A TRADE-OFF BETWEEN MONETARY POLICY TRANSMISSION AND SYSTEMIC RISK

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Abstract. We study how interbank funding links monetary policy transmission to systemic risk in a banking system with heterogeneous access to deposit funding. Using bank-level data from China, we show that monetary policy easing reallocates liquidity through the interbank market: large banks raise household demand deposits and lend in the interbank market, while small banks expand loans through interbank borrowing. During economic downturns, greater reliance on interbank funding is associated with higher systemic risk. To interpret these facts, we build a structural model with deposit-rich and deposit-poor banks and interbank rollover risk. The model shows that monetary policy easing reallocates liquidity and boosts lending, but also raises run risk. It reveals a macroprudential trade-off: a regulatory limit on interbank funding weakens monetary policy transmission but reduces systemic risk.

Date: 18th October 2026.

Key words and phrases. Monetary policy transmission, systemic risk, interbank funding, pecuniary externality, trade-off.

JEL classification: E5, G28, E02.

Chen: Emory University; Xiao: INSE, Peking University; Zha: Federal Reserve Bank of Atlanta, Emory University, and NBER. We are grateful to Saleem Bahaj, the Associate Editor, and an anonymous referee for their detailed comments, which have considerably improved this paper. We also thank Wei Cui, Wenxin Du, Hanming Fang, Zhiguo He, Nobu Kiyotaki, Chang Ma, Vincenzo Quadrini, Harrison Shieh, Yongqing Wang, Shang-jin Wei, and seminar participants of 2021 NBER Chinese Economy Meeting, Sixth Bank of Canada-Tsinghua PBCSF-Toronto University Conference in Chinese Economy, 2021 China Meeting of Econometric Society, 2021 Chinese International Conference in Macroeconomy, 2021 SWUFE International Conference in Macroeconomics, 2021 AFR Summer Institute of Economics and Finance, Peking, Renmin University, and Southwest University of Finance and Economics for helpful discussions. The views expressed herein are those of the authors and do not necessarily reflect those of the Federal Reserve Bank of Atlanta, the Federal Reserve System, or the National Bureau of Economic Research.

I. Introduction

Monetary policy operates through banking systems with heterogeneous banks linked by interbank markets. Lower policy rates stimulate credit and real activity, but they can also encourage balance-sheet expansion funded by fragile liabilities. This tension makes it essential to understand how monetary policy transmits in banking systems with uneven funding capacity, and how that transmission interacts with financial stability.

This paper studies a trade-off between monetary policy transmission and systemic risk in a two-tier banking system with heterogeneous access to deposit funding. In many economies, large banks (LBs) can expand deposits across regions, while small banks (SBs) face tighter deposit bases and rely more on interbank funding. After monetary policy easing, these differences reallocate liquidity through the interbank market: deposit-rich banks extend interbank credit to deposit-constrained banks, amplifying the real effects of policy. The same reallocation also raises interconnectedness and rollover exposure, which increases vulnerability to adverse shocks.

We investigate this trade-off using China as a laboratory. In the Chinese setting, state-owned banks correspond to LBs in our terminology, while non-state banks correspond to SBs; we use LBs and SBs throughout. China offers a transparent setting in which banks differ sharply in access to deposits, reflecting institutional arrangements and regulatory constraints, and in which the shift toward interest-rate-based monetary policy expanded the role of interbank funding. Episodes of stress—including the post-2018 slowdown and the property-sector crisis—underscore the fragility associated with interbank reliance, especially among SBs. While China's institutions are distinctive, the mechanism we study is general and applies to banking systems in which monetary policy works through heterogeneous banks with unequal access to deposit funding.

We assemble bank-level micro data into a bank-quarter panel to study how interbank funding shapes monetary transmission and systemic risk. The data yield three findings. First, monetary policy easing reallocates funding: SBs increase interbank borrowing, while LBs expand household demand deposits and reduce interbank borrowing. Second, this reallocation amplifies monetary policy transmission: lending by SBs rises after policy-rate reductions, and the response operates through interbank funding. Third, heavier reliance on interbank funding is associated with higher systemic risk during downturns, measured by expected capital shortfalls, and this vulnerability becomes more pronounced after 2018 amid China's growth slowdown.

Motivated by these facts, we develop a simple three-period model that isolates the mechanism that generates both amplification and fragility. Banks with higher deposit transaction costs—and thus lower deposit sensitivity to policy rates—respond to monetary policy easing by expanding interbank borrowing, which reallocates liquidity from deposit-rich banks to more productive but deposit-constrained banks. This channel strengthens monetary policy transmission. Yet individual

banks do not internalize how their interbank borrowing raises aggregate rollover risk, so the same channel increases the probability and severity of bank runs after adverse productivity shocks. The simple model makes precise the externality that underlies the trade-off between monetary policy effectiveness and financial stability.

We then study a fully dynamic quantitative model calibrated to the Chinese data with segmented deposit markets, interbank funding, and endogenous run risk. The model quantifies the liquidity reallocation channel and evaluates interbank funding regulation. Absent regulation, monetary policy easing induces excessive leverage among SBs that do not internalize the systemic risk created by their funding choices. A regulatory limit on interbank funding reduces run risk and dampens the amplification of adverse shocks, but it weakens monetary policy transmission by restricting liquidity reallocation from LBs to SBs. Welfare improves under optimal regulation because the reduction in systemic risk outweighs the loss from weaker monetary policy transmission.

The paper contributes to three literatures. First, it adds to work on bank-based monetary transmission. The traditional bank lending channel emphasizes policy-driven changes in funding conditions (Bernanke and Blinder, 1988, 1992; Kashyap and Stein, 1994), while the balance-sheet channel highlights the role of net worth and leverage (Gertler and Kiyotaki, 2010; Gertler and Karadi, 2011). We show that heterogeneity in funding structures—not balance-sheet size alone—is central for the transmission of interest-rate-based monetary policy. Second, it relates to research on interbank markets and monetary transmission. Whereas existing studies often view interbank markets as venues for short-term liquidity smoothing (e.g., Bianchi and Bigio (2022)), we treat interbank funding as a structural complement to retail deposits in a segmented banking system, and we quantify the resulting liquidity reallocation channel. Third, it speaks to the risk-taking channel of monetary policy and systemic risk. We provide evidence that interbank funding mediates the trade-off: it strengthens monetary transmission in normal times but increases vulnerability during downturns (Jiménez, Ongena, Peydró, and Saurina, 2014; Dell'Ariccia, Laeven, and Suarez, 2017). Our structural model rationalizes this evidence through a pecuniary externality in interbank borrowing.

Our liquidity-reallocation channel is also related to the mechanism in Cui and Radde (2020), who study a general-equilibrium environment in which search frictions endogenously determine the liquidity (resaleability) of privately issued assets, and asset liquidity governs firms' financing capacity. Although their focus is corporate finance rather than banking, both settings highlight how endogenous liquidity constraints amplify real allocations when financing constraints bind. In our model, deposit-funding constraints for SBs increase their reliance on interbank liquidity, strengthening the transmission of monetary policy easing and increasing exposure to run risk after adverse productivity shocks.

More broadly, our framework builds on macro-finance models of banking and systemic risk (He and Krishnamurthy, 2013; Brunnermeier and Sannikov, 2014; Gertler, Kiyotaki, and Prestipino, 2020). By combining segmented deposit markets, interbank funding, and endogenous run risk in a fully dynamic model, we link empirical evidence on monetary policy transmission to welfare analysis and macroprudential policy design. The model highlights a fundamental trade-off: macroprudential constraints on interbank funding attenuate monetary policy transmission but improve financial stability and welfare by reducing systemic risk.

We also contribute to the literature on China's monetary and banking system (Chen, Ren, and Zha, 2018; Liu, Wang, and Xu, 2021; Chen, Gao, Higgins, Waggoner, and Zha, 2023; Fang, Wang, and Wu, 2025). We complement these studies by estimating an interest-rate-based monetary policy rule and by documenting how interbank funding links monetary policy transmission to systemic risk in a two-tier banking system.

The rest of the paper is organized as follows. Section II presents the institutional background, describes the data, and constructs monetary policy shocks. Section III presents empirical results on the role of interbank funding. Section IV develops the simple three-period model that characterizes the trade-off between monetary policy transmission and systemic risk. Section V extends the analysis to the fully dynamic quantitative model and conducts welfare analysis of optimal interbank funding regulation. Section VI concludes.

II. Institutional Background and Data

This section explains why China provides a useful setting for studying our mechanism and summarizes the data used in the empirical analysis in Section III. The contrast between state (large) and non-state (small) banks—particularly in the strength and stickiness of their deposit bases and their reliance on the interbank funding market—is unusually stark. Section II.A provides the institutional background. Section II.B describes how we construct a quarterly series of monetary policy shocks. Section II.C describes the construction of a bank-quarter panel for publicly listed Chinese banks, containing balance-sheet measures of interbank funding, household demand deposits, loans, and systemic risk.[1]

A. *Institutional Background*

China's monetary and banking system provides a useful setting for studying how interbank funding mediates monetary policy transmission and systemic risk. Four institutional features are particularly relevant for the mechanisms formalized in Sections IV and V: the use of the 7-day interbank repo rate (R007) as an operational policy rate, a segmented (two-tier) banking system,

[1]For details of variables and their corresponding data sources, see Appendix A.

a de facto ceiling on deposit interest rates, and the rapid expansion of wholesale funding. For a broader account of China's financial reforms, see Chen and Zha (2025).

To measure the stance of monetary policy over our sample period, we use the 7-day pledged repo weighted rate (R007) as the policy rate. During the early 2010s, the People's Bank of China conducted regular 7-day reverse-repo open-market operations via rate bidding and publicly announced the winning rates, indicating that policy implementation was centered on the 7-day horizon by the start of our sample period.[2] Consistent with this practice, the PBC's *2014 Annual Report* highlights R007 as a headline measure of money-market conditions.[3] With the introduction of the interest-rate corridor in 2015, the 7-day repo rate emerged as the PBC's preferred operating policy target. We therefore treat R007 as the policy rate in both the empirical analysis and the theoretical framework.

China's monetary policy operates through a banking system that is sharply segmented between LBs and SBs. LBs operate nationwide branch networks and have broad access to stable retail deposits, whereas SBs—joint-stock, city, and rural commercial banks—typically face geographic and institutional constraints in deposit collection. This segmentation generates persistent heterogeneity in funding structures: LBs rely predominantly on deposits, while SBs depend more heavily on interbank funding. This two-tier structure motivates the heterogeneous-bank environment in the model, with deposit-rich banks acting as net providers of interbank liquidity and deposit-constrained banks as net borrowers.

These funding asymmetries are reinforced by institutional constraints on deposit rate competition. Despite the formal removal of deposit rate ceilings, effective limits remain in place through a self-discipline mechanism among major banks, which restricts upward deviations of deposit rates relative to benchmark rates, and through the macroprudential assessment framework, which discourages aggressive deposit pricing. As a result, banks—especially SBs—face a de facto ceiling on deposit rates. This institutional feature limits their ability to attract deposits by offering higher rates and further entrenches differences in deposit funding capacity across bank types.

Against this backdrop of segmented deposit markets and constrained deposit pricing, China has experienced a pronounced expansion of wholesale funding, particularly through negotiable certificates of deposit (NCDs). Reintroduced in 2013, NCDs provided SBs with an alternative funding source that is benchmarked to interbank rates and largely unconstrained by deposit rate regulations. During the period of monetary easing beginning in 2014–2015, issuance of NCDs by SBs expanded rapidly, while LBs became the primary purchasers. This development led to a

[2]See PBC *Announcement on Open Market Operations* (October 9, 2012; November 12, 2013; and January 21, 2014), available at `https://www.pbc.gov.cn`.

[3]People's Bank of China Annual Report 2014, Figure "Trends of Money Market Interest Rates," available at `https://www.pbc.gov.cn/en/3688110/3688259/3689032/3709448/3709460/index.html`.

marked increase in interbank interconnectedness and a growing reliance on wholesale funding by SBs. The resulting shift in funding composition is central to both the amplification of monetary policy transmission and the buildup of systemic risk emphasized in the model.

B. *Estimation of China's Interest-Rate-Based Monetary Policy Rule*

Guided by the institutional background in Section II.A, we use the 7-day pledged repo weighted rate (R007) as the policy rate in estimating China's interest-rate-based monetary policy rule. We construct quarterly monetary policy shocks following Chen, Ren, and Zha (2018), who decompose movements in the policy rate into a systematic component and an orthogonal shock. Our deviation from Chen, Ren, and Zha (2018) is to use R007 rather than M2 growth as the policy variable. The monetary policy equation is thus specified as

$$R_t = \gamma_0 + \gamma_R R_{t-1} + \gamma_\pi(\pi_t - \pi^*) + \gamma_{x,t}(g_{x,t} - g^*_{x,t}) + \epsilon_{R,t}, \tag{1}$$

where R_t denotes the quarterly average of R007, π_t is quarterly CPI inflation, and $g_{x,t}$ is quarterly real GDP growth. We set the inflation target to $\pi^* = 0.875$ percent, corresponding to an annualized rate of 3.5 percent, and let $g^*_{x,t}$ denote the GDP growth target announced in the State Council's Annual Report on the Work of Government (RWG). The residual $\epsilon_{R,t}$ is the monetary policy shock. Throughout the paper, a negative $\epsilon_{R,t}$ corresponds to an unexpected decline in the policy rate, i.e., monetary policy easing.

Following Chen, Ren, and Zha (2018), the response to GDP growth and the volatility of policy shocks are allowed to differ depending on whether GDP growth is above or below the official target. Specifically, the rule uses $(\gamma_{x,t}, \sigma_{R,t}) = (\gamma_{x,a}, \sigma_{R,a})$ when $g_{x,t} \geq g^*_{x,t}$ and $(\gamma_{x,t}, \sigma_{R,t}) = (\gamma_{x,b}, \sigma_{R,b})$ when $g_{x,t} < g^*_{x,t}$, where $\sigma_{R,t}$ is the volatility (the standard deviation) of the policy shock $\epsilon_{R,t}$.

We estimate Equation (1) by maximum likelihood over 2001Q1–2018Q4.[4] Table 1 reports the baseline estimates using R007. The estimated rule displays substantial interest-rate smoothing and an asymmetric response to deviations of GDP growth from the official target, consistent with Chen, Ren, and Zha (2018). Figure 1 plots the quarterly average of R007, its estimated systematic component, and the implied monetary policy shocks. The resulting shock series captures policy-rate movements unexplained by the estimated rule and is used in the bank-level analysis of monetary policy transmission. Appendix B.A reports the serial-correlation check for the estimated shocks, robustness using R001, and tests against a constant-parameter policy rule.

[4]We exclude later periods, particularly the COVID-19 era, during which GDP growth targeting was suspended and the interest-rate-based monetary policy rule was no longer operative.

C. *Data on Banks' Interbank Funding Activities and Systemic Risk*

We construct a bank-quarter panel using quarterly balance-sheet information from the China Stock Market and Accounting Research (CSMAR) database, which collects financial statements from all publicly listed banks in China. The sample includes 25 listed banks: 5 LBs (state-owned banks) and 20 SBs (non-state-owned banks), comprising 8 joint-stock commercial banks, 9 city commercial banks, and 3 rural commercial banks.

Interbank (non-deposit) funding for each bank is measured as the sum of borrowings from other financial institutions, central bank loans, bonds payable (including negotiable certificates of deposit, NCDs), and financial assets sold under repurchase agreements. The bank-quarter panel spans 2013Q1–2018Q4.[5] For the deposit margin, we use household (personal) demand deposits. This measure is closest to the theoretical model, in which households hold demand deposits, and to the mechanism emphasized in Section II.A: LBs' broader branch and ATM networks make deposits and withdrawals more convenient for households. We scale interbank funding, household demand deposits, and loans by total equity, denoted $W_{b,t}$, $D_{b,t}$, and $L_{b,t}$.

Systemic risk is measured using SRISK. Following Acharya, Pederson, Philippon, and Richardson (2017) and Brownlees and Engel (2017), we define SRISK as the expected capital shortfall of a financial institution in a systemic event. We obtain daily SRISK estimates for Chinese listed banks from the Volatility Institute at NYU and aggregate them to the quarterly frequency. To align the interpretation of systemic risk in the data with the theory, Section V constructs a model analogue, $SRISK_t^{model}$, an expected capital-shortfall object (the expected net worth shortfall of SBs in the run state).

Panel A of Table S1 reports summary statistics for the bank-quarter panel, separately for LBs and SBs. In levels, LBs hold more interbank funding (mean 1.146 tn RMB) than SBs (0.443 tn RMB), reflecting their larger scale. By contrast, the equity-scaled dynamics of interbank funding differ sharply: the mean of ΔInterbankFunding/Equity is 17.907% for LBs versus 54.285% for SBs, with substantially greater dispersion for SBs (Std.Dev. 61.516 versus 16.199).

Similar heterogeneity appears in household-demand-deposit and lending dynamics. LBs exhibit larger average equity-scaled changes in household demand deposits, but smaller average equity-scaled changes in loans than SBs (13.710% versus 8.134% for ΔDemandDeposit/Equity, and 64.116% versus 94.966% for ΔLoan/Equity). These patterns are consistent with LBs' advantage in attracting household deposits and SBs' greater sensitivity of lending to monetary policy conditions.

[5]The bank-level sample ends in 2018Q4 mainly because certain balance-sheet components used to measure interbank (non-deposit) funding cease to be consistently available after that date.

By contrast, SRISK levels are much larger for LBs in absolute terms (mean 497.973 billion RMB versus 113.328 billion RMB for SBs), again reflecting the larger size of LBs. As shown in Figure 2, systemic risk grows much more rapidly for SBs over time when normalized to a common baseline, highlighting their disproportionate contribution to systemic risk dynamics.

Figure 2 summarizes the evolution of monetary policy, interbank funding, bank loans, and systemic risk for LBs and SBs. The top-left panel plots the monetary policy rate (the 7-day repo rate) together with the interbank funding cost (the at-issue yield of 3-month AAA-rated NCDs), showing that while the two series broadly co-move, interbank funding costs exhibit periods of notable divergence from the policy rate.

The top-right panel displays interbank (non-deposit) funding as a share of total liabilities and documents a pronounced and persistent divergence across bank types: the interbank funding share rises sharply for SBs after 2015, while remaining comparatively low and stable for LBs. The bottom-left panel shows total loans issued by each bank type, normalized to their respective 2012Q4 levels, with faster loan growth for SBs over the sample period. The bottom-right panel plots systemic risk (SRISK), also normalized to 2012Q4 levels, and shows that normalized systemic risk grows more rapidly for SBs, despite much larger absolute SRISK levels for LBs due to their larger size.

We distinguish two normalizations used in the paper. Table S1 reports equity-scaled changes (as in Section III) to facilitate cross-bank comparisons of balance-sheet adjustments, whereas the top-right panel of Figure 2 reports interbank funding as a share of total liabilities to emphasize funding composition. Together, these summary statistics and data series document cross-sectional and time-series variation in interbank activities that underpin the evidence in Section III and discipline the calibration of the quantitative model in Section V.

III. Motivating Evidence

This section presents evidence that motivates the theoretical work in Sections IV and V. It documents three facts that are difficult to reconcile with a homogeneous banking system: (i) monetary policy shocks induce *differential* interbank funding responses across LBs and SBs; (ii) interbank funding is associated with stronger credit responses for SBs, consistent with a mediating role for interbank funding; and (iii) greater interbank funding reliance is associated with higher systemic risk exposure in economic downturns during the post-2018 period. Throughout the empirical analysis, we classify China's state-owned banks as LBs and its non-state banks as SBs, consistently with the terminology used in the model.

A. *Impacts of Monetary Policy on Interbank Funding and Household Demand Deposits*

We begin by using bank-quarter observations to estimate panel regressions in which the dependent variable is (i) the year-over-year change in a bank's interbank funding volume scaled by total equity, denoted $W_{b,t}$, and (ii) the analogous year-over-year change in household demand deposits scaled by total equity, denoted $D_{b,t}$. We allow for persistence by including lags of the dependent variable and include bank, year, and seasonal fixed effects:

$$F_{b,t} = \alpha\epsilon_{R,t-1} + \beta\epsilon_{R,t-1} \times I(SB_b) + \varphi \sum_{h=1}^{2} F_{b,t-h} + \gamma_x X_{b,t-1} + \gamma_m Macro_{t-1} + \alpha_b + \tau_y + \tau_s + \epsilon_{b,t}, \quad (2)$$

where $F_{b,t}$ represents either the wholesale funding $W_{b,t}$ or household demand deposits $D_{b,t}$. $\epsilon_{R,t}$ is the monetary policy shock from the estimated policy rule in Section II.B (a negative shock corresponds to an unexpected decline in the policy rate, i.e., monetary policy easing); $I(SB_b)$ is an indicator for SBs. $X_{b,t-1}$ collects lagged bank characteristics and interactions used as heterogeneity controls; and $Macro_{t-1}$ includes standard macro controls.

Table 2 shows two key results. Columns (1) and (2) report regressions with interbank funding growth as the dependent variable, while columns (3) and (4) report analogous regressions for household demand deposit growth; within each pair, the second specification adds bank-level and macro control variables. The results are robust across specifications.

First, in the interbank-funding regressions (columns (1)–(2)), LBs reduce their reliance on interbank (non-deposit) funding when monetary policy eases: the coefficient on the policy shock, α, is positive and statistically significant, implying that a negative policy shock lowers $W_{b,t}$ for LBs. By contrast, SBs respond in the opposite direction. In both columns (1) and (2), the interaction term β is negative and highly significant, and the implied response $\alpha+\beta$ is also negative and statistically significant, indicating that monetary policy easing increases interbank funding for SBs.

Turning to household demand deposits (columns (3)–(4)), LBs experience a statistically significant increase following monetary policy easing, as reflected in the negative and significant estimates of α (-4.327 and -4.398). The interaction coefficient β, which measures the differential response of SBs relative to LBs, is positive and statistically significant (3.252 and 3.019). Because a monetary policy easing is a negative shock in our convention, the positive sign of β offsets the negative LB response. As a result, the implied response for SBs, $\alpha + \beta$, is small and statistically insignificant (-1.075 and -1.380). These estimates show that household demand deposits respond more strongly at LBs than at SBs, consistent with heterogeneity in access to retail deposits. As we will show in our theoretical framework, this heterogeneity is key to understanding the interbank funding channel of monetary policy.

