of steady-state deposit-weighted capitalization quantiles $H(e)$. Shown at steady state, at the start of the relief ($t = 0$), and at the start of its last quarter ($t = 3$). Shows the least-capitalized banks holding 99% of steady-state deposits. The vertical dashed line gives the LR requirement when it is reinstated, while the horizontal dashed line signals the capital requirement.

Figure 8 displays the loan-to-equity ratio $l_t(e)/e$ as a function of capitalization e in steady state, right after the relief starts ($t = 0$) and at the start of its last quarter ($t = 3$). Panel (b) shows that the least-capitalized 45% of banks lend more after the relief starts, with the increase being larger the less capitalized they are. In steady state, the least-capitalized banks face near-term issuance after

loan losses. The leverage relief removes that risk, causing these banks to lend more: the leverage channel. As these banks are also the banks with the least slack relative to the LR requirement, this is consistent with the causal evidence of Koont & Walz (2021) that large US banks with less slack during the LR requirement increased lending more after the Fed implemented leverage relief in 2020.

The better-capitalized banks with non-binding capital requirements lend marginally less as the loan spread falls due to increased competition from the least-capitalized banks. These banks barely benefit from the relief: they were unlikely to hit the LR requirement during the year of the relief in the first place. The banks with a binding capital requirement do not change their loan-to-equity ratio as they were not at an interior solution to begin with, so their choices do not change with small price changes.

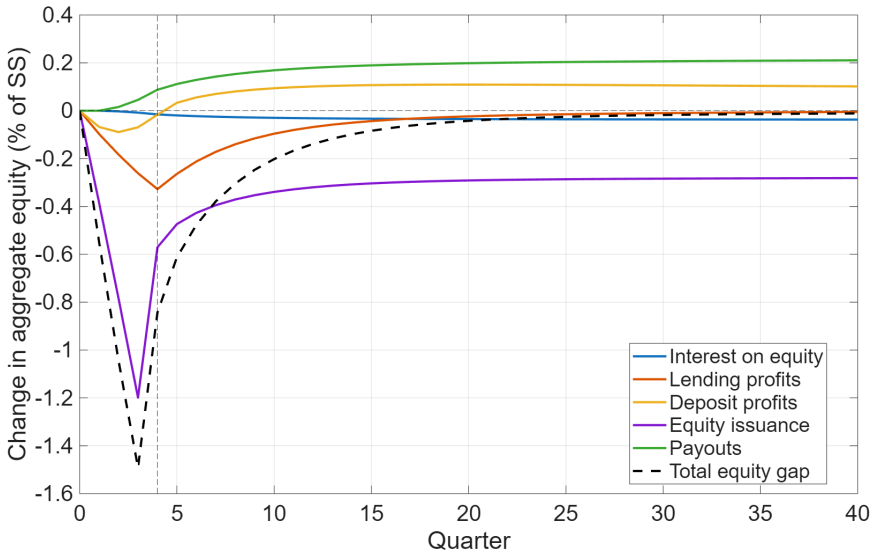
Panel (a) also shows what undercapitalized banks ($e < \underline{e}$) do: their loan-to-equity ratio becomes decreasing in e around $\underline{e}$, lending more relative to equity as their capitalization falls. The loan-to-equity ratio of undercapitalized banks also increases over time: at $t = 3$ all undercapitalized banks have a binding capital requirement—lending as much as they are allowed to. This explains why the residual is so large: banks that would need to recapitalize and would not lend without leverage relief are present and lending a lot. At the start of the last quarter of leverage relief ($t = 3$), all banks with $e > \underline{e}$ have a lower loan-to-equity ratio than in steady state; their lending is crowded out by undercapitalized banks lending much more, reducing the return to lending of all banks.

5.1.2 Why does equity change?

Equity falls by up to 1.5% during leverage relief. Figure 9 decomposes the drop in aggregate equity into proximate causes: differences in issuance, profits, and payouts. Profits are further decomposed into three parts: the return on investing equity into reserves rE, the aggregate lending profit $\alpha^L L_t$, and deposit profits, which are the remainder.

Most of the drop in equity comes from a decrease in issuance; banks that would have fallen below the LR requirement without leverage relief no longer have to issue equity. Not all of the drop in issuance is made up at the end of leverage relief: cumulative equity issuance is 0.6% of steady-state equity lower right after the relief, as some banks managed to (partially) recover their equity deficits with profits rather than issuance, hurting their longer-term equity position. Still, issuance is above steady-state levels right after leverage relief ends, as more banks are near the LR requirement than in steady state, causing more banks to issue equity.

Figure 9: Proximate causes of the change in equity



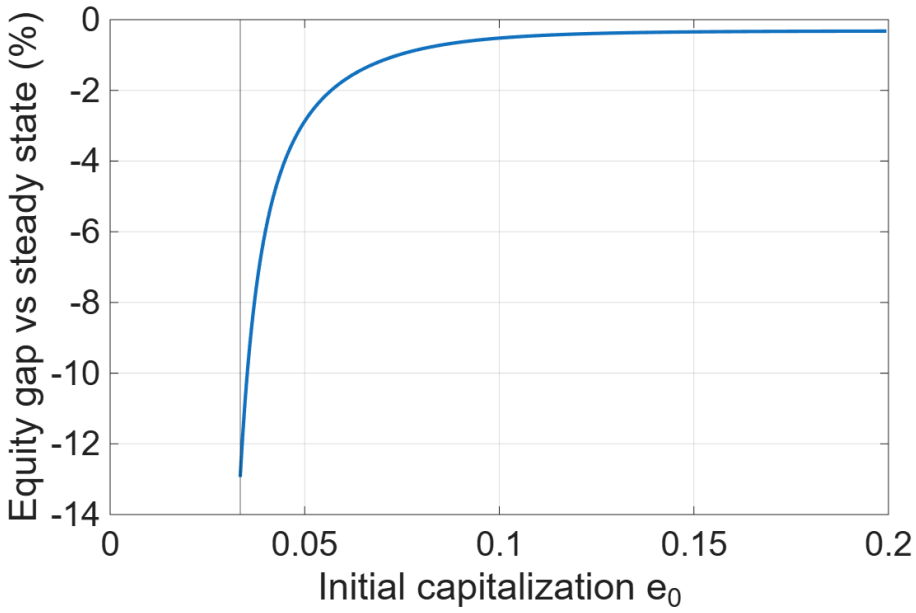
Notes: Cumulative contribution of each flow to the gap between aggregate equity and its steady-state level, in percent of steady-state equity. The dashed vertical line marks the end of leverage relief.

While 80% of the drop in equity is explained by lower issuance, the reduction in lending profits due to more competition for loans contributes about 20% of the drop in equity at its peak. In contrast to the benchmark, the effect of deposit competition on earnings is small. As banks take more deposits during leverage relief, their equity falls marginally. Moreover, this effect is largely due to a shift in profits: as attracting sticky deposits costs incentives upfront, banks have lower profits when they grow but higher profits thereafter or when they shrink. Towards the end of the relief, the total effect of deposit profits on equity is already approximately 0, turning positive thereafter. Payouts have a mild positive effect on equity: as equity falls, mechanically banks pay out less equity, partially offsetting the drop. Interest on equity invested mechanically moves the other way, but is quantitatively less strong.

To what extent does lower equity translate into fewer loans? In contrast to the steady-state case, where the loan-to-equity ratio rises monotonically in capitalization, undercapitalized banks have higher loan-to-equity ratios than many better-capitalized banks during the leverage relief. This raises the question: to what extent does the drop in equity actually translate into fewer loans during the leverage relief?

Figure 10 shows the expected change in equity over the first three quarters of the relief (at $t = 3$) relative to the steady state of banks across the capitalization distribution. All banks lose equity relative to the steady state, with banks losing less when they are better capitalized. Consistent

Figure 10: Equity loss by initial capitalization

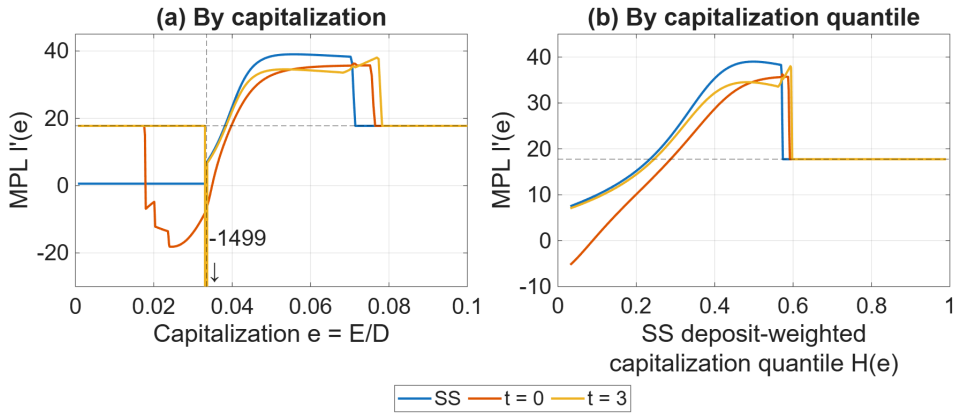


Notes: Deposit-weighted change in equity at $t = 3$ of the surviving banks that entered leverage relief at capitalization e_0, in percent deviation from the equity the same banks would hold in steady state. The vertical line marks the LR requirement $\underline{e}$.

with issuance being the leading cause of the change in aggregate equity, the gap is much larger for the least-capitalized banks, which lose up to 13% more of their steady-state equity, as they were the ones most likely to issue equity before. Better-capitalized banks lose a lot less equity, as they were not likely to issue equity in the first place and thus avoided less issuance. Still, all banks lose equity as increased competition means lower profits on loans. Banks in the middle lose more than the best-capitalized banks as they also start lending less, which reduces expected profits: lending has positive NPV throughout, as the loan spread never turns negative.

Figure 11 displays the marginal propensity to lend (MPL) $l'(e)$—introduced by Bellifemine et al. (2025)—during leverage relief for different levels of capitalization: how much more banks lend when they receive an additional unit of equity. This is slightly different from the loan-to-equity plot, as the same loan-to-equity ratio implies less lending when equity is lower, which this graph incorporates. The graph shows that for the least-capitalized banks, the MPL turns negative: banks lend more as they lose equity. At $t = 0$, this holds for the least-capitalized 10% of banks and all undercapitalized banks until $e \approx 2\%$, which is where the capital requirement starts binding. When banks' capitalization falls further, their lending does fall. Consistent with the simple model, in the last quarter of the relief ($t = 3$) it only obtains for banks with $e \approx \underline{e}$, where it turns extremely

Figure 11: Marginal propensity to lend out of equity



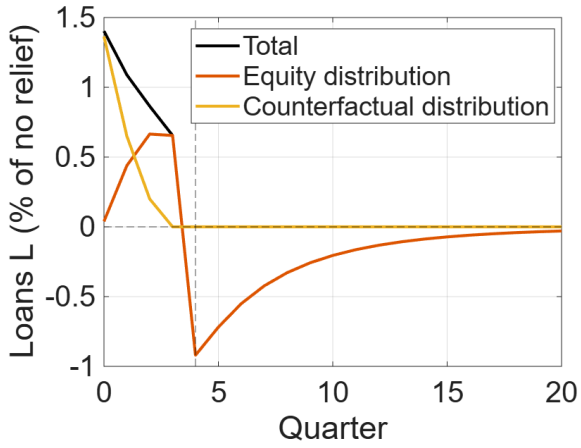
Notes: Panel (a): as a function of e. Panel (b): as a function of steady-state deposit-weighted capitalization quantiles $H(e)$. Shown at steady state, at the start of the relief ($t = 0$), and at the start of its last quarter ($t = 3$); below $\underline{e}$ the steady-state policy is the assumed $l(e) = l(\underline{e})e/\underline{e}$. Panel (a) shows $e \leq 0.1$; at all three dates the capital requirement binds, $l'(e) = \xi_K$, from $e = 0.078$ on. Capitalization levels below which no more than 0.1% of deposits lie at any date of the transition are omitted. Panel (b) shows the least-capitalized banks holding 99% of steady-state deposits. In the last quarter, $l(e)$ jumps at $\underline{e}$; panel (a) cuts the axis and the arrow gives the minimum, and panel (b) omits the first points, where the slope spans this jump. The vertical dashed line gives the LR requirement, while the horizontal dashed line signals the capital requirement ξ_K.

negative: banks go from almost no lending to a binding capital requirement. This is the deferred issuance channel: lower equity raises lending for these banks.

The logic here is as in the simple model. As these banks' capitalization falls, they are less likely to be sufficiently lucky with deposit outflows and loan gains to recover their capitalization before leverage relief ends. As a result, losses increase equity issuance costs, but loan gains decrease equity issuance costs by a symmetric amount. This makes the banks more risk-neutral as equity issuance becomes unavoidable. As loans have positive NPV, on average there are more gains than losses, making banks closer to risk-neutrality and inclined to lend more. This effect becomes stronger closer to the end of leverage relief as capitalization is less likely to recover.

However, the MPL alone does not answer how much of the lending change can be attributable to equity changing. Figure 12 shows the lending change that would happen if banks made decisions as if their state variable were to change as usual during leverage relief, but the distribution of banks' capitalization and aggregate deposits is kept fixed at their steady-state values, while market prices still clear. Note that in particular, this means that aggregate equity and deposits are kept fixed. The yellow line then gives how much equity would change with this counterfactual steady-state distribution, and the red line is the residual: the difference between actual lending and lending with the steady-state distribution fixed at its counterfactual level.

Figure 12: Lending from the change in the capitalization distribution after a deposit inflow



Notes: In percent of loans after the same inflow without leverage relief. Total: the change in loans. Counterfactual distribution: the change in loans when banks follow the policies under leverage relief, but deposits and the distribution of capitalization follow their paths after the inflow without leverage relief, and prices clear the deposit and loan markets. Equity distribution: the total minus the counterfactual-distribution change. The dashed vertical line marks the end of leverage relief.

At the start, all lending change would also occur with the counterfactual distribution: the distribution has not had time to move yet. However, over time counterfactual distribution lending goes to zero. As the end of the leverage relief draws near, banks that are not undercapitalized are no longer affected by the leverage relief, as after realized losses push these banks into undercapitalized territory, the leverage relief has likely already ended. Thus, all of the increase in loans at the end of the relief can be ascribed to the deferred issuance channel.

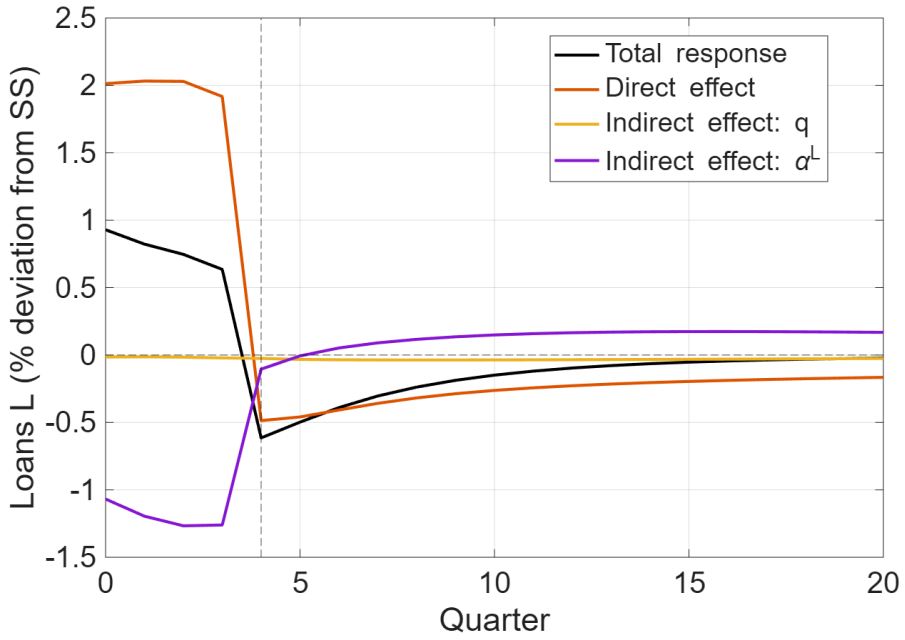
After the relief ends, all of the drop in lending can be ascribed to changes in equity (and deposits, but those change little): the leverage relief has already ended, so the only remaining effect it has is on equity and deposits.

5.2 PE versus GE

This subsection investigates to what extent general equilibrium feedback effects affect the lending response. The decomposition follows Bellifemine et al. (2025); it is not exact, as the model is not linearized.

Figure 13 decomposes the lending response into a direct partial equilibrium effect and general equilibrium effects. Each line incorporates both changes in policy functions and changes in the distribution of banks from either the direct effect or a price change in the case of an indirect effect. The direct effect consists of how much loan supply would increase if banks faced the same prices,

Figure 13: Direct and indirect effects on lending



Notes: Percentage deviations of loans from steady state. Direct effect: both prices at their steady-state values. Indirect effects: one price on its equilibrium path, the other at its steady-state value. The dashed vertical line marks the end of leverage relief.

but with leverage relief. This direct effect thus incorporates both channels: lower issuance yielding lower equity levels (deferred issuance channel), and more lending as banks are willing to take more risk (leverage channel). The general equilibrium effects consist of the change in loan supply if a specific price were changed as it is in the general equilibrium outcome, but without leverage relief, while other prices remain constant.

The largest effect is the direct/partial equilibrium effect: in the absence of price adjustments, banks' lending would expand by 2% for much of the relief. Increased competition for loans decreases banks' lending through the loan spread by 1%, increasing to 1.2% over the relief period, dampening the lending response.

Changes in the price of deposits have little effect on the supply of loans. This is likely because the price of deposits does not change much: banks incorporate that depositors on average stay about 9 years, so they choose to take few additional deposits in response to leverage relief. This is rather different from the benchmark, where banks have no such intertemporal considerations and do compete much more fiercely for deposits.

5.3 Varying the length of the relief

Figure 14 compares the IRFs of four-quarter leverage relief with those of a six-quarter leverage relief. Overall, longer leverage relief leads to amplified effects: panel (a) shows that when a longer leverage relief is announced, banks lend more throughout the relief, but less after the relief. Panel (b) shows that this increase is mainly driven by banks' loan-to-equity ratio increasing: with a longer time until potential equity issuance, banks are more willing to lend and take risk. However, panel (c) shows that this has a downside: equity falls faster. This is in part because equity falls slightly faster during the four quarters that leverage relief is applied, and in part because it lasts longer, leading to a total drop of 2.6% of equity at the end of the relief. This reduction in equity drives the reduction in loans at the end of leverage relief. Panel (d) shows that deposits increase much more during leverage relief.

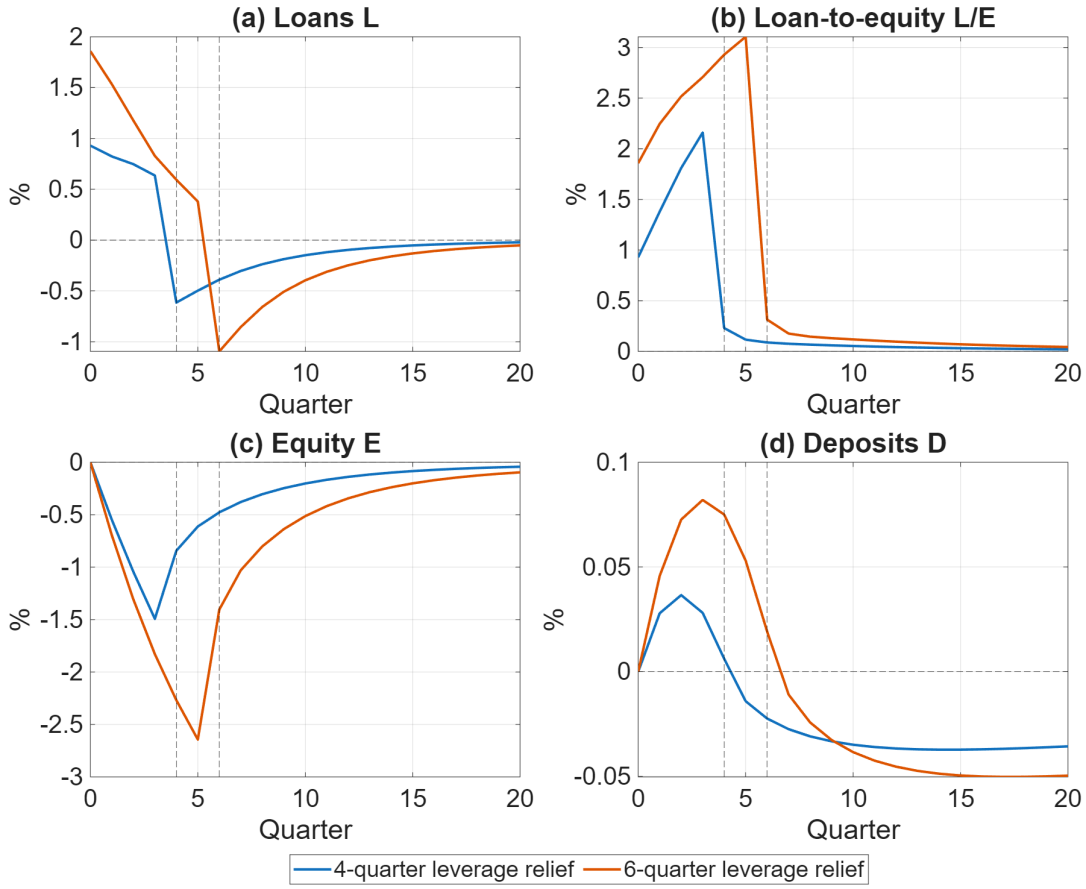
During the first three quarters of leverage relief, equity falls 0.34%-point more with longer leverage relief. This happens despite avoided issuance being approximately the same amount. Lending profits cause the majority of the additional drop in equity: cumulative lending profits are 0.22%-point lower, while deposit profits are 0.14%-point lower as banks spend more on attracting deposits.

5.4 Leverage relief after deposit inflows

During Covid, between December 2019 and September 2020, euro area household and NFC deposits rose by 8.0% while bank equity fell by 0.1%. Against this backdrop, the ECB implemented leverage relief in September 2020. This subsection compares the lending response after all banks receive a proportional deposit inflow and leverage relief versus one without leverage relief. In this exercise, I assume that all banks in steady state saw an 8.0% deposit increase, while equity fell 0.1%. After the initial inflow, deposit demand is unchanged, making deposits slowly return to their old steady-state level. Figure 15 shows what this does to the capitalization distribution of banks. After the inflow, 14.2% of deposits move below the LR requirement and need to be recapitalized in the absence of leverage relief. In the absence of leverage relief, this would lead to 0.16% of steady-state equity in additional issuance.

Figure 16 shows how loans, the loan-to-equity ratio, equity and deposits behave after an inflow with and without leverage relief. The increase in deposits leads to more lending, but less than proportionally, as many banks are near the constraints. Throughout the ten years plotted here, equity rises as banks do not fully replace the deposits that leave, saving them equity they would otherwise spend competing for deposits.

Figure 14: Aggregate IRFs: four- vs. six-quarter leverage relief

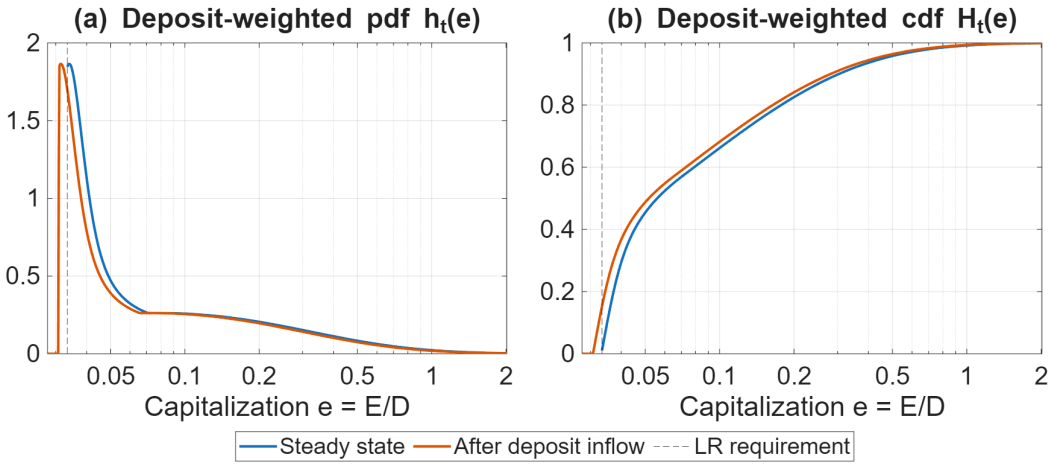


Notes: Variables are percentage deviations from steady state. Dashed vertical lines mark the end of each leverage relief period.

Figure 17 compares the difference in loans and deposits with and without an inflow. This figure shows that after an inflow, leverage relief leads to a change in loans at the peak of 1.40% instead of 0.93%. Moreover, the subsequent drop in lending increases from 0.61% to 0.92%. Deposits move by a similar factor; at the peak the increase in deposits rises from 3.7bps to 5.6bps, and the trough deepens from -3.7bps to -5.4bps. Equity is also more important for banks after an inflow, as more of them are near the LR requirement, where near-term equity issuance is likely: this causes both more of an increase in the loan-to-equity ratio and more of a drop in equity due to leverage relief as more issuance is avoided.

Table 5 displays why equity falls more after leverage relief after a deposit inflow. Indeed, 0.49%-point lower equity issuance accounts for most of the 0.56%-point drop. Of the avoided issuance, 0.16%-point is already avoided at $t = 0$ by banks that became undercapitalized due to the deposit inflow, whereas there are no undercapitalized banks at $t = 0$ with leverage relief without an inflow.

Figure 15: Capitalization before and after the deposit inflow



Notes: Deposit-weighted distribution of $e = E/D$, with the capitalization axis on a logarithmic scale. Panel (a) is the density with respect to $\log e$; panel (b) the cumulative distribution. The inflow raises deposits by 8.0% and lowers equity by 0.1%. The dashed line marks the LR requirement: 14.2% of deposits lie below it after the inflow, against none before. Shows the least-capitalized banks holding 99.9% of deposits.

Lending and deposit profits also fall more, as banks expand lending and deposit taking more due to more banks being at risk of equity issuance. However, in total this effect is 0.1%-point, which is only a fifth of the effect of issuance.

Table 5: The effect of leverage relief on equity at $t = 3$, with and without a preceding deposit inflow

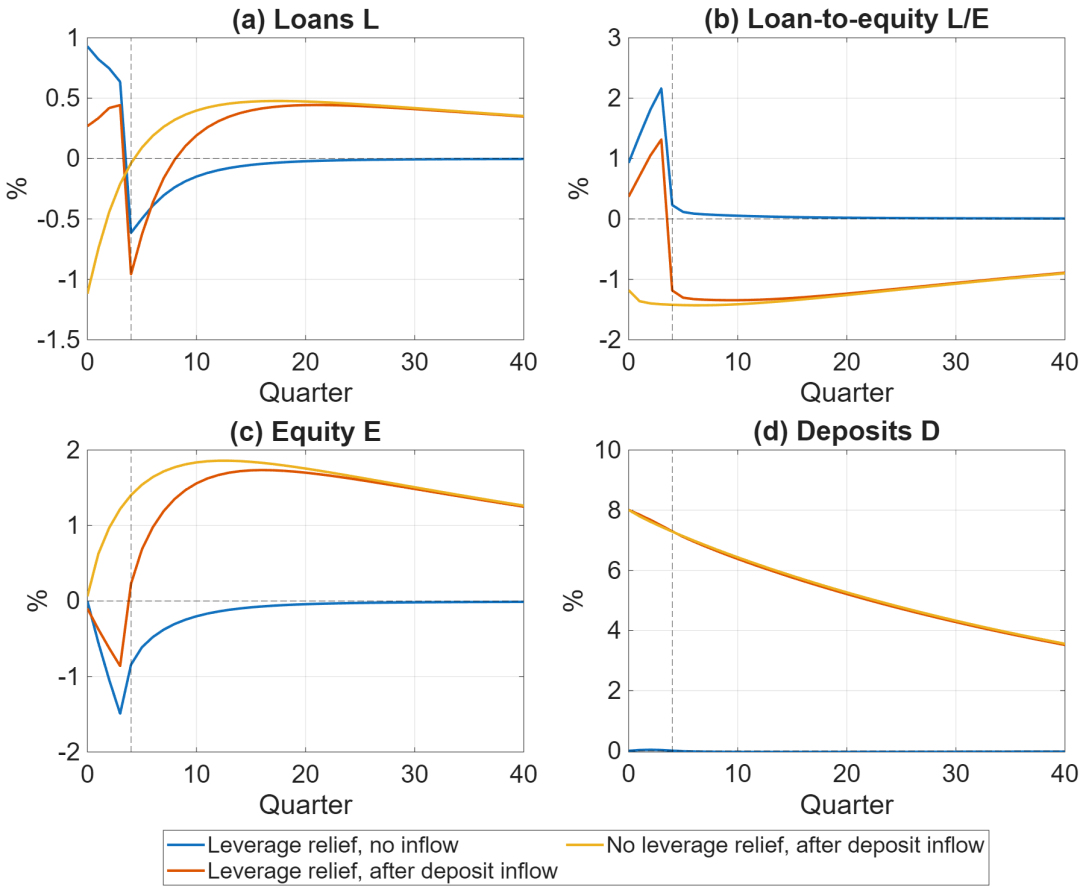
	No inflow	Inflow	Difference
Lending profits	−0.26	−0.34	−0.08
Deposit profits	−0.07	−0.09	−0.02
Issuance	−1.20	−1.69	−0.49
Total change	−1.49	−2.06	−0.56

Notes: Cumulative contribution of each flow from $t = 0$ to $t = 3$ to the gap between equity with and without leverage relief, in percent of equity without leverage relief at $t = 3$. Without an inflow the counterfactual is the steady state itself. Issuance includes the forced recapitalization at $t = 0$ in the setting with an inflow and without leverage relief. The total change also includes minor factors not shown: interest on equity and the outflow of equity through bank exit. Issuance is backed out of the law of motion of aggregate equity, so that the rows and these minor factors add up to the total change.

5.5 Comparative statics

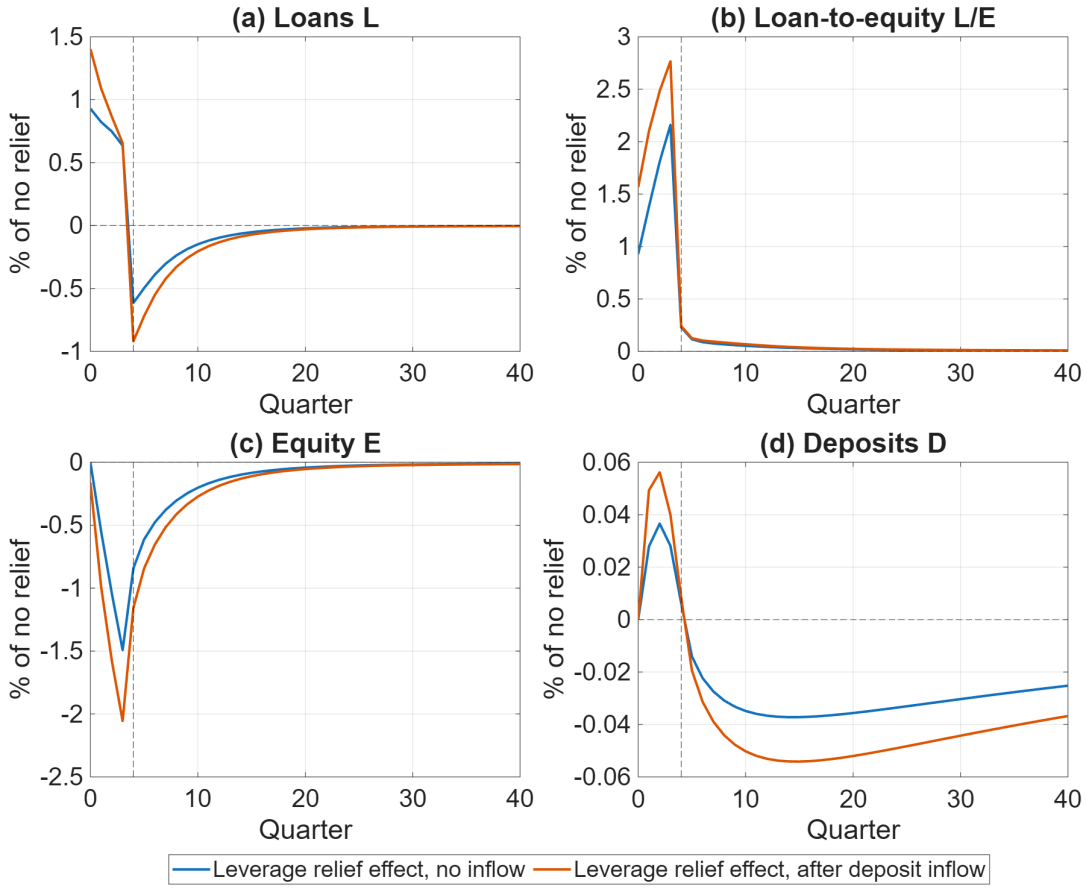
Appendix J gives the impulse response functions with different parameters for comparative statics. In particular, it shows that the duration of deposits does not impact bank lending much.

Figure 16: Aggregate response to four-quarter leverage relief, with and without a preceding deposit inflow



Notes: Percentage deviations from the pre-inflow steady state, so the two inflow arms begin displaced rather than at zero. The inflow is transitory: deposit demand is unchanged, so deposits return to their original level and the economy to its original steady state.

Figure 17: The effect of leverage relief, with and without a preceding deposit inflow



Notes: Each setting divided by its own counterfactual without leverage relief: in Figure 16 the effect from the inflow is much larger than anything leverage relief does. All panels are ratios in percent. Without an inflow, the counterfactual is the steady state itself.

6 Benchmark: flexible deposits

This section develops a flexible-deposit benchmark to establish what the role of stickiness is in driving the sticky-deposit model's response to leverage relief. In particular, it shows that in a dynamic model where the LR requirement limits deposit supply of banks, while a capital requirement limits loans, lending falls during leverage relief. The reason is that leverage relief allows a bank to take an unlimited amount of deposits. This pushes the return on deposits to zero, reducing bank profits and hence bank equity. As a result, the capital requirement becomes tighter, forcing banks to lend less. In the flexible-deposit benchmark, deposits only stay in the bank overnight. In this benchmark, the rate of depositors exiting a bank λ^D goes to infinity and adjustment costs $\theta = 0$. The former implies that depositors leave a bank arbitrarily fast, while the latter implies that banks can freely adjust their deposit levels, undoing the two characteristics of stickiness in the model. As a result, banks no longer pay upfront incentives ($q_t \to 1$), and depositors receive a competitively set interest rate r_t^D. As banks can perfectly adjust their leverage ratio by changing how many deposits they hold, there is no longer the risk of idiosyncratic shocks triggering equity issuance. The marginal value of equity $\tilde{V}_t$ is the same for every bank, and the model can be written as one of a representative bank holding capital E_t.

I calibrate the benchmark to the same equilibrium steady-state loan spread as with sticky deposits.[13] Deposits are still fixed at 1, and the deposit spread adjusts to keep the bank in steady state. The capital requirement binds, and hence lending is one-to-one with bank equity, as in the capital channel of monetary policy (e.g., Van den Heuvel (2002); Wang (2025)).[14] The main departure from this literature is that banks can and do issue equity: in steady state, banks choose to issue equity if the equilibrium marginal value of equity exceeds $1 + \psi$.

The benchmark is formally solved in Appendix D. This section discusses the main insights.

[13] It is not possible to do exactly the same calibration as with sticky deposits, notably as banks always have two binding leverage requirements: the deposit-to-equity and loan-to-equity ratios are fixed at the regulatory amounts. Moreover, banks always have no buffer over the LR requirement. Targeting the loan spread rather than a quantity ensures that the capital requirement binds: the capital requirement binds if and only if $\alpha^L > 0$. This is the interesting case for dynamics as a non-binding capital requirement implies that $\alpha_t^L = 0$ locally for small shocks regardless of what happens to the bank as these banks do not have endogenous risk-aversion as they avoid involuntary issuance by adjusting deposits.

[14] The more recent papers in the tradition of Gertler & Kiyotaki (2010), including Wang (2025); Bellifemine et al. (2025), consider endogenous leverage requirements based on agency friction. Here, the leverage requirement not only depends on equity, but also on the value of the bank. This creates slightly more nuanced mechanics as value also changes. The exogenous leverage requirements considered here are as in e.g. Begenau et al. (2026); Abad et al. (2026).