Taken together, these results are consistent with a banking system that is not homogeneous across bank types: monetary policy easing is associated with a reallocation of funding toward

interbank liabilities at SBs, while LBs expand household demand deposits and reduce interbank borrowing.

To keep the proper controls given the small panel, we retain, throughout all exercises, only interaction terms in which the two underlying variables are significantly correlated, as reported in Table S2. Table S2 reports several correlation blocks that guide this choice: bank type is significantly related to liquidity and fixed-asset growth, and interbank funding growth is correlated with balance-sheet characteristics in different ways across LBs and SBs. We focus on the informative margins and avoid saturating the regressions with many weak interaction terms.

The different funding responses are also evident in dynamics. We estimate panel local projections of $W_{b,t+q}$ on the monetary policy shock (and its interaction with bank type), controlling for lagged values of $W_{b,t-h}$, bank fixed effects (α_b), year fixed effects (τ_y), and seasonal fixed effects (τ_s):

$$W_{b,t+q} = \alpha_q \epsilon_{R,t} + \beta_q \epsilon_{R,t} \times I(SB_b) + \varphi_q \sum_{h=1}^{2} W_{b,t-h} + \alpha_{b,q} + \tau_{y,q} + \tau_{s,q} + \epsilon_{b,t+q}. \tag{3}$$

We estimate this equation for horizons $q = 0, 1, \ldots, 8$. Figure 3 reports the resulting dynamic responses. The dashed line shows $-\alpha_q$, which captures the response of interbank funding at LBs to monetary policy easing, while the solid line shows $-(\alpha_q + \beta_q)$, the corresponding response for SBs.

The responses are persistent across horizons and differ clearly across bank types. Following a negative (monetary policy easing) shock, interbank funding growth declines for LBs and increases for SBs over the first several quarters. This dynamic evidence complements the static results reported in Table 2.

B. *Interbank Funding and Monetary Policy Transmission*

We next examine whether interbank funding plays a role in the transmission of monetary policy to bank loans for different types of banks. Let $L_{b,t}$ denote the year-over-year change in loans scaled by total equity. We estimate

$$\begin{aligned} L_{b,t} = {} & \alpha_\epsilon \epsilon_{R,t-1} + \beta_\epsilon \, \epsilon_{R,t-1} \times I(SB_b) + \alpha_W W_{b,t} + \beta_W W_{b,t} \times I(SB_b) \\ & + \varphi \sum_{h=1}^{2} L_{b,t-h} + \gamma_x X_{b,t-1} + \gamma_m Macro_{t-1} + \alpha_b + \tau_y + \tau_s + \epsilon_{b,t}, \end{aligned} \tag{4}$$

where columns (1)–(2) in Table 3 exclude $W_{b,t}$ and $W_{b,t} \times I(SB_b)$ (the *total effect*), while columns (3)–(4) include these terms (the *mediation specification*).

Table 3 delivers two main results. First, the response of loan growth to monetary policy differs across bank types. In the total-effect specifications, the implied coefficient $\alpha_\epsilon + \beta_\epsilon$ is negative and

statistically significant, indicating that monetary policy easing leads to a stronger expansion of loan growth at SBs relative to LBs.

This differential lending response is consistent with the results documented in Table 2. Following monetary policy easing, LBs reduce interbank funding and expand household demand deposits, while SBs increase their reliance on interbank funding.

Second, interbank funding plays a mediating role in the effects of monetary policy on loan growth for SBs. In the mediation specifications, the implied effect $\alpha_W + \beta_W$ is positive and statistically significant. Moreover, once interbank funding is included, the coefficient on the monetary policy shock, $\alpha_\epsilon + \beta_\epsilon$, is reduced and, more importantly, becomes statistically insignificant. This result points to interbank funding as an important channel through which monetary policy affects SB lending—a major ingredient in Sections IV and V.

C. *Interbank Funding and Systemic Risk*

We now study the relationship between interbank funding and systemic risk. We estimate panel regressions of SRISK on interbank funding and its interaction with GDP growth during the slow-growth period ($t \geq 2018Q3$). We control for the 2018Q1–2018Q2 regulatory window to isolate the effect of this interaction.

$$\begin{aligned} SRISK_{b,t} = {} & \alpha_r W_{b,t-1} \times I(t \geq 2018Q3) + \beta_r g_{t-1} \times W_{b,t-1} \times I(t \geq 2018Q3) \\ & + \alpha_l W_{b,t-1} \times I(2018Q1 \leq t \leq 2018Q2) \\ & + \beta_l g_{t-1} \times W_{b,t-1} \times I(2018Q1 \leq t \leq 2018Q2) + \alpha W_{b,t-1} + \beta\, g_{t-1} \times W_{b,t-1} \\ & + \gamma_x X_{b,t-1} + \gamma_m Macro_{t-1} + \alpha_b + \tau_y + \tau_s + \epsilon_{b,t}, \end{aligned} \tag{5}$$

where g_{t-1} is real GDP growth and $X_{b,t-1}$ includes various bank controls and their interactions with GDP growth.

Table 4 shows that, during the slow-growth period ($t \geq 2018Q3$), the effect of interbank funding on systemic risk shows up for SBs. In particular, the interaction term $g_{t-1} \times W_{b,t-1}$ is negative and statistically significant for SBs (columns (3)–(4)). This estimate implies that when macro growth deteriorates, greater reliance on interbank funding raises systemic risk. By contrast, the corresponding interaction estimates for LBs are not statistically significant (columns (1)–(2)). This asymmetry matches the amplification mechanism developed later in the paper: interbank funding strengthens monetary policy transmission by expanding SB lending in normal times, but it raises downside vulnerability when adverse macro conditions arrive.

A natural concern is whether the regulatory tightening on interbank markets implemented since 2018Q1 has effects that persist beyond that narrow window.[6] To address this concern, Appendix B re-estimates the SRISK regression allowing the regulation indicator to remain on from 2018Q1 through the end of the sample. Table S6 shows the same conclusion: for SBs, the key interaction term during the slow-growth period remains negative and statistically significant. The main result is robust to how we date the regulatory episode.

Overall, the evidence in this section yields a coherent set of findings: monetary policy shocks induce a reallocation of interbank funding toward SBs; this reallocation helps explain stronger lending responses for SBs; and at the same time greater interbank funding reliance raises systemic risk during economic downturns. These findings motivate the modeling in Sections IV and V.

IV. A Simple Model of Monetary Policy Transmission and Systemic Risk

In this section, we develop a simple three-period model that isolates how heterogeneous access to deposit funding and interbank trading jointly shape monetary policy transmission and systemic risk.[7] Two forms of bank heterogeneity are central. SBs have less scope to expand deposit funding when the policy rate is lower and therefore rely more heavily on interbank funding, whereas LBs can expand deposits more readily and supply interbank liquidity. At the same time, SBs are more efficient in intermediating capital and thus have a stronger demand for funds.

The model delivers two analytical results. First, the interbank market reallocates funds from deposit-rich LBs to deposit-constrained SBs, thereby strengthening monetary policy transmission. Second, because an individual SB does not internalize how its leverage affects fire-sale recovery and system-wide run risk, the decentralized economy accumulates excessive interbank exposure when the policy rate is lower. This pecuniary externality generates the regulatory trade-off analyzed below. The closed-form comparative statics provide the analytical foundation for the quantitative exercises in Section V; formal derivations and proofs are collected in Appendix C.

The section proceeds as follows. Sections IV.A–IV.C introduce the environment, household deposit demand, and the banks' balance sheets and funding constraints. Section IV.D closes the model, identifies the marginal buyer of capital, and states the consolidated resource constraint. Sections IV.E–IV.G then characterize monetary policy transmission, bank fragility, and the regulatory trade-off between the two.

[6] Beginning in 2018Q1, financial institutions with total assets exceeding RMB 500 billion were subject to a cap on planned NCD issuance: issuance in a given year could not exceed one-third of the previous year's total liabilities net of current-year interbank liabilities. The regulation was extended to all financial institutions starting in 2019Q1.

[7] While we focus on two distinct bank types for tractability, the model's mechanisms naturally extend to a broader distribution of deposit sensitivities to policy rates.

A. *Environment*

The economy lasts for three periods, $t = 0, 1, 2$, and is populated by a representative household consisting of a unit measure of members. A fraction s are bankers, and the remaining fraction $1 - s$ are workers. Among the bankers, a fraction ς operates SBs, while the remaining fraction $1 - \varsigma$ operates LBs. The two types of banks are competitive and are indexed by $j \in \{SB, LB\}$. The household owns both bank types, receives their dividends, and provides complete consumption insurance among its members. It saves through foreign bonds and bank deposits. Type-j banks use net worth n_t^j and one-period deposits d_t^j to finance capital and liquid reserves a_t^j, and they trade one-period interbank bonds ib_t^j. In the equilibrium studied below, LBs use their stronger deposit base to provide interbank funding to SBs.

There are two goods: a nondurable good and a durable productive asset, "capital". Capital does not depreciate, and its aggregate supply is fixed at $\bar{K}$. At the beginning of $t = 0$, the representative household is endowed with this fixed capital stock and sells it to the banks at the competitive price Q_0.

Banks employ capital together with nondurable inputs in production. Let k_t^j denote the capital held after trading at t by an individual type-j bank, and let K_t^j denote the corresponding aggregate holdings. Between t and $t + 1$, k_t^j units of capital generate $Z_{t+1}k_t^j$ units of nondurable output and leave the capital intact, where Z_{t+1} denotes aggregate productivity. Thus, capital purchased at $t = 0$ produces $Z_1 k_0^j$ at $t = 1$, after which the remaining capital can be traded at price Q_1. Its value at $t = 1$ is therefore $(Z_1 + Q_1)k_0^j$. Capital held after trading at $t = 1$ produces the terminal return $Z_2 k_1^j$, with $Q_2 = 0$.[8]

We set $Z_2 = \bar{Z}$, while Z_1 is stochastic. Thus, aggregate uncertainty arises only at the rollover date $t = 1$, when the run decision is made. Agents know the distribution of Z_1 at $t = 0$ and observe its realization at the beginning of $t = 1$.

The two bank types differ in their efficiency in screening and monitoring non-financial investment. The nondurable input required to manage k_t^j units of capital at a type-j bank is

$$F^j(k_t^j; K_t^j) = \alpha^j K_t^j k_t^j, \tag{6}$$

where $\alpha^j \geq 0$ is the type-j management-cost parameter. The marginal management cost faced by an individual bank is therefore $\alpha^j K_t^j$, which increases with the aggregate amount of capital managed by its bank type. We normalize SBs to be the more efficient intermediaries:

$$\alpha^{SB} = 0 < \alpha^{LB}. \tag{7}$$

This efficiency difference gives SBs a stronger demand for capital. Because their deposit funding is less elastic, they borrow from deposit-rich LBs through the interbank market to finance capital

[8] $Q_2 = 0$ because capital has no continuation value after the terminal date $t = 2$.

investment. Having specified the capital technology and the source of interbank flows, we next characterize the household's portfolio choices.

B. *Household*

We now characterize the household's portfolio choices. The household chooses consumption, saving, and portfolio allocation across bank deposits and one-period foreign bonds. Foreign bonds B_t earn the gross policy rate $R_{b,t}$ between t and $t+1$ and entail no transaction cost. By contrast, households incur a transaction cost when depositing in banks. We allow banks to differ in deposit transaction costs, reflecting heterogeneity in branch and ATM network coverage and payment accessibility. These costs are borne by households when using deposits for transactions and liquidity management, and are lower for LBs. Specifically, the deposit transaction cost for bank group j is a convex function of aggregate deposits, denoted as D^j, normalized by the aggregate net worth of bank group j, denoted as N^j:

$$f(D_t^j) = \xi(1 - \frac{1}{\eta^j}) \left(\frac{D_t^j}{N_t^j} \right)^{\eta^j} N_t^j, \qquad \eta^j \geq 1,\ \xi > 0, j = LB, SB \tag{8}$$

Its marginal cost is

$$f'(D_t^j) = \xi(\eta^j - 1) \left(\frac{D_t^j}{N_t^j} \right)^{\eta^j - 1}. \tag{9}$$

Thus, the marginal transaction cost of deposits is increasing in the deposit-to-net-worth ratio.

The specification of this convex cost function ensures that, within each bank type, banks with different net worth face the same deposit demand relative to their net worth for a given deposit rate. This feature helps make bank decision variables linear in individual net worth. For simplicity, we assume that deposits in either SBs or LBs enjoy repayment guarantees from the government. Accordingly, deposits held at a bank from t to $t+1$ are one-period bonds that promise to pay the non-contingent gross rate of return $R_{d,t}^j$ at $t+1$.[9]

The curvature parameter η^j determines how rapidly the marginal cost of deposits increases as deposits expand relative to bank net worth. We assume $\eta^{LB} < \eta^{SB}$, implying that marginal deposit costs rise more slowly for LBs than for SBs. As we will show later, heterogeneity in households' deposit transaction costs across banks implies different deposit responses across bank types when policy rates change, which in turn encourages SBs to exploit interbank funding to expand their external funding source when the policy rate is lower.

At $t = 0$, the initial bank net worths $\{n_0^{SB}, n_0^{LB}\}$ are taken as given by individual banks and are financed by the household through the initial transfer ζ_0 defined below. At the beginning of periods

[9]In the event of a bank run, the government taxes the household a lump-sum amount equal to the difference between the committed deposit repayment and the residual value of the bank assets.

$t = 1, 2$, the representative household receives the gross returns on deposits and bonds chosen in the previous period. The household then chooses consumption, bonds, and deposits:

$$\{C_t,\, B_t,\, D_t^{LB},\, D_t^{SB}\} \quad \text{for } t = 0, 1,$$

and chooses terminal consumption C_2 at $t = 2$ (with terminal deposits and bond equal to zero).

The household maximizes expected utility

$$E_0 \sum_{t=0}^{2} \beta^t u(C_t)$$

subject to the following period-by-period budget constraints. At $t = 0$,

$$C_0 + B_0 + \zeta_0 + \sum_j \left(D_0^j + f(D_0^j) \right) = W + T_0 + Q_0 \bar{K}. \tag{10}$$

At $t = 1$,

$$C_1 + B_1 + \zeta_1 + \sum_j \left(D_1^j + f(D_1^j) \right) = W + R_{b,0} B_0 + \sum_j \left(R_{d,0}^j D_0^j + \Pi_1^j \right) + T_1, \tag{11}$$

At $t = 2$,

$$C_2 = W + R_{b,1} B_1 + \sum_j \left(R_{d,1}^j D_1^j + \Pi_2^j \right) + T_2, \tag{12}$$

where $j \in \{LB, SB\}$, W is the household's exogenous endowment, and Π_t^j denotes dividends from type-j bankers rebated to the household in each period.

The variable T_t denotes the central bank's net lump-sum transfer to the household at t. It consolidates the cash flows associated with changes in banks' reserve balances held at the central bank, the reserve-management payments collected from banks, and, when a bank cannot fully repay its insured retail deposits, the central bank's cost of covering the deposit shortfall. In particular, if the cost of covering the shortfall on insured retail deposits is sufficiently large relative to the other components, T_t becomes negative, in which case it represents a lump-sum tax on the household. The complete state-contingent transfer rule is given in (26), after we describe the banks' optimization problem.

The household's aggregate initial transfer to bankers is

$$\zeta_0 \equiv s\varsigma n_0^{SB} + s(1-\varsigma) n_0^{LB} = N_0^{SB} + N_0^{LB},$$

which finances the given initial net worths. At $t = 1$, the household provides the entering bankers with the aggregate startup transfer.

$$\zeta_1 \equiv W_1^{SB} + W_1^{LB}.$$

The Euler equation for bonds is given by

$$(R_{b,t})^{-1} = E_t \left[\beta \frac{u'(C_{t+1})}{u'(C_t)} \right], \qquad t = 0, 1. \tag{13}$$

The Euler equation for deposits at banks of type j is[10]

$$\left(1+f'(D_t^j)\right)\left(R_{d,t}^j\right)^{-1} = E_t\left[\beta\frac{u'(C_{t+1})}{u'(C_t)}\right], \qquad t=0,1. \tag{14}$$

Combining (13) and (14) to eliminate the stochastic discount factor gives

$$\frac{R_{d,t}^j}{R_{b,t}} = 1+f'(D_t^j), \qquad t=0,1, \tag{15}$$

and substituting (9) into (15) yields the deposit-demand schedule[11]

$$\frac{D_t^j}{N_t^j} = \left(\frac{R_{d,t}^j - R_{b,t}}{\xi\left(\eta^j-1\right)R_{b,t}}\right)^{\frac{1}{\eta^j-1}}. \tag{16}$$

Equation (16) implies that a lower policy rate induces households to hold more deposits, since a lower policy rate reduces the opportunity cost of holding deposits relative to bonds. Importantly, heterogeneity in curvature across banks ($\eta^{LB} < \eta^{SB}$) implies that LBs can attract household demand deposits at lower marginal cost than SBs when the policy rate $R_{b,t}$ falls. This implication is consistent with the empirical finding in Section III. In Table 2, the interaction coefficient β is positive and statistically significant for household demand deposits, while α is negative and statistically significant, consistent with the model's assumption of heterogeneous access to household demand deposits across the two groups of banks.

C. *Bankers*

We next characterize bank balance sheets, funding constraints, and rollover exposure. The purpose is to show how deposit funding, interbank positions, and regulatory constraints jointly determine the amount of capital each bank type can finance and why SBs become vulnerable to an interbank run.

Each banker operates a bank of type j. Initial bank net worth n_0^j is given. At $t=0,1$, the banker chooses capital k_t^j, reserves a_t^j, deposits d_t^j, and an interbank position ib_t^j.[12] We refer to capital investment as "non-financial loans" to distinguish it from interbank credit.

Balance sheets and net worth. The policy rate $R_{b,0}$ is set at the beginning of $t=0$, while the productivity shock Z_1 is realized at the beginning of $t=1$. Conditional on the policy rate and realized productivity state, the net worth of a type-j banker at the beginning of period t is the sum

[10]Since the only aggregate uncertainty is the realization of Z_1, the expectation at $t=0$ is taken over Z_1. Once Z_1 is realized at $t=1$, there is no additional uncertainty before $t=2$. Thus, the E_1 operators in Equations (13) and (14), as well as in all subsequent expressions, are degenerate.

[11]If $\eta^j = 1$, the deposit-pricing condition reduces to $R_{d,t}^j = R_{b,t}$.

[12]Throughout the paper, our sign convention is $ib_t^j > 0$ for interbank borrowing and $ib_t^j < 0$ for interbank lending by a type-j bank.

of the gross returns on reserves and non-financial loans net of deposit and interbank funding costs. Accordingly, at $t = 1, 2$, net worth n_t^j evolves according to

$$n_t^j = a_{t-1}^j + (Q_t + Z_t)k_{t-1}^j - R_{ib,t-1}ib_{t-1}^j - R_{d,t-1}^j d_{t-1}^j, \tag{17}$$

where Q_t is the price of capital at t, $R_{ib,t-1}$ and $R_{d,t-1}^j$ are the gross rates on interbank claims and deposits at $t-1$, respectively. For $t = 0, 1$, the bank j finances its capital, reserves, and the reserve-management cost, which we describe below, with net worth, deposits, and its interbank position. The flow-of-funds constraint is as follows:

$$(Q_t + \alpha^j K_t^j)k_t^j = n_t^j + ib_t^j + d_t^j - a_t^j - \chi(x_t^j). \tag{18}$$

The left-hand side is total capital expenditure, including management costs. The right-hand side is internal and external funding net of reserves and the reserve-management cost $\chi(x_t^j)$.

Reserve requirement and reserve-management cost. We represent reserve-management costs in reduced form. The expected net reserve-management need is

$$x_t^j = \tau n_t^j + \rho d_t^j - a_t^j,$$

where $\rho d_t^j - a_t^j$ is the expected net reserve gap associated with the reserve requirement and τn_t^j captures an additional component of reserve-management needs proportional to bank net worth. We focus on the equilibrium region in which $x_t^j \geq 0$. The associated reserve-management cost is

$$\chi(x_t^j) = r_{b,t}x_t^j, \qquad r_{b,t} = R_{b,t} - 1. \tag{19}$$

Conditional on x_t^j, the cost increases with the policy rate. Appendix C.A provides a detailed explanation of this reduced-form cost.[13]

Incentive and liquidity constraints. To limit banks' ability to raise external funds, we assume that bankers can divert assets for personal use. After choosing the bank's portfolio at the beginning of period t, a banker decides whether to operate "honestly" or divert funds. An honest banker holds the assets until their returns are realized at $t+1$, fulfills the corresponding obligations to creditors, and retains the bank's franchise value V_t^j. A banker who diverts is detected at the end of the period and loses the franchise value. Creditors therefore provide funding only if V_t^j is at least as large as the gain from diversion.

Divertibility depends on the funding source. A banker can divert a fraction $\theta \in (0, 1)$ of funds financed with net worth or retail deposits, but only a fraction $\theta\omega$, with $\omega \in (0, 1]$, of funds financed through interbank borrowing. The lower diversion rate captures the stronger monitoring capacity

[13] In this appendix, the central bank offers reserve-management insurance at the premium $\chi(x_t^j)$, while uninsured shortfalls must be covered at the discount window.

of interbank creditors. For a bank with $ib_t^j > 0$, the divertible amount is

$$\theta[(Q_t + \alpha^j K_t^j)k_t^j + a_t^j + \chi(x_t^j) - ib_t^j + \omega ib_t^j]$$

The component $(Q_t + \alpha^j K_t^j)k_t^j + a_t^j + \chi(x_t^j) - ib_t^j$ is the expenditure on capital, reserves, and the reserve-management cost financed by net worth or deposits; ωib_t^j is the divertible portion of interbank borrowing. Interbank loans made by a lending bank are also harder to divert than its other assets: a lender can divert only a fraction $\theta\gamma$, where $\gamma \in (0, 1]$, of its interbank loans. Combining the borrower and lender cases gives the incentive constraint

$$\theta[n_t^j + d_t^j + \omega ib_t^j \cdot I_{ib_t^j>0} + (1-\gamma)ib_t^j \cdot I_{ib_t^j<0}] \leq V_t^j \tag{20}$$

where $I_{ib_t^j>0}$ and $I_{ib_t^j<0}$ are indicators for interbank borrowing and lending, respectively. Equation (20) is the bank's endogenous funding limit. External funding expands the balance sheet but also increases the amount that can be diverted, thereby tightening the incentive constraint.

We focus on the equilibrium in which LBs lend and SBs borrow. The deposit schedule in (16) gives LBs the stronger funding base, while $\alpha^{SB} < \alpha^{LB}$ gives SBs the stronger demand for capital. Appendix C.B derives the conditions supporting this direction of interbank flows.

Each bank is also subject to a liquidity requirement,

$$a_t^j \geq \kappa n_t^j. \tag{21}$$

Here κ measures required liquid assets relative to net worth. Since reserves yield less than capital, the requirement binds in the equilibrium of interest and $a_t^j = \kappa n_t^j$. The parameters ρ and κ play distinct roles. The reserve requirement ρ is tied to deposits and affects their effective return, pricing, and response to monetary policy. The liquidity requirement κ instead links reserves to net worth and directly limits leverage and balance-sheet risk taking.[14] A higher κ therefore reduces run exposure but also limits capital reallocation through interbank funding, whereas ρ primarily affects monetary transmission through deposit-side funding costs.

Together, the incentive and liquidity constraints limit the moral hazard associated with insured deposits along two distinct margins. The liquidity constraint limits asset-side risk taking by preventing banks from allocating their entire balance sheets to capital, whereas the incentive constraint limits liability-side risk taking by preventing banks from expanding leverage without bound through insured deposit funding. Thus, although deposit insurance makes retail deposits safe for households, the model restricts the associated incentives for excessive capital risk taking and leverage.

[14]Cui and Radde (2020) show that intermediaries may need to hold a minimum quantity of liquid assets even without a formal reserve requirement. This is consistent with institutional arrangements in countries such as the United States, where liquidity requirements remain relevant even when statutory reserve requirements are low or absent.

Maturity mismatch and interbank run. SBs finance two-period capital investment with one-period liabilities: deposits and interbank bonds issued at $t = 0$ mature at $t = 1$, before the capital investment reaches its terminal maturity at $t = 2$. SBs must therefore repay or refinance their short-term liabilities while the capital remains in place.

At $t = 1$, LBs decide whether to roll over their maturing interbank claims by extending new interbank credit IB_1. Under rollover, $IB_1 > 0$, allowing SBs to continue financing their capital holdings. If LBs do not roll over, $IB_1 = 0$; we define this rollover failure as an interbank run. SBs must then liquidate capital at the fire-sale price $Q_1^* < Q_1$ to meet their maturing obligations.

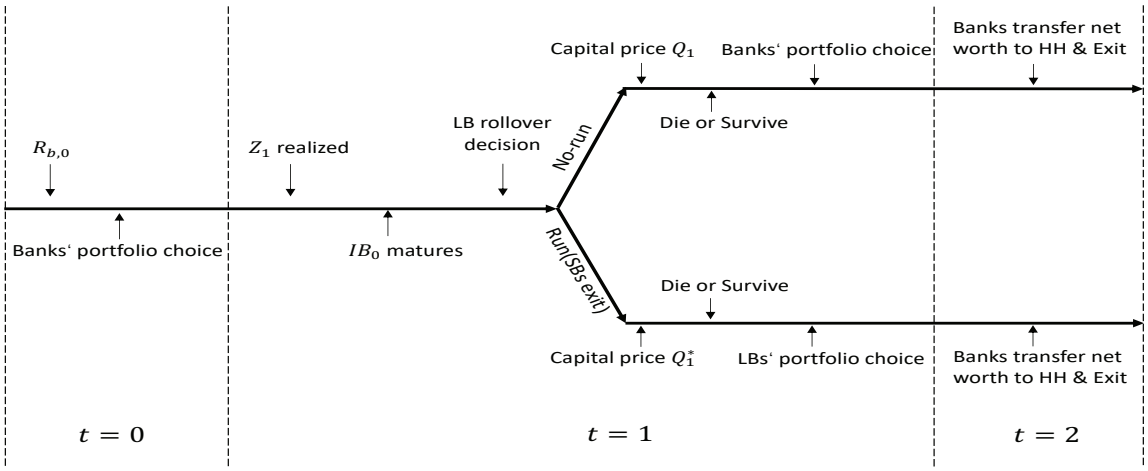
For tractability, we abstract from retail-deposit runs and assume that deposits held by the representative household are effectively insured and sticky. Runs are therefore confined to the interbank funding leg of SB balance sheets. The likelihood of a run depends on the recovery value of SB assets relative to promised repayments: it increases with SB leverage and decreases with realized productivity Z_1.

Interbank bonds are traded competitively between SBs (borrowers) and LBs (lenders). At $t = 0$, the promised gross rate $R_{ib,0}$ is determined by interbank-market clearing, taking into account expected repayment in both the no-run and run states. Conditional on rollover at $t = 1$, new interbank credit IB_1 is issued at the gross rate $R_{ib,1}$, which clears the interbank market at $t = 1$.

Timeline of events. At $t = 0$, monetary policy rate $R_{b,0} = R_b^L < \bar{R}_b$; from $t = 1$ onward, the policy rate equals its steady-state level $\bar{R}_b$. Knowing the distribution but not the realization of Z_1, banks choose capital, reserves, deposits, and one-period interbank positions. SBs borrow from LBs, and both bank types invest in capital.

At the beginning of $t = 1$, Z_1 is realized, capital held from $t = 0$ produces $Z_1 k_0^j$, and the deposits and interbank claims issued at $t = 0$ mature. LBs then decide whether to extend new interbank credit IB_1. With rollover, capital trades at Q_1; bankers of both types exit with probability $1-\sigma$ or survive with probability σ, and surviving banks choose new one-period positions. Without rollover, $IB_1 = 0$, SBs liquidate capital at Q_1^*, and SB net worth is wiped out; existing SB bankers exit and no new SB bankers enter. Only LB bankers then face the exit shock, and exiting LBs are replaced. In either branch, exiting bankers transfer any residual net worth to the household and return to the worker pool. At $t = 2$, the date-1 liabilities are settled, surviving banks receive the terminal capital return $Z_2 k_1^j$, distribute their remaining net worth to the household, and exit; capital has no continuation value, so $Q_2 = 0$.

This timing captures how an initially low policy rate at $t = 0$ can expand credit and investment while increasing exposure to a rollover crisis after an adverse productivity realization at $t = 1$. The following diagram summarizes the sequence and the two rollover branches.



Bankers' optimization. We now turn to the optimization problem for individual banks. The bank's objective is to maximize the expected present discounted value of the dividend payouts to the household. Since bankers are financially constrained, it is optimal for them to delay dividend payouts until exit.

At $t = 0$, a banker of type j chooses capital k_0^j, reserves a_0^j, deposits d_0^j, and interbank funding ib_0^j to maximize expected continuation value. Let $P \equiv P(IB_0, R_{b,0}, Z_1)$ denote the state-contingent run probability defined in (31). In the competitive equilibrium, an individual banker takes the aggregate run-probability schedule as given when choosing its own ib_0^j, because P is determined by aggregate recovery values. The banker therefore evaluates expected returns over the distribution of Z_1, but does not internalize the derivative of P with respect to its own borrowing choice. In the run state the SB defaults and gets zero. In the no-run state, the banker exits at $t = 1$ with probability $1 - \sigma \in (0, 1)$ and survives with probability σ. Using $m_1 = u'(C_1)/u'(C_0)$, the value function at $t = 0$ can be written as

$$V_0^j = \max E_0\Big[\beta m_1\Big((1-\sigma)n_1^j + \sigma V_1^j\Big)\Big], \tag{22}$$

subject to (18), (17), the incentive constraint (20) and the liquidity requirement (21). Note that $V_1^{SB} = 0$ in the run state.

Similarly, at $t = 1$, conditional on no run, bankers of type j solve a problem analogous to their $t = 0$ problem, taking equilibrium objects at $t = 1$ as given. The economy ends at $t = 2$, so the value function at $t = 1$ is proportional to net worth at $t = 2$:

$$V_1^j = \max \beta m_2\, n_2^j, \qquad m_2 \equiv \frac{u'(C_2)}{u'(C_1)}. \tag{23}$$

At $t = 2$, bankers distribute their remaining net worth n_2^j as dividends to the household and exit.

D. *Aggregation and Equilibrium*

We now aggregate individual choices and close the model. Uppercase letters denote bank-group aggregates: $\{K_t^j, N_t^j, A_t^j, D_t^j\}$ are capital, net worth, reserves, and deposits for bank type j, and IB_t denotes aggregate interbank credit from LBs to SBs. Interbank-market clearing equates aggregate SB borrowing with aggregate LB lending. Symmetry within each bank type maps individual choices into these aggregates, as described in Appendix C.D. This subsection establishes the two equilibrium objects needed for the subsequent analysis: which bank type prices capital at the margin and how individual budgets aggregate into the economy-wide resource constraint.

Throughout the following discussion of capital choices, $t \in \{0, 1\}$ unless explicitly stated otherwise. Since the aggregate capital stock is fixed, capital-market clearing requires

$$K_t^{SB} + K_t^{LB} = \bar{K}. \tag{24}$$

To characterize the equilibrium capital price, it remains to determine which bank type is the marginal buyer of capital. SBs have a higher underlying return on capital because $\alpha^{SB} = 0 < \alpha^{LB}$, but their capital investment is limited by their incentive constraint. LBs, by contrast, hold both capital and positive interbank claims. They can finance an additional unit of capital by reducing interbank lending, so no corresponding upper bound on their capital holdings binds. The capital first-order conditions therefore imply

$$E_t\big[\beta_{t+1}^{LB}(Z_{t+1} + Q_{t+1})\big] - \alpha^{LB} K_t^{LB} = Q_t < E_t\big[\beta_{t+1}^{SB}(Z_{t+1} + Q_{t+1})\big], \tag{25}$$

where β_{t+1}^j denotes the stochastic discount factor of type-j bank. The first and last expressions in (25) are the expected discounted marginal returns of capital (net of marginal capital-management costs) for LBs and SBs, respectively. Although the SB marginal return exceeds Q_t, its binding funding constraint prevents it from purchasing an additional unit of capital. LBs therefore absorb the residual capital supply and are the marginal buyers of capital.[15] The same conclusion holds in the run allocation. SBs liquidate their capital and cease to be buyers, so LBs absorb the entire capital stock and are the unique marginal buyers at the fire-sale price Q_1^*.

Having characterized market clearing and marginal capital pricing, we complete the equilibrium by consolidating the central-bank and private-sector budgets.

The central bank issues reserves, receives reserve-management payments from banks, covers deposit shortfalls in the run state, and transfers its net receipts to the household. Its consolidated budget constraint is

$$T_t = \sum_{j \in \{SB, LB\}} \Big[A_t^j - A_{t-1}^j + \chi(X_t^j)\Big] - \mathbf{1}_{\mathcal{R}_t}\left(1 - u^{SB}\right) R_{d,t-1}^{SB} D_{t-1}^{SB}, \qquad t = 0, 1, 2, \tag{26}$$

[15] See Appendix C.E for details.

where X_t^j is the aggregate reserve shortfall of type-j banks, u^{SB} is the run-state SB recovery rate defined in (30), and $\mathbf{1}_{\mathcal{R}_t}$ equals one if a run is realized at t and zero otherwise. We set $A_{-1}^j = 0$ and $\mathbf{1}_{\mathcal{R}_t} = 0$ at $t = 0, 2$. The summation in (26) rebates net reserve issuance and reserve-management premium receipts, while the final term finances the unpaid portion of insured SB deposits in a run. Appendix C.C provides the detailed flows.

Following Gertler and Kiyotaki (2015), total output Y_t is the sum of output from capital and household endowment, net of capital management and deposit transaction costs:[16]

$$Y_t = Z_t \bar{K} + W - \sum_{j \in \{SB, LB\}} \left[\alpha^j (K_t^j)^2 + f(D_t^j) \right] \tag{27}$$

The consolidated resource constraint is[17]

$$C_t + B_t = Y_t + R_{b,t-1} B_{t-1}. \tag{28}$$

Together, the market-clearing conditions and the consolidated resource constraint close the model. They also make the productive role of interbank funding explicit: moving capital toward the more efficient SB sector raises net output, but the financial structure limits how much of the fixed capital stock SBs can finance.

E. *Monetary Policy Transmission*

This subsection isolates the beneficial role of interbank funding in monetary policy transmission. In line with the empirical findings in Section III, we show that SB interbank borrowing, capital demand, and non-financial lending are higher at a lower initial policy rate. This result provides the transmission side of the regulatory trade-off studied in Section IV.G.

At $t = 0$, monetary policy operates through the policy rate $R_{b,0}$, which affects SB balance-sheet choices through reserve-management costs. For a fixed capital price Q_0, the following proposition shows that SB interbank borrowing is decreasing in the initial policy rate $R_{b,0}$ when η^{SB} is sufficiently large:

Proposition 1. Holding all other prices and continuation values fixed, SB interbank borrowing and capital demand are decreasing in the initial policy rate $R_{b,0}$ for a given capital price Q_0 if η^{SB} is sufficiently large:

$$\frac{\partial ib_0^{SB}}{\partial R_{b,0}}\Big|_{Q_0} < 0, \frac{\partial k_0^{SB}}{\partial R_{b,0}}\Big|_{Q_0} < 0. \tag{29}$$

[16] We set $Z_0 = 0$ as a timing convention because capital chosen at $t = 0$ first generates the return Z_1 at $t = 1$. Initial bank net worth n_0^j is taken as given, so the model does not include a capital return inherited from a period before $t = 0$. Besides, because $K_2^j = D_2^j = 0$, the aggregate output is $Y_2 = Z_2 \bar{K} + W$.

[17] We set $B_{-1} = 0$, since there are no inherited bond holdings before $t = 0$, and $B_2 = 0$, since no bonds are carried beyond the terminal date. The corresponding resource constraints are therefore $C_0 + B_0 = Y_0$ and $C_2 = Y_2 + R_{b,1} B_1$.

Intuitively, a lower initial policy rate relaxes the incentive constraints for both LBs and SBs, which in turn allows both types of banks to increase external funding. Households, however, incur high transaction costs when depositing in SBs. When the parameter η^{SB} is sufficiently high, the deposit response of SBs to changes in the policy rate is small, so SBs need to issue interbank bonds to complement deposit funding. Together, these results from the simple model summarize how a lower initial policy rate is associated with larger SB balance sheets and greater demand for interbank funding and capital.

F. *Bank Fragility*

This subsection examines how interbank exposure at $t = 0$ affects bank fragility at $t = 1$. We first characterize the recovery rate and run probability as functions of IB_0 and Z_1. We then show that the pecuniary externality leads to more interbank borrowing in the decentralized equilibrium than under the constrained social planner, resulting in a higher run probability following an adverse realization of Z_1.[18]

If an interbank run occurs at $t = 1$, SBs must liquidate capital at the fire-sale price $Q_1^* < Q_1$. Let u^{SB} denote the recovery rate on SB liabilities in the run state, defined as the ratio of their liquidation value to promised repayments:

$$u^{SB} = \frac{(Q_1^* + Z_1)k_0^{SB} + a_0^{SB}}{R_{ib,0}ib_0^{SB} + R_{d,0}^{SB}d_0^{SB}}, \tag{30}$$

and following Gertler and Kiyotaki (2015), we specify the run risk by

$$P \equiv P(IB_0, R_{b,0}, Z_1) = \Big[1 - \min\big(u^{SB}(IB_0, R_{b,0}, Z_1),\, 1\big)\Big]^{\delta_p}. \tag{31}$$

Under this formulation, a bank run remains a sunspot outcome. Nevertheless, the probability associated with the sunspot is state contingent and depends on the realized recovery rate u^{SB}. The parameter $\delta_p > 0$ governs the curvature of the run-probability function.

Equations (30)–(31) summarize the fragility mechanism. Let IB_0 denote aggregate interbank borrowing by SBs at $t = 0$. A larger IB_0 raises the short-term claims that must be rolled over at $t = 1$, while a higher Z_1 raises productive income and the fire-sale price Q_1^*. Thus, interbank borrowing lowers recovery and raises run risk, whereas productivity has the opposite effects. The same funding reallocation that directs capital toward more efficient SBs in normal times therefore increases rollover exposure in the adverse state. The promised interbank rate $R_{ib,t}$ clears the interbank

[18] All technical details in this subsection can be found in Appendix C.F.

market and prices this risk through expected recovery; Appendix C.F provides the detailed run-equilibrium and pricing conditions. Formally,

$$\frac{\partial u^{SB}}{\partial IB_0} < 0, \qquad \frac{\partial u^{SB}}{\partial Z_1} > 0, \tag{32}$$

hence P is weakly increasing in IB_0 and weakly decreasing in Z_1, with strict effects when run risk is active.

We next show how the pecuniary externality in interbank funding leads to more interbank borrowing in the decentralized economy than is socially optimal. When choosing ib_0^{SB}, an individual SB takes aggregate prices and the run-probability schedule as given. It values the private funding benefit of additional borrowing but does not internalize how its contribution to aggregate interbank borrowing affects fire-sale recovery and run risk. To characterize the socially optimal level of interbank borrowing, consider a constrained social planner subject to the same household optimality conditions and the same bank incentive and liquidity constraints as the decentralized economy. Let $V_1(N_1)$ and $V_1^*(N_1^*)$ denote household continuation utility from $t = 1$ onward in the no-run and run allocations:

$$\begin{aligned} V_1(N_1) &= u(C_1(N_1)) + \beta u(C_2(N_1)), \\ V_1^*(N_1^*) &= u(C_1^*(N_1^*)) + \beta u(C_2^*(N_1^*)). \end{aligned} \tag{33}$$

Here $N_1 = (N_1^{LB}, N_1^{SB})$ is the vector of bank net worths at $t = 1$ in the no-run allocation, and $N_1^* = ((N_1^{LB})^*, (N_1^{SB})^*)$ is its run-state counterpart. Because SBs default and do not continue after a run, $(N_1^{SB})^* = 0$.

The planner chooses (C_0, IB_0) to maximize

$$\max_{C_0, IB_0} \; u(C_0) + \beta E_0[P\, V_1^*(N_1^*) + (1-P)V_1(N_1)]\,; \tag{34}$$

Conditional on (C_0, IB_0), the resource constraint at $t = 0$, household optimality, bank balance sheets, market clearing, and the bank constraints determine K_0^{LB}, K_0^{SB}, D_0^{LB}, D_0^{SB}, and the state-contingent continuation allocations. Appendix C.G states the full implementability system and derives the planner's first-order conditions. The planner's optimality condition for IB_0 is

$$0 = \beta E_0\left[(1-P)\frac{\partial V_1}{\partial IB_0} + P\frac{\partial V_1^*}{\partial IB_0}\right] - u'(C_0)\;\frac{\partial}{\partial IB_0}\left[\alpha^{LB}(K_0^{LB})^2 + \sum_j f(D_0^j)\right] + \beta E_0\left[\left(V_1^* - V_1\right)\frac{\partial P}{\partial IB_0}\right]. \tag{35}$$

The first two terms constitute the private marginal trade-off: they capture the effects of interbank borrowing on continuation utility and contemporaneous resource costs. The final term is the pecuniary externality. Since a run lowers continuation utility, $V_1^*(N_1^*) - V_1(N_1) < 0$, and P is weakly increasing in IB_0, this term is non-positive wherever the derivative exists. The planner therefore chooses no more aggregate interbank borrowing than the decentralized economy; the two choices coincide when run risk is negligible and the externality vanishes.

We compare equilibrium allocations under the two initial-policy-rate cases $R_{b,0} = R_b^L$ and $R_{b,0} = \bar{R}_b$. For any object X_0 and any allocation or regulatory rule m considered below, define the difference between these cases as

$$\Delta X_0^m \equiv X_0^m|_{R_b^L} - X_0^m|_{\bar{R}_b}. \tag{36}$$

The following proposition compares the response of interbank funding under the constrained planner allocation and the decentralized equilibrium.

Proposition 2. Suppose run risk is inactive in the $R_{b,0} = \bar{R}_b$ case, whereas the $R_{b,0} = R_b^L < \bar{R}_b$ case activates a nondegenerate run-risk externality. Then the change in aggregate interbank borrowing is strictly larger in the decentralized equilibrium than under the constrained social planner:

$$\Delta IB_0^{DE} > \Delta IB_0^{CSP}. \tag{37}$$

This inequality formalizes how the pecuniary externality affects the difference in interbank credit between the two initial policy rate cases. An individual SB takes aggregate IB_0 and the associated run probability as given, whereas the constrained social planner internalizes how aggregate interbank borrowing raises run risk. Because the two allocations coincide at $R_{b,0} = \bar{R}_b$, the planner's lower borrowing level when the externality is active at $R_{b,0} = R_b^L$ implies $\Delta IB_0^{CSP} < \Delta IB_0^{DE}$.

From the monotonicity of P in IB_0, we then have

$$P\Big(IB_0^{DE}|_{R_b^L}, R_b^L, Z_1\Big) > P\Big(IB_0^{CSP}|_{R_b^L}, R_b^L, Z_1\Big), \tag{38}$$

which means that following an adverse realization of Z_1 that activates the run risk region, this excessive exposure to interbank borrowing lowers recovery and raises the run probability.

G. *Trade-Off Between Monetary Policy Transmission and Bank Fragility*

This subsection combines the transmission mechanism in Section IV.E with the fragility mechanism in Section IV.F. We first introduce an interbank-borrowing limit that implements the constrained-planner allocation. Then we compare looser and tighter limits along the two dimensions of the trade-off: the effectiveness of monetary policy transmission and the run probability following an adverse realization of Z_1.

To implement the above social planner's choice of interbank credit, we set a simple regulatory rule, which is an upper bound on interbank borrowing of the form

$$IB_0 \leq \phi\, IB_0^{DE}, \tag{39}$$

where $\phi \in (0, 1]$ is chosen by the regulator. Setting

$$\phi = \phi^* \equiv \frac{IB_0^{CSP}}{IB_0^{DE}}$$

implements the planner's interbank borrowing level IB_0^{CSP}. The regulation (39) is nonbinding when the recovery rate satisfies $u^{SB} \geq 1$ and run risk is inactive, but it binds when $R_{b,0} = R_b^L$ and a subsequent economic downturn raises systemic risk in the decentralized equilibrium because of the externality discussed above. To highlight the trade-off, we compare a looser regime ($\phi = \phi^l = 1$) to a tighter regime ($\phi = \phi^* < 1$).