6.1 Banks' choices and aggregates

In this benchmark, banks' expected profits are

$$\left(rE_{jt} + \alpha_t^L L_{jt} + (r - r_t^D)D_{jt}\right) dt. \tag{15}$$

Each deposit earns the deposit spread $r - r_t^D$ at no cost. Whenever $r > r_t^D$ and $\alpha_t^L > 0$, lending and deposit-taking return a profit on average, making both leverage requirements bind for any bank—$L_{jt} = \xi_K E_{jt}$, $D_{jt} = (\xi_L - 1)E_{jt}$—and as a result they hold in the aggregate:

$$L_t = \xi_K E_t, \qquad D_t = (\xi_L - 1)E_t. \tag{16}$$

6.2 Aggregate equity & equity issuance

Aggregate equity evolves according to

$$dE_t = \int dE_{jt} dj - E_t \lambda^B dt, \tag{17}$$

where dE_{jt} is the change in equity of surviving banks. By the law of large numbers, idiosyncratic loan shocks integrate out across banks. Banks' equity thus grows with the average profit and equity issuance, but shrinks as banks exit. Total equity issuance by banks is eq. $\text{iss.}_t dt = \int dF_{jt} dj$. Using that $\int \mu^D h de = \frac{dD_t}{D_t} + \lambda^B$ by market clearing, $D_t \int l h de = L_t$, the definition of r_t^D (1), and that $q_t \to 1$, $\theta = 0$, it follows that in the benchmark aggregate equity evolves as follows:

$$\frac{dE_t}{E_t} = \left(\overbrace{r + (r - r_t^D)\frac{D_t}{E_t} + \alpha_t^L \underbrace{\frac{L_t}{E_t}}_{\xi_K}}^{\text{ROE}} - \lambda^B + \text{eq. iss.}_t \right) dt. \tag{18}$$

Outside leverage relief, $D_t/E_t = \xi_L - 1$. Note that banks with more equity demand more deposits and supply more loans, pushing down the intermediation margins as equity grows. The prices on the right-hand side come from plugging in aggregate bank deposit demand and loan supply into the inverse deposit supply function and the inverse loan demand function. If equity issuance were not an option, steady-state equity would be the level of equity where the ROE, which is decreasing in equity, equals λ^B, such that aggregate equity would remain unchanged.

However, if intermediation is sufficiently profitable, banks might want to issue equity in steady

state. If the marginal value of equity $\tilde{V}_t \geq 1 + \psi$, banks issue equity. The marginal value of equity is

$$\tilde{V}_t = \int_t^\infty \lambda^B \exp\left(-\int_t^s \left(r + \lambda^B - \text{ROE}_u\right) du\right) ds, \quad \text{ROE}_t = r + (r - r_t^D)\frac{D_t}{E_t} + \alpha_t^L \xi_K. \tag{19}$$

The steady-state value of equity increases in the ROE. As equity rises, the ROE falls and banks are less inclined to issue equity, so the steady state remains unique. If banks want to issue equity at the no-issuance steady state, steady-state equity is the level at which they are indifferent between issuing and not issuing: $\tilde{V} = 1 + \psi$.

Notably, banks issue 2.9% of their steady-state equity per year in the benchmark. This compares with 1.68% in the sticky-deposit model, and 3.5% for the 20 largest US banks over a 22-year span (Baron, 2020).

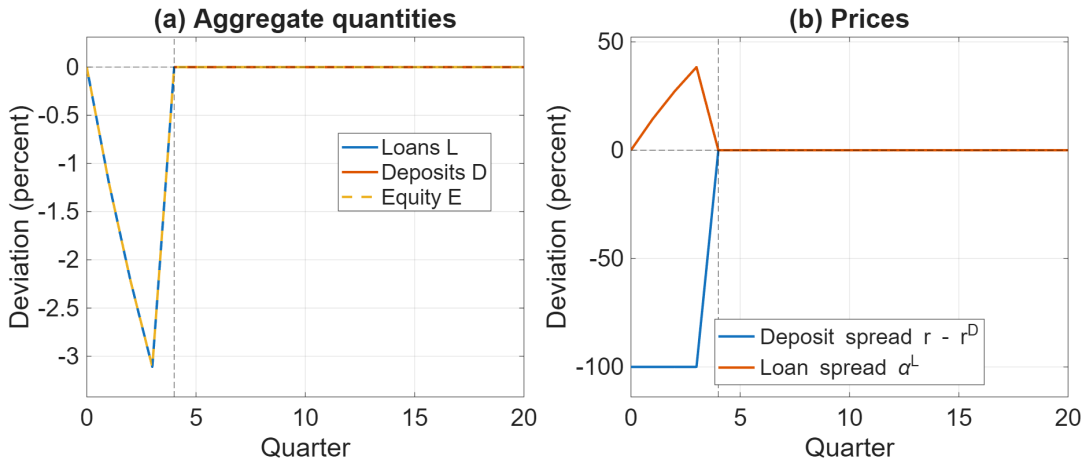
6.3 Effects of leverage relief on bank lending

Figure 18 shows how aggregate quantities and prices adjust to four-quarter leverage relief. Panel (a) shows that both equity and loans fall during the relief, falling to 3.11% below steady state at the start of the last quarter. Note that loans and equity fall together as loans are a multiple of equity as the capital requirement binds throughout the relief. After the leverage relief ends, loans, equity, and deposits instantly return to their steady-state values. Panel (b) shows that during the relief, the loan spread increases as loan supply falls, while the deposit spread goes away completely—falls 100%. This drop in deposit spread comes from the first-order condition of the banks: as in the sticky-deposit model, leverage relief allows a bank to take an infinite amount of deposits. As each marginal deposit earns the deposit spread, this yields the first-order condition $r_t^D = r$, closing the deposit spread.

Leverage relief in the benchmark does not operate through the two channels of the sticky-deposit model. The leverage channel does not apply: banks can perfectly offset idiosyncratic shocks, and as a result all banks act as if risk-neutral and lend as much as the capital requirement allows them.

There is a deferred issuance channel in the sense that loans move because equity moves. However, here a drop in equity causes a decrease in loans—opposite to the expansion in the sticky-deposit model. The closing deposit spread lowers equity in two ways. First, deposit profits vanish. Second, issuance stops: once deposits are no longer limited by equity, an extra unit of equity no longer earns deposit profits, and in my calibration $\tilde{V}_t$ falls below $1 + \psi$. Issuance resumes only once equity

Figure 18: Aggregate response to four-quarter leverage relief: flexible deposits



Notes: Percentage deviations from the steady state of the flexible-deposit benchmark. Panel (a): loans L, deposits D, and equity E; deposits are not shown during the relief, when they are unbounded. Panel (b): the deposit spread $r - r_t^D$, which equals $q_t(r - r_t^D)$ in Figure 5 as $q_t = 1$ with flexible deposits, and loan spread α^L. The dashed vertical line marks the end of the relief.

has fallen far enough for loan profits to restore $\tilde{V}_t = 1 + \psi$, which takes longer than four quarters. Figure 19 shows that in the last quarter of the relief, stopped issuance accounts for about two thirds of the fall in equity and lower deposit profits for about half. Together these exceed the total fall, as higher lending profits offset about a fifth of it: the loan spread rises proportionally more than loans fall. At reinstatement, a lump of issuance restores equity to its steady-state level.

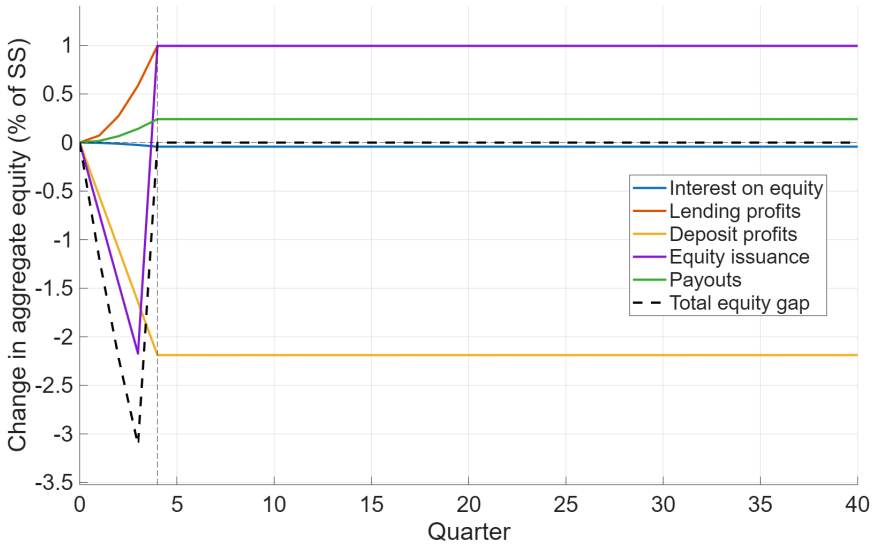
At reinstatement banking is as profitable as it is in steady state. This means that banks issue equity until $\tilde{V}_t = 1 + \psi$ holds again, which returns equity to its steady-state level as deposit supply and loan demand are static. Adjustment is therefore instant, unlike in the sticky-deposit model where lending remains depressed.

In conclusion, without deposit stickiness, leverage relief primarily creates more competition for bank deposits, lowering equity and loans, contrary to the Federal Reserve's stated aim of expanding credit (Board of Governors of the Federal Reserve System, 2020).

7 Conclusion

This paper proposed a general equilibrium quantitative model to analyse the bank lending response to a leverage relief. With deposit stickiness, this is characterized by a leverage channel and a deferred issuance channel, both of which expand lending. During the leverage relief, less-capitalized banks lend more as they no longer fear equity issuance after loan losses. Lower equity due to deferred

Figure 19: Proximate causes of the change in equity: flexible deposits



Notes: Cumulative contribution of each flow to the gap between aggregate equity and its steady-state level in the flexible-deposit benchmark, in percent of steady-state equity. The dashed vertical line marks the end of leverage relief.

issuance further contributes to lending during the leverage relief, but hurts lending after. As less-capitalized banks lend more, they crowd out the lending of better-capitalized banks. A limitation is that the paper does not consider financial instability, which would likely increase as a result of undercapitalized banks crowding out better-capitalized banks' lending.

Not taking deposit stickiness into account leads to different conclusions on the effectiveness of leverage relief.

References

Abad, J., Bigio, S., Garcia-Villegas, S., Marbet, J., & Nuño, G. (2026). The heterogeneous bank lending channel of monetary policy.

Achdou, Y., Han, J., Lasry, J., Lions, P., & Moll, B. (2020). Online appendix: Numerical methods for income and wealth distribution in macroeconomics: A continuous-time approach.

Achdou, Y., Han, J., Lasry, J.-M., Lions, P.-L., & Moll, B. (2022). Income and wealth distribution in macroeconomics: A continuous-time approach. *The Review of Economic Studies*, *89*(1), 45–86.

Acosta-Smith, J., Grill, M., & Lang, J. H. (2024). The leverage ratio, risk-taking and bank stability. *Journal of Financial Stability*, *74*, 100833.

Baron, M. (2020). Countercyclical bank equity issuance. *The Review of Financial Studies*, *33*(9), 4186–4230.

Basten, C., & Juelsrud, R. (2026). Cross-selling in bank-household relationships: Mechanisms and implications for pricing. *The Review of Financial Studies*, *39*(6), 1751–1784.

BCBS. (2020). *RBC 20 - calculation of minimum risk-based capital requirements.* Retrieved August 26, 2026, from `https://www.bis.org/basel_framework/chapter/RBC/20.htm`

Begenau, J., Bigio, S., Majerovitz, J., & Vieyra, M. (2026). A Q-theory of banks. *Review of Economic Studies*, *93*(1), 106–143.

Begenau, J., & Stafford, E. (2023). Uniform rate setting and the deposit channel.

Bellifemine, M., Jamilov, R., & Monacelli, T. (2025). HBANK: Monetary policy with heterogeneous banks.

Benetton, M., Hébert, B., & McQuade, T. (2025). *Deposit competition and pass-through: Theory and evidence beyond rates.* Presentation, EUR Finance seminar series.

Bianchi, J., & Bigio, S. (2022). Banks, liquidity management, and monetary policy. *Econometrica*, *90*(1), 391–454.

Blanchard, O. J. (1985). Debt, deficits, and finite horizons. *Journal of Political Economy*, *93*(2), 223–247.

Blickle, K., Li, J., Lu, X., & Ma, Y. (2025). The dynamics of deposit flightiness and its impact on financial stability.

Board of Governors of the Federal Reserve System. (2020, April). *Federal Reserve Board announces temporary change to its supplementary leverage ratio rule to ease strains in the Treasury market resulting from the coronavirus and increase banking organizations' ability to provide credit to households and businesses.* Retrieved August 26, 2026, from `https://www.federalreserve.gov/newsevents/pressreleases/bcreg20200401a.htm`

Bolton, P., Chen, H., & Wang, N. (2011). A unified theory of Tobin's q, corporate investment, financing, and risk management. *Journal of Finance*, *66*(5), 1545–1578.

Bolton, P., Chen, H., & Wang, N. (2013). Market timing, investment, and risk management. *Journal of Financial Economics*, *109*(1), 40–62.

Bolton, P., Li, Y., Wang, N., & Yang, J. (2025). Dynamic banking and the value of deposits. *Journal of Finance*, *80*(4), 2063–2105.

Breckenfelder, J., & Ivashina, V. (2023). Bank balance sheet constraints and bond liquidity.

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

Chiu, C.-W., Hill, J., et al. (2018). The rate elasticity of retail deposits in the United Kingdom: A macroeconomic investigation. *International Journal of Central Banking*, *14*(2), 113–158.

Corbae, D., & D'Erasmo, P. (2021). Capital buffers in a quantitative model of banking industry dynamics. *Econometrica*, *89*(6), 2975–3023.

De Nederlandsche Bank. (2021, June 22). *DNB follows ECB in extending leverage ratio relief for banks until 31 March 2022.* Retrieved 2026-10-31, from https://www.dnb.nl/en/sector-news/2021/sector-news-2021/dnb-follows-ecb-in-extending-leverage-ratio-relief-for-banks-until-31-march-2022/ (Accessed 31 October 2026)

Décamps, J.-P., Gryglewicz, S., Morellec, E., & Villeneuve, S. (2017). Corporate policies with permanent and transitory shocks. *The Review of Financial Studies*, *30*(1), 162–210.

Dempsey, K. (2026). Capital requirements with non-bank finance. *Review of Economic Studies*, *93*(3), 1635–1670.

EBA. (2026a). *Other systemically important institutions (O-SIIs).* Retrieved August 26, 2026, from https://www.eba.europa.eu/risk-and-data-analysis/risk-analysis/risk-monitoring/other-systemically-important-institutions-o-siis

EBA. (2026b). *Pillar 3 Data Hub.* EBA Data Hub. Retrieved August 26, 2026, from https://edap-public.eba.europa.eu/Report/index/MTE1?rhversion=20260806152911-2

ECB. (2016, November). *The Supervisory Review and Evaluation Process: What's new?* Supervision Newsletter. Retrieved August 26, 2026, from https://www.bankingsupervision.europa.eu/press/publications/newsletter/2016/html/nl161116.en.html

ECB. (2021, June). *ECB extends leverage ratio relief for banks until March 2022.* Press release. Retrieved August 26, 2026, from https://www.bankingsupervision.europa.eu/press/pr/date/2021/html/ssm.pr210618~6cae096a27.en.html

ECB. (2025, November). *Aggregated results of the 2025 SREP.* ECB Banking Supervision. Retrieved August 26, 2026, from https://www.bankingsupervision.europa.eu/activities/srep/2025/html/ssm.srep202511_aggregatedresults2025.en.html

ECB. (2026a). *Balance Sheet Items (BSI).* ECB Data Portal. Retrieved September 3, 2026, from https://data.ecb.europa.eu/data/datasets/BSI

ECB. (2026b). *Pillar 2 requirement.* ECB Banking Supervision. Retrieved August 26, 2026, from https://www.bankingsupervision.europa.eu/activities/srep/pillar-2-requirement/html/index.en.html

Egan, M. L., Hortaçsu, A., Kaplan, N. A., Sunderam, A., & Yao, V. (2025). Dynamic competition for sleepy deposits.

European Union. (2026). *Directive 2013/36/EU on access to the activity of credit institutions and the prudential supervision of credit institutions.* Official Journal of the European Union, L 176. Retrieved August 26, 2026, from https://eur-lex.europa.eu/eli/dir/2013/36/2026-07-11

Fischer, E. O., Heinkel, R., & Zechner, J. (1989). Dynamic capital structure choice: Theory and tests. *Journal of Finance*, *44*(1), 19–40.

Flannery, M. J. (1982). Retail bank deposits as quasi-fixed factors of production. *American Economic Review*, *72*(3), 527–536.

FSB. (2025). *2025 list of global systemically important banks (G-SIBs).* Retrieved August 26, 2026, from https://www.fsb.org/2025/11/2025-list-of-global-systemically-important-banks-g-sibs/

Gertler, M., & Kiyotaki, N. (2010). Financial intermediation and credit policy in business cycle analysis. In *Handbook of monetary economics* (Vol. 3, pp. 547–599). Elsevier.

Goldstein, R., Ju, N., & Leland, H. (2001). An EBIT-based model of dynamic capital structure. *Journal of Business*, *74*(4), 483–512.

Grodzicki, M., Klaus, B., Pancaro, C., & Reghezza, A. (2023). Euro area bank deposit costs in a rising interest rate environment. In *Financial Stability Review, may 2023.* Frankfurt am Main: European Central Bank. Retrieved 1 November 2026,

from https://www.ecb.europa.eu/press/financial-stability-publications/fsr/focus/2023/html/ecb.fsrbox202305_04~7fbb3af52c.en.html (Box 4)

He, Z., Nagel, S., & Song, Z. (2022). Treasury inconvenience yields during the COVID-19 crisis. *Journal of Financial Economics*, *143*(1), 57–79.

Hellmann, T. F., Murdock, K. C., & Stiglitz, J. E. (2000). Liberalization, moral hazard in banking, and prudential regulation: Are capital requirements enough? *American Economic Review*, *90*(1), 147–165.

Hennessy, C. A., & Whited, T. M. (2005). Debt dynamics. *Journal of Finance*, *60*(3), 1129–1165.

Hugonnier, J., & Morellec, E. (2017). Bank capital, liquid reserves, and insolvency risk. *Journal of Financial Economics*, *125*(2), 266–285.

Jamilov, R., & Monacelli, T. (2026). Bewley banks. *Review of Economic Studies*, *93*(3), 1889–1925.

Jermann, U., & Xiang, H. (2023). Dynamic banking with non-maturing deposits. *Journal of Economic Theory*, *209*, 105644.

Jermann, U., & Xiang, H. (2025). Rules versus discretion in capital regulation. *Journal of Financial Economics*, *169*, 104060.

Koont, N., Santos, T., & Zingales, L. (2024). *Destabilizing digital "bank walks"* (Tech. Rep.). National Bureau of Economic Research.

Koont, N., & Walz, S. (2021). The value of countercyclical capital requirements: Evidence from COVID-19. *Columbia Business School Research Paper Forthcoming*, *72*, 1-25.

Li, Y., & Li, Y. (2024). Payment risk and bank lending: reassessing the bundling of payment services and credit provision.

Lu, X., & Wu, L. (2026). Banking on inattention.

Rahman, A., & Warusawitharana, M. (2023, June). *Impact of leverage ratio relief announcement and expiry on bank stock prices* (FEDS Notes). Board of Governors of the Federal Reserve System. (June 29, 2023)

Rochet, J.-C. (1992). Capital requirements and the behaviour of commercial banks. *European Economic Review*, *36*(5), 1137–1170.