Proposition 3. Given all other prices, a looser interbank-borrowing limit strengthens monetary-policy transmission via capital reallocation.

$$\Delta\left(Q_0 k_0^{SB}\right)^{\phi^l} > \Delta\left(Q_0 k_0^{SB}\right)^{\phi^*}, \tag{40}$$

$$\Delta\left[\left(Q_0 + \alpha^{LB} K_0^{LB}\right) k_0^{LB}\right]^{\phi^l} < \Delta\left[\left(Q_0 + \alpha^{LB} K_0^{LB}\right) k_0^{LB}\right]^{\phi^*}. \tag{41}$$

The superscripts ϕ^l and ϕ^* indicate the difference ΔX under the looser and tighter regulatory rules, respectively.

The intuition is simple: compared with the $R_{b,0} = \bar{R}_b$ case, the $R_{b,0} = R_b^L$ case produces a larger increase in interbank borrowing and SB capital expenditure under the looser regulatory rule than under the tighter rule, where interbank borrowing is constrained at the CSP level. In other words, a looser interbank-borrowing limit strengthens monetary policy transmission through the interbank funding channel.

Under the tighter regime ($\phi = \phi^*$), SB interbank borrowing is constrained. As a result, the increase in IB_0, as well as the induced expansion in SB balance sheets and SB capital demand, is attenuated relative to the looser regime. Thus, the interbank-funding amplification channel of monetary policy is dampened when the interbank credit market is regulated.

Therefore, the change in SB capital expenditure is larger without regulation than under regulation if $R_{b,0}$ is lower, whereas LBs' demand for capital increases less without regulation than under regulation. Given that the aggregate supply of capital is fixed, SBs obtain a larger share of capital in the unregulated $R_{b,0} = R_b^L$ case, which leads to higher output. Consequently, a higher ϕ strengthens the transmission of monetary policy.

The same interbank-borrowing expansion that strengthens monetary policy transmission can also increase SB financial fragility in adverse states. In particular, we show that a higher ϕ leads to higher systemic risk at $t = 1$ when Z_1 is small.

Proposition 4. Given all other prices other than Q_1^*, for realizations of Z_1 sufficiently low that run risk is active under the looser regime, run risk is strictly higher under the looser interbank-borrowing limit:

$$P^{\phi^l} > P^{\phi^*}. \tag{42}$$

Intuitively, for sufficiently low realizations of Z_1, a looser interbank-borrowing limit (a higher ϕ) reduces the recovery rate by raising promised repayments to interbank creditors relative to

liquidation values, which in turn increases run risk. Therefore, relative to the looser regime ($\phi = \phi^l$), the tighter regime ($\phi = \phi^*$) lowers run probability in adverse states by limiting the interbank leverage SBs can build up at $t = 0$.

Taken together, the simple model highlights a trade-off between monetary policy transmission and financial stability. A looser interbank borrowing limit amplifies the response of SB borrowing and investment when $R_{b,0}$ is lower, but it also raises run risk when adverse shocks materialize. A tighter limit ($\phi = \phi^*$) dampens the interbank-funding amplification channel by restraining leverage, while improving resilience by reducing run probability in adverse states. In the richer quantitative model (Section V), the higher run probability under a looser interbank-borrowing limit translates into larger output and welfare losses during economic downturns, quantifying the trade-off between monetary policy transmission and systemic risk.

V. The Quantitative Model

This section embeds the mechanisms developed in the three-period model of Section IV within an infinite-horizon economy calibrated to China. Relative to the simple model, the quantitative environment adds four ingredients needed to connect the framework to the data: a ceiling on deposit-rate spreads, direct household investment in capital, type-specific banker survival probabilities, and a quadratic adjustment cost for household bond holdings. These additions allow us to quantify the contribution of interbank funding to monetary policy transmission and to evaluate the trade-off created by a regulatory limit on interbank borrowing.

To avoid repeating the setup in Section IV, the main text describes only these additional ingredients and the quantitative specializations of the baseline environment. Appendix D provides the recursive formulation, equilibrium definition, and numerical algorithm. The section proceeds as follows: Section V.A describes the environment; Section V.B documents the calibration strategy; and Section V.C quantifies the optimal regulation of interbank borrowing.

A. *Environment*

Except for the changes described here, the environment and notation follow Section IV. Time is measured in quarters and the horizon is infinite. A type-j banker survives to the next period with probability σ^j, following Gertler, Kiyotaki, and Prestipino (2016). We specialize deposit-funding heterogeneity by setting $\eta^{SB} > \eta^{LB} = 1$, so that household deposit transaction costs are positive for SBs but vanish for LBs.

The representative household can invest directly in productive capital alongside banks, capturing the importance of non-bank credit in China, particularly for small and micro enterprises. Production remains linear in capital and subject to aggregate productivity shocks Z. We normalize SBs

to be the most efficient investors and households to be the least efficient ($\alpha^{SB} = 0 < \alpha^{LB} < \alpha^{h}$), and we set aggregate capital to $\bar{K} = 1$. Household bond holdings are subject to the quadratic adjustment cost $g(B_t) \equiv \frac{\upsilon}{2} B_t^2$, which captures China's strict capital controls.

China's dual-track regulation imposes a ceiling on deposit rates,

$$R_d^{SB} \leq \overline{R}_d \equiv \lambda R_d^{LB}, \qquad \lambda > 1,$$

which provides a reduced-form representation of limited deposit-rate competition for SBs.[19] A binding ceiling on the deposit-rate spread makes SBs' deposits effectively insensitive to policy rates and shifts their funding toward the interbank market during episodes of monetary policy easing.

Because SB net worth is wiped out in a run, we use the expected SB net worth shortfall as a model analogue of systemic risk (and of SRISK in the data). Specifically, our model-implied systemic risk measure is

$$\text{SRISK}_t^{model} \equiv P_t \widetilde{N}^{SB} \tag{43}$$

where P_t is the run probability evaluated in period t, and $\widetilde{N}^{SB}$ denotes SB net worth in the period immediately preceding the productivity shock. The run-risk externality is the same as in Section IV.F: individual banks take the equilibrium run-risk schedule as given and do not internalize how aggregate interbank borrowing raises rollover-failure risk and losses outside the borrowing bank. Section V.C quantifies the resulting policy trade-off.[20]

B. *Calibration*

At a quarterly frequency, the model contains 27 parameters. We set a subset directly from the literature or available data, without solving for the model equilibrium, and jointly calibrate the remainder to steady-state moments. Appendix Table S7 reports the parameter values, and Appendix Table S8 reports the targeted moments.

For the pre-set parameters, we set the quarterly household discount factor to $\beta = 0.99$, a standard value in the literature. The household endowment W is set to be 2.5 times the size of capital income Z in the steady state. The steady-state policy net interest rate r_b targets the average three-month interbank offered rate during 2013Q4–2018Q4. The reserve requirement ρ is set to 0.2, consistent with China's required reserve ratio in 2013. The liquidity constraint parameter κ is set to 1.4, matching the median ratio of reserves to equity for all banks in our sample. The deposit rate ceiling multiplier λ is set to 1.0008, consistent with the regulated spread between the upper bounds

[19] Appendix B.B shows that deposit-rate spreads respond positively to monetary policy shocks but exhibit little systematic heterogeneity across bank types, motivating a ceiling that can bind for SBs.

[20] Appendix D.A.6 characterizes the deposit-rate ceiling and shows that it can bind for SBs when they borrow in the interbank market, while it is slack for LBs.

of deposit rates for LBs and SBs. We adopt $\rho_z = 0.95$ and $\rho_{R_b} = 0.95$ as the serial correlations for the productivity and policy rate shocks, following standard values in the literature. For SBs, we normalize $\alpha^{SB} = 0$ and set $\omega = 1$. The net-worth component of reserve-management needs, $\tau = 1.3$, implies a reserve-management cost of approximately 0.1% of total reserves. We set the quarterly first-arrival probability of the adverse productivity shock to $h = 0.081$. Together with the 2.5% shock size used below, this implies a quarterly standard deviation of approximately 0.007, consistent with the literature. We calibrate the parameters η^{SB} and υ using households' non-arbitrage conditions across deposit types and between deposits and bonds.[21] Using bank-level deposit rates from individual banks' semiannual financial reports over 2010–2019, we estimate the elasticity of SBs' deposits-to-net-worth ratio with respect to the deposit-rate spread relative to LBs and set $\eta^{SB} = 1.5$. Using the same data and the ratio of net international investment position to GDP (NIIP-to-GDP ratio), we estimate the elasticity of the deposit–bond rate spread with respect to NIIP-to-GDP and set $\upsilon = 0.03$.

The remaining eight parameters are jointly calibrated to eight empirical steady-state moments:[22] (1) α^{LB}, the capital management cost for LBs; (2) α^h, the capital management cost for households; (3) γ, the share of interbank bond holdings that is divertible for LBs; (4) θ, the bank asset seizure rate; (5) σ^{LB}, the survival probability of LBs; (6) σ^{SB}, the survival probability of SBs; (7) ξ, the parameter governing SBs' deposit cost; and (8) Z, the return on capital.

The target moments discipline the relative returns, balance-sheet composition, and funding structure of LBs and SBs in the Chinese data. Specifically, the calibration targets the annualized return on capital for SBs (7.3 percent) and LBs (6.4 percent), which pin down the efficiency gap in capital intermediation across bank types. To discipline interbank pricing and rollover risk, we target the average annualized spread between the interbank bond yield and the policy rate (0.8 percent). We also match the household sector's share of capital investment outside the banking system (0.2), which governs the relative importance of non-bank credit. On the balance-sheet side, the calibration targets the deposit-to-equity ratio of LBs (9.7), the ratio of total assets between LBs and SBs (1.2), and the ratio of total equity between the two bank groups (2.8), thereby anchoring relative size and leverage across bank types. Finally, we target the total-liability-to-equity ratio of SBs (14.8) to discipline their reliance on non-deposit funding. Together, these moments ensure that the calibrated economy reproduces the observed heterogeneity in funding structures, returns, and scale between LBs and SBs that underlies the empirical patterns documented in Section III.

[21] See Appendix D.A.4.

[22] Appendix A describes the sources of the empirical moments.

C. *Optimal Regulation of Interbank Funding Markets*

We now quantify the regulatory trade-off motivated by Section IV.G. Specifically, we impose a ceiling on interbank borrowing by SBs that is non-binding in steady state but becomes binding following monetary policy easing. When it binds, the ceiling dampens the transmission of monetary policy to credit but mitigates the run-risk externality by limiting SB leverage. This regulation is expressed as:

$$ib_t^j \leq \Phi ib_{ss}^j \text{ if } ib_t^j \geq 0,$$

where Φ denotes the regulatory ceiling multiplier in the quantitative model, and ib_{ss}^j denotes the steady-state level of interbank borrowing.

The optimal ceiling Φ maximizes household welfare. Welfare gains are computed as the constant percentage increase in benchmark consumption that equalizes lifetime utility between the benchmark and regulated economies. The policy experiment begins with a one-time easing that lowers the net policy rate $r_{b,0}$ by 0.58 percentage points (58 basis points). From period 7 onward, conditional on no previous arrival, a negative 2.5% productivity shock occurs in each period with probability h and can occur only once. Let C_t and C_t^o denote consumption paths under the benchmark and regulated cases, and V^o the household's lifetime utility under regulation. Then the welfare measure Δ_C solves:

$$E_0 \sum_{t=0}^{\infty} \beta^t \log[C_t(1+\Delta_C)] = E_0 \sum_{t=0}^{\infty} \beta^t \log C_t^o \equiv V^o.$$

Figure 4 reports a conditional impulse response in which the productivity shock first arrives in period 7. Monetary easing under regulation produces more muted increases in interbank funding and SBs' capital before the shock. Once the shock occurs, regulation substantially cushions the downturn: *ib* falls by about 19.0%, compared with 55.0% in the benchmark; SBs' capital falls by about 18.3%, versus 54.3%; output contracts by about 1.78%, rather than 4.05%; and model-implied systemic risk reaches about 0.52%, compared with 4.43%. Household consumption falls by about 0.70% under regulation, less than half of the 1.47% decline in the benchmark.

The effects of optimal regulation on output, welfare, and run frequency are reported in the right column of Table 5, with the benchmark economy shown in the left column for comparison. The optimal ceiling is $\Phi^* = 1.06$. Regulation reduces the unconditional run frequency in period 7 from 0.28% to 0.03%. In the absence of the negative productivity shock, regulation reduces output by 0.35% on impact. Output in period 7 is 2.36% higher under optimal regulation than in the benchmark economy. As a result, optimal interbank funding regulation yields an unconditional expected welfare gain equivalent to a 0.10% increase in consumption relative to the benchmark case.

To summarize, our quantitative analysis demonstrates that while interbank funding enhances monetary policy transmission to the real economy, it also raises systemic vulnerability in economic downturns. Optimal regulation strikes a balance between these effects, improving household welfare by curbing banks' exposure to systemic risk without fully negating the benefits of interbank funding.

VI. Conclusion

This paper studies how interbank funding shapes the transmission of interest-rate-based monetary policy and the accumulation of systemic risk in banking systems with heterogeneous access to deposit funding. In two-tier banking systems, monetary easing affects banks asymmetrically: banks with limited capacity to expand deposits rely more heavily on interbank funding, while deposit-rich banks act as liquidity providers. This reallocation of liquidity strengthens monetary policy transmission but simultaneously increases interconnectedness and rollover risk, giving rise to a fundamental trade-off between monetary effectiveness and financial stability.

Using bank-level data from China, we show that monetary policy easing reallocates funding through interbank markets, with SBs expanding interbank borrowing while LBs expand household demand deposits, thereby amplifying monetary transmission. At the same time, greater reliance on interbank funding is associated with higher systemic risk during economic downturns, particularly since 2018 amid China's growth slowdown. A model with heterogeneous deposit sensitivity and interbank funding shows that this amplification arises from a pecuniary externality—banks do not internalize aggregate rollover risk—and that regulating interbank funding can improve welfare by reducing crisis risk, albeit at the cost of weaker monetary transmission.

While China provides a transparent empirical setting, the mechanism we identify is more general. Many banking systems feature heterogeneous access to deposit funding and active interbank markets, implying that similar trade-offs may arise elsewhere. Recent liquidity stress among U.S. regional banks—occurring after the withdrawal of quantitative easing and amid rising loan losses—illustrates this tension, suggesting that the role of wholesale funding highlighted in this paper may be central to understanding both the amplification of stress and the macroprudential trade-offs faced by policymakers during episodes of regional bank fragility.

TABLE 1. Estimated Monetary Policy Rule

Coefficient	**Estimate**	**SE**	**p-value**
γ_R	0.773	0.072	0.000
γ_π	0.210	0.085	0.014
$\gamma_{x,a}$	-0.070	0.041	0.089
$\gamma_{x,b}$	0.277	0.114	0.015
$\sigma_{R,a}$	0.004	0.000	0.000
$\sigma_{R,b}$	0.005	0.001	0.000

Note: Estimated results from the endogenously switching monetary policy rule. SE denotes standard error.

Table 5. Effects of interbank funding regulation

	Benchmark Economy	Optimal Regulation $\Phi^* = 1.06$
Run Frequency in Period 7	0.28%	0.03%
Output on Impact of Monetary Ease Δ from Benchmark Economy	0	-0.35%
Output in Period 7 Δ from Benchmark Economy	0	2.36%
Unconditional Welfare Gain Δ Consumption	0	0.10%

Note: Δ denotes "change."

TABLE 2. Effects of monetary policy on interbank funding and household demand deposits

	Interbank funding		Household demand deposits	
	(1)	(2)	(3)	(4)
ϵ_{t-1}: α	6.938**	5.672*	-4.327***	-4.398***
	(2.978)	(2.886)	(1.325)	(1.344)
$\epsilon_{t-1} \times I(SB_b)$: β	-16.94***	-17.65***	3.252**	3.019**
	(3.400)	(3.499)	(1.398)	(1.376)
$\epsilon_{t-1} \times FA_{b,t-1}$		0.0203		0.0546
		(0.2239)		(0.0805)
$\alpha + \beta$	-9.998***	-11.98***	-1.075	-1.380
$Controls$	NO	YES	NO	YES
$MacroControls$	NO	YES	NO	YES
$BankFE$	YES	YES	YES	YES
$YearFE$	YES	YES	YES	YES
$SeasonalFE$	YES	YES	YES	YES
N	384	384	384	384
$R-square$	0.3737	0.3978	0.1070	0.1175

Note: The dependent variables are the year-over-year changes in interbank funding and household demand deposits, each scaled by total equity. The main explanatory variables are the monetary policy shock (ϵ_{t-1}), the dummy variable equal to one for SBs and zero otherwise ($I(SB_b)$), and their interaction terms.

Control variables include lagged return on equity ($ROE_{b,t-1}$), the lagged quarterly change in the share of interbank liabilities in total liabilities (IL_{t-1}), and the lagged quarterly growth rate of fixed assets ($FA_{b,t-1}$). Macro control variables include lagged quarterly GDP growth and lagged CPI inflation. Bank, year, and seasonal fixed effects are included. Robust standard errors clustered at the bank level are reported in parentheses. Asterisks ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

TABLE 3. Mediating effects of interbank funding

	Total effect		Mediation effect	
	(1)	(2)	(3)	(4)
ϵ_{t-1}: α_ϵ	3.422***	2.936***	2.717**	2.542**
	(1.136)	(1.033)	(1.141)	(1.073)
$\epsilon_{t-1} \times I(SB_b)$: β_ϵ	-6.025***	-6.349***	-4.868***	-4.946***
	(1.575)	(1.530)	(1.475)	(1.458)
$W_{b,t}$: α_W			0.0613	0.0662
			(0.0778)	(0.0802)
$W_{b,t} \times I(SB_b)$: β_W			-0.0177	-0.0113
			(0.0776)	(0.0778)
$\epsilon_{t-1} \times FA_{b,t-1}$		0.0389		-0.0255
		(0.1164)		(0.1093)
$W_{b,t} \times FA_{b,t-1}$				-0.00158**
				(0.000576)
$\alpha_\epsilon + \beta_\epsilon$	-2.603*	-3.413**	-2.150	-2.404
$\alpha_W + \beta_W$			0.0437*	0.0550**
$Controls$	NO	YES	NO	YES
$MacroControls$	NO	YES	NO	YES
$BankFE$	YES	YES	YES	YES
$YearFE$	YES	YES	YES	YES
$SeasonalFE$	YES	YES	YES	YES
N	359	359	359	359
$R-square$	0.2592	0.2699	0.2687	0.2823

Note: The dependent variable is a bank-quarter observation of the year-over-year change in loans scaled by total equity. The right-hand-side variables include the monetary policy shock (ϵ_{t-1}), a dummy variable equal to one if the bank is an SB and zero otherwise ($I(SB_b)$), and their interaction. Columns (3)–(4) also include interbank funding ($W_{b,t}$) and its interactions shown in the table.

Control variables include lagged return on equity ($ROE_{b,t-1}$), the lagged quarterly change in the share of interbank liabilities in total liabilities (IL_{t-1}), and the lagged quarterly growth rate of fixed assets ($FA_{b,t-1}$). Macro control variables include lagged GDP growth and lagged CPI inflation. Bank, year, and seasonal fixed effects are included. Robust standard errors clustered at the bank level are reported in parentheses. Asterisks ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

TABLE 4. Effects of interbank funding on systemic risk

	LBs		SBs	
	(1)	(2)	(3)	(4)
$I(t \geq 2018Q3) \times W_{b,t-1} : \alpha_r$	-26.52	4.517	6.152***	6.478***
	(31.51)	(50.39)	(2.008)	(1.539)
$I(t \geq 2018Q3) \times g_{t-1} \times W_{b,t-1} : \beta_r$	4.236	-0.0813	-0.9153***	-0.9563***
	(4.627)	(7.486)	(0.2904)	(0.2202)
$I(2018Q1 \leq t \leq 2018Q2) \times W_{b,t-1} : \alpha_l$	-76.20	47.05	-5.741	-9.546
	(167.3)	(119.4)	(5.127)	(7.056)
$I(2018Q1 \leq t \leq 2018Q2) \times g_{t-1} \times W_{b,t-1} : \beta_l$	10.89	-7.024	0.8217	1.383
	(24.21)	(17.44)	(0.7581)	(1.040)
$g_{t-1} \times W_{b,t-1} : \beta$	-1.353	-0.1963	0.00979	0.0275
	(2.405)	(2.277)	(0.0851)	(0.0722)
$W_{b,t-1}$	9.363	0.6299	0.0264	-0.1126
	(16.58)	(15.45)	(0.6535)	(0.5611)
g_{t-1}	-3.267	63.33	7.138	29.94**
	(53.89)	(87.38)	(8.706)	(13.01)
$g_{t-1} \times FA_{t-1}$		-3.880		
		(5.415)		
$g_{t-1} \times IL_{t-1}$				3.093**
				(1.403)
$Controls$	NO	YES	NO	YES
$MacroControls$	NO	YES	NO	YES
$BankFE$	YES	YES	YES	YES
$YearFE$	YES	YES	YES	YES
$SeasonalFE$	YES	YES	YES	YES
N	125	125	318	318
$R-square$	0.0308	0.0828	0.0413	0.1078

Note: The dependent variable is the SRISK at the bank-quarter level. Explanatory variables include lagged year-over-year change in interbank funding scaled by total equity ($W_{b,t-1}$), lagged real GDP growth (g_{t-1}), and indicator variables for the slow-growth period ($I(t \geq 2018Q3)$) and the regulation-implementation window ($I(2018Q1 \leq t \leq 2018Q2)$). The specifications include $g_{t-1} \times W_{b,t-1}$ and, for each period indicator, its interaction with $W_{b,t-1}$ and its triple interaction with $g_{t-1} \times W_{b,t-1}$.

Control variables include lagged return on equity ($ROE_{b,t-1}$), the lagged quarterly change in the share of interbank liabilities in total liabilities (IL_{t-1}), and the lagged quarterly growth rate of fixed assets ($FA_{b,t-1}$). Macro control variables include lagged CPI inflation. Columns (1)–(2) report results for LBs, while columns (3)–(4) report results for SBs. Bank, year, and seasonal fixed effects are included. Robust standard errors clustered at the bank level are reported in parentheses. Asterisks ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

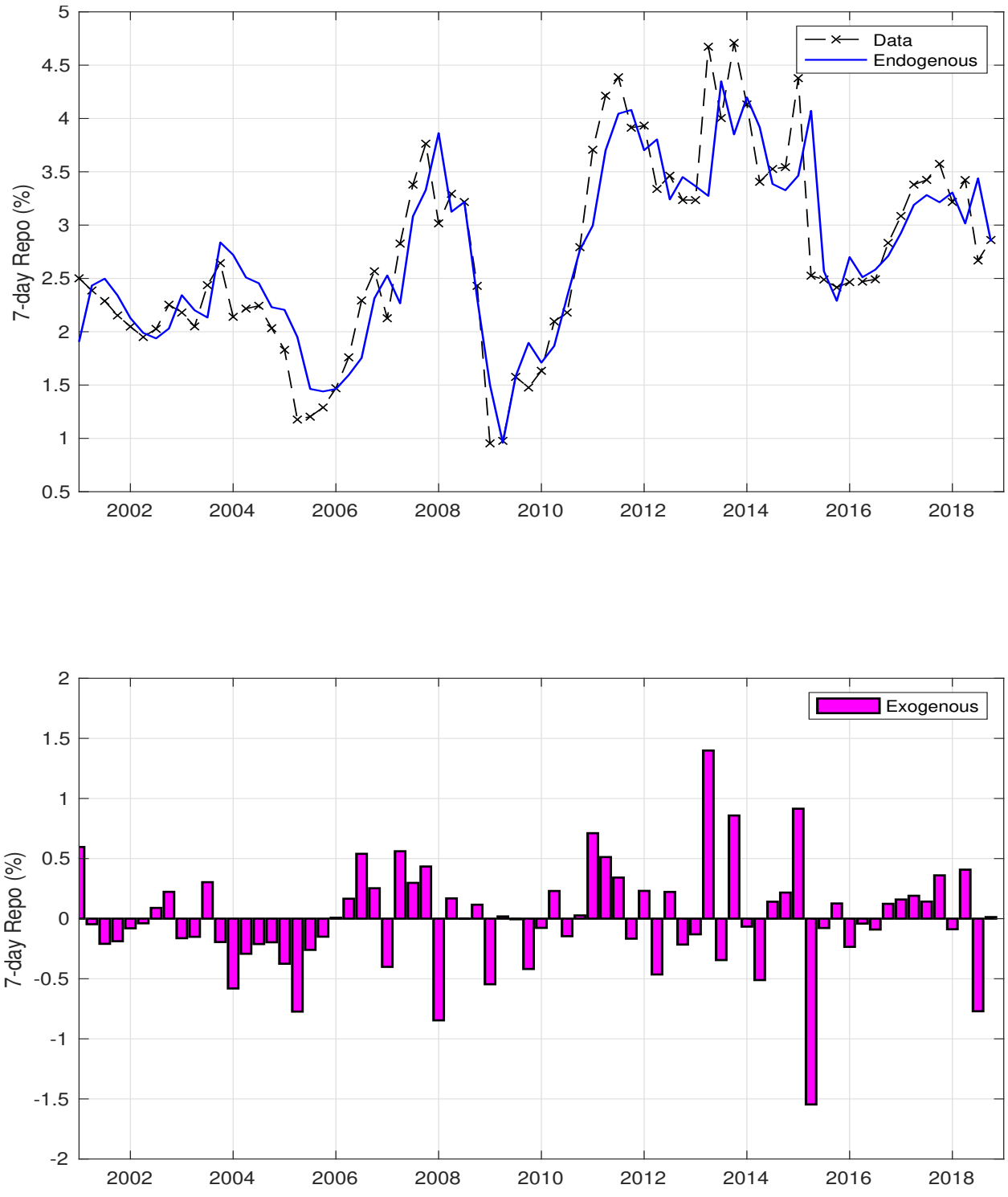


FIGURE 1. Endogenous and Exogenous Components of R007

Note: The figure shows the quarterly average level of R007, the estimated systematic component of monetary policy, and the implied exogenous policy shocks. The difference between the actual R007 rate and its fitted systematic component represents the series of exogenous monetary policy shocks.
Sources: CEIC.

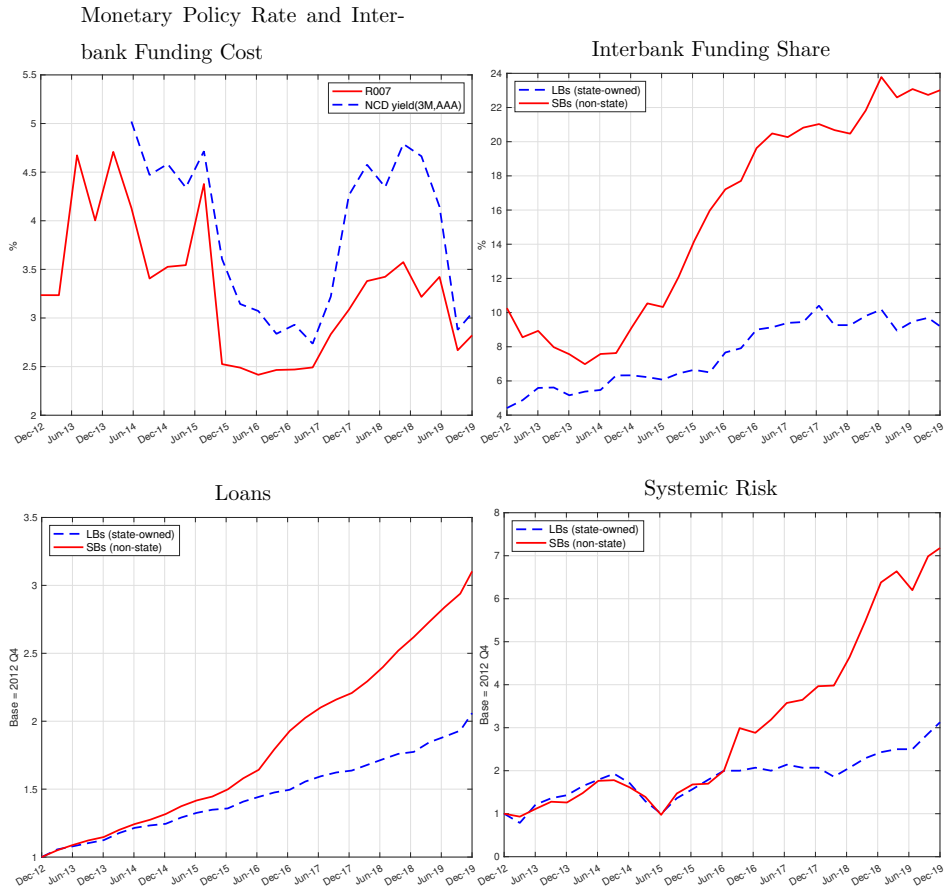


FIGURE 2. Monetary Policy and Interbank Funding Issuance

Note: The four panels are organized as follows: the top-left panel displays the monetary policy rate (measured by the 7-day repo rate) and the interbank funding cost (measured by the at-issue yield of 3-month AAA-rated NCDs); the top-right panel shows interbank (non-deposit) funding as a share of total liabilities for LBs and SBs; the bottom-left panel plots total loans issued by LBs and SBs, normalized to their respective 2012Q4 levels; and the bottom-right panel illustrates systemic risk for each bank type, normalized to their respective 2012Q4 levels.

Sources: CSMAR and CEIC.

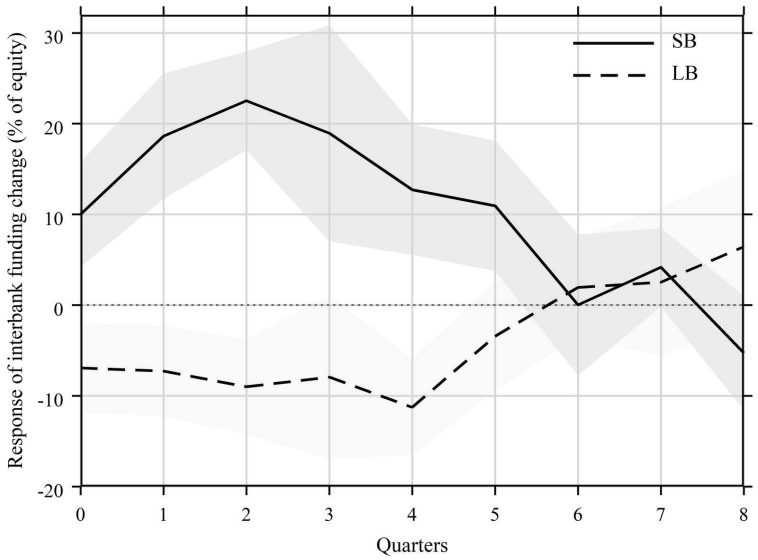


FIGURE 3. Dynamic responses of interbank funding to monetary policy easing. The dashed line shows the response for LBs ($-\alpha_q$); the solid line shows the response for SBs ($-(\alpha_q+\beta_q)$). Shaded areas represent 90% confidence intervals.

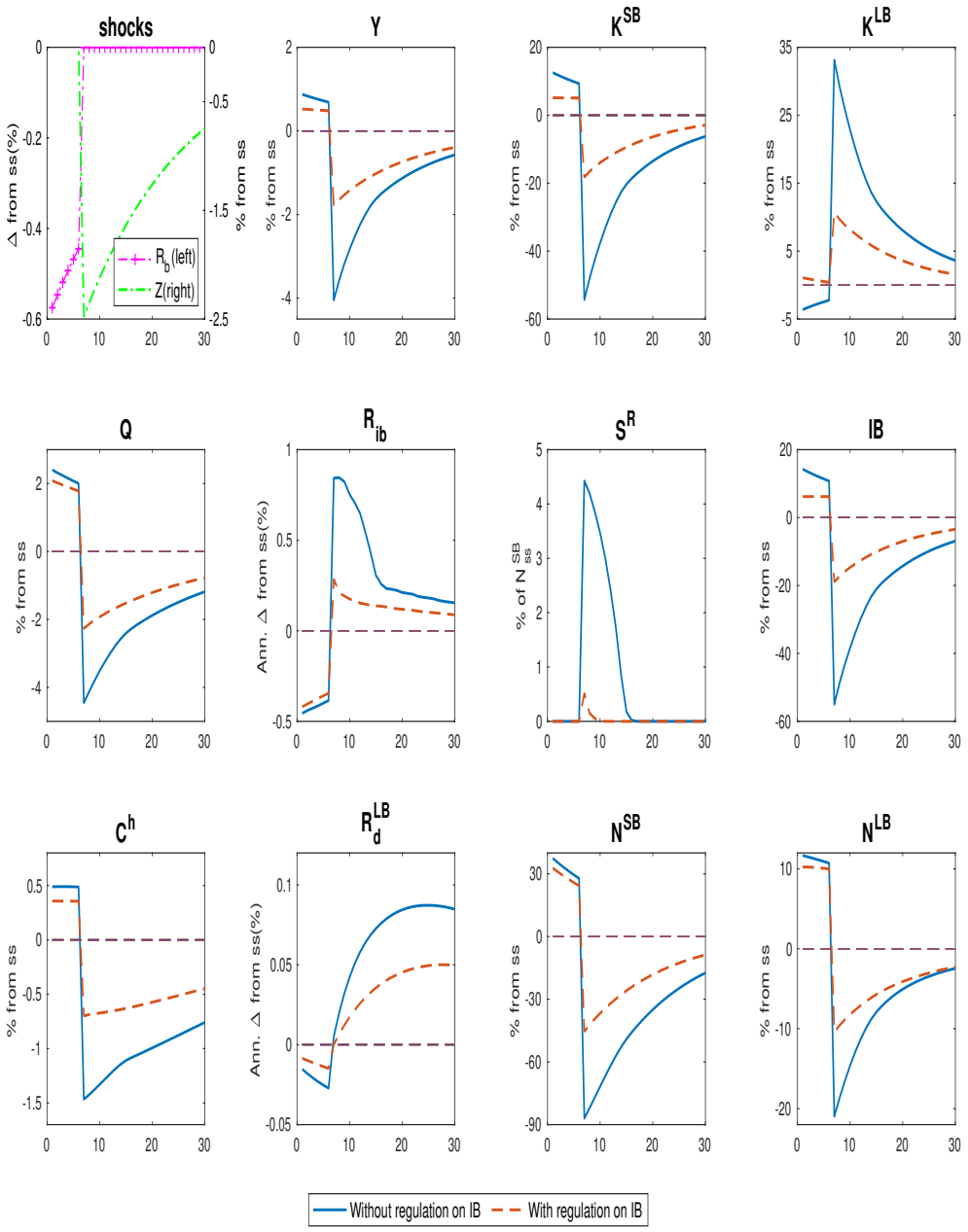


FIGURE 4. Monetary policy easing followed by a period-7 negative productivity shock: the role of interbank funding regulation

References

Acharya, V., L. Pederson, T. Philippon, and M. Richardson (2017): "Measuring Systemic Risks," *Review of Financial Studies*, 30, 2–47.

Bernanke, B., and A. Blinder (1988): "Credit, Money, and Aggregate Demand," *American Economic Review*, 78, 435–439.

——— (1992): "The Federal Funds Rate and the Channels of Monetary Transmission," *American Economic Review*, 82, 901–921.

Bianchi, J., and S. Bigio (2017): "Banks, Liquidity Management and Monetary Policy," National Bureau of Economic Research Working Paper No. 20490.

——— (2022): "Banks, Liquidity Management and Monetary Policy," *Econometrica*, 90(1), 391–454.

Brownlees, C., and R. Engel (2017): "SRISK: A Conditional Capital Shortfall Measure of Systemic Risk," *Review of Financial Studies*, 30, 48–79.

Brunnermeier, M., and Y. Sannikov (2014): "A Macroeconomic Model with a Financial Sector," *American Economic Review*, 104, 379–421.

Chen, K., H. Gao, P. C. Higgins, D. F. Waggoner, and T. Zha (2023): "Monetary Stimulus Amidst the Infrastructure Investment Spree: Evidence from China's Loan-level Data," *Journal of Finance*, 78(2), 1147–1204.

Chen, K., J. Ren, and T. Zha (2018): "The Nexus of Monetary Policy and Shadow Banking in China," *American Economic Review*, 108(12), 3891–3936.

Chen, K., and T. Zha (2025): "China's Macroeconomic Development: The Role of Gradualist Reforms," *Journal of Economic Literature*, 63(4), 1331–1362.

Cui, W., and S. Radde (2020): "Search-Based Endogenous Asset Liquidity and the Macroeconomy," *Journal of the European Economic Association*, 18(5), 2221–2269.

Dell'Ariccia, G., L. Laeven, and G. Suarez (2017): "Bank Leverage and Monetary Policy's Risk Taking Channel: Evidence from the United States," *Journal of Finance*, LXXII, 613–654.

Drechsler, I., A. Savov, and P. Schnabl (2017): "The Deposits Channel of Monetary Policy," *Quarterly Journal of Economics*, 132, 1819–1876.

Fang, H., Y. Wang, and X. Wu (2025): "Collateral-Based Monetary Policy: Evidence From China," *International Economic Review*, 66(5), 1839–1881.

Gertler, M., and P. Karadi (2011): "A Model of Unconventional Monetary Policy," *Journal of Monetary Economics*, 58(1), 17–34.

Gertler, M., and N. Kiyotaki (2010): "Financial Intermediation and Credit Policy in Business Cycle Analysis," in *Handbook of Monetary Economics*, ed. by B. M. Friedman, and M. Woodford, vol. 3, chap. 11, pp. 547–599. Elsevier B. V.

——— (2015): "Banking, Liquidity and Bank Runs in an Infinite-Horizon Economy," *American Economic Review*, 105(7), 2011–2043.

Gertler, M., N. Kiyotaki, and A. Prestipino (2016): "Wholesale Banking and Bank Runs in Macroeconomic Modeling of Financial Crises," in *Handbook of Macroeconomics*, ed. by J. Taylor, and H. Uhlig, vol. 2B. Elsevier, Amsterdam.

——— (2020): "A Macroeconomic Model with Financial Panics," *Review of Economic Studies*, 87, 240–288.

He, Z., and A. Krishnamurthy (2013): "Intermediary Asset Pricing," *American Economic Review*, 103, 732–770.

Jiménez, G., S. Ongena, J.-L. Peydró, and J. Saurina (2014): "Hazardous Times for Monetary Policy: What Do Twenty-Three Million Bank Loans Say About the Effects of Monetary Policy on Credit Risk-Taking?," *Econometrica*, 82(2), 463–505.

Kashyap, A., and J. Stein (1994): "Monetary Policy and Bank Lending," in *Monetary Policy*. University of Chicago Press, Chicago, IL.

Liu, Z., P. Wang, and Z. Xu (2021): "Interest Rate Liberalization and Capital Misallocations," *American Economic Journal: Macroeconomics*, 13(2), 373–419.

Xiao, K. (2020): "Monetary Transmission through Shadow Banks," *Review of Financial Studies*, 33, 2379–2420.

In this appendix, tables, figures, and equations are labeled with the prefix "S" to denote supplemental material.

Appendix A. Data Sources

- R007/R001: 7-day/1-day interbank repo rate. Source: CEIC.
- W: Year-over-year change in interbank funding divided by total equity of each bank. Source: CSMAR.
- D: Year-over-year change in household (personal) demand deposits divided by total equity of each bank. We collect total personal deposits and personal demand deposits from banks' financial reports. Because most banks report total personal deposits quarterly but personal demand deposits semiannually, we use within-bank log-linear interpolation to fill missing total personal deposit observations, first within the same calendar quarter and then, when necessary, using all available observations for the bank. Missing personal demand deposits are imputed using a bank-specific structural ratio, defined as the 2012–2018 mean of personal demand deposits divided by total personal deposits, multiplied by the corresponding total personal deposits.
- $I(SB)$: Bank type. Source: WIND.
- STK: Cash flow from stock investment divided by total liability of each bank. Source: CSMAR.
- IL: Quarterly change in the share of interbank liabilities in total liabilities of each bank. Source: CSMAR.
- LIQ: Growth of cash or cash equivalents of each bank. Source: CSMAR.
- L: Year-over-year change in total loans divided by total equity of each bank. Source: WIND.
- SRISK: Quarterly average of banks' systemic risk. Source: New York University's Volatility Institute website.
- g: Real GDP growth rate. Source: CEIC.
- Annualized spread between interbank bond yield and policy rate: Average daily spread between 3-month NCD with rate "A-" and 3-month interbank offered rate in 2019. Source: WIND and CEIC.
- LBs' leverage ratio: Average asset-to-equity ratio of LBs from 2013 to 2018. Source: CSMAR.
- LBs' deposit to equity ratio: Average deposit-to-equity ratio of LBs from 2013 to 2018. Source: CSMAR.
- Share of LBs' capital in total capital: Average share of state-owned enterprises' fixed asset investment in the total fixed asset investment of state-owned and private enterprises from 2013 to 2017. Source: CEIC.
- Ratio of capital between LBs and SBs: Average ratio of asset holdings between LBs and SBs from 2013 to 2018. Source: CSMAR.

• Ratio of total equity between LBs and SBs: Ratio of total equity between listed LBs and SBs in 2013. Source: CSMAR.

• SBs' ratio of total liability to equity: Average ratio of SBs' total liability to equity from 2013 to 2018. Source: CSMAR.

TABLE S1. Summary Statistics

Variables	# of Obs	Mean	Std. Dev.	Min	Max
Panel A: Bank-level Variables					
LBs					
InterbankFunding(tn RMB)	110	1.146	0.437	0.423	2.302
ΔInterbankFunding/Equity(%)	110	17.907	16.199	-19.034	96.370
ΔDemandDeposit/Equity(%)	110	13.710	13.287	-41.700	48.238
ΔLoan/Equity(%)	105	64.116	15.450	32.696	103.195
FA(%)	110	4.435	8.439	-4.286	39.332
IL(%)	110	-0.055	1.075	-3.966	3.887
ROE(%)	110	10.050	4.420	2.982	20.568
SRISK(bn RMB)	125	497.973	174.921	-24.904	833.049
SBs					
InterbankFunding(tn RMB)	274	0.443	0.367	0.014	1.438
ΔInterbankFunding/Equity(%)	274	54.285	61.516	-93.726	265.140
ΔDemandDeposit/Equity(%)	274	8.134	11.555	-54.081	61.641
ΔLoan/Equity(%)	254	94.966	23.102	24.246	167.395
FA(%)	274	7.362	13.478	-7.292	76.614
IL(%)	274	-0.306	2.251	-7.551	8.790
ROE(%)	274	9.678	4.482	1.869	21.187
SRISK(bn RMB)	318	113.328	80.001	-1.509	292.816
Panel B: Macro Variables					
R007 shock(%)(ϵ_R)	24	0.05	0.57	-1.55	1.40
GDP(%)	24	7.188	0.410	6.7	8.1
CPI(%)	24	100.512	0.704	99.202	101.709

Note: "IL" represents the lagged change in interbank liability share. "FA" is the lagged growth rate of fixed assets. "ROE" represents the lagged return on equity (Trailing Twelve Months). "DemandDeposit" refers to household demand deposits. "SRISK" measures the expected capital shortfall in a financial crisis. "R007 shock" refers to the 7-day repo rate shock, "GDP" is lagged real GDP growth rate, and "CPI" is lagged CPI inflation rate.

TABLE S2. Correlation

	$FA_{b,t-1}$	$IL_{b,t-1}$	$ROE_{b,t-1}$
All Banks			
$I(SB_b)$	0.1077**	-0.0572	-0.0378
	(0.035)	(0.264)	(0.857)
LBs			
$W_{b,t-1}$	0.2108**	-0.0975	-0.0544
	(0.018)	(0.279)	(0.547)
SBs			
$W_{b,t-1}$	0.0124	-0.1326**	-0.0442
	(0.825)	(0.018)	(0.433)

Note: Asterisks ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

APPENDIX B. ADDITIONAL EMPIRICAL RESULTS

This section reports additional results that support the empirical work in Section III. We first illustrate the decomposition of R001 into its systematic component and the monetary policy shock. We then estimate the sensitivity of deposit spread to the policy rates across different types of banks. Lastly, we show that the systemic-risk results are robust to allowing the 2018 regulatory indicator to remain on from 2018Q1 through the end of the sample.