Rochet, J.-C., & Villeneuve, S. (2011). Liquidity management and corporate demand for hedging and insurance. *Journal of Financial Intermediation*, *20*(3), 303–323.

Sabet, S., & Schneider, P. (2024). The nested–drift algorithm.

Van den Heuvel, S. J. (2002). Does bank capital matter for the transmission of monetary policy? *Economic Policy Review, Federal Reserve Bank of New York*, *8*(1).

Wang, O. (2025). Banks, low interest rates, and monetary policy transmission. *Journal of Finance*, *80*(3), 1379–1416.

A Solution to the full model banks' problem

This section solves the HJB equation of the banks.

A.1 The solution in steady state

In this section, I drop the dependence on j in the notation as it is always about the same bank. Moreover, time subscripts are also dropped as I consider the steady state solution.

The value of a bank with D deposits and E equity is defined to be $V(D, E)$. In steady-state

$$V(D, E) = Dv\left(\frac{E}{D}\right). \tag{20}$$

Proof. This is proven in subsection A.3 for the general time-varying case. □

Here, $v(e) := V(1, e)$. Thus, it is sufficient to solve for v. For compactness, define expected per-deposit profits

$$\mu_t^E(e, \mu^D, l) := er + (1-\beta)r - (1-q_t)(\mu^D + \lambda^D) - \frac{\theta}{\kappa}\left|\mu^D\right|^\kappa + l\alpha_t^L, \tag{21}$$

so that bank j's expected profits are $D_{jt}\mu_t^E(e_{jt}, \mu_{jt}^D, l_{jt})$. The HJB when there is no issuance is

$$rV(D,E) = \max_{\mu^D, l \le \xi_K E/D} \lambda^B(E - V) + \mu^D D\partial_D V + \\ \mu^E\left(\frac{E}{D}, \mu^D, l\right) D\partial_E V + \frac{1}{2}\sigma_D^2 D^2 \partial_{DD} V + \frac{1}{2} l^2 \sigma_L^2 D^2 \partial_{EE} V.$$

Using equation (20), we can rewrite the derivatives of V. The derivatives are:

$$\partial_D V(D,E) = v(e) - ev'(e), \quad \partial_E V = v'(e), \quad \partial_{DD} V = \frac{e^2}{D} v''(e), \quad D^2 \partial_{EE} V = \frac{1}{D} v''(e).$$

Using these derivatives and substituting in equation (20) for V, the HJB written in terms of v is

$$(r + \lambda^B)v = \max_{\mu^D, l \leq \xi_K e} \lambda^B e + \mu^D(v - ev') + \mu^E(e, \mu^D, l)v' + \frac{1}{2}\sigma_D^2 e^2 v'' + \frac{1}{2} l^2 \sigma_L^2 v''. \tag{22}$$

At $e = \underline{e} := (\xi_L - 1)^{-1}$, the banker has to issue equity at a marginal cost of $1 + \psi$. This yields the boundary condition

$$v'(\underline{e}) = 1 + \psi.$$

When $e > \overline{e}$, the banker has to pay out any equity held in excess, yielding

$$v'(\overline{e}) = 1.$$

As μ^D is unrestricted and the adjustment cost is strictly convex and coercive, the first order condition for changing the deposit base holds with equality at an interior optimum,

$$v - ev' = \left(1 - q + \theta \operatorname{sgn}(\mu^D) \left|\mu^D\right|^{\kappa - 1}\right) v'.$$

Writing $z := v/v' - e - (1 - q)$ for the net marginal value of a deposit, this yields

$$\mu^D = \operatorname{sgn}(z) \left(\frac{|z|}{\theta}\right)^{\frac{1}{\kappa - 1}}.$$

The solution is two-sided and interior for every e: a bank with $z > 0$ grows its deposit base, one with $z < 0$ shrinks it, and only a bank with $z = 0$ holds deposits flat. A bank with $\mu^D < -\lambda^D$ sheds depositors faster than they leave of their own accord, paying the adjustment cost to do so. Strict convexity, $\kappa > 1$, is what keeps this choice finite in both directions. Moreover, the first-order condition for lending is

$$l(e) = \frac{\alpha^L v'(e)}{-\sigma_L^2 v''(e)}.$$

Thus, capital over equity is

$$\frac{L}{E} = \frac{l}{e} = \frac{\alpha^L}{\sigma_L^2} \frac{v'(e)}{e v''(e)}.$$

$\frac{v'(e)}{ev''(e)}$ is the inverse of (endogenous) relative risk-aversion in Bolton et al. (2025).

A.2 Time-varying prices

With time-varying prices, the bankers' utility has the form

$$U_t^b(D,E) = Dv_t\left(\frac{E}{D}\right).$$

Other than the fact that prices are time-varying, nothing changes. The HJB has an additional term to reflect the effect of changing prices

$$(r+\lambda^B)v_t = \max_{\mu^D, l\leq \xi_K e} \partial_t v_t + \lambda^B e + \mu^D(v_t - ev_t') + \mu_t^E(e,\mu^D,l)v' + \frac{1}{2}\sigma_D^2 e^2 v_t'' + \frac{1}{2}l^2\sigma_L^2 v_t'' \tag{23}$$

The first order conditions remain the same, except that there are now time subscripts.

A.3 Proof: functional form value function

Lemma 3. *The value function of the bank $U_t^b(D,E)$ can be written as $Dv_t\left(\frac{E}{D}\right)$*

Proof. Let v_t be the value of a bank with one deposit at time t. First, assume that $U_t^b(D,E) = Dv_t\left(\frac{E}{D}\right)$. Then, a bank with D deposits and E equity makes the same decisions as a bank with one deposit and $\frac{E}{D}$ equity. To see this, note that $\frac{\partial V(D,E)}{\partial \mu^D} = D\left(\partial_D U_t^b(D,E) - \frac{\partial \mu_t^E}{\partial \mu^D}\partial_E U_t^b(D,E)\right)$. Differentiating the HJB equation for a bank with one deposit gives $\frac{\partial v(E/D)}{\partial \mu^D} = \partial_D U_t^b(1,E/D) - \frac{\partial \mu_t^E}{\partial \mu^D}\partial_E U_t^b(1,E/D)$. First note that μ_t^E only depends on the ratio $e_t := \frac{E_t}{D_t}$. Thus, it is the same term in both expressions. Moreover, I showed earlier that with this assumed functional form, the first partial derivatives of U_t^b also only depend on e. As $D>0$, these two first order conditions are a multiple of one another and thus have the same solution. That is, the same μ^D is optimal for both banks with D deposits and E equity and one with 1 deposit and E/D equity. An analogous argument holds for l.

Now, define the normalized deposits of a surviving bank as $D_s^* := D_s/D_t$ for $s>t$. As $E_s = D_t D_s^* e_s$, the value of this bank is

$$U_t^b(D,E) = \mathbb{E}_t\int_t^\infty \exp\left(-(r+\lambda^B)(s-t)\right)\lambda^B E_s ds = \\ D\mathbb{E}_t\int_t^\infty \exp\left(-(r+\lambda^B)(s-t)\right)\lambda^B D_s^* e_s ds = Dv(E/D).$$

The second-to-last integral can be recognized as the value function for a bank with one deposit and initial equity ratio $e_t = E/D$ at time t, which under the same risk realizations would have $D_s^* e_s$ equity at time s. □

B Evolution of the distribution of bank capitalization

This section explains how the deposit-weighted distribution of bank capitalization evolves over time.

Bank-level deposits D_{jt} and equity E_{jt} of surviving banks follow the evolution equations (5) and (6) respectively with independent increments. Moreover, with a rate λ^B banks exit and switch to a state with $(D_{jt}, E_{jt}) = (0, 0)$. For a surviving bank, i.e. $(D, E) \neq (0, 0)$, the density of banks over characteristics $\tilde{f}_t(D, E)$ evolves according to the Kolmogorov forward equation (Achdou et al., 2022)

$$\partial_t \tilde{f}_t(D, E) = \mathcal{A}^* \tilde{f}_t(D, E) - \lambda^B \tilde{f}_t(D, E). \tag{24}$$

Here, $\mathcal{A}^*$ is the adjoint of the infinitesimal generator $\mathcal{A}$ of (D_j, E_j) for an arbitrary surviving bank j. The probability mass at $(D, E) = 0$ of exited banks changes by $\lambda^B \iint_{\{D,E>0\}} \tilde{f}_t(D, E) dD dE = \lambda^B(1 - \tilde{F}_t(0, 0))$, with $\tilde{F}_t$ the CDF of $\tilde{f}_t$. Let the mass of surviving banks be $M_t := 1 - \tilde{F}_t(0, 0)$. The problem gives $M_0 = 1$ and the KF equation for exited banks[15] gives $dM_t = -\lambda^B M_t$.

Rather than work with the distribution of all banks, I work with the distribution of surviving banks to reduce the dimensionality of the problem. This density $f_t(D, E) := \frac{\tilde{f}_t(D,E)}{M_t}$ by Ito's lemma evolves according to

$$\partial_t f_t(D, E) = \frac{d\tilde{f}_t}{M_t} - \frac{\tilde{f}_t}{M_t}\frac{dM_t}{M_t} = \mathcal{A}^* \frac{\tilde{f}_t(D, E)}{M_t} - \lambda^B \frac{\tilde{f}_t(D, E)}{M_t} + \lambda^B \frac{\tilde{f}_t}{M_t} = \mathcal{A}^* f_t(D, E), \tag{25}$$

where I used that $\mathcal{A}^*$ is a linear operator, so M_t can be brought inside it.

It cannot be assumed that there is a stationary distribution f over (D, E).[16] However, banks' decisions are homogeneous of degree 1 in D, so equilibrium can be characterized without the full distribution f_t; it is pinned down by the deposit-weighted capitalization density $h_t(e)$ and aggregate deposits, as Lemma 4 shows. Intuitively, h_t is the distribution obtained by sampling a deposit at random and recording the capitalization of the bank holding it. Formally, the share of aggregate

[15] Combine this KF equation with Ito's lemma saying $dM_t = d(1 - \tilde{F}_t(0, 0)) = -d\tilde{F}_t(0, 0) = -\lambda^B(1 - \tilde{F}_t(0, 0)) = -\lambda^B M_t$.

[16] Deposits follow a geometric Brownian motion without any reflection. When adjustment costs are equal to infinity such that $\mu_t^D = 0$, a geometric Brownian motion for deposits means that the deposit distribution at time t will be log-normal with variance $t\sigma_D^2$ increasing over time. Banks choosing μ_t^D with finite adjustment costs can offset this to some extent, but likely not fully.

deposits in banks with capitalization at most e is

$$H_t(e) := \frac{1}{\mathbb{E}^{F_t}(D)} \int_0^\infty \int_0^{eD} D f_t(D, E) dE dD,$$

and differentiating in e yields the density

$$h_t(e) := H_t'(e) = \frac{1}{\mathbb{E}^{F_t}(D)} \int_0^\infty D^2 f_t(D, eD) dD.$$

$\mathbb{E}^{F_t}(D)$ is the unweighted expectation of a surviving bank's deposits at time t, which equals aggregate deposits divided by the mass of surviving banks D_t/M_t.

To bound the state space, I assume banks pay out equity whenever capitalization e_{jt} would otherwise exceed a threshold $\overline{e}$, so $e_{jt} \in [\underline{e}, \overline{e}]$. The threshold is set high enough to be quantitatively irrelevant. Because e_{jt} has a non-degenerate Brownian component, the process is irreducible on the compact interval $[\underline{e}, \overline{e}]$ and thus admits a unique stationary distribution $h(e)$. This stationary $h(e)$ is used for defining the equilibrium.

Differentiating the definition of the density in time gives the evolution equation for h_t

$$\partial_t h_t(e) = \frac{1}{\mathbb{E}^{F_t}(D)} \int_0^\infty D^2 \partial_t f_t(D, eD) dD - \frac{\partial_t \mathbb{E}^{F_t}(D)}{\mathbb{E}^{F_t}(D)} \underbrace{\left(\frac{1}{\mathbb{E}^{F_t}(D)} \int_0^\infty D^2 f_t(D, eD) dD \right)}_{h_t(e)}. \tag{26}$$

The first term transports the deposit-weighted mass through the law of motion of f_t. The second term corrects for aggregate deposit growth, reweighting each deposit so that the distribution still integrates to one. Deposit growth of surviving banks equals the percentage growth in aggregate deposits plus λ^B, as surviving banks also absorb the deposits of banks that exited.

Proof.

$$\frac{\partial_t \mathbb{E}^{F_t}(D)}{\mathbb{E}^{F_t}(D)} = \frac{d(D_t/M_t)}{D_t/M_t} = \frac{dD_t}{D_t} - \frac{dM_t}{M_t} = \frac{dD_t}{D_t} + \lambda^B.$$

□

B.1 How to define aggregates in terms of h

Let X_t be either aggregate loans L_t^s issued by the banking sector or the change in deposits dD_t^d demanded by the banking sector, and let $x_t(e)$ be either the policy function for loans per deposit $l_t(e)$ or net deposit growth $\mu_t^D(e)$. Both aggregates X_t can be written as functions of their respective

policy function $x_t(e)$ and the distribution $h_t(e)$.

Lemma 4. *Each aggregate can be expressed through its policy function $x_t(e)$ and the deposit-weighted capitalization density $h_t(e)$ alone,*

$$X_t = D_t \int_0^\infty x_t(e) h_t(e) de. \tag{27}$$

Proof.

$$X_t := \int X_{jt} dj = M_t \int_0^\infty \int_0^\infty x_t(E/D) D f_t(D, E) dE dD = M_t \int_0^\infty \int_0^\infty x_t(E/D) D^2 f_t(D, E) \underbrace{\frac{1}{D} dE}_{de} dD$$

Using integration by substitution, using Fubini's theorem to swap the order of integration, and taking $x_t(E/D)$ out of the inner integral as it only depends on e, this yields

$$M_t \int_0^\infty x_t(e) \underbrace{\int_0^\infty D^2 f_t(D, De) dD}_{\mathbb{E}^{F_t}(D) h_t(e)} de = M_t \mathbb{E}^{F_t}(D) \int_0^\infty x_t(e) h_t(e) de = D_t \int_0^\infty x_t(e) h_t(e) de.$$

□

C Numerical procedure

In this section, I explain how the steady state is found numerically, and how transitions are computed.

C.1 Adjustment of the problem

The payout threshold $\overline{e}$ (introduced in Appendix B) coincides with the upper end of the grid. It binds essentially never: banks pay out less than $10^{-19}\%$ of aggregate equity per quarter, and varying $\overline{e}$ has no large effect on the results.

C.2 Steady state

My numerical procedure for the steady state largely follows Achdou et al. (2022) and the numerical appendix of an older version of the paper by Achdou et al. (2020). The main innovation is in going from two state variables to one state variable.

C.2.1 Overview & setup

The code first approximates the value function v given a guess of the price of deposits q_n, starting at q_0. The code then computes the steady-state deposit-weighted distribution of banks h and the aggregate drift in deposit demand with this value function and corresponding h. If the drift is approximately 0, the code stops. Otherwise, the guess is updated to q_{n+1}, and the process is repeated.

The value function v and distribution of banks h are approximated at N points of a discrete grid for capitalization e between $\underline{e}$ and $\overline{e}$. One such value is e_i, $i = 1, \ldots, N$. Specifically $e_1 = \underline{e}$ and $e_N = \overline{e}$. Moreover, the grid is equidistant in logs. That means that $\Delta \log e := \log(e_i) - \log(e_{i-1}) = \frac{\log(\overline{e}) - \log(\underline{e})}{N-1}, \quad i = 2, \ldots, N$. I use the expressions for the non-uniform grids in section 7 of Achdou et al. (2020).[17]

C.2.2 Solving the steady state HJB equation

The algorithm for solving the HJB equation largely follows Achdou et al. (2022). Unlike their paper, I reduce two state variables to one. The HJB equation is solved in one dimension using an upwinding scheme as in Achdou et al. (2022), but now the direction depends on the coefficient on v' rather than the drift of e.The construction of forward and backward derivatives is the same as in their paper.

The steady-state HJB equation is:

$$(r + \lambda^B)v = \lambda^B e + \mu^D v + \left(\mu^E - e\mu^D\right) v' + \frac{1}{2}\left(e^2\sigma_D^2 + l^2\sigma_L^2\right) v''.$$

To simplify later expressions I abuse notation and define vectors representing functions in the main text at the grid points:

$$u_i := \lambda^B e_i + \mu_i^D v_i^n$$

$$\mu_i^e := \mu_i^E - e_i\mu_i^D$$

$$\sigma_{e,i}^2 := e_i^2\sigma_D^2 + l_i^2\sigma_L^2$$

[17] Using a non-uniform grid this way makes it easier to solve for the distribution later on. As there are relatively more grid points for low values of e, where mass is relatively large and the value function changes a lot, the solution is also more accurate than with a uniform grid.

In discretized form, the HJB equation is

$$(r+\lambda^B)v_i = u_i + (\mu_i^e)^- \frac{v_i - v_{i-1}}{\Delta e_{i,-}} + (\mu_i^e)^+ \frac{v_{i+1} - v_i}{\Delta e_{i,+}} + \frac{1}{2}\sigma_{e,i}^2 \frac{\frac{v_{i+1}-v_i}{\Delta e_{i,+}} - \frac{v_i - v_{i-1}}{\Delta e_{i,-}}}{\frac{1}{2}(\Delta e_{i,-} + \Delta e_{i,+})},$$

where $(\cdot)^- := \min(\cdot, 0)$ and $(\cdot)^+ := \max(\cdot, 0)$. Moreover, $\Delta e_{i,-} := e_i - e_{i-1}$ and $\Delta e_{i,+} := e_{i+1} - e_i$.

A guess v^n is updated into a new guess v^{n+1} using the implicit method by computing

$$v^{n+1} = ((r + \lambda^B + \Delta^{-1})I_N - A^{\text{HJB}})^{-1} b,$$

where I_N is the identity matrix and b an $N \times 1$ vector with $b_i = u_i + \Delta^{-1} v_i^n$ for $2 \leq i \leq N-1$. $\Delta > 0$ is a constant when not placed in front of e_i or $\log e_i$.