A. *Robustness to the Monetary Policy Estimation*

This subsection reports robustness checks for the policy-rule estimation used to construct monetary policy shocks. First, for the baseline R007 specification in Table 1, the Ljung–Box Q test does not reject the null of no serial correlation in the estimated monetary policy shocks (p-value = 0.48), consistent with the interpretation of $\epsilon_{R,t}$ as an orthogonal policy innovation.

Second, we re-estimate the rule using the one-day repo rate (R001). Table S3 reports the corresponding estimates. The coefficients remain statistically significant and qualitatively similar to the baseline R007 estimates. Figure S1 decomposes R001 into its fitted systematic component and the estimated policy shock. The top panel displays the actual R001 rate together with the estimated systematic (endogenous) component implied by the policy rule. The bottom panel reports the residual component, which we interpret as the monetary policy shock, $\epsilon_{R,t}$. By construction, these residuals are orthogonal to the information set used in the policy rule. A negative shock corresponds to an unexpected decline in the policy rate, i.e., monetary policy easing. These results are similar to those when the R007 series is used.

TABLE S3. Estimated Monetary Policy Rule Using R001

Coefficient	Estimate	SE	p-value
γ_R	0.723	0.074	0.000
γ_π	0.124	0.063	0.047
$\gamma_{x,a}$	-0.070	0.031	0.022
$\gamma_{x,b}$	0.265	0.103	0.010
$\sigma_{R,a}$	0.003	0.000	0.000
$\sigma_{R,b}$	0.005	0.001	0.000

Note: Estimated results from the endogenously switching monetary policy rule. SE denotes standard error.

Third, we test the endogenously switching specification in Equation (1) against a constant-parameter alternative in which $\gamma_{x,t} = \gamma_x$ and $\sigma_{R,t} = \sigma_R$ for all t. For R007, the likelihood-ratio test rejects the constant-parameter specification with a p-value of 0.12%. For R001, the constant-parameter specification is rejected with a p-value below 0.01%. These robustness checks support the use of the regime-switching policy rule and show that the construction of monetary policy shocks is not sensitive to using R007 rather than R001.

B. *Impacts of Monetary Policy on Deposit Spreads*

We next examine how monetary policy affects deposit spreads, defined as the difference between the policy rate and the deposit rate. Our primary interest is whether the sensitivity of deposit spreads to policy rates—hereafter, the "deposit beta"—differs systematically between LBs and SBs.

The simple model delivers a sharp prediction. When policy rates decline, banks facing less sensitive deposit demand (higher η^j) must compress deposit spreads more aggressively in order to induce deposit inflows. As a result, even though deposit quantities respond less, the pass-through from policy rates to deposit spreads is stronger. Absent regulatory constraints, this mechanism implies that SBs—whose deposit demand is less sensitive to policy rates—should exhibit larger deposit betas than LBs. However, if deposit rate ceilings are binding, SBs may be unable to lower deposit spreads to their desired extent, attenuating or eliminating the differential response across bank types.

To test these predictions, we estimate the following specification:

$$\begin{aligned} DepSpread_{b,t} = \alpha\, \epsilon_{R,t-1} + \beta\, \epsilon_{R,t-1} \times I(SB_b) + \gamma_x X_{b,t-1} + \gamma_m Macro_{t-1} \\ + \alpha_b + \tau_y + \tau_s + \epsilon_{b,t}, \end{aligned} \tag{S1}$$

FIGURE S1. Endogenous and exogenous components of R001

Note: The top panel shows the quarterly level of R001 and the estimated systematic (endogenous) component implied by the policy rule. The bottom panel shows the residual component, interpreted as monetary policy shocks. The gap between the actual R001 rate and the systematic component represents the sequence of exogenous monetary policy shocks.
Source: CEIC.

where $DepSpread_{b,t}$ denotes the semi-annual deposit spread for bank b at time t, defined as the monetary policy rate minus the deposit rate. The coefficient α captures the response of deposit

spreads to monetary policy shocks for LBs, while the interaction coefficient β measures the differential response for SBs. The vector $X_{b,t-1}$ includes lagged bank-level controls, and $Macro_{t-1}$ includes standard macroeconomic controls such as GDP growth and CPI inflation. Bank, year, and seasonal fixed effects (α_b, τ_y, and τ_s) absorb time-invariant heterogeneity and common shocks.

Table S4 reports the estimation results. Several findings are noteworthy. First, across specifications, the estimated coefficient α is positive and highly significant, indicating that deposit spreads at LBs increase with policy rates. Equivalently, when the policy rate declines, LBs reduce deposit spreads, but less than one-for-one. This positive deposit beta is consistent with existing empirical evidence documenting incomplete pass-through of monetary policy to deposit rates (Drechsler, Savov, and Schnabl, 2017; Xiao, 2020).

Second, the interaction coefficient β is economically small and statistically insignificant (0.0410 and -0.0225). This result indicates that SBs do not exhibit a systematically different deposit-spread response to monetary policy shocks relative to LBs in this price regression. We therefore do not interpret Table S4 as direct evidence of differential price pass-through across bank types. Instead, we interpret this result more narrowly. The absence of a significant price interaction is consistent with constrained deposit pricing in China: deposit-rate ceilings mute differential price adjustment by preventing SBs' deposit rates from deviating too far from those of LBs. The household-demand-deposit quantity response in Table 2 therefore provides more direct evidence of heterogeneous deposit responses across bank types. Taken together, these findings motivate the incorporation of deposit-rate ceilings into the quantitative model developed in Section V.

C. *Robustness to Interbank Funding Regulation*

A potential concern for the empirical results in Sections III.A and III.C is that the tightening of interbank funding regulation beginning in 2018Q1–2018Q2 may have persistent effects that contaminate the estimated responses to monetary policy shocks and the relationship between interbank funding and systemic risk. In particular, if regulatory constraints on negotiable certificates of deposit (NCDs) and other wholesale funding instruments continue to bind beyond the initial regulatory window, the baseline specifications—which isolate 2018Q1–2018Q2 separately—may understate the role of regulation in shaping banks' funding and risk dynamics.

To address this concern, we re-estimate both the interbank funding / household-demand-deposit regressions and the SRISK regressions using alternative specifications that allow regulatory effects to persist from 2018Q1 through the end of the sample. We first revisit the funding regressions in Section III.A by augmenting Equation (2) with an additional interaction term $I(t \geq 2018Q1) \times I(SB_b)$.

TABLE S4. Effect of Monetary Policy Interest Rates on Deposit Rate Spread

	(1)	(2)
ϵ_{t-1}: α	0.5025***	0.3174***
	(0.0322)	(0.0296)
$\epsilon_{t-1} \times I(SB_b)$: β	0.0410	-0.0225
	(0.0406)	(0.0389)
$\epsilon_{t-1} \times FA_{b,t-1}$		0.00777**
		(0.00331)
$\alpha + \beta$	0.5435***	0.2948***
$Controls$	NO	YES
$MacroControls$	NO	YES
$BankFE$	YES	YES
$YearFE$	YES	YES
$SeasonalFE$	YES	YES
N	234	226
$R-square$	0.3348	0.6991

Note: This table reports regression results in which the dependent variable is a bank-semiannual observation of the deposit rate spread, defined as the policy rate minus the deposit rate. The right-hand-side variables include the monetary policy shock (ϵ_{t-1}), a dummy variable equal to one if the bank is an SB and zero otherwise ($I(SB_b)$), and their interaction. Control variables include lagged return on equity ($ROE_{b,t-1}$), the lagged quarterly change in the share of interbank liabilities in total liabilities (IL_{t-1}), and the lagged quarterly growth rate of fixed assets ($FA_{b,t-1}$). Macro control variables include lagged GDP growth and lagged CPI inflation. Bank, year, and seasonal fixed effects are included. Robust standard errors clustered at the bank level are reported in parentheses. Asterisks ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table S5 reports the estimates. Three points are worth emphasizing. First, consistent with the baseline results in Table 2, monetary policy easing continues to induce opposite interbank funding responses across bank types. LBs reduce interbank funding following an easing shock, while SBs expand interbank borrowing. The implied response for SBs ($\alpha+\beta$) remains negative and statistically significant for interbank funding, even after allowing for persistent regulatory effects. Second, the household-demand-deposit results also mirror the baseline evidence. LBs experience a significant increase in household demand deposits following monetary policy easing ($\alpha = -4.433$ and -4.499), while the interaction coefficient β is positive and significant (3.420 and 3.187). The sign of β is opposite to that of α, leaving the implied SB response $\alpha + \beta$ small and statistically insignificant (-1.013 and -1.312). This confirms that the key heterogeneity emphasized in Section III.A—a stronger household-demand-deposit response at LBs than at SBs—is not driven by how the

post-2018 regulatory period is dated. The coefficient on $I(t \geq 2018Q1) \times I(SB_b)$ is negative and significant in the interbank funding regressions, indicating that tighter regulation lowers the level of interbank funding at SBs. Importantly, however, this term does not overturn the differential marginal response to monetary policy shocks. Thus, regulation affects the scale of interbank activity but does not alter the qualitative reallocation mechanism documented in Section III.A.

We next examine whether the relationship between interbank funding and systemic risk documented in Section III.C is sensitive to how regulatory tightening is modeled. Specifically, we replace $I(2018Q1 \leq t \leq 2018Q2)$ in Equation (5) with $I(t \geq 2018Q1)$ and estimate:

$$\begin{aligned} SRISK_{b,t} = {} & \alpha_r W_{b,t-1} \times I(t \geq 2018Q3) + \beta_r g_{t-1} \times W_{b,t-1} \times I(t \geq 2018Q3) \\ & + \alpha_l W_{b,t-1} \times I(t \geq 2018Q1) + \beta_l g_{t-1} \times W_{b,t-1} \times I(t \geq 2018Q1) \\ & + \alpha W_{b,t-1} + \beta\, g_{t-1} \times W_{b,t-1} \\ & + \gamma_x X_{b,t-1} + \gamma_m Macro_{t-1} + \alpha_b + \tau_y + \tau_s + \epsilon_{b,t}, \end{aligned} \tag{S2}$$

with the same variable definitions and fixed effects as in the baseline SRISK specification.

Table S6 reports the corresponding SRISK regressions. The results closely mirror those in Table 4. In particular, during the slow-growth period ($I(t \geq 2018Q3)$), the interaction between interbank funding and GDP growth remains negative and statistically significant for SBs. This implies that when macroeconomic conditions deteriorate, greater reliance on interbank funding continues to raise systemic risk exposure, as measured by SRISK. Moreover, as in the baseline results, the same interaction terms are statistically insignificant for LBs, reinforcing the asymmetric role of interbank funding across bank types.

Overall, Tables S5 and S6 demonstrate that the main empirical findings in Sections III.A and III.C are robust to alternative treatments of interbank funding regulation. While tighter regulation after 2018Q1 affects the level of interbank activity, it does not overturn the central mechanisms identified in the data: monetary policy easing reallocates funding through interbank markets toward SBs, amplifying credit expansion in normal times, and this same reliance on interbank funding increases systemic risk exposure when macroeconomic conditions deteriorate.

Appendix C. Technical Details of the Simple Model

This appendix provides derivations and supporting results for the three-period simple model in Section IV. Sections C.A to C.G provide details on the simple model, and Section C.H gives proofs of all lemmas and propositions in Section IV and this Appendix section.

TABLE S5. Monetary-policy effects on bank funding: robustness to interbank-funding regulation

	Interbank funding		Household demand deposits	
	(1)	(2)	(3)	(4)
ϵ_{t-1}: α	7.609**	6.204**	-4.433***	-4.499***
	(3.013)	(2.858)	(1.352)	(1.369)
$\epsilon_{t-1} \times I(SB_b)$: β	-17.84***	-18.52***	3.420**	3.187**
	(3.287)	(3.372)	(1.473)	(1.443)
$I(t \geq 2018Q1) \times I(SB_b)$	-17.99***	-17.73**	4.291	4.215
	(5.388)	(6.742)	(3.663)	(3.605)
$\epsilon_{t-1} \times FA_{b,t-1}$		0.0297		0.0538
		(0.2287)		(0.0813)
$\alpha + \beta$	-10.23***	-12.32***	-1.013	-1.312
$Controls$	NO	YES	NO	YES
$MacroControls$	NO	YES	NO	YES
$BankFE$	YES	YES	YES	YES
$YearFE$	YES	YES	YES	YES
$SeasonalFE$	YES	YES	YES	YES
N	384	384	384	384
$R-square$	0.3799	0.4039	0.1125	0.1227

Note: The dependent variables are the year-over-year changes in interbank funding and household demand deposits, each scaled by total equity. The main explanatory variables are the monetary policy shock (ϵ_{t-1}), the dummy variable equal to one for SBs and zero otherwise ($I(SB_b)$), and their interaction terms. ($I(t \geq 2018Q1)$) is the indicator variable for the regulation-onward period.

Control variables include lagged return on equity ($ROE_{b,t-1}$), the lagged quarterly change in the share of interbank liabilities in total liabilities (IL_{t-1}), and the lagged quarterly growth rate of fixed assets ($FA_{b,t-1}$). Macro control variables include lagged quarterly GDP growth and lagged CPI inflation. Bank, year, and seasonal fixed effects are included. Robust standard errors clustered at the bank level are reported in parentheses. Asterisks ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

A. *An analysis of the reserve-management cost*

This subsection provides a detailed analysis of the reserve-management cost. Because banks face an idiosyncratic deposit-withdrawal shock, they may experience a reserve shortfall. They have two choices: borrowing from the discount window ex post or purchasing reserve-management insurance ex ante. We provide a sufficient condition under which banks optimally purchase insurance ex

TABLE S6. Interbank funding and systemic risk: robustness to alternative treatments of regulation

	LBs		SBs	
	(1)	(2)	(3)	(4)
$I(t \geq 2018Q3) \times W_{b,t-1} : \alpha_r$	49.68	-42.53	11.89*	16.02*
	(166.2)	(131.0)	(6.300)	(7.696)
$I(t \geq 2018Q3) \times g_{t-1} \times W_{b,t-1} : \beta_r$	-6.654	6.943	-1.737*	-2.339*
	(24.33)	(19.50)	(0.9159)	(1.122)
$I(t \geq 2018Q1) \times W_{b,t-1} : \alpha_l$	-76.20	47.05	-5.741	-9.546
	(167.3)	(119.4)	(5.127)	(7.056)
$I(t \geq 2018Q1) \times g_{t-1} \times W_{b,t-1} : \beta_l$	10.89	-7.024	0.8217	1.383
	(24.21)	(17.44)	(0.7581)	(1.040)
$g_{t-1} \times W_{b,t-1} : \beta$	-1.353	-0.1963	0.00979	0.0275
	(2.405)	(2.277)	(0.0851)	(0.0722)
$W_{b,t-1}$	9.363	0.6299	0.0264	-0.1126
	(16.58)	(15.45)	(0.6535)	(0.5611)
g_{t-1}	-3.267	63.33	7.138	29.94**
	(53.89)	(87.38)	(8.706)	(13.01)
$g_{t-1} \times FA_{t-1}$		-3.880		
		(5.415)		
$g_{t-1} \times IL_{t-1}$				3.093**
				(1.403)
Controls	NO	YES	NO	YES
MacroControls	NO	YES	NO	YES
BankFE	YES	YES	YES	YES
YearFE	YES	YES	YES	YES
SeasonalFE	YES	YES	YES	YES
N	125	125	318	318
$R - square$	0.0308	0.0828	0.0413	0.1078

Note: The dependent variable is the SRISK at the bank-quarter level. Explanatory variables include lagged year-over-year change in interbank funding scaled by total equity ($W_{b,t-1}$), lagged real GDP growth (g_{t-1}), and indicator variables for the slow-growth period ($I(t \geq 2018Q3)$) and the regulation-onward period ($I(t \geq 2018Q1)$). The specifications include interactions between interbank funding and GDP growth, as well as interactions that vary across these periods.

Control variables include lagged return on equity ($ROE_{b,t-1}$), the lagged quarterly change in the share of interbank liabilities in total liabilities (IL_{t-1}), and the lagged quarterly growth rate of fixed assets ($FA_{b,t-1}$). Macro control variables include lagged CPI inflation. Columns (1)–(2) report results for LBs, while columns (3)–(4) report results for SBs. Bank, year, and seasonal fixed effects are included. Robust standard errors clustered at the bank level are reported in parentheses. Asterisks ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

ante. Under this arrangement, the reserve-management cost function $\chi(\cdot)$ can be interpreted as an administratively specified insurance premium.

The insurance contract is a stylized central-bank facility rather than a competitively priced, actuarially fair contract. At the beginning of period t, before the idiosyncratic deposit outflow is

realized, the central bank posts the premium schedule $\chi(x_t^j)$ defined below. An insured bank pays this premium ex ante. If its realized reserve gap is positive, the central bank supplies exactly the liquidity needed to cover the shortfall, with no additional state-contingent payment by the bank; if the bank has a reserve surplus, neither party makes an additional payment. This arrangement leaves banks of each type homogeneous ex post.

Following Bianchi and Bigio (2017), after banks choose their portfolios, each bank experiences an idiosyncratic deposit withdrawal νd_t^j, where $\nu \sim U[-1,1]$ has mean zero. The shock redistributes deposits within the banking system rather than generating an aggregate outflow. Given the reserve requirement ρ, the realized reserve funding gap of a type-j bank is

$$\begin{aligned} x_t^j(\nu) &= \tau n_t^j + \rho(1-\nu)d_t^j - \left(a_t^j - \nu d_t^j\right) \\ &= \tau n_t^j + \left\{\rho + (1-\rho)\nu\right\}d_t^j - a_t^j, \end{aligned} \tag{S3}$$

where τn_t^j captures an additional component of reserve-management needs proportional to bank net worth, $x_t^j(\nu) > 0$ indicates a reserve shortfall, and $x_t^j(\nu) \leq 0$ indicates a reserve surplus. Define the expected net reserve funding gap as

$$\begin{aligned} x_t^j &\equiv E_\nu\Big[x_t^j(\nu)\Big] \\ &= \tau n_t^j + \rho d_t^j - a_t^j. \end{aligned} \tag{S4}$$

We focus on the parameter region in which the expected net reserve gap satisfies $x_t^j > 0$. If bank $j \in \{SB, LB\}$ purchases insurance, the administratively specified premium is

$$\begin{aligned} \chi(x_t^j) &= r_{b,t} x_t^j \\ &= r_{b,t}\big(\tau n_t^j + \rho d_t^j - a_t^j\big), \end{aligned} \tag{S5}$$

where $r_{b,t}$ is the net policy rate. If the bank does not purchase insurance, when $x_t^j(\nu) > 0$, the bank covers the realized shortfall by borrowing from the central bank discount window at the net policy rate plus a penalty spread, $r_{b,t} + \iota$, where $\iota > 0$. Denote the expected amount of discount-window borrowing by I_t^j:

$$\begin{aligned} I_t^j &\equiv E_\nu\left[\Big[x_t^j(\nu)\Big]_+\right] \\ &= \frac{1}{2}\int_{\max\left\{-1,\, \frac{a_t^j - \tau n_t^j - \rho d_t^j}{(1-\rho)d_t^j}\right\}}^{1} \left[\tau n_t^j + \left\{\rho + (1-\rho)\nu\right\}d_t^j - a_t^j\right] d\nu, \end{aligned} \tag{S6}$$

where $[y]_+ \equiv \max\{y, 0\}$. The expected reserve-management cost without insurance is therefore

$$(\chi_t^j)^{NI} = (r_{b,t} + \iota) I_t^j. \tag{S7}$$

The bank prefers to purchase insurance if $\chi(x_t^j) < (\chi_t^j)^{NI}$, that is, if

$$r_{b,t}\big(\tau n_t^j + \rho d_t^j - a_t^j\big) < (r_{b,t} + \iota) I_t^j. \tag{S8}$$

For $I_t^j > 0$, rearranging (S8) gives the following sufficient condition:

$$\iota > r_{b,t}\left[\frac{\tau n_t^j + \rho d_t^j - a_t^j}{I_t^j} - 1\right]. \tag{S9}$$

We assume that the penalty spread satisfies (S9) at the equilibrium allocation. Hence, all banks purchase reserve-management insurance in equilibrium, while discount-window borrowing remains an off-equilibrium outside option.

B. *Solving bankers' problem at $t = 0$ and $t = 1$*

This subsection describes the optimization problem of bankers of type j and provides the comparative statics reported in Proposition 1.

Because the banker's problem is homogeneous of degree one in current net worth n_t^j, it is convenient to work with *ratios* to net worth. For any variable $x_t^j \in \{a_t^j, d_t^j, ib_t^j\}$ define $\psi_{x,t}^j \equiv x_t^j/n_t^j$, and let $\psi_t^j \equiv V_t^j/n_t^j$ denote the normalized value.

With reserve insurance premium (19), and when holding excess reserves is costly in the relevant equilibrium, the liquidity requirement binds, so

$$a_t^j = \kappa n_t^j \qquad \Longleftrightarrow \qquad \psi_{a,t}^j = \kappa. \tag{S10}$$

Using (S10), the banker's balance sheet (18) at $t = 0$ or 1 can be written as

$$(Q_t + \alpha^j K_t^j)k_t^j = \big[1 - \kappa - r_{b,t}(\tau - \kappa)\big]n_t^j + \big(1 - \rho r_{b,t}\big)d_t^j + ib_t^j. \tag{S11}$$

Let the gross return on one unit of banker j's capital purchased at $t = 0$ and $t = 1$ be $R_{k,1} \equiv (Q_1 + Z_1)/(Q_0 + \alpha^j K_0^j)$ and $R_{k,2} \equiv Z_2/(Q_1 + \alpha^j K_1^j)$ (conditional on no run).