I construct A^{HJB} as follows:

$$A^{\text{HJB}} = \begin{bmatrix} y_1 & z_1 & 0 & \dots & \dots & \dots & \dots \\ x_2 & y_2 & z_2 & 0 & \dots & \dots & \dots \\ 0 & \vdots & \vdots & \ddots & \ddots & \ddots & \ddots \\ \vdots & \ddots & \ddots & \ddots & 0 & x_N & y_N \end{bmatrix}$$

where

$$x_i = \frac{-(\mu_i^e)^-}{\Delta e_{i,-}} + \frac{1}{2}\frac{\sigma_{e,i}^2}{(\Delta e_{i,-})\frac{1}{2}(\Delta e_{i,-} + \Delta e_{i,+})} \quad \forall i \geq 2, \quad x_1 = 0,$$

$$z_i = \frac{(\mu_i^e)^+}{\Delta e_{i,+}} + \frac{1}{2}\frac{\sigma_{e,i}^2}{(\Delta e_{i,+})\frac{1}{2}(\Delta e_{i,-} + \Delta e_{i,+})} \quad \forall i \leq N-1, \quad z_N = 0,$$

$$y_i = -(x_i + z_i).$$

To deal with the boundary condition[18] I introduce two extra grid points: $e_0 := \exp(\log e_1 - \Delta \log e)$ and $e_{N+1} := \exp(\log e_N + \Delta \log e)$. This definition solves the issue that $\Delta e_{i,-}$ and $\Delta e_{i,+}$ were not defined for $i = 1$ and $i = N$ respectively. Moreover, I set

$$\frac{v_1 - v_0}{\Delta e_{1,-}} = 1 + \psi, \quad \frac{v_{N+1} - v_N}{\Delta e_{N,+}} = 1.$$

As the terms with these derivatives are not captured by $A^{\text{HJB}} v^{n+1}$ they have to be moved into the

[18] Achdou et al. (2022) do not explicitly consider the boundary conditions. In their code, they deal with a reflecting boundary in the same way, but do not have a reward (or penalty) for mass being reflected.

b. Thus,

$$b_1 = u_1 + \Delta^{-1} v_1^n - (1+\psi)\left((\mu_1^e)^- + \frac{1}{2}\frac{\sigma_{e,1}^2}{\frac{1}{2}(\Delta e_{1,-} + \Delta e_{1,+})}\right),$$

and

$$b_N = u_N + \Delta^{-1} v_N^n + 1\left((\mu_N^e)^+ + \frac{1}{2}\frac{\sigma_{e,N}^2}{\frac{1}{2}(\Delta e_{N,-} + \Delta e_{N,+})}\right)$$

Lastly, I choose the initial guess for the value function differently. Achdou et al. (2022) recommend setting the drift in the state variable equal to zero and then solving for policy functions. In this setting, that is hard to implement as it is not easy to solve for the drift.[19] Thus, I instead guess an initial value function by guessing policy functions. Then I construct the A^{HJB} and b matrix and vector from the procedure above, given these policy functions. The initial guess is then $v^0 = ((r+\lambda^B)I_N - A^{\text{HJB}})^{-1} b$. Note that this is the same as the updating step when $\Delta = \infty$, so the old guess does not matter except through A^{HJB}.

I choose $\mu^D(e) = \lambda^B, l(e) = \xi_K e$ as the guess for the policy functions.

C.2.3 Solving for the stationary deposit-weighted distribution of banks

Equation (26) gives the evolution of h_t. I restate this expression below:

$$\partial_t h_t(e) = \frac{1}{\mathbb{E}^{F_t}(D)} \int_0^\infty D^2 \partial_t f_t(D, eD) dD - \frac{\partial_t \mathbb{E}^{F_t}(D)}{\mathbb{E}^{F_t}(D)} h_t(e).$$

In steady state, for the distribution not to change, it needs to hold that

$$\partial_t h_t(e) = 0.$$

This can be rewritten as

$$\frac{1}{\mathbb{E}^{F_t}(D)} \int_0^\infty D^2 \partial_t f_t(D, eD) dD = \frac{\partial_t \mathbb{E}^{F_t}(D)}{\mathbb{E}^{F_t}(D)} h(e).$$

As the banks' problem is homogeneous of degree 1 in (D, E), the evolution equation not only holds when f_t is the true distribution of banks, but also for any distribution p_t over (D, E) consistent with the deposit-weighted distribution of banks h_t. The reason is that two banks with one deposit

[19] I tried to solve this by setting $\mu^D = -\lambda^D$ and $l = 0$ and choosing the dividend equal to the profits. This way, the value function is easy to solve for. However, this made for bad initial guesses leading to difficult convergence. Sabet & Schneider (2024) note that this finite difference scheme only has guaranteed local convergence. Thus, a good initial guess is paramount.

choose to buy the same amount of new deposits and lend the same as one bank with two deposits. In particular, I can choose p_t such that all banks have 1 deposit and the marginal equity distribution is h_t.[20] Using this expression we have to find

$$\int_0^\infty D^2 \partial_t p_t(D, eD) dD = \frac{\partial_t \mathbb{E}^{P_t}(D)}{\mathbb{E}^{P_t}(D)} h(e), \tag{28}$$

where the expectation of deposits on the left-hand side can be ignored as it is 1.

From now on let h be a vector representing the marginal contribution of the area between two grid points to the CDF. That is $h_i = H(e_i + \Delta e_{i,+}/2) - H(e_i - \Delta e_{i,-}/2)$. The pdf is then $h(e_i) \approx \frac{h_i}{(\Delta e_{i,+} + \Delta e_{i,-})/2}$. This is also how Achdou et al. (2020) deal with a non-uniform grid. Below I lay out a linear transformation that maps the vector h to a discretized version of $\int_0^\infty D^2 \partial_t p_t(D, eD) dD$, the left-hand side of equation (28). An invariant distribution h is then the eigenvector of this mapping of which the eigenvalue is the growth rate of aggregate deposits in surviving banks $\frac{\partial_t \mathbb{E}^{P_t}(D)}{\mathbb{E}^{P_t}(D)}$. Such an invariant h can be obtained for any guess of the price of deposits q_n. However, in general this would lead to a perpetually growing or shrinking aggregate deposit demand. Only for the steady-state price q, this growth rate equals λ^B, which leaves aggregate deposit demand unchanged over time (see Appendix B).

Integrating equation (28) between $e_i - \Delta e_{i,-}/2$ and $e_i + \Delta e_{i,+}/2$ gives on the right-hand side

$$\frac{\partial_t \mathbb{E}^{P_t}(D)}{\mathbb{E}^{P_t}(D)} \int_{e_i - \Delta e_{i,-}/2}^{e_i + \Delta e_{i,+}/2} h(e) de = \frac{\partial_t \mathbb{E}^{P_t}(D)}{\mathbb{E}^{P_t}(D)} h_i.$$

On the left-hand side, I change the order of integration and substitute $E = eD$, so that $de = dE/D$:

$$\int_{e_i - \Delta e_{i,-}/2}^{e_i + \Delta e_{i,+}/2} \int_0^\infty D^2 \partial_t p_t(D, eD) dD de = \int_0^\infty \int_{D(e_i - \Delta e_{i,-}/2)}^{D(e_i + \Delta e_{i,+}/2)} D \partial_t p_t(D, E) dE dD.$$

This expression is easy to compute as $\partial_t p_t = \mathcal{A}^* p_t$, where $\mathcal{A}^*$ is the adjoint of the infinitesimal generator of (D, E).

I solve this equation in two steps. I will define matrices W, A^{dist}, and B such that if h_t is the deposit-weighted distribution of banks, then $W A^{\text{dist}\prime} B h = \int_0^\infty D^2 \partial_t p_t(D, eD) dD$. Thus, in

[20] Strictly speaking this cannot be done, as p_t is not a pdf (it is infinite at $D = 1$ and 0 otherwise). However, this does not matter here as I discretize the state space. The intuition is that in the discretization, there is no distinguishable difference between a variable with a continuous distribution on a narrow support and a degenerate distribution; all gets mapped to the same grid point. This is the same reason why Achdou et al. (2022) can solve for a distribution with a mass point using the Kolmogorov forward equation. Formally, a pdf with exactly the same discretization can be found where deposits are uniformly distributed on $(1 - \varepsilon, 1 + \varepsilon)$ for some $0 < \varepsilon < 1 - \exp(-\Delta \log e)$, independent of the equity distribution.

discretized terms, we have to solve

$$(WA^{\text{dist}\prime}B)h = \left(\int_{\underline{e}}^{\overline{e}} \mu^D(e)h(e)de\right) h$$

where h is a vector, and $\int_{\underline{e}}^{\overline{e}} \mu^D(e)h(e)de$ discretizes to $\sum_i \mu_i^D h_i$. Note that h is an eigenvector of $WA^{\text{dist}\prime}B$ with eigenvalue $\int_{\underline{e}}^{\overline{e}} \mu^D(e)h(e)de$, the expected net deposit drift under h. However, as the eigenvalue itself depends on h, this is a nonlinear eigenvalue problem. To avoid this complication, I approximate the eigenvalue by the drift of deposits when banks are equally weighted. Let g_t be the discretized equally-weighted distribution of banks over equity-per-deposit e, then I define W^{eq} such that $\partial_t g_t = W^{\text{eq}} A^{\text{dist}\prime} B g_t$.

The equally-weighted invariant distribution of banks' capitalization $g(e)$ is found as in Achdou et al. (2022). First, the eigenvector with eigenvalue 0 of $W^{\text{eq}}A^{\text{dist}\prime}B$ is extracted. This procedure gives a multiple of g; normalizing gives the invariant g. Then, I compute the approximate drift in deposits by computing $\int_{\underline{e}}^{\overline{e}} \mu^D(e)g(e)de$. Using this approximate drift, I search for the eigenvector of $WA^{\text{dist}\prime}B$ with this as an approximate eigenvalue. The corresponding eigenvector is generally a multiple of h.[21]

Now, I define the individual matrices. Matrix B maps h_t to the distribution p_t over (D, E) with all mass at $D = 1$ and h as marginal distribution of E. $A^{\text{dist}\prime}$ is the transpose of the infinitesimal generator of (D, E) and thus maps p_t to $\partial_t p_t$. Lastly, W maps mass in (D, E) space back to e space and weights observations by their deposits to discretize $\int D \cdot dD$ — one power of D lower than $\int D^2 \partial_t p_t \, dD$ above, since the Jacobian of $E = eD$ already absorbed one power when the cell integration turned the density p_t into the mass vector h. W^{eq} does the same as W, but weights all banks equally, yielding an equally weighted distribution instead of the deposit-weighted distribution.

Construction of matrices. The B matrix is constructed as follows:

$$B = \begin{bmatrix} \mathbf{0}_N \\ I_N \\ \mathbf{0}_N \end{bmatrix},$$

[21] In my setting, this works well as g and h are close. If this procedure does not work, you will notice it; for an eigenvector to be a distribution vector, all components need to be of the same sign. An irreducible continuous-time Markov chain has a unique invariant distribution. Hence, there can only be one eigenvector where all components are of the same sign, as otherwise there would be two stationary distributions. If g is not close, all you have to do is consider more eigenvectors around your guess of the eigenvalue and see which one can be a distribution. Of course, you could also check all eigenvectors, but for a large grid, this is computationally expensive.

where I_N is an $N \times N$ identity matrix and $\mathbf{0}_N$ an $N \times N$ matrix of zeroes. This way

$$p_t := Bh = \begin{pmatrix} 0_N \\ h \\ 0_N \end{pmatrix},$$

where 0_N is an $N \times 1$ vector of 0s. Note that this is not necessarily the pdf p_t, but a multiple of it. However, as eigenvectors are defined up to scale, that does not matter.

Now, I compute the discretized version of $\partial_t p_t$ with two state variables as in Achdou et al. (2022). First, note that as all banks have $D = 1$, I only need three grid points in the deposit dimension: as time is continuous, deposits can move at most one grid point. I thus discretize p_t as a $3N \times 1$ vector. Each component corresponds to the probability mass around that value. The first N components have an index $(-1, i)$. Similarly, the next N components have an index $(0, i)$ and the last N components have an index $(1, i)$. At these grid points, deposits take values such that

$$\log D_{-1,i} = -\Delta \log e, \quad \log D_{0,i} = 0, \quad \log D_{1,i} = \Delta \log e.$$

Moreover, $E_{-1,i} = E_{0,i} = E_{1,i} = e_i$.

I discretize the Kolmogorov forward equation by approximating $\partial_t p_t \approx (A^{\text{dist}})' p_t$ and decompose the discretized infinitesimal generator A^{dist} into 9 submatrices:

$$A^{\text{dist}} = \begin{bmatrix} A_{-1,-1} & A_{-1,0} & A_{-1,1} \\ A_{0,-1} & A_{0,0} & A_{0,1} \\ A_{1,-1} & A_{1,0} & A_{1,1} \end{bmatrix}.$$

As

$$A^{\text{dist}\prime} B = \begin{bmatrix} A'_{0,-1} \\ A'_{0,0} \\ A'_{0,1} \end{bmatrix},$$

it is only necessary to compute $A^{\text{dist}}_{0,-1}$, $A^{\text{dist}}_{0,0}$ and $A^{\text{dist}}_{0,1}$. These matrices are constructed as in Achdou et al. (2022) by discretizing the infinitesimal generator of (D, E) at the relevant grid points. The infinitesimal generator at $D = 1$ in continuous form is

$$\mathcal{A}(p_t) = \mu^E(e)\partial_E p_t + \mu^D(e)\partial_D p_t + \frac{1}{2}\sigma_D^2 \partial_{DD} p_t + \frac{1}{2} l(e)^2 \sigma_L^2 \partial_{EE} p_t.$$

The infinitesimal generator in discretized form consists of

$$A^{\text{dist}}_{0,-1} = \text{diag}(\chi), \quad A^{\text{dist}}_{0,0} = \begin{bmatrix} y_1 & z_1 & 0 & \dots & \dots & \dots & \dots & \dots \\ x_2 & y_2 & z_2 & 0 & \dots & \dots & \dots & \dots \\ 0 & \vdots & \vdots & \ddots & \ddots & \ddots & \ddots & \ddots \\ \vdots & \ddots & \ddots & \ddots & \ddots & 0 & x_N & y_N \end{bmatrix}, \quad A^{\text{dist}}_{0,1} = \text{diag}(\zeta),$$

where diag refers to a matrix with the vector between brackets on the diagonal. The definitions of x, y, and z differ from the x, y, and z in A^{HJB}. These components take the form

$$\begin{aligned} x_i &= \frac{-(\mu^E_i)^-}{\Delta e_{i,-}} + \frac{1}{2}\frac{l_i^2\sigma_L^2}{(\Delta e_{i,-})^{\frac{1}{2}}(\Delta e_{i,-} + \Delta e_{i,+})} \quad \forall i \geq 2, \quad x_1 = 0, \\ z_i &= \frac{(\mu^E_i)^+}{\Delta e_{i,+}} + \frac{1}{2}\frac{l_i^2\sigma_L^2}{(\Delta e_{i,+})^{\frac{1}{2}}(\Delta e_{i,-} + \Delta e_{i,+})} \quad \forall i \leq N-1, \quad z_N = 0, \\ \chi_i &= \frac{-(\mu^D_i)^-}{1-\exp(-\Delta \log e)} + \frac{1}{2}\frac{\sigma_D^2}{(1-\exp(-\Delta \log e))^{\frac{1}{2}}(\exp(\Delta \log e) - \exp(-\Delta \log e))}, \\ \zeta_i &= \frac{(\mu^D_i)^+}{\exp(\Delta \log e)-1} + \frac{1}{2}\frac{\sigma_D^2}{(\exp(\Delta \log e)-1)^{\frac{1}{2}}(\exp(\Delta \log e) - \exp(-\Delta \log e))}, \\ y_i &= -(x_i + z_i + \chi_i + \zeta_i). \end{aligned}$$

At $e_1 = \underline{e}$ there is no grid point below. Setting $x_1 = 0$ reflects the mass that would otherwise leave the grid back onto $\underline{e}$.

The matrix W^{eq} maps the corresponding changes in (D, E) to changes in $e = \frac{E}{D}$. This matrix is constructed as follows:

$$W^{\text{eq}} = \begin{bmatrix} W^{\text{eq}}_{-1} & W^{\text{eq}}_0 & W^{\text{eq}}_1 \end{bmatrix},$$

where W^{eq}_j are $N \times N$ matrices of the form

$$W^{\text{eq}}_{-1} = \begin{bmatrix} 0 & 0 & 0 & \dots & \dots \\ 1 & 0 & 0 & \dots & \dots \\ 0 & 1 & 0 & \dots & \dots \\ \vdots & \vdots & \vdots & \ddots & \ddots \\ \dots & \dots & \dots & 1 & 1 \end{bmatrix}, \quad W^{\text{eq}}_0 = I_N, \quad W^{\text{eq}}_1 = \begin{bmatrix} 1 & 1 & 0 & \dots & \dots \\ 0 & 0 & 1 & \dots & \dots \\ \vdots & \ddots & \ddots & \ddots & \ddots \\ \dots & \dots & \dots & \dots & 1 \\ \dots & \dots & \dots & 0 & 0 \end{bmatrix}.$$

As $\log e = \log E - \log D$ and the grid is equidistant in logs, a decrease in deposits of one grid point

maps to an e one grid point higher, and vice versa. Mass that would fall outside $[\underline{e}, \overline{e}]$ is reflected back to the nearest boundary point through issuance or forced payouts.

The matrix W maps the same changes, but weights each bank by its deposits D_j:[22]

$$W = \begin{bmatrix} D_{-1}W_{-1}^{\text{eq}} & D_0 W_0^{\text{eq}} & D_1 W_1^{\text{eq}} \end{bmatrix}, \quad D_j = \exp(j\Delta \log e).$$

C.3 Transitions

This subsection explains how I solve for transitions. I first explain what changes in general if the distribution is time-varying. I then give specifics for how I incorporate a reserve exemption.

Given a distribution h_t, the distribution of banks evolves according to

$$\partial_t h_t(e) = \frac{1}{\mathbb{E}^{F_t}(D)} \int_0^\infty D^2 \partial_t f_t(D, eD) dD - \frac{\partial_t \mathbb{E}^{F_t}(D)}{\mathbb{E}^{F_t}(D)} h_t(e).$$

The first term can be computed by constructing $W A_t^{\text{dist}\prime} B h_t$ with W and A_t^{dist} defined as in steady state, but with time-varying policy functions, state variables and prices in A_t^{dist}. As in steady state, B maps h_t to a distribution p_t with all mass at $D = 1$, so that $\mathbb{E}^{P_t}(D) = 1$ and the prefactor drops out. The distribution is updated by computing

$$(I_N - \Delta t W A_t^{\text{dist}\prime} B)^{-1} h_t = \tilde{h}_{t+\Delta t},$$

where Δt is the length of a time step. Now, in general $\tilde{h}_{t+\Delta t}$ will not preserve mass; if deposits grow its total mass will be larger than one, otherwise smaller than one. The correction $\frac{\partial_t \mathbb{E}^{F_t}(D)}{\mathbb{E}^{F_t}(D)} h_t(e)$ reduces each element proportional to its mass to ensure that mass is preserved. Thus, I can compute

$$h_{t+\Delta t,i} = \frac{\tilde{h}_{t+\Delta t,i}}{\sum_k \tilde{h}_{t+\Delta t,k}}.$$

This is equivalent to subtracting the correction term. The implicit method, therefore, does not require solving a non-linear equation when updating the distribution.