Combining (17) with (S11) and dividing by n_t^j yields

$$\frac{n_{t+1}^j}{n_t^j} = \underbrace{\kappa + R_{k,t+1}\big[1 - \kappa - r_{b,t}(\tau - \kappa)\big]}_{\equiv A_t} + \underbrace{\big[R_{k,t+1}(1 - \rho r_{b,t}) - R_{d,t}^j\big]}_{\equiv A_{d,t}^j}\psi_{d,t}^j + \underbrace{(R_{k,t+1} - R_{ib,t})}_{\equiv A_{ib,t}}\psi_{ib,t}^j, \tag{S12}$$

where A_t, $A_{d,t}^j$, and $A_{ib,t}$ are the net returns to equity, deposit funding for banker j, and interbank funding, respectively. Define the $t = 0$ and $t = 1$ marginal value of net worth as

$$\Omega_1^j \;\equiv\; \beta m_1\big((1 - \sigma^j) + \sigma^j \psi_1^j\big), \tag{S13}$$

and $\Omega_2^j \equiv \beta m_2$, with $\Omega_1^j > 0$ and $\Omega_2^j > 0$. In the expressions below, E_t is used only as compact notation for the two-period derivation. For $t = 0$, it is the expectation over the distribution of Z_1. For $t = 1$, Z_1 has already been realized and there is no further aggregate uncertainty before $t = 2$,

so the E_1 operator is degenerate and the expressions reduce to their realized-state values. Then homogeneity implies $\psi_t^j = E_t\left[\Omega_{t+1}^j \left(n_{t+1}^j / n_t^j\right)\right]$. Substituting (S12) gives

$$\psi_t^j = E_t\left[\Omega_{t+1}^j \left(A_t + A_{d,t}^j \, \psi_{d,t}^j + A_{ib,t} \, \psi_{ib,t}^j\right)\right]. \tag{S14}$$

Denote $\mu_{e,t}^j \equiv E_t\left[\Omega_{t+1}^j A_t\right], \mu_{d,t}^j \equiv E_t\left[\Omega_{t+1}^j A_{d,t}^j\right]$, and $\mu_{ib,t}^j \equiv E_t\left[\Omega_{t+1}^j A_{ib,t}^j\right]$ as the expected marginal values of equity, deposit and interbank credit. These definitions characterize the no-run continuation. In the run continuation, both relevant returns change: the capital return is evaluated at the fire-sale price Q_{t+1}^*, while an interbank claim on SBs pays the recovery-adjusted return $u^{SB} R_{ib,t}$. The corresponding run-state objects are introduced below.

We now focus on the equilibrium where incentive constraint (20) binds. A binding IC constraint for SBs implies

$$\psi_t^{SB} = \theta(1 + \psi_{d,t}^{SB} + \omega \psi_{ib,t}^{SB}). \tag{S15}$$

Combining (S14) and (S15) yields the closed-form expression

$$\psi_{ib,t}^{SB} = \frac{\mu_{e,t}^{SB} - \theta - \left(\theta - \mu_{d,t}^{SB}\right) \psi_{d,t}^{SB}}{\theta\omega - \mu_{ib,t}^{SB}}. \tag{S16}$$

For SBs, which borrow in equilibrium in the interbank market, we assume that the agency friction is sufficiently strong that the denominator of Equation (S16), $\theta\omega - \mu_{ib,t}^{SB}$, is positive for both $t = 0$ and $t = 1$. Moreover, it is sensible to assume that $\mu_{d,t}^{SB} - \theta < 0$. Otherwise, the bankers can use deposit issuance to relax the incentive constraint. For the active borrowing region used below, we maintain the ordering $\mu_{e,t}^{SB} > \theta > \mu_{d,t}^{SB}$, so that the equity-value term relaxes the IC while deposit funding is costly at the margin. These assumptions ensure that the incentive constraint binds.

We now discuss the conditions for SBs (LBs) to be borrowers (lenders) in the interbank market. To this end, we derive the FOCs of the bank's problem. The normalized problem for bank j with non-negative ib and non-negative capital investment k^j for $t = 0, 1$ is:

$$\begin{aligned} \max_{\psi_{ib,t}^j, \psi_{d,t}^j} \quad & \psi_t^j = \mu_{e,t}^j + \mu_{d,t}^j \psi_{d,t}^j + \mu_{ib,t}^j \psi_{ib,t}^j, \\ & \theta(1 + \psi_{d,t}^j + \omega \psi_{ib,t}^j) \leq \mu_{e,t}^j + \mu_{d,t}^j \psi_{d,t}^j + \mu_{ib,t}^j \psi_{ib,t}^j \\ & \psi_{ib,t}^j \geq 0 \\ & \psi_{d,t}^j (1 - \rho r_{b,t}) + \psi_{ib,t}^j + [1 - \kappa - r_{b,t}(\tau - \kappa)] \geq 0 \end{aligned} \tag{S17}$$

Let ϖ_t, $\varpi_{ib,t}$, and $\varpi_{k,t}$ denote the Lagrange multipliers on the incentive constraint, the interbank-funding sign constraint, and the capital non-negativity constraint, respectively. The Lagrangian is

$$\begin{aligned} \mathscr{L} = & (1 + \varpi_t)(\mu_{e,t}^j + \mu_{d,t}^j \psi_{d,t}^j + \mu_{ib,t}^j \psi_{ib,t}^j) - \varpi_t \theta [1 + \psi_{d,t}^j + \omega \psi_{ib,t}^j] \\ & + \varpi_{ib,t} \psi_{ib,t}^j + \varpi_{k,t} \{\psi_{d,t}^j (1 - \rho r_{b,t}) + \psi_{ib,t}^j + [1 - \kappa - r_{b,t}(\tau - \kappa)]\} \end{aligned}$$

The first-order conditions for $\psi^j_{d,t}$ and $\psi^j_{ib,t}$ are

$$\frac{\partial \mathscr{L}}{\partial \psi^j_{d,t}} = \mu^j_{d,t} - \varpi_t(\theta - \mu^j_{d,t}) + \varpi_{k,t}(1 - \rho r_{b,t}) = 0$$
$$\frac{\partial \mathscr{L}}{\partial \psi^j_{ib,t}} = \mu^j_{ib,t} - \varpi_t(\theta\omega - \mu^j_{ib,t}) + \varpi_{ib,t} + \varpi_{k,t} = 0$$

For a potential borrower in the interbank market, capital investment must be positive, thus $\varpi_{k,t} = 0$.

Therefore, the no-arbitrage condition for a potential borrower in the interbank market is given by

$$\frac{\mu^j_{d,t}}{\mu^j_{ib,t}} \geq \frac{\theta - \mu^j_{d,t}}{\theta\omega - \mu^j_{ib,t}}.$$

Similarly, we could derive the first-order conditions for bank j to be a potential lender in the interbank market ($\psi^j_{ib,t} \leq 0$):

$$\frac{\partial \mathscr{L}}{\partial \psi^j_{d,t}} = \mu^j_{d,t} - \varpi_t(\theta - \mu^j_{d,t}) + \varpi_{k,t}(1 - \rho r_{b,t}) = 0$$
$$\frac{\partial \mathscr{L}}{\partial \psi^j_{ib,t}} = \mu^j_{ib,t} - \varpi_t(\theta(1-\gamma) - \mu^j_{ib,t}) - \varpi_{ib,t} + \varpi_{k,t} = 0$$

We will show later that under Assumption 1 ($\omega + \gamma > 1$), capital investment must be positive, so $\varpi_{k,t} = 0$. Therefore, the no-arbitrage condition becomes

$$\frac{\mu^j_{d,t}}{\mu^j_{ib,t}} \leq \frac{\theta - \mu^j_{d,t}}{\theta(1-\gamma) - \mu^j_{ib,t}}.$$

Therefore, for SBs (LBs) to be ex ante borrowers (lenders), the equilibrium is characterized by the following two no-arbitrage conditions:

$$\frac{\mu^{LB}_{d,t}}{\mu^{LB}_{ib,t}} = \frac{\theta - \mu^{LB}_{d,t}}{\theta(1-\gamma) - \mu^{LB}_{ib,t}} \tag{S18}$$
$$\frac{\mu^{SB}_{d,t}}{\mu^{SB}_{ib,t}} = \frac{\theta - \mu^{SB}_{d,t}}{\theta\omega - \mu^{SB}_{ib,t}} \tag{S19}$$

These conditions can be equivalently expressed as

$$\mu^{LB}_{ib,t} = (1-\gamma)\mu^{LB}_{d,t},\ \mu^{SB}_{ib,t} = \omega\mu^{SB}_{d,t}. \tag{S20}$$

Assumption 1. $\omega + \gamma > 1$.

The following lemma establishes the necessity of Assumption 1 for LB portfolio choices under the maintained active-region orderings that the marginal-value-weighted expected capital return of SBs is weakly higher than that of LBs and that $R^{SB}_{d,t} \geq R^{LB}_{d,t}$, with at least one strict inequality.

Lemma S1. If Assumption 1 does not hold, i.e., if $\omega+\gamma \leq 1$, then LBs cannot simultaneously have positive interbank lending and positive capital investment in an active interbank equilibrium.

Equivalently, $\omega+\gamma>1$ is necessary for an active imperfect-specialization equilibrium in which LBs both lend in the interbank market and make non-financial loans directly. Since in practice LBs usually lend to firms to fund their capital investment, we think it reasonable to restrict attention to this case.

C. *Central bank*

The central bank is owned by the household. In each period it issues reserves to banks and receives reserve-management insurance premia $\chi(\cdot)$. The complete state-contingent transfer rule is given in (26). In a normal outcome, $\mathbf{1}_{\mathcal{R}_t}=0$, so for $t=0,1,2$ it reduces to

$$T_t = \sum_{j\in\{SB,LB\}} \Big[A_t^j - A_{t-1}^j + \chi(X_t^j)\Big], \qquad t=0,1,2, \tag{S21}$$

where $A_{-1}^j = A_2^j = 0$.

In a run outcome, SBs default on deposits and interbank liabilities and the central bank (or government) covers the shortfall between promised deposit repayments and liquidation proceeds. This is financed by an additional tax on the household. Let $(\cdot)^*$ denote run-state objects. The corresponding transfer is

$$T_t^* = \sum_{j\in\{SB,LB\}} \Big[(A_t^j)^* - (A_{t-1}^j)^* + \chi^*(X_t^j)\Big] - \big(1-u^{SB}\big)\, R_{d,t-1}^{SB} D_{t-1}^{SB}, \tag{S22}$$

where u^{SB} is the recovery rate defined in (30) and, in the run outcome, $(A_1^{SB})^* = (A_2^{SB})^* = (A_2^{LB})^* = 0$.

D. *Aggregation and net worth dynamics*

Let $s\in(0,1)$ denote the measure of bankers and let $\varsigma\in(0,1)$ denote the share of SBs among bankers at $t=0$ and in the no-run continuation. For any representative-bank variable ℓ_t^j of type $j\in\{SB,LB\}$, define the corresponding aggregate at $t=0$, or at $t=1$ conditional on no run, by

$$L_t^j = \begin{cases} s\varsigma\, \ell_t^{SB}, & j=SB,\\ s(1-\varsigma)\, \ell_t^{LB}, & j=LB. \end{cases}$$

In particular, $K_t^{SB} = s\varsigma\, k_t^{SB}$ and $K_t^{LB} = s(1-\varsigma)\, k_t^{LB}$, and similarly for net worth, deposits, and reserves. In the run continuation at $t=1$, the SB sector defaults and has no new entrants, whereas the LB mass remains $s(1-\varsigma)$. The run-state equations therefore set SB continuation objects to

zero and aggregate LB choices using the unchanged LB mass. We define aggregate interbank credit IB_t as total SB borrowing (equivalently, total LB lending), so market clearing implies

$$IB_t \equiv s\varsigma\, ib_t^{SB} = -s(1-\varsigma)\, ib_t^{LB}.$$

Using these mappings yields sector-level aggregates (examples):

$$A_t^{SB} = \kappa N_t^{SB}, \qquad A_t^{LB} = \kappa N_t^{LB},$$
$$D_t^{SB} = s\varsigma\, d_t^{SB}, \qquad D_t^{LB} = s(1-\varsigma)\, d_t^{LB}.$$

Aggregating the bank's balance sheet (18) requires keeping the sign of the LB interbank position explicit. Hence

$$(Q_t + \alpha^{SB} K_t^{SB}) K_t^{SB} + A_t^{SB} + \chi(X_t^{SB}) = N_t^{SB} + D_t^{SB} + IB_t,$$
$$(Q_t + \alpha^{LB} K_t^{LB}) K_t^{LB} + A_t^{LB} + \chi(X_t^{LB}) + IB_t = N_t^{LB} + D_t^{LB}.$$

In the no-run equilibrium, aggregate net-worth dynamics follow from (17) for $t = 1, 2$:

$$N_t^{SB} = \sigma_t^{SB}\Big[A_{t-1}^{SB} + (Z_t + Q_t)K_{t-1}^{SB} - R_{ib,t-1} IB_{t-1} - R_{d,t-1}^{SB} D_{t-1}^{SB}\Big] + W_t^{SB},$$
$$N_t^{LB} = \sigma_t^{LB}\Big[A_{t-1}^{LB} + (Z_t + Q_t)K_{t-1}^{LB} + R_{ib,t-1} IB_{t-1} - R_{d,t-1}^{LB} D_{t-1}^{LB}\Big] + W_t^{LB}. \tag{S23}$$

Here $\sigma_1^j = \sigma$ and $\sigma_2^j = 1$, reflecting exit/entry at $t = 1$ only in the no-run branch. The term W_1^j is the aggregate startup fund of entering bankers of type j at $t = 1$. In the no-run equilibrium, exiting bankers of both types are replaced. We set $W_2^j = 0$; the initial net worth N_0^j is instead financed through ζ_0 and treated as an initial condition. In the run equilibrium, $(N_1^{SB})^* = 0$ and the SB entry term W_1^{SB} is zero, while only the LB entry term W_1^{LB} remains.

If all incumbent SB or LB bankers have the same net worth, then the dividend paid to the household by exiting type-j bankers in the no-run equilibrium at $t = 1$ is

$$\Pi_1^j = \frac{1-\sigma}{\sigma}\big(N_1^j - W_1^j\big),$$

and the total startup fund for the entering banks is given by

$$\zeta_1 = W_1^{LB} + W_1^{SB},$$

which is the object that enters the household budget constraint (11) at $t = 1$. In the run equilibrium, failed SB bankers have zero residual net worth and pay no dividend, while the startup transfer reduces to $\zeta_1^* = W_1^{LB}$.

E. *Marginal buyer of capital*

To characterize the equilibrium capital price, it remains to determine which bank type absorbs the marginal unit of this fixed capital supply. SBs have a higher underlying return on capital because $\alpha^{SB} = 0 < \alpha^{LB}$, but their capital investment is limited by their incentive and balance-sheet constraints.

Let $\mathcal{S}_t^j > 0$ denote the type-j bank's shadow value of balance-sheet resources at t, and $\lambda_{K,t}^{SB} > 0$ denote the shadow value of relaxing the binding SB capital-funding limit normalized by balance-sheet resources. Then the SB capital first-order condition is

$$E_t\left[\Omega_{t+1}^{SB}(Z_{t+1} + Q_{t+1})\right] = \mathcal{S}_t^{SB}\left(Q_t + \lambda_{K,t}^{SB}\right). \tag{S24}$$

Here, Ω_{t+1}^{SB} is the marginal continuation value of SB net worth at $t+1$. Dividing by $\mathcal{S}_t^{SB}$ gives

$$E_t\left[\beta_{t+1}^{SB}(Z_{t+1} + Q_{t+1})\right] = Q_t + \lambda_{K,t}^{SB}. \tag{S25}$$

where $\beta_{t+1}^{SB} = \frac{\Omega_{t+1}^{SB}}{\mathcal{S}_t^{SB}}$ is SB's stochastic discount factor at $t+1$. The left-hand side is the shadow present value of the expected marginal return of capital. Hence the SB willingness to pay for capital is

$$p_t^{SB,\mathrm{WTP}} = Q_t + \lambda_{K,t}^{SB} > Q_t. \tag{S26}$$

Here, $p_t^{SB,\mathrm{WTP}}$ denotes the SB willingness to pay for capital. Thus, SBs would purchase more capital if their funding limit were relaxed, but they cannot absorb the marginal unit at the equilibrium allocation.

LBs, by contrast, hold both capital and interbank claims and can finance an additional unit of capital by reducing interbank lending. Therefore, no capital-funding upper bound binds for LBs, and their capital first-order condition is

$$E_t\left[\beta_{t+1}^{LB}(Z_{t+1} + Q_{t+1})\right] - \alpha^{LB} K_t^{LB} = Q_t, \tag{S27}$$

where β_{t+1}^{LB} is LB's stochastic discount factor at $t+1$. It follows that

$$p_t^{LB,\mathrm{WTP}} = Q_t < p_t^{SB,\mathrm{WTP}}. \tag{S28}$$

Here, $p_t^{LB,\mathrm{WTP}}$ denotes the LB willingness to pay for capital. SBs are therefore constrained buyers, whereas LBs absorb the residual capital supply and are the marginal buyers in the no-run allocation. Although the equilibrium price is jointly determined by bank optimality conditions and market clearing, the LB marginal condition equates its willingness to pay to Q_t.

The same conclusion is particularly transparent in the run allocation. SBs liquidate their capital and cease to be buyers, so that

$$(K_1^{SB})^* = 0, \qquad (K_1^{LB})^* = \bar{K}. \tag{S29}$$

LBs therefore absorb the entire capital stock and are the unique marginal buyers at the fire-sale price Q_1^*. Thus, LBs are the marginal buyers of capital in both the no-run and run allocations.

F. *Run, Recovery Rate, and Run Risk*

We now turn to $t = 1$ to analyze the possibility of runs. The rollover decision is made by interbank creditors: LBs holding maturing claims on SBs decide whether to extend new interbank credit.

Equation (S16), together with (16), implies that desired aggregate interbank borrowing is an increasing function of aggregate interbank credit, denoted by IB_1.

$$IB_1^d = \frac{\mu_{e,1}^{SB}(IB_1) - \theta - \left(\theta - \mu_{d,1}^{SB}(IB_1)\right)\left(\frac{R_{d,1}^{SB}(IB_1) - R_{b,1}}{\xi(\eta^{SB}-1)R_{b,1}}\right)^{\frac{1}{\eta^{SB}-1}}}{\theta\omega - \mu_{ib,1}^{SB}(IB_1)} n_1^{SB}(IB_1) \equiv \mathscr{D}(IB_1). \tag{S30}$$

Here $\mathscr{D}(\cdot)$ denotes aggregate interbank demand.

When LB creditors roll over, equilibrium aggregate interbank credit is a positive fixed point of Equation (S30), $IB_1 = \mathscr{D}(IB_1) > 0$. We focus on the two self-fulfilling equilibria shown in Figure S2: a run equilibrium in which LB creditors do not roll over and interbank credit to SBs collapses ($IB_1 = 0$), and a no-run equilibrium in which LB creditors roll over and interbank credit remains positive ($IB_1 > 0$).

In the run equilibrium, each SB expects other SBs also to be unable to refinance because their LB creditors do not roll over. Given this system-wide refusal by lenders, feasible new interbank credit is zero for every SB, so $ib_1 = 0$ and $IB_1 = 0$. SBs must then fire-sell their capital at the low price Q_1^*. By contrast, in the no-run equilibrium, each SB expects LB creditors to roll over across the sector. Rollover credit is therefore available, desired aggregate borrowing is consistent with the positive fixed point $IB_1 = \mathscr{D}(IB_1) > 0$, and the higher capital price Q_1 keeps SBs solvent.

In a run outcome at $t = 1$, SBs liquidate capital at the fire-sale price $Q_1^* < Q_1$ and repay creditors out of liquidation proceeds. The recovery rate is defined in (30):

$$u^{SB} = \frac{(Q_1^* + Z_1)k_0^{SB} + a_0^{SB}}{R_{ib,0}ib_0^{SB} + R_{d,0}^{SB}d_0^{SB}}.$$

Lemma S2. Given all prices other than Q_1^*, a negative productivity shock strictly reduces the SB recovery rate u^{SB} and weakly increases the run probability P. Equivalently,

$$\frac{\partial u^{SB}}{\partial Z_1} > 0,$$

and P is weakly decreasing in Z_1.

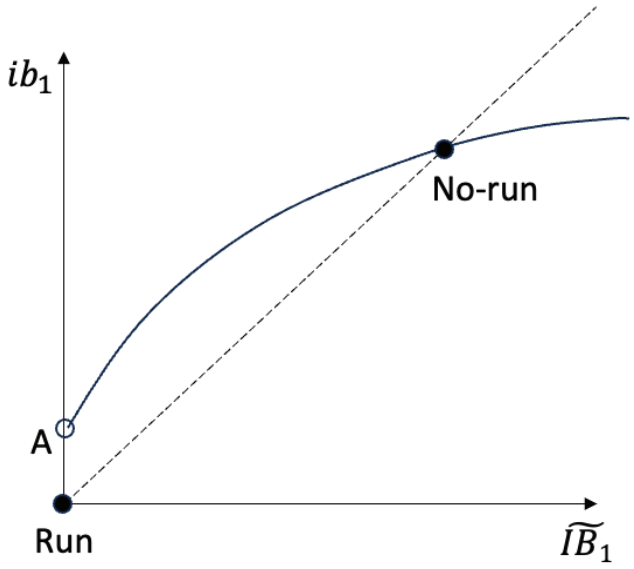


FIGURE S2. Equilibria: Run and No-Run

Lemma S3. Given all prices other than Q_1^*, an increase in aggregate interbank funding strictly reduces the SB recovery rate u^{SB} and weakly increases the run probability P:

$$\frac{\partial u^{SB}}{\partial IB_0} < 0. \tag{S31}$$

We next show how run risk P is priced into the equilibrium promised interbank rate $R_{ib,t}$. Here, E_t denotes the conditional expectation relevant to the two-period pricing condition. At $t = 0$, the expectation is taken over the distribution of Z_1. At $t = 1$, Z_1 has already been realized and there is no further aggregate uncertainty, so the expectation is degenerate. The LB non-arbitrage condition between capital investment and interbank lending is

$$\begin{aligned} &E_t\{\Omega_{t+1}^{LB}\left[R_{k,t+1}^{LB}(1-\rho r_{b,t}) - R_{d,t}^{LB}\right]\} \\ &\quad = \frac{1}{1-\gamma}\Bigg\{E_t\left[\Omega_{t+1}^{LB} R_{k,t+1}^{LB}\right] \\ &\qquad - R_{ib,t}E_t\Big[(1-P)\widetilde{\Omega}_{t+1}^{LB} + P\Omega_{t+1}^{*LB}u^{SB}\Big]\Bigg\}. \end{aligned} \tag{S32}$$

The interbank claim pays the promised gross rate $R_{ib,t}$ in the no-run state and the recovery-adjusted rate $u^{SB}R_{ib,t}$ in the run state. Therefore, the term multiplying $R_{ib,t}$ in (S32) is the

expected marginal-value-weighted repayment factor. Equivalently, (S32) can be written as

$$R_{ib,t}E_t\Big[(1-P)\widetilde{\Omega}^{LB}_{t+1}+P\Omega^{*LB}_{t+1}u^{SB}\Big]-E_t\big\{\Omega^{LB}_{t+1}\left(R^{LB}_{d,t}+R^{LB}_{k,t+1}\rho r_{b,t}\right)\big\}$$
$$=\gamma E_t\big\{\Omega^{LB}_{t+1}\left[R^{LB}_{k,t+1}-\left(R^{LB}_{d,t}+R^{LB}_{k,t+1}\rho r_{b,t}\right)\right]\big\}.$$

The left-hand side is the effective net return on $(-ib^{LB})$, and the right-hand side is the effective net return on k^{LB}, where $\widetilde{\Omega}^{LB}_{t+1}$ and Ω^{*LB}_{t+1} denote the marginal values of net worth in the no-run and run states, respectively.