The HJB equation with A_t^{HJB} as before but with time-varying inputs can be iterated as in Achdou et al. (2022) to solve for the HJB equation in the transition.

Leverage relief. Leverage relief allows banks to operate with capitalization $e < \underline{e}$. I extend

[22] Instead of $\exp(-\Delta \log e)$ in front of W_{-1}^{eq} and $\exp(\Delta \log e)$ in front of W_1^{eq}, we can also use a second order Taylor approximation around 0 and write $(1 - \Delta \log e + \frac{1}{2}(\Delta \log e)^2)$ and $1 + \Delta \log e + \frac{1}{2}(\Delta \log e)^2$. This sets the density that "leaks away" because $\Delta \log e \neq 0$ to 0. Results should be comparable.

the state space below $\underline{e}$ by adding $N/2$ log-equidistant grid points, giving an extended grid of size $3N/2$. This means that capitalization can approach 0. When capitalization would otherwise fall below the lowest grid point, banks are forced to raise equity as before.

I solve the HJB backward in two phases. For periods $T^{\text{relief}} + \Delta t, \ldots, T$, reserves count toward the LR requirement; I solve for the HJB equation on the regular grid starting from the steady-state value function. At period T^{relief}, I extend the value function to the larger grid by extrapolating below $\underline{e}$. For periods $0, \ldots, T^{\text{relief}}$, I solve on the extended grid. As banks with insufficient equity at the moment of suspension have to issue equity, the value function v of a bank with insufficient capitalization e at time T^{relief} is $v_{T^{\text{relief}}+\Delta t}(\underline{e}) - (1+\psi)(\underline{e} - e)$.

The distribution evolves forward symmetrically. For periods $1, \ldots, T^{\text{relief}}$, banks' capitalization is allowed to move on the whole extended grid. When the exemption ends, the mass of all banks with $e < \underline{e}$ is moved to $\underline{e}$ as banks are forced to issue equity. For periods $T^{\text{relief}} + \Delta t, \ldots, T$, the distribution of capitalization evolves on the regular grid.

D Solution to the banks' problem in section 6

This section solves the bank's problem in the flexible-deposit benchmark ($\theta = 0, \lambda^D \to \infty$). First, I show that there is a representative bank, which issues equity if its marginal value of equity is high enough. Then, I solve the HJB with and without a binding LR requirement and derive the steady state. Lastly, I discuss how I solve for the transitions.

D.1 Representative bank and equity issuance

By the argument in Appendix A.3, the value function is homogeneous of degree one in equity E_t. That means that the value function can be written as $V_t^{\text{flex}}(E_t) = \tilde{V}_t E_t$, where $\tilde{V}_t$ is a time-varying constant. Moreover, I will also show that as the marginal cost and benefit of a deposit are constant, all banks will hold the same amount of deposits relative to equity. As a result, this setting can be represented by a representative bank.

A bank issues equity when its value increases after issuance. Under issuance costs $dH_{jt} = \psi dF_{jt}$, a bank issuing $dF_t = m_t E_t$ pays $(1+\psi)m_t E_t$, the issued amount plus issuance costs, while its value rises by $\tilde{V}_t m_t E_t$. The issued amount cancels, so a bank is willing to issue whenever

$$\tilde{V}_t \geq 1 + \psi. \tag{29}$$

If this inequality is strict, all banks issue and there is a discrete jump up in equity after which the inequality holds with equality. If the inequality does not hold, no bank issues and issuance is zero. If the inequality holds with equality, banks are indifferent between issuance and no issuance. Some banks will issue with a mass consistent with the equilibrium prices that make banks indifferent or is consistent with steady state.

D.2 The value function

With $\lambda^D \to \infty$ and $\theta = 0$, deposits are a choice variable and deposit shocks are irrelevant, as the bank can fully offset them. Using the definition (1) of r_t^D, the deposit-profit term in expected profits μ_{jt}^E (21) with $\theta = 0$ can be rewritten as

$$D_{jt}\left(r - q_t r_t^D - (1-q_t)(\mu_{jt}^D - \lambda^B)\right).$$

As $\lambda^D \to \infty$, $q_t \to 1$: by (1), $q_t r_t^D$ contains the incentive cost $\lambda(1-q_t)$, which diverges for any $q_t < 1$, so deposit profits would go to $-\infty$ and no bank would take deposits. Thus, deposit profits simplify to the spread times the total number of deposits: $D_{jt}(r - r_t^D)$.

Let V_t^{flex} be the value of the bank with flexible deposits. This gives the HJB equation

$$(r+\lambda^B)V_t^{\text{flex}}(E) = \lim_{\lambda^D\to\infty} \max_{D\le(\xi_L-1)E, L\le\xi_K E} \lambda^B E + \left(rE + \alpha_t^L L + (r - r_t^D)D\right)\partial_E V_t^{\text{flex}} + \frac{1}{2}L^2\sigma_L^2\partial_{EE}V_t^{\text{flex}} + \partial_t V_t^{\text{flex}}. \quad (30)$$

By the same argument as in Appendix A.3, the value function is homogeneous of degree one in E:

$$V_t^{\text{flex}}(E) = \tilde{V}_t E \implies \partial_E V_t^{\text{flex}} = \tilde{V}_t, \quad \partial_{EE}V_t^{\text{flex}} = 0.$$

It follows from differentiating the HJB equation that either

$$r_t^D = r \text{ or } D = (\xi_L - 1)E \quad \& \quad r > r_t^D.$$

The latter will always be relevant as $\lim_{r_t^D\to r} D^*(q_t(r - r_t^D)) = \infty$. As $\partial_{EE}V_t^{\text{flex}} = 0$, the first-order condition for L is

$$\alpha_t^L = 0 \text{ or } L = \xi_K E \quad \& \quad \alpha_t^L > 0.$$

Plugging in the constraints,[23] $\mu^E E = rE + \alpha_t^L L + (r - r_t^D)D$.

Substituting the homogeneity result into the HJB (30) and dividing by E gives an ordinary differential equation in the marginal value of equity,

$$\partial_t \tilde{V}_t = \left(r + \lambda^B - \mu_t^E\right) \tilde{V}_t - \lambda^B. \tag{31}$$

Setting $\partial_t \tilde{V}_t = 0$ gives the steady-state marginal value of equity

$$\tilde{V} = \frac{\lambda^B}{r + \lambda^B - \mu^E}.$$

In steady state, aggregate equity is constant, so profits on equity plus issuance equal the payouts of exiting banks. Absent issuance this requires $\mu^E = \lambda^B$, and the marginal value of equity simplifies to $\frac{\lambda^B}{r}$. By (29), no issuance thus obtains in steady state if and only if

$$\frac{\lambda^B}{r} \leq 1 + \psi.$$

As $\lambda^B > r$, the marginal value of equity exceeds one and whether this inequality holds thus depends on the values of the other parameters. For the calibration in this paper, this does not hold and banks issue in steady state. The steady state is still unique; if banks have more aggregate equity E, ROE μ^E will be lower as loan demand and deposit supply are downward sloping. As $\tilde{V}_t$ is an increasing function of the ROE, banks issue until aggregate equity is high enough that $\tilde{V}_t = 1 + \psi$. Moreover, not every loan and deposit spread can be calibrated; if these spreads are too high, banks issue so much that equity continuously grows.

D.3 Leverage relief

Without the LR requirement, the bank demands unbounded deposits whenever $r_t^D < r$, so in equilibrium $r_t^D \to r$. As $\lambda^D \to \infty$, aggregate deposits equal new-depositor supply (2) with $q_t = 1$, so deposit profits are

$$(r - r_t^D)D_t = \bar{D}\left(r - r_t^D\right)^{1-1/\gamma^D}.$$

Deposits diverge while deposit profits go to zero if and only if $\gamma^D > 1$, as in the calibration. During the relief, therefore, $\mu^E E = rE + \alpha_t^L L$, and (31) holds with this lower μ^E.

[23] If one constraint does not bind, the term is 0 by the FOC, so this holds everywhere.

D.4 Transitions

Transitions can be solved as follows: the ODE (31) is iterated backwards from the terminal steady state to get the marginal value of equity at each instant in time. This value can then be used to calculate issuance at each moment in time through (29). Prices are set where supply meets demand. Equity is iterated forward.

E Micro-foundation of the households and deposit demand

Throughout this appendix the bond rate is constant at r, so $\int_t^s r_u du = r(s-t)$ and every discount factor below evaluates in closed form. The derivation is stated for a general rate path where that costs nothing, and the constant rate is imposed wherever it removes a step.

There are multiple overlapping generations of perpetual-youth households, in the tradition of Blanchard (1985). $\lambda^D dt$ new households are born each instant dt. Households live for τ^D periods, which is exponentially distributed with mean $1/\lambda^D$. This implies that each instant dt, each household dies with rate $\lambda^D dt$. This ensures that in equilibrium, the total mass of households is constant and equals one. Households consume upon death and while young. Utility is linear in consumption while young and upon death; thus, wealth does not change household bond and deposit demand. Moreover, households are deep-pocketed: they can consume negative amounts. This makes bank and firm ownership irrelevant for deposit and bond supply.

Households whose bank has exited and who have to find a new bank face the same problem as a newly born household because of quasi-linear utility and households being deep-pocketed. Thus, in the part below, I model death as what happens first: bank exit or household death. The inverse of this rate is the duration of an average deposit. Let the stochastic time until bank exit be denominated τ^B. The stochastic time until a bank-deposit link is broken up is then $\tau := \min\{\tau^D, \tau^B\}$. The minimum of these two exponential distributions is distributed exponentially with a rate $\lambda := \lambda^B + \lambda^D$.

A household, indexed by its time of birth t, chooses consumption while young $C_t^d(t)$, deposits $D^d(t)$, bonds bought while young $B_t^d(t)$, and consumption upon death or exit of its bank $C_{t+\tau}^d(t)$.

In principle, the household could consume at intermediate times. However, the household is indifferent between consuming and not consuming at intermediate times, as its discount rate is the risk-free rate in equilibrium. Thus, limiting ourselves to consumption while young and upon death is without loss of generality.

A household's utility is

$$C_t^d(t) + \mathbb{E}_t \left(\int_t^{t+\tau} \exp\left(- \int_t^s r_u du \right) x(D^d(t)) ds + \left(\exp\left(- \int_t^{\tau^D} r_s ds \right) C_{t+\tau}^d(t) \right) \right)$$

subject to budget constraints

$$C_t^d(t) + q_t D^d(t) = -B_t^d(t), \quad C_{t+\tau}^d(t) = B_{t+\tau}^d(t) + D^d(t)$$

and the evolution equation of bonds

$$dB_s^d(t) = r_s B_s^d(t) ds + \beta r_s D^d(t) ds.$$

The $\beta r_s ds$ interest paid on deposits is deposited in bonds to be consumed upon death. Inspired by Bianchi & Bigio (2022), I choose the functional form

$$x(D) = \bar{D}^{\gamma^D} \frac{D^{1-\gamma^D}}{1-\gamma^D},$$

where $\bar{D}$ shifts the level of deposit demand and γ^D governs the elasticity.

There are no random shocks to deposit holdings. In this specification, payments happen between accounts of the same depositor at different banks. This is not necessary: as long as the payments are mean zero and independent of the time of death, the results go through.

Solving the bond evolution equation gives

$$B_{t+\tau}^d(t) = \exp\left(\int_t^{t+\tau} r_s ds \right) B_t^d(t) + \beta D^d(t) \int_t^{t+\tau} \exp\left(\int_s^{t+\tau} r_u du \right) r_s ds.$$

Since $-\frac{d}{ds} \exp\left(\int_s^{t+\tau} r_u du \right) = r_s \exp\left(\int_s^{t+\tau} r_u du \right)$, the integral evaluates to $\exp\left(\int_t^{t+\tau} r_s ds \right) - 1$, so upon death interest payments on deposits give the household $\beta D^d(t) \left(\exp\left(\int_t^{t+\tau} r_s ds \right) - 1 \right)$ more bonds and consumption. Combining this expression with the second budget constraint gives

$$C_{t+\tau}^d(t) = \exp\left(\int_t^{t+\tau} r_s ds \right) \left(B_t^d(t) + \beta D^d(t) \right) + (1-\beta) D^d(t).$$

Substituting both constraints gives an objective

$$C_t^d(t) + \mathbb{E}_t\left(\int_t^{t+\tau} \exp\left(-\int_t^s r_u du\right) x(D^d(t))ds\right) + \\ \mathbb{E}_t\left(-(C_t^d(t) + q_t D^d(t)) + \beta D^d(t) + \exp\left(-\int_t^{t+\tau} r_s ds\right)(1-\beta)D^d(t)\right) = \\ x(D^d(t))\mathbb{E}_t\left(\int_t^{t+\tau} \exp\left(-\int_t^s r_u du\right) ds\right) - \left(q_t - \beta - (1-\beta)\mathbb{E}_t \exp\left(-\int_t^{t+\tau} r_s ds\right)\right) D^d(t). \quad (32)$$

The payout at closure is on average discounted with

$$\mathbb{E}_t \exp\left(-\int_t^{t+\tau} r_u du\right) = \int_t^\infty \lambda \exp(-\lambda(s-t))\mathbb{E}_t \exp\left(-\int_t^s r_u du\right) ds = \lambda \int_t^\infty \mathbb{E}_t \exp\left(-\int_t^s (r_u + \lambda) du\right) ds, \quad (33)$$

which integrates to

$$\frac{\lambda}{r+\lambda},$$

and the value of an annuity that pays one during the deposit's life (with which the utility is discounted) is

$$\mathbb{E}_t\left(\int_t^{t+\tau} \exp\left(-\int_t^s r_u du\right) ds\right) = \int_t^\infty \underbrace{\mathbb{P}(t+\tau \geq s)}_{\exp(-\lambda(s-t))} \mathbb{E}_t\left(\exp\left(-\int_t^s r_u du\right)\right) ds = \\ \int_t^\infty \mathbb{E}_t\left(\exp\left(-\int_t^s (r_u + \lambda) du\right)\right) ds.$$

Note that this expression can be rewritten as $\mathbb{E}_t \exp\left(-\int_t^{t+\tau} r_s ds\right)/\lambda$, because the final expression is λ times 33. Using the expression found for $\mathbb{E}_t \exp\left(-\int_t^{t+\tau} r_s ds\right)$, this integral evaluates to

$$\frac{1}{r+\lambda}.$$

The FOC for deposits is

$$x'(D^d(t)) = \frac{q_t - \beta - (1-\beta)\mathbb{E}_t \exp\left(-\int_t^{t+\tau} r_s ds\right)}{\mathbb{E}_t\left(\int_t^{t+\tau} \exp\left(-\int_t^s r_u du\right) ds\right)},$$

where for my functional form $x'(D) = \left(\bar{D}/D\right)^{\gamma^D}$. The ratio $q_t/\mathbb{E}_t\left(\int_t^{t+\tau} \exp\left(-\int_t^s r_u du\right) ds\right)$ is the price of a deposit relative to how much it costs to buy bonds such that on average a depositor gets

1 payout upon the end of the deposit contract. With a constant bond rate the annuity factor is

$$\mathbb{E}_t\left(\int_t^{t+\tau}\exp\left(-\int_t^s r_u du\right)ds\right)=\int_t^{\infty}\exp(-(r+\lambda)(s-t))ds=\frac{1}{r+\lambda},$$

so the rate at which a deposit's payoffs are discounted over the life of the relationship is r itself.

Lemma 5 (Return on deposits)**.** *A deposit yields the expected return r_t^D in* (1)*.*

Proof. A deposit costs q_t and has a book value of one. Over its life the bank pays interest at the rate βr, and when the relationship breaks (at rate λ), the depositor receives one having paid q_t, a capital gain of $1-q_t$. The expected income per deposit is therefore $\beta r+\lambda(1-q_t)$; dividing by the q_t invested gives $r_t^D=\frac{\beta r}{q_t}+\frac{\lambda(1-q_t)}{q_t}$, or equivalently $q_t=\frac{\beta r+\lambda}{r_t^D+\lambda}$. □

Using $q_t=\frac{\beta r+\lambda}{r_t^D+\lambda}$, the right-hand side of the first-order condition can then be written as

$$\frac{(\beta r+\lambda)(r-r_t^D)}{r_t^D+\lambda}=q_t(r-r_t^D).$$

Together with the expressions above, deposit demand from young households is

$$\left(\frac{\bar{D}}{D^d(t)}\right)^{\gamma^D}=q_t(r-r_t^D),\qquad D^d(t)=\bar{D}\left(q_t(r-r_t^D)\right)^{-1/\gamma^D}.$$

This expression holds at every date, not only in the steady state, because the bond rate does not move. Demand goes to infinity as $r_t^D\to r$, so the deposit spread $q_t(r-r_t^D)$ is always positive. The elasticity of deposit demand with respect to $q_t(r-r_t^D)$ equals

$$\frac{dD^d(t)}{dq_t(r-r_t^D)}\frac{q_t(r-r_t^D)}{D^d(t)}=-\frac{1}{\gamma^D}.$$

Notice that

$$D^d(t)q_t(r-r_t^D)=\bar{D}(q_t(r-r_t^D))^{1-1/\gamma^D}\to 0 \text{ as } r_t^D\to r$$

as long as $\gamma^D>1$, i.e. demand is inelastic, which I assumed to be the case.

F Proofs

F.1 Proposition 1

Proof. It is useful to rewrite the FOC as

$$\alpha(1+\psi\mathbb{P}(F>0)) = -\mathbb{E}(\varepsilon(1+\psi 1_{F>0})).$$

The LHS is the expected excess return on lending times the expected marginal utility, while the RHS consists of the utility costs, because lending returns and issuance are negatively correlated. In the never-issuance and unconditional-issuance segments

$$\mathbb{E}(\varepsilon(1+\psi 1_{F>0})|D \in \text{segment}_i) = \mathbb{E}(\varepsilon|D \in \text{segment}_i)(1+\psi 1_{F>0}|D \in \text{segment}_i) = 0,$$

as issuance is independent of lending. However, in the conditional-issuance segment the two are correlated:

$$-\mathbb{E}(\varepsilon(1+\psi 1_{F>0})|D \in \text{conditional issuance}) = -\left((1-p)\varepsilon_L(1+\psi)+p\varepsilon_H\right) = (1-p)(-\varepsilon_L)\psi,$$

where the last equality uses that $p\varepsilon_H + (1-p)\varepsilon_L = \mathbb{E}(\varepsilon) = 0$. Note that as $\varepsilon_L < -\alpha < 0$, all terms are positive.

Using this, the FOC can be written as

$$\alpha\left(1+\psi\left(\mathbb{P}(\text{conditional issuance})(1-p)+\mathbb{P}(\text{unconditional issuance})\right)\right) = \mathbb{P}(\text{conditional issuance})(1-p)(-\varepsilon_L)\psi$$

Or, to make it more legible, we put all terms with $\mathbb{P}$(conditional issuance) to the RHS to get

$$\alpha\left(1+\psi\mathbb{P}(\text{unconditional issuance})\right) = \mathbb{P}(\text{conditional issuance})(1-p) * -(\alpha+\varepsilon_L)\psi,$$

where again all terms on the RHS are positive.

Note that as the distribution and the effect of lending on profits are continuous, $\mathbb{P}$(unconditional issuance) goes continuously from a finite number between 0 and 1 to 0, while $\mathbb{P}$(conditional issuance) goes from 0 to 1 as K goes from 0 to ∞. At $K = 0$ the LHS is larger than 0, while the RHS is 0. The LHS then decreases to α while the RHS increases to $(1-p) * -(\alpha+\varepsilon_L)\psi$. Thus, this condition implies that there is a (finite) solution. Otherwise, loans would be infinite. Uniqueness follows from

both sides changing monotonically in opposite directions with K.

Filling in $(\alpha + \varepsilon_L) = -1$ gives the final expression. □

F.2 Proposition 2

Proposition 2. *Let L_T denote optimal lending when one period lasts T years, let $e = E_0$ denote the bank's capitalization, and let the density $\tilde{g}$ of $\tilde{G}$ be continuous and positive at 0. As $T \to 0$,*

$$\sqrt{T}L_T \to \begin{cases} \dfrac{\underline{e} - e}{\tilde{\varepsilon}_H} & \text{if } e < \underline{e}, \\ \dfrac{e - \underline{e}}{-\tilde{\varepsilon}_L} & \text{if } e > \underline{e}, \end{cases} \qquad \frac{L_T}{\sqrt{T}} \to \frac{\tilde{\alpha}^L \underline{e}\left(1 + \psi\left(1 - \tilde{G}(0)\right)\right)}{\psi \tilde{g}(0)\tilde{\sigma}_{\tilde{\varepsilon}}^2} \text{ if } e = \underline{e},$$

where $\tilde{\sigma}_{\tilde{\varepsilon}}^2 = p\tilde{\varepsilon}_H^2 + (1-p)\tilde{\varepsilon}_L^2$.

Proof. Write $NLE_1 = e + T\tilde{r}(1+e)$, $D_1 = 1 + \sqrt{T}\eta$ with $\eta \sim \tilde{G}$, $\alpha^L = T\tilde{\alpha}^L$, and $\varepsilon_s = \sqrt{T}\tilde{\varepsilon}_s$ for $s \in \{H, L\}$. Define $c := p\tilde{\varepsilon}_H = -(1-p)\tilde{\varepsilon}_L > 0$, which uses $\mathbb{E}(\tilde{\varepsilon}) = 0$.

How the FOC works in this setting. Issuance occurs in the good state if and only if $D_1 > \overline{D}$, and in the bad state if and only if $D_1 > \underline{D}$, where

$$\overline{D} - 1 = \frac{e - \underline{e} + T\tilde{r}(1+e) + \left(T\tilde{\alpha}^L + \sqrt{T}\tilde{\varepsilon}_H\right)L}{\underline{e}}, \qquad \underline{D} - 1 = \frac{e - \underline{e} + T\tilde{r}(1+e) + \left(T\tilde{\alpha}^L + \sqrt{T}\tilde{\varepsilon}_L\right)L}{\underline{e}}. \tag{34}$$

Let $P_T^I(L)$ denote the probability of issuance and $P_T^C(L) := \mathbb{P}\left(\underline{D} < D_1 \leq \overline{D}\right)$ the probability of conditional issuance. Conditioning on the loan outcome, and using that deposit and loan shocks are independent,

$$\mathbb{E}(\varepsilon 1_{F>0}) = p\varepsilon_H \mathbb{P}(D_1 > \overline{D}) + (1-p)\varepsilon_L \mathbb{P}(D_1 > \underline{D}).$$

As $\mathbb{E}(\varepsilon) = 0$, $p\varepsilon_H = -(1-p)\varepsilon_L = \sqrt{T}c$, so this equals $\sqrt{T}c\left[\mathbb{P}(D_1 > \overline{D}) - \mathbb{P}(D_1 > \underline{D})\right] = -\sqrt{T}cP_T^C(L)$, as in the proof of Proposition 1. Hence the derivative of the objective $V(L) = \mathbb{E}\left[NLE_1 + (\alpha^L + \varepsilon)L - \psi F\right]$ satisfies

$$\frac{V'(L)}{T} = \tilde{\alpha}^L\left(1 + \psi P_T^I(L)\right) - \psi c \frac{P_T^C(L)}{\sqrt{T}}. \tag{35}$$

The first term is the spread benefit, which lies in $\left[\tilde{\alpha}^L, \tilde{\alpha}^L(1+\psi)\right]$. The second is the cost of conditional issuance. Hence $V'(L) > 0$ if $P_T^C(L)/\sqrt{T} \to 0$, and $V'(L) < 0$ if $P_T^C(L)/\sqrt{T} \to \infty$.

V is concave in L, as F is the maximum of 0 and a function linear in L. Therefore $V'(a) > 0$ implies $L_T > a$, and $V'(b) < 0$ implies $L_T < b$. Each case below evaluates (35) at a trial level of

lending, rescaled by the rate at which L_T moves.

By (35), the sign of V' depends on how P_T^C compares to $\sqrt{T}$. In each case below, I determine where the thresholds $\overline{D}$ and $\underline{D}$ lie relative to 1, the point at which D_1 concentrates, and translate this into a bound on P_T^C using two facts about D_1. First, as η has support in $(-1, \infty)$, $\mathbb{P}(D_1 \leq 1-\delta) = 0$ for any $\delta > 0$ once $\sqrt{T} < \delta$: if both thresholds lie below 1, conditional issuance becomes impossible. Second, by Chebyshev's inequality, $\mathbb{P}(|D_1 - 1| > \delta) \leq \tilde{\sigma}_D^2 T/\delta^2$: if both thresholds lie above 1, conditional issuance becomes rare relative to $\sqrt{T}$, and if 1 lies between them, it becomes almost certain.

Case 1: $e < \underline{e}$**.** Let $m^* = (\underline{e} - e)/\tilde{\varepsilon}_H$. Fix $m > 0$ and set $L = m/\sqrt{T}$. By (34),

$$\overline{D} - 1 \to \frac{\tilde{\varepsilon}_H(m - m^*)}{\underline{e}}, \qquad \underline{D} - 1 \to \frac{e - \underline{e} + \tilde{\varepsilon}_L m}{\underline{e}} < 0.$$

If $m < m^*$, both thresholds lie below $1 - \delta$ for some $\delta > 0$ and T small, so $P_T^C = 0$ and $V' > 0$. If $m > m^*$, then $\underline{D} < 1 - \delta < 1 + \delta < \overline{D}$ for some $\delta > 0$ and T small, so $P_T^C \geq 1 - \tilde{\sigma}_D^2 T/\delta^2 \to 1$, and $V' < 0$. Hence $m < \sqrt{T}L_T < m'$ for small T, for any $m < m^* < m'$, and $\sqrt{T}L_T \to m^*$.

Case 2: $e > \underline{e}$**.** Let $m^* = (e - \underline{e})/(-\tilde{\varepsilon}_L)$ and again set $L = m/\sqrt{T}$. Now

$$\overline{D} - 1 \to \frac{e - \underline{e} + \tilde{\varepsilon}_H m}{\underline{e}} > 0, \qquad \underline{D} - 1 \to \frac{-\tilde{\varepsilon}_L(m^* - m)}{\underline{e}}.$$

If $m < m^*$, both thresholds lie above $1 + \delta$ for some $\delta > 0$ and T small, so $P_T^C \leq \mathbb{P}(D_1 > 1 + \delta) \leq \tilde{\sigma}_D^2 T/\delta^2$. Then $P_T^C/\sqrt{T} \to 0$ and $V' > 0$. If $m > m^*$, $V' < 0$ as in Case 1. Hence $\sqrt{T}L_T \to m^*$.

Case 3: $e = \underline{e}$**.** Fix $k \geq 0$ and set $L = \sqrt{T}k$. By (34), both thresholds are now within order T of 1, and therefore inside the range of the deposit shock, which is of order $\sqrt{T}$. In units of the annual deposit flow, $\bar{\eta}_H := (\overline{D} - 1)/\sqrt{T}$ and $\bar{\eta}_L := (\underline{D} - 1)/\sqrt{T}$ both tend to 0, and

$$\bar{\eta}_H - \bar{\eta}_L = \frac{\overline{D} - \underline{D}}{\sqrt{T}} = \sqrt{T}\frac{(\tilde{\varepsilon}_H - \tilde{\varepsilon}_L)k}{\underline{e}}.$$

By the mean value theorem, $P_T^C = \tilde{G}(\bar{\eta}_H) - \tilde{G}(\bar{\eta}_L) = \tilde{g}(\zeta_T)\,(\bar{\eta}_H - \bar{\eta}_L)$ for some ζ_T between $\bar{\eta}_L$ and $\bar{\eta}_H$, and $\tilde{g}(\zeta_T) \to \tilde{g}(0)$ by continuity. Moreover, $P_T^I \to 1 - \tilde{G}(0)$. Since $c(\tilde{\varepsilon}_H - \tilde{\varepsilon}_L) = p\tilde{\varepsilon}_H^2/(1-p) = \tilde{\sigma}_\varepsilon^2$, (35) gives

$$\frac{V'(\sqrt{T}k)}{T} \to \tilde{\alpha}^L\left(1 + \psi\left(1 - \tilde{G}(0)\right)\right) - \frac{\psi\tilde{g}(0)\tilde{\sigma}_\varepsilon^2}{\underline{e}}k.$$

This limit is strictly decreasing in k, positive at $k = 0$, and zero at

$$\kappa = \frac{\tilde{\alpha}^L \underline{e} \left(1 + \psi \left(1 - \tilde{G}(0)\right)\right)}{\psi \tilde{g}(0) \tilde{\sigma}_\varepsilon^2}.$$

Hence $V'(\sqrt{T}k) > 0$ for $k < \kappa$ and $V'(\sqrt{T}k) < 0$ for $k > \kappa$ when T is small, so $L_T/\sqrt{T} \to \kappa$. □

G European capital requirements, collecting bank-level capital requirements and data cleaning

Data on (CET-1) European capital requirements has not been centrally available until recently. While the EBA's Transparency Exercise discloses capital measures, it does not disclose bank-level requirements. Under Basel III, banks have to disclose so-called Pillar 3 reports, in which there is a table called "key metrics 1" (KM1) which contains a bank's capital, its assets, capital and leverage ratios, and their respective requirements broken down by element. However, only since 2026 has the EBA published this data for the largest banks in an easily downloadable format in the data hub (EBA, 2026b). For data before June 2025, the data needs to be collected from individual banks. This is non-trivial as many banks provide their disclosure as a PDF, and although the format is standardized, some banks interpret certain rows differently, requiring judgement. While public information on bank requirements goes some way to recreating these ratios, it misses specific buffers. The next subsection talks about how capital requirements are decided, which data is only available in Pillar 3 reports and which data can be cross-verified. The section thereafter discusses how inconsistencies within the Pillar 3 reports and between the Pillar 3 reports and information published by supervisors were resolved.

G.1 Capital requirements, their components, and public data sources

Under Basel III, there are three risk-weighted capital ratios and a leverage ratio that are subject to requirements. These requirements are the sum of three parts: Pillar 1, Pillar 2, and buffers. I need one measure of distance to the capital requirement; for that measure, I use the minimum of the distances to the requirement of the three capital ratios.

G.1.1 Capital requirement

The three capital requirements differ by the measure of capital used. Common Equity Tier 1 (CET-1) is the most restrictive measure; Tier 1 capital allows more debt-like products to also be counted as equity, while total capital allows even more liabilities to be counted as equity. For each measure of capital, there are different Pillar 1 and 2 requirements to be met. The buffers always have to be met with CET-1 capital and thus increase all three requirements by the same amount.

The Pillar 1 requirement is the same for all banks: 4.5% for CET-1, 6% for Tier 1 capital, and 8% for total capital (BCBS, 2020).

The Pillar 2 requirement (P2R) is set by the relevant regulator, the ECB, based on the riskiness of a bank's activities and published in a table on its website (ECB, 2026b). Generally[24], 75% of the requirement has to be met with Tier 1 capital, and a further 75% of that Tier 1 capital (56.25% of the requirement) has to be CET-1 capital.

Banks further have to meet buffers, all of which have to be held in CET-1 capital, i.e., the buffers increase all three requirements by the same amount. All banks have a flat 2.5% capital conservation buffer.[25] In addition, banks have to hold countercyclical buffers (CCyB), which are set at the national level. A bank's countercyclical buffer requirement is then an exposure-weighted average of the national countercyclical buffers in the countries in which it has operations. As bank-level information on the countries in which banks have operations is not centrally publicly available, pre-2025 buffers need to be collected from all the individual banks. National macro-prudential regulators can further impose bank-specific systemic risk buffers, where the exact height is not disclosed by the regulator at the bank level but depends on the geographic and sectoral make-up of the bank's activities, requiring bank-level filings. Globally (G-SII) or nationally systemically important (O-SII) banks have an additional buffer based on how important they are to the global or national economy. The FSB (2025) publishes an annual list of G-SIIs with their G-SII buffers. For bank-periods in the sample the surcharge is either 1.0% or 1.5%. The EBA (2026a) publishes annual lists of EU O-SIIs together with their O-SII buffers.

[24] This is a minimum; regulators can set higher amounts to be met with Tier 1 or CET-1. The minimum seems to be the requirement in most Pillar 3 reports (some banks put down different numbers, but these could be errors). More evidence of the minimum being the norm can be found in the aggregate data: from 2021, the average P2R for CET-1 has always been 75% of 75% of the average total P2R, up to rounding (ECB, 2025). As the minimum and average coincide, there can only be minimal dispersion.

[25] This looks similar to a Pillar 1 requirement. However, European regulators treat buffers differently from Pillar 1 and 2 capital requirements; always listing them separately. A breach of buffers mostly limits payouts to shareholders and variable remuneration. The law is unclear on when banks can have their license withdrawn, with lots of cross-references, but my understanding is that that only happens if the Pillar 1 and 2 requirements are at risk of being violated (European Union, 2026).

In addition to these requirements, the ECB communicates Pillar 2 Guidance (P2G) to the bank. This is an additional capital buffer that banks are expected to hold on top of the rest, but it is not legally binding. However, a violation can cause the supervisor to "define individually tailored supervisory measures" (ECB, 2016). Neither the ECB nor the banks publish this guidance. However, the ECB publishes the average level of the guidance, and in its communication it always gives a figure of average capital requirements inclusive of P2G.[26] This has to be met with CET-1, so it increases all capital requirements equally. I assume all banks have the average level for P2G when calculating excess capital, and assume that banks treat it as any requirement. During all years in the period, average P2G equalled 1.3%.

G.1.2 The leverage requirement

The leverage requirement is relatively simple. The Pillar 1 requirement is 3% for all banks. In addition, there is the P2R for the LR, but this is relatively small; on average 2 bps in 2024, and 3bps in 2025 for euro area banks (ECB, 2025), especially concentrated in European subsidiaries of foreign banks that hold little deposits and are thus outside the sample (ECB, 2026b). P2G was non-existent before 2024, and averaged 4bps in 2024 and 5bps in 2025. Globally systemic banks also have to add half their CET-1 G-SII buffer as an additional requirement: in the sample either 0.5% or 0.75%. No other buffers exist.

G.2 Resolution of inconsistencies

As a baseline, I calculated the distance to the capital requirement as the banks' self-reported "CET1 available after meeting the total SREP own funds requirements" (row 12), which is CET-1 as a fraction of risk-weighted assets net of Pillar 1 and 2 requirements, minus the "Combined buffer requirement" (row 11). Some banks seem to use interpretations of certain lines in the KM1 table that differ from the standard, requiring judgement on which numbers to trust. When the internal checks came up with issues in these measurements, I went to alternative calculations; the details are spelled out below. To gain further confidence that the reported numbers are accurate, I checked certain lines that are reported by the banks against values reported by external sources, most of which match up. The details are spelled out below.

[26] See chart 5 of the SREP (ECB, 2025).

G.2.1 Internal checks

To check the quality of the parsed data, I checked the following internal identities and investigated the failures:

1. Check if different documents carrying the same periods hold the same value.
2. Check if values are in reasonable ranges.
3. Check if euro amounts of capital and risk-weighted assets give rise to the listed capital ratios.
4. Check if the total own funds requirements are the sum of the 8% and the P2R.
5. The combined buffer requirement has to be the sum of the individual buffer requirements.
6. Check if the total leverage ratio requirement is 3% plus the P2R.
7. Check if excess CET-1 after SREP 1 equals the reported CET-1 ratio net of the bottom-up-calculated maximum of the three capital requirements.

When different documents disagree on values, the report with the value for the capital ratios closest to the Transparency Exercise was used; likely, it was an issue with restatements or a data entry error.

403 out of 463 bank-periods (87.0%) had banks follow reporting formats consistent with my interpretation. Some alternative interpretations of variables were internally consistent for banks earlier in the sample. 8 banks in 14 bank-periods constructed CET-1 available after the SREP requirement as CET-1 net of only the CET-1 Pillar 1 and P2R requirements, while other (Tier 1 or AT1) requirements were more binding. In these cases, I reinstated row 12 with the actual excess capital. BPCE and NLB in some periods used idiosyncratic definitions reported in footnotes; I corrected for these idiosyncratic definitions. In one bank-period, Revolut reported a combined buffer requirement (row 11) that was off by the O-SII buffer; I added back the O-SII buffer.

In one case, a bank reported inconsistent values without a clear alternative method that mattered for how much excess capital is reported. La Banque Postale consistently reported P2Rs inconsistent with self-reported total capital requirements and with the P2R reported by the ECB. As the ECB-reported P2Rs are consistent with the reported total capital requirements, I decided to trust the total requirements. For all other banks, inconsistencies in the report did not matter for how excess capital is calculated.

G.2.2 External checks

I also did the following checks against external sources to see if the reported values are for the correct entity and free from errors. When small discrepancies remain, I used the values from the Pillar 3 reports.

1. Do reported capital ratios match the EBA's Transparency Exercise capital ratios?
2. Do reported G-SII and O-SII buffers correspond with the lists reported by global and national risk boards?
3. Do Pillar 2 buffer requirements approximately correspond with those reported by the ECB?

Capital ratio agreement. Some banks had rather different capital ratios than those reported by the EBA. In these cases, either the EBA's numbers were on a consolidated basis, while the bank's numbers were the bank daughter, or restatements meant that the value changed over time.

If it were an issue with consolidation and I could not find Pillar 3 reports for the consolidated bank, I dropped these observations from the sample, which was the case for Argenta, Novo Banco, and 4 bank-periods for Eurobank. This is necessary because in all cases, the EBA reported much lower capital ratios than the daughter banks reported.

When there is no issue with consolidation, it is likely a problem with restatements. I accepted a mismatch up to 0.25pp. If this were breached, I looked for another filing with values closer to the Transparency Exercise.

KBC reported capital before the quarter's profit is added to equity, while the EBA used a measure inclusive of the profit. In this case, I decided to use the EBA's measure instead. Citadele Bank's capital ratio was off by 1%-point in June of 2025. This was likely because they sold a subsidiary around that time. I chose to go with the EBA value instead.

Only in the case of BIL is there an unexplained remaining mismatch in capital ratios in excess of 0.25pp with the EBA; the self-reported leverage ratio in 2024H1 is 0.28pp lower than that reported by the EBA, and the CET-1 is 0.25pp lower.

G-SII & O-SII buffers. For these buffers, the sample has only 2 bank-periods where reported values are off. All G-SIIs give the same G-SII buffer as the FSB. 342 out of 380 (90.0%) of bank-periods with regulator-reported O-SII requirements match regulator sources up to rounding. Another 36 bank-periods report a lower value than the regulator, but higher than the period before, likely because higher buffers do not get applied immediately but get phased in over time. The

remaining 2 bank-periods appeared to report a wrong value; Revolut in 2025H1 reports a 0 O-SII buffer, while the Lithuanian regulator has had it at 2% unchanged from the year before. LHV reported 2.315% instead of 2% in 2025H1. This is odd, as the requirement remained 2% in both 2025 and 2026. In these cases, I replaced the buffers with the regulator-reported buffers. These banks are small (in total ca. 0.17% of sample deposits), making them unimportant for deposit-weighted averages.

Pillar 2 agreement. The bank-reported P2Rs match ECB-reported within 10bps in 380 out of 386 (98.4%) bank-periods.[27] The remaining discrepancies are no larger than 60bps (220bps being the average P2R). The ECB informed me that P2Rs are generally set annually, but can change during the year for a number of reasons. They can change on an ad hoc basis, mostly after mergers. All 6 mismatched bank-periods had complete acquisitions around the period. As the ECB website only reports the most updated value for the P2R, it could be a value that was not applicable when the Pillar 3 report was published.

G.3 Missing data

Four banks only reported annual Pillar 3 reports for some periods of the sample. For the banks in the years where this applied, I assumed that the year-end values for the capital and leverage requirements also applied at the half-year. For the capital ratios, I used the values reported by the Transparency Exercise.

This applies to Crelan in all years, ING in 2022 and 2023, AikGroup in 2022, and Eurobank in 2024.

G.4 Changes in legal entity

Three changes in legal entities happened in the original sample. Volkswagen Financial merged other activities with Volkswagen Bank. As the activities changed, I decided to keep both as separate banks in the sample. Alpha Bank changed its legal structure during the sample, adding a holding company above the bank. As this is a pure legal change, I map both to the same bank. Similarly, Aareal Bank was bought by a consortium that added a holding company. I map both banks to the same bank. The bank drops out of the sample for this reason. The old legal entity, which only existed in

[27] This is less than the 457 bank-periods in the sample, as some banks had no ECB-published P2Rs in some years that they were in the Transparency Exercise. These banks were likely supervised by national regulators in these periods.

the first half of the sample, would (just) clear the 30% average deposits over assets threshold, but the bank over all 7 periods does not.

H Overview of the banks in the sample

Table 6 gives the composition of the sample by country, and Table 7 lists the individual banks.

I Regressions

I did two regressions to investigate the sensitivity of interest rates with respect to the ECB's average deposit facility rate within a half year. The bank-level data is from the Transparency Exercise, while the deposit facility rate data is from the ECB's Data Portal.

The main specification is

$$\frac{\text{Deposit interest expenditure}_{it}}{\text{Total deposits}_{it}} = \sum_{k=1}^{5} \left(\beta_k \text{ECB dep. rate}_t \times \frac{\text{Type } k \text{ deposits}_{it}}{\text{Total deposits}_{it}} \right) + \varepsilon_{it},$$

where the type k refers to either household, NFC, central bank, government, other banks or other financial institutions. The intuition is that this shows how interest expenditures covary with different types of deposits. This does not necessarily identify how much of that rise of interest expenditure is due to these types of depositors receiving higher interest rate payments, but I do not have that data for the euro area. It could be that banks where central banks deposit a lot are banks that also tend to pay depositors well. I impose an intercept of 0 for all types of deposits as that corresponds to the functional form I have in the model. As a second specification I use

$$\frac{\text{Deposit interest expenditure}_{it}}{\text{Total deposits}_{it}} = \sum_{k=1}^{5} \left(\alpha_k \frac{\text{Type } k \text{ deposits}_{it}}{\text{Total deposits}_{it}} + \beta_k \text{ECB dep. rate}_t \times \frac{\text{Type } k \text{ deposits}_{it}}{\text{Total deposits}_{it}} \right) + \varepsilon_{it},$$

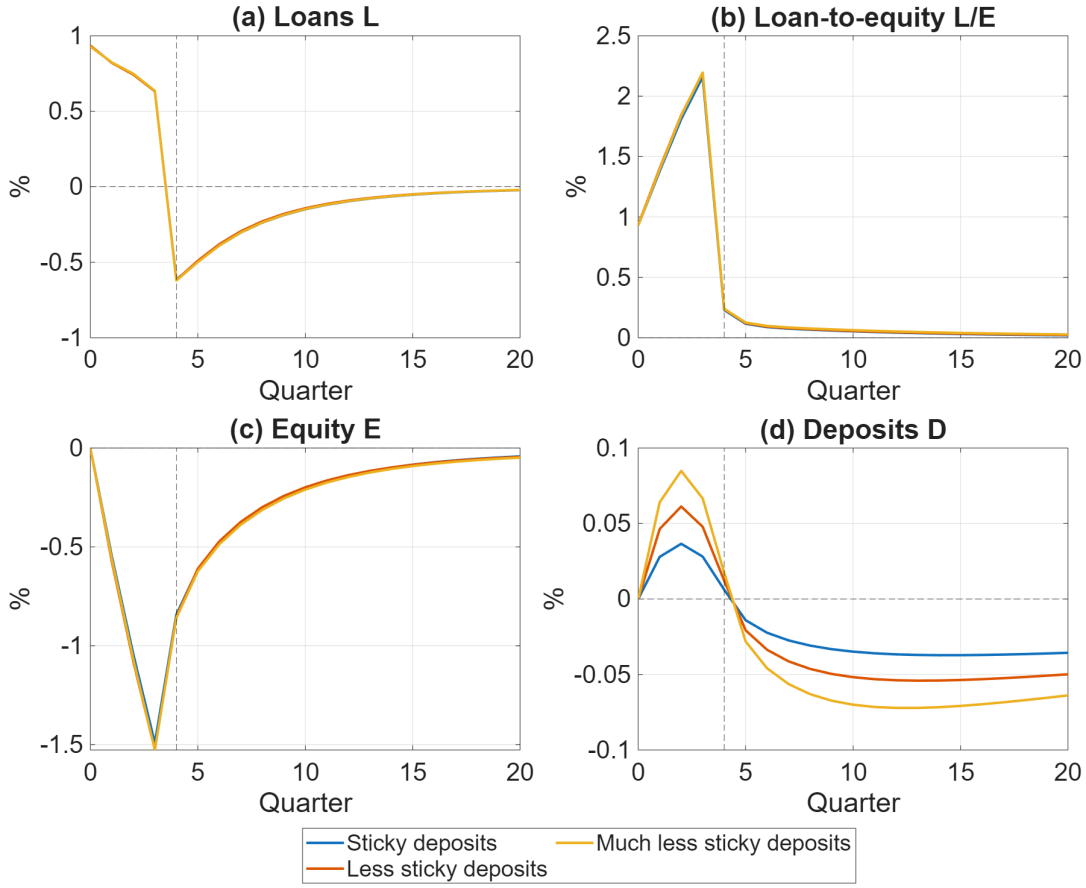
which allows for category specific intercepts. Table 8 shows the regression results of the two specifications. Note that for central banks, other banks and other financial institutions the coefficient is much closer to 1 than for households and NFCs. Governments are odd; their intercept is extremely negative, but the interest rate received seems to be reasonably procyclical in the second specification with an intercept. In the first specification these two cancel out. Overall government deposits are a small part of the sample: less than 4%.

J Additional comparative statics

J.1 Varying deposit stickiness

Digitalization and AI agents that can handle the switching may make consumers switch banks more often. Koont, Santos, & Zingales (2024) predict that with digitalization, consumers will re-optimize more often. Of course, this need not happen; Egan et al. (2025) show that depositors of digital banks stay longer with the bank as they do not need to switch banks when they move houses. Figure 20 shows comparative statics with respect to the duration of deposits λ^D, comparing the baseline results with settings where deposits on average leave a bank after 4.75 years (less sticky) and 0.5 years (much less sticky). The loan, loans-to-equity, and equity changes are only marginally different for these changes in stickiness. Banks do take more deposits when they stay at the bank for a shorter time during the exemption. Overall, some stickiness yields nearly the same effect on the effectiveness of leverage relief on lending as much stickiness. It seems that the lack of adjustment costs is the main driver of the difference in behaviour with the benchmark.

Figure 20: Aggregate response to four-quarter leverage relief across deposit stickiness



Notes: Percentage deviations from each economy's own steady state. Total deposit duration is $1/(\lambda^D + \lambda^B)$: 8.8 years for sticky deposits (the baseline calibration, $\lambda^D = 0$), 4.75 years for less sticky deposits ($\lambda^D = 0.097$), and half a year for much less sticky deposits ($\lambda^D = 1.886$). Only λ^D differs between the three economies; no other parameter is recalibrated. The dashed vertical line marks the end of leverage relief.

Table 6: Banks and bank-periods by country

Country	Code	Banks	Average periods	Deposit share (%)
France	FR	7	7.0	34.08
Spain	ES	10	7.0	18.69
Italy	IT	11	7.0	12.57
Netherlands	NL	4	7.0	11.44
Germany	DE	7	5.7	8.89
Belgium	BE	3	7.0	3.06
Austria	AT	4	6.5	2.85
Finland	FI	2	7.0	2.43
Ireland	IE	2	7.0	1.81
Greece	GR	4	6.0	1.72
Portugal	PT	2	7.0	1.46
Cyprus	CY	3	5.7	0.28
Slovenia	SI	1	7.0	0.19
Malta	MT	2	7.0	0.14
Luxembourg	LU	2	5.0	0.14
Lithuania	LT	2	6.5	0.13
Estonia	EE	2	6.0	0.10
Latvia	LV	1	7.0	0.03
Croatia	HR	0	–	0.00
Slovakia	SK	0	–	0.00

Notes: All euro area countries as of 2025 are reported. *Average periods* is the mean number of semi-annual observations per bank; the sample is unbalanced. *Deposit share* is the country's share of sample deposits: the sum of its banks' shares of deposits in each period, divided by the number of periods.

Table 7: Sample banks

Name	Ctry	N	Dep. (EUR bn)	Share (%)	Dep./ assets (%)	Excess LR (pp)	Excess CET-1 (pp)
Crédit Agricole	FR	7	1026.1	9.60	49.4	2.09	6.10
Banco Santander	ES	7	821.7	7.69	46.5	1.40	1.50
BNP Paribas	FR	7	772.4	7.23	31.4	0.78	1.40
BPCE	FR	7	652.4	6.11	45.7	1.68	2.63
ING	NL	7	609.4	5.70	59.7	1.45	2.16
Crédit Mutuel	FR	7	528.5	4.95	54.9	4.06	6.66
Deutsche Bank	DE	7	469.3	4.39	34.6	0.98	1.35
Société Générale	FR	7	430.6	4.03	30.9	0.90	2.07
UniCredit	IT	7	409.0	3.83	49.2	2.56	5.16
Intesa Sanpaolo	IT	7	382.7	3.59	48.5	2.67	2.94
CaixaBank	ES	7	368.8	3.45	65.6	2.43	2.54
BBVA	ES	7	355.1	3.32	48.9	3.59	2.22
Rabobank	NL	7	336.4	3.15	53.3	3.97	4.76
Commerzbank	DE	7	286.1	2.68	52.4	1.65	3.19
ABN AMRO	NL	7	222.1	2.08	56.1	2.24	2.53
La Banque Postale	FR	7	202.7	1.90	64.0	3.68	6.89
Erste Group	AT	5	199.7	1.89	59.6	3.76	2.77
KBC	BE	7	195.6	1.83	58.4	2.22	2.44
Nordea	FI	7	194.2	1.82	36.3	1.87	2.84
Banco de Sabadell	ES	7	152.0	1.42	61.8	1.96	2.85
ICCREA	IT	7	109.7	1.03	64.8	4.80	7.56
Raiffeisen	AT	7	106.3	1.00	51.8	4.58	3.37
AIB	IE	7	99.7	0.93	73.2	4.66	4.16
BayernLB	DE	7	97.0	0.91	35.4	1.52	5.85
BPER	IT	7	95.2	0.89	65.2	2.55	3.47
Bank of Ireland	IE	7	93.5	0.88	69.4	3.50	3.07
Banco BPM	IT	7	93.2	0.87	49.1	2.05	4.21
Belfius	BE	7	88.3	0.83	52.5	3.25	3.29
Caixa Geral de Depósitos	PT	7	79.9	0.75	77.5	5.34	5.70
BCP	PT	7	76.4	0.71	78.8	3.26	3.17
Bankinter	ES	7	72.2	0.68	62.1	1.76	2.77
Volkswagen Financial	DE	2	70.2	0.64	34.8	11.55	3.96
MPS	IT	7	67.8	0.63	54.4	3.22	4.63
OP	FI	7	65.7	0.61	46.1	6.34	5.33
Cassa Centrale	IT	7	64.5	0.60	71.2	5.72	10.34
Eurobank	GR	3	64.5	0.59	68.0	4.74	1.89
Unicaja	ES	7	61.4	0.58	62.2	2.20	4.45
Piraeus Bank	GR	7	55.6	0.52	71.0	3.34	1.99
ASN Bank	NL	7	55.0	0.51	74.9	1.95	8.14
NBG	GR	7	54.0	0.51	71.2	5.39	3.65
ABANCA	ES	7	49.8	0.47	65.4	3.51	3.08
Alpha Bank	GR	7	47.2	0.44	64.4	3.88	2.38
Kutxabank	ES	7	44.0	0.41	67.1	4.97	4.95
Crelan	BE	7	42.9	0.40	78.1	1.21	10.23
BCC	ES	7	38.7	0.36	62.3	2.74	1.60
Credem	IT	7	35.1	0.33	61.6	2.33	4.15
Ibercaja	ES	7	33.3	0.31	69.5	2.80	3.72
Volkswagen Bank	DE	3	32.7	0.31	43.4	10.58	3.57
HASPA	DE	7	32.6	0.30	54.2	5.11	3.83
BAWAG	AT	7	32.4	0.30	54.0	2.53	3.03
S-Finanzgruppe	DE	7	31.5	0.29	54.8	3.42	6.88
FinecoBank	IT	7	29.2	0.27	84.4	1.73	13.67
Banca Popolare di Sondrio	IT	7	28.5	0.27	50.6	2.65	3.29
RCI	FR	7	28.0	0.26	42.4	5.17	1.87
Mediolanum	IT	7	26.8	0.25	66.2	3.98	8.77
Volksbank Wien	AT	7	21.3	0.20	68.8	4.27	2.56
NLB	SI	7	19.8	0.19	76.5	6.24	2.55
Bank of Cyprus	CY	7	17.6	0.16	70.0	4.78	5.15
Hellenic Bank	CY	3	14.4	0.14	73.0	2.99	6.24
Revolut	LT	6	13.7	0.13	88.0	1.32	7.91
BIL	LU	7	11.9	0.11	37.6	2.05	3.19
Bank of Valletta	MT	7	11.6	0.11	78.6	4.33	8.02
Luminor Bank	EE	5	8.7	0.08	57.7	6.21	3.27
Quintet	LU	3	6.3	0.06	43.7	1.60	6.70
AikGroup	CY	7	5.5	0.05	72.5	8.71	3.79
LHV	EE	7	4.2	0.04	57.1	4.07	4.03
Citadele	LV	7	3.5	0.03	71.4	5.74	4.06
MeDirect	MT	7	3.3	0.03	67.1	1.45	2.33
Artea bankas	LT	7	2.7	0.03	60.0	6.46	5.09

Notes: Figures are averages over the sample periods in which the bank reports. When an ECB-supervised bank is a holding company with only one subsidiary, the name of that subsidiary is reported instead, but the data are from the holding company. For banks with a name change during the sample, the most recent name is used. *N* gives the number of such periods per bank. *Ctry* is the country of incorporation. Deposits are household and non-financial corporate deposits, in billions of euro; *Share of deposits* is the bank's share of sample deposits in each period, averaged over the periods it reports. *Excess LR* and *Excess CET-1* are the bank's leverage ratio and CET-1 ratio less its own disclosed requirement and average P2G in that year, in percentage points. Banks are sorted from most to least deposits.

Table 8: Deposit beta by counterparty

	Dependent variable: *Deposit rate*	
	No category intercepts	With category intercepts
	(1)	(2)
Households		0.221
		(0.138)
NFC		0.518
		(0.410)
Central banks		0.391
		(0.462)
General government		−2.440***
		(0.829)
Credit institutions		3.411***
		(1.210)
Other financial		0.769
		(0.629)
Households × DFR	0.248***	0.181***
	(0.093)	(0.064)
NFC × DFR	0.285	0.132
	(0.219)	(0.148)
Central banks × DFR	1.108*	1.116**
	(0.574)	(0.514)
General government × DFR	0.071	0.788**
	(0.496)	(0.355)
Credit institutions × DFR	1.728***	0.733**
	(0.542)	(0.305)
Other financial × DFR	1.546***	1.305***
	(0.300)	(0.266)
Observations	454	454
R^2	0.446	0.511

Notes: Implied cost of deposit funding—interest expense on deposits over the average deposit stock, annualized, in pp—on the six counterparty shares and their interactions with the ECB deposit facility rate (DFR). Column (1) restricts the six category intercepts to zero, so each counterparty's rate is proportional to the policy rate; column (2) leaves them free. A cluster-robust Wald test rejects the restriction: $F = 15.53$ on 6 and 68 df, $p = 4.0 \times 10^{-11}$. Standard errors in parentheses are clustered by bank. DFR refers to the deposit facility rate. Sample: 454 bank-periods, 69 banks, H1 2022–H1 2025—454 of the 457 bank-periods carrying a disclosed capital requirement, the remainder of bank-periods having a year-to-date interest expense that cannot be differenced into a half-year flow as the bank was not in the Transparency Exercise the year before. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.