Equation (S32) prices the run probability into the expected returns for IB. To see this point, we rewrite (S32) as

$$R_{ib,t}=\frac{E_t\{\Omega^{LB}_{t+1}\left[\gamma R^{LB}_{k,t+1}+(1-\gamma)\left(R^{LB}_{d,t}+R^{LB}_{k,t+1}\rho r_{b,t}\right)\right]\}}{E_t\Big[(1-P)\,\widetilde{\Omega}^{LB}_{t+1}+P\Omega^{*LB}_{t+1}\,u^{SB}\Big]} \tag{S33}$$

Since $\Omega^{*LB}_{t+1}<\widetilde{\Omega}^{LB}_{t+1}$ and $u^{SB}<1$ in the event of a run, a higher run probability lowers the expected repayment factor in the denominator. Holding the numerator and the other state-contingent objects fixed, $R_{ib,t}$ therefore increases with P.

G. *Constrained social planner's problem*

This subsection derives the planner's first-order condition and highlights the externality emphasized in the main text. The constrained social planner chooses C_0 and IB_0, while household optimality, bank balance sheets, market clearing, and the same incentive and liquidity constraints as in the decentralized equilibrium determine the remaining date-0 quantities, prices, and state-contingent continuation allocations. At date 0, the planner solves

$$\max_{C_0,IB_0}\ u(C_0)+\beta E_0[(1-P)V_1(N_1)+PV^*_1(N^*_1)] \tag{S34}$$

subject to the following implementability conditions:

$$C_0+B_0=W-\alpha^{LB}(K^{LB}_0)^2-\sum_{j\in\{SB,LB\}}f(D^j_0). \tag{S35}$$

$$A^j_0=\kappa N^j_0,\qquad j\in\{SB,LB\}, \tag{S36}$$

$$\chi(X^j_0)=r_{b,0}(\tau N^j_0+\rho D^j_0-A^j_0),\qquad j\in\{SB,LB\}. \tag{S37}$$

$$Q_0K^{SB}_0=N^{SB}_0+IB_0+D^{SB}_0-A^{SB}_0-\chi(X^{SB}_0), \tag{S38}$$

$$(Q_0+\alpha^{LB}K^{LB}_0)K^{LB}_0=N^{LB}_0-IB_0+D^{LB}_0-A^{LB}_0-\chi(X^{LB}_0). \tag{S39}$$

$$D^j_0=N^j_0\left(\frac{R^j_{d,0}-R_{b,0}}{\xi(\eta^j-1)R_{b,0}}\right)^{\frac{1}{\eta^j-1}},\qquad j\in\{SB,LB\}. \tag{S40}$$

$$K_0^{SB} + K_0^{LB} = \bar{K}, \tag{S41}$$

$$IB_0 = s\varsigma\, ib_0^{SB} = -s(1-\varsigma)\, ib_0^{LB} > 0. \tag{S42}$$

$$\mathcal{J}_0^{SB} = 0, \qquad \mathcal{J}_0^{LB} = 0. \tag{S43}$$

$$P = \left[1 - \min\left(\frac{(Q_1^* + Z_1)K_0^{SB} + \kappa N_0^{SB}}{R_{ib,0}IB_0 + R_{d,0}^{SB}D_0^{SB}}, 1\right)\right]^{\delta_p}, \tag{S44}$$

$$(Q_1^* + \alpha^{LB}\bar{K})\bar{K} = (N_1^{LB})^* + (D_1^{LB})^* - \kappa(N_1^{LB})^* - \chi^*(X_1^{LB}), \tag{S45}$$

$$\theta\left[(N_1^{LB})^* + (D_1^{LB})^*\right] = (\mu_{e,1}^{LB})^*(N_1^{LB})^* + (\mu_{d,1}^{LB})^*(D_1^{LB})^*. \tag{S46}$$

For each bank type j, $\mathcal{J}_0^j = 0$ compactly denotes equilibrium conditions characterizing the bank's date-0 optimization problem, including its first-order conditions, and incentive constraint. The last two conditions above display the run-state equations that pin down Q_1^*.

By Equations (S35)–(S46), the variables $\left\{K_0^j, D_0^j, R_{d,0}^j\right\}_{j\in\{LB,SB\}}$, Q_0, Q_1, $R_{ib,0}$, and P can be written as functions of $(C_0, IB_0; R_{b,0}, Z_1)$ for each realized productivity state. Equivalently, one may formulate the reduced problem in (B_0, IB_0) and recover C_0 from (S35).

Using the resource constraint to substitute out C_0, applying the envelope conditions for the induced continuation equilibria, and differentiating the reduced objective with respect to IB_0 yields

$$\begin{aligned} 0 = \;& \beta E_0\left[(1-P)\frac{\partial V_1}{\partial IB_0} + P\frac{\partial V_1^*}{\partial IB_0}\right] \\ & - u'(C_0)\frac{\partial}{\partial IB_0}\left[\alpha^{LB}(K_0^{LB})^2 + \sum_j f(D_0^j)\right] \\ & + \beta E_0\left[(V_1^* - V_1)\frac{\partial P}{\partial IB_0}\right]. \end{aligned} \tag{S47}$$

The first line is the same price-taking marginal trade-off faced in the decentralized equilibrium. The endogenous response of Q_1^* is retained in the reduced-form derivative $\partial P/\partial IB_0$. The decentralized equilibrium omits only the last term because an individual SB takes the aggregate run-probability schedule as given when choosing its own interbank borrowing.

To illustrate the externality, Figure S3 compares interbank credit under $R_{b,0} = \bar{R}_b$ and $R_{b,0} = R_b^L$. Since aggregate and individual SB interbank borrowing satisfy $IB_0 = s\varsigma\, ib_0^{SB}$, the aggregate comparison in Proposition 2 maps one-for-one into the individual borrowing comparison shown in the figure. The individual SB borrowing choice implied by the planner's condition can be expressed as the following ex-ante borrowing rule.

$$ib_0^{SB,CSP} = \Xi(P(IB_0(R_{b,0}), R_{b,0}, Z_1); R_{b,0}, Z_1)\,. \tag{S48}$$

The planner chooses $ib_0^{SB,CSP}$ at $t = 0$ by evaluating the state-contingent run probabilities and continuation values under E_0 over the distribution of Z_1. The solid lines correspond to $R_{b,0} = \bar{R}_b$,

where $P = 0$ and $u^{SB} > 1$, so that $ib_0^{SB,CSP} = ib_0^{SB,DE}$. The horizontal axis reports individual SB interbank borrowing at $t = 0$, denoted by ib_0^{SB}, while the vertical axis reports the borrowing level implied by the relevant optimality condition, denoted by $\Xi(\cdot)$. In the decentralized equilibrium, each individual SB takes the aggregate run probability P as given, so its borrowing condition does not respond to the effect of aggregate interbank borrowing on P. This yields the flat borrowing rule Ξ^{DE}. By contrast, the constrained social planner recognizes that higher ib_0^{SB} raises aggregate interbank borrowing $IB_0 = s\varsigma ib_0^{SB}$, which increases run risk in adverse states and lowers the social value of additional borrowing. This internalization produces the downward-sloping borrowing rule Ξ^{CSP}. Equilibrium borrowing is the fixed point at which the relevant borrowing rule intersects the 45° line. Relative to the solid rules for $R_{b,0} = \bar{R}_b$, the dashed rules for $R_{b,0} = R_b^L$ shift upward. Once the run-risk externality becomes active, the dashed CSP rule lies below the corresponding dashed DE rule. Because borrowing is the same under the two allocations when $R_{b,0} = \bar{R}_b$, the increase in interbank borrowing is larger in the decentralized equilibrium than under the constrained social planner. Hence, $\Delta IB_0^{DE} > \Delta IB_0^{CSP}$, or equivalently, $\Delta ib_0^{SB,DE} > \Delta ib_0^{SB,CSP}$.

H. *Proofs of Lemmas and Propositions in the Simple Model*

Proof of Lemma S1. Suppose, toward a contradiction, that Assumption 1 does not hold, so that $\omega + \gamma \leq 1$, but LBs simultaneously lend in the interbank market and hold positive capital in an active interbank equilibrium. SBs borrow in the interbank market and hold positive capital in this equilibrium. Under the maintained interior active-region conditions, both types of banks have positive deposits, their incentive constraints bind with strictly positive multipliers, and the multipliers on the capital non-negativity and interbank sign constraints are zero. Let the multipliers on the SB and LB incentive constraints be $\varpi_t^{SB} > 0$ and $\varpi_t^{LB} > 0$, respectively.

For SBs, the first-order conditions for deposits and interbank borrowing are

$$(1 + \varpi_t^{SB})\mu_{d,t}^{SB} = \varpi_t^{SB}\theta, \tag{S49}$$

$$(1 + \varpi_t^{SB})\mu_{ib,t}^{SB} = \varpi_t^{SB}\theta\omega. \tag{S50}$$

Dividing (S50) by (S49) gives

$$\mu_{ib,t}^{SB} = \omega\mu_{d,t}^{SB}. \tag{S51}$$

Moreover, (S49) implies

$$\mu_{d,t}^{SB} = \frac{\varpi_t^{SB}}{1 + \varpi_t^{SB}}\theta > 0. \tag{S52}$$

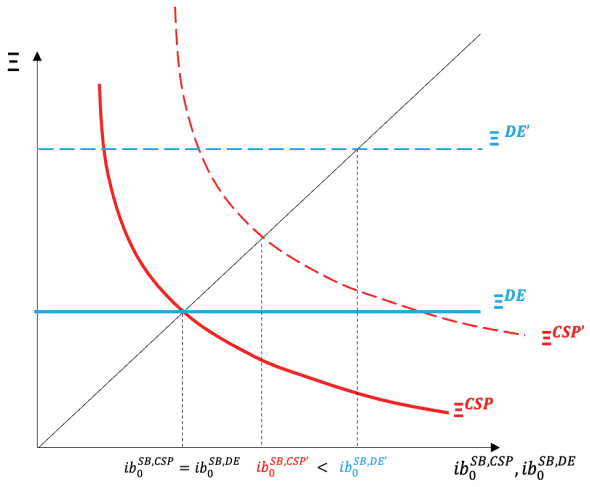


FIGURE S3. Decentralized equilibrium vs. planner: interbank borrowing under alternative values of the initial policy rate $R_{b,0}$. The curves plot the borrowing rule $\Xi(\cdot)$ against individual SB interbank borrowing ib_0^{SB} (horizontal axis). Because $IB_0 = s\varsigma ib_0^{SB}$, the individual and aggregate comparisons are equivalent. Equilibrium borrowing is a fixed point where the relevant curve intersects the 45° line. In the decentralized equilibrium (DE), each SB takes the aggregate run probability P as given, yielding the flat rule Ξ^{DE}. The constrained social planner (CSP) internalizes how higher aggregate interbank borrowing increases run risk and lowers the social value of additional borrowing (Appendix C.G), producing the downward-sloping rule Ξ^{CSP}. The solid lines correspond to $R_{b,0} = \bar{R}_b$, and the dashed lines correspond to $R_{b,0} = R_b^L$. Once the run-risk externality is active, the difference in borrowing between the two initial-policy-rate cases is larger in the DE than under the CSP; the figure does not impose a sign on the CSP borrowing response.

For LBs, interbank lending enters the incentive constraint with coefficient $1-\gamma$. Their first-order conditions for deposits and interbank lending are therefore

$$(1+\varpi_t^{LB})\mu_{d,t}^{LB} = \varpi_t^{LB}\theta, \tag{S53}$$

$$(1+\varpi_t^{LB})\mu_{ib,t}^{LB} = \varpi_t^{LB}\theta(1-\gamma). \tag{S54}$$

Hence,

$$\mu_{ib,t}^{LB} = (1-\gamma)\mu_{d,t}^{LB}. \tag{S55}$$

From the definitions of the expected marginal values of deposits and interbank credit,

$$\mu_{d,t}^{j} = E_t\left[\Omega_{t+1}^{j}\left((1-\rho r_{b,t})R_{k,t+1}^{j} - R_{d,t}^{j}\right)\right], \tag{S56}$$

$$\mu_{ib,t}^{j} = E_t\left[\Omega_{t+1}^{j}\left(R_{k,t+1}^{j} - R_{ib,t}\right)\right]. \tag{S57}$$

Because $R_{ib,t}$, $R^j_{d,t}$, and $r_{b,t}$ are known at date t, substituting (S56) and (S57) into (S51) and dividing by $E_t[\Omega^{SB}_{t+1}] > 0$ gives

$$R_{ib,t} = \frac{E_t\left[\Omega^{SB}_{t+1} R^{SB}_{k,t+1}\right]}{E_t\left[\Omega^{SB}_{t+1}\right]} - \omega\left[(1-\rho r_{b,t})\frac{E_t\left[\Omega^{SB}_{t+1} R^{SB}_{k,t+1}\right]}{E_t\left[\Omega^{SB}_{t+1}\right]} - R^{SB}_{d,t}\right]. \tag{S58}$$

Similarly, substituting the same definitions into (S55) and dividing by $E_t[\Omega^{LB}_{t+1}] > 0$ yields

$$R_{ib,t} = \frac{E_t\left[\Omega^{LB}_{t+1} R^{LB}_{k,t+1}\right]}{E_t\left[\Omega^{LB}_{t+1}\right]} - (1-\gamma)\left[(1-\rho r_{b,t})\frac{E_t\left[\Omega^{LB}_{t+1} R^{LB}_{k,t+1}\right]}{E_t\left[\Omega^{LB}_{t+1}\right]} - R^{LB}_{d,t}\right]. \tag{S59}$$

Equating the two expressions for $R_{ib,t}$ in (S58) and (S59), and collecting terms, gives

$$\begin{aligned}(\omega+\gamma-1)&\left[(1-\rho r_{b,t})\frac{E_t\left[\Omega^{SB}_{t+1} R^{SB}_{k,t+1}\right]}{E_t\left[\Omega^{SB}_{t+1}\right]} - R^{SB}_{d,t}\right] \\ &= [1-(1-\gamma)(1-\rho r_{b,t})]\left[\frac{E_t\left[\Omega^{SB}_{t+1} R^{SB}_{k,t+1}\right]}{E_t\left[\Omega^{SB}_{t+1}\right]} - \frac{E_t\left[\Omega^{LB}_{t+1} R^{LB}_{k,t+1}\right]}{E_t\left[\Omega^{LB}_{t+1}\right]}\right] \\ &\quad + (1-\gamma)\left(R^{SB}_{d,t} - R^{LB}_{d,t}\right).\end{aligned} \tag{S60}$$

By (S52), (S56), and $E_t[\Omega^{SB}_{t+1}] > 0$,

$$(1-\rho r_{b,t})\frac{E_t\left[\Omega^{SB}_{t+1} R^{SB}_{k,t+1}\right]}{E_t\left[\Omega^{SB}_{t+1}\right]} - R^{SB}_{d,t} > 0. \tag{S61}$$

In addition, since $0 < \gamma \leq 1$, $\rho \geq 0$, and $r_{b,t} \geq 0$,

$$1-(1-\gamma)(1-\rho r_{b,t}) = \gamma + (1-\gamma)\rho r_{b,t} > 0. \tag{S62}$$

Under the maintained active-region return orderings,

$$\frac{E_t\left[\Omega^{SB}_{t+1} R^{SB}_{k,t+1}\right]}{E_t\left[\Omega^{SB}_{t+1}\right]} \geq \frac{E_t\left[\Omega^{LB}_{t+1} R^{LB}_{k,t+1}\right]}{E_t\left[\Omega^{LB}_{t+1}\right]}, \tag{S63}$$

$$R^{SB}_{d,t} \geq R^{LB}_{d,t}, \tag{S64}$$

with at least one of these inequalities being strict. At $t = 1$, the expectation operator is degenerate and $\Omega^{SB}_2 = \Omega^{LB}_2 = \beta m_2$, so (S63) reduces to the realized-return ordering $R^{SB}_{k,2} \geq R^{LB}_{k,2}$. At $t = 0$, (S63) is the expectation-consistent form of the maintained return ordering.

Equations (S62)–(S64) imply that the right-hand side of (S60) is strictly positive. Since the bracket multiplying $\omega+\gamma-1$ on the left-hand side is strictly positive by (S61), it follows that

$$\omega+\gamma-1>0, \tag{S65}$$

or equivalently, $\omega+\gamma>1$. This contradicts the supposition that $\omega+\gamma\leq 1$. Therefore, if Assumption 1 does not hold, LBs cannot simultaneously have positive interbank lending and positive capital investment in an active interbank equilibrium. □

Proof of Proposition 1. Throughout the proof, all derivatives are evaluated holding all other prices and continuation values fixed. Because n_0^{SB} is given, changes in normalized and level interbank borrowing have the same sign. From the binding incentive constraint (S15) and the interior no-arbitrage condition $\mu_{ib,0}^{SB}=\omega\mu_{d,0}^{SB}$, we obtain

$$\psi_{ib,0}^{SB}=-\frac{1}{\omega}\psi_{d,0}^{SB}+\frac{\mu_{e,0}^{SB}-\theta}{\omega\left(\theta-\mu_{d,0}^{SB}\right)}. \tag{S66}$$

Differentiating (S66) with respect to $R_{b,0}$ gives

$$\begin{aligned}\frac{\partial\psi_{ib,0}^{SB}}{\partial R_{b,0}}=&-\frac{1}{\omega}\frac{\partial\psi_{d,0}^{SB}}{\partial R_{b,0}}\\&+\frac{\partial}{\partial R_{b,0}}\left[\frac{\mu_{e,0}^{SB}-\theta}{\omega\left(\theta-\mu_{d,0}^{SB}\right)}\right].\end{aligned} \tag{S67}$$

We first establish the sign of the second term in (S67). From the definitions of $\mu_{e,0}^{SB}$ and $\mu_{d,0}^{SB}$, and using $r_{b,0}=R_{b,0}-1$, we have

$$\frac{\partial\mu_{e,0}^{SB}}{\partial R_{b,0}}=-(\tau-\kappa)E_0\left[\Omega_1^{SB}R_{k,1}^{SB}\right], \tag{S68}$$

$$\frac{\partial\mu_{d,0}^{SB}}{\partial R_{b,0}}=-\rho E_0\left[\Omega_1^{SB}R_{k,1}^{SB}\right]. \tag{S69}$$

Consequently,

$$\begin{aligned}&\frac{\partial}{\partial R_{b,0}}\left[\frac{\mu_{e,0}^{SB}-\theta}{\omega\left(\theta-\mu_{d,0}^{SB}\right)}\right]\\&=\frac{1}{\omega}\left[\frac{\partial\mu_{e,0}^{SB}/\partial R_{b,0}}{\theta-\mu_{d,0}^{SB}}+\frac{\left(\mu_{e,0}^{SB}-\theta\right)\left(\partial\mu_{d,0}^{SB}/\partial R_{b,0}\right)}{\left(\theta-\mu_{d,0}^{SB}\right)^2}\right]\\&=-\frac{E_0\left[\Omega_1^{SB}R_{k,1}^{SB}\right]}{\omega\left(\theta-\mu_{d,0}^{SB}\right)^2}\left[(\tau-\kappa)\left(\theta-\mu_{d,0}^{SB}\right)+\rho\left(\mu_{e,0}^{SB}-\theta\right)\right].\end{aligned} \tag{S70}$$

To determine the sign of the expression in brackets, combine the normalized value equation

$$\psi_0^{SB} = \mu_{e,0}^{SB} + \mu_{d,0}^{SB}\psi_{d,0}^{SB} + \mu_{ib,0}^{SB}\psi_{ib,0}^{SB}$$

with the binding incentive constraint

$$\psi_0^{SB} = \theta\left(1 + \psi_{d,0}^{SB} + \omega\psi_{ib,0}^{SB}\right)$$

and the no-arbitrage condition $\mu_{ib,0}^{SB} = \omega\mu_{d,0}^{SB}$. These equations imply

$$\mu_{e,0}^{SB} - \theta = \left(\theta - \mu_{d,0}^{SB}\right)\left(\psi_{d,0}^{SB} + \omega\psi_{ib,0}^{SB}\right). \tag{S71}$$

Substituting (S71) into (S70) yields

$$\begin{aligned}\frac{\partial}{\partial R_{b,0}}&\left[\frac{\mu_{e,0}^{SB} - \theta}{\omega\left(\theta - \mu_{d,0}^{SB}\right)}\right] \\ &= -\frac{E_0\left[\Omega_1^{SB} R_{k,1}^{SB}\right]}{\omega\left(\theta - \mu_{d,0}^{SB}\right)}\left[\tau - \kappa + \rho\psi_{d,0}^{SB} + \rho\omega\psi_{ib,0}^{SB}\right].\end{aligned} \tag{S72}$$

Because the liquidity constraint binds, $a_0^{SB} = \kappa n_0^{SB}$, and we assume the expected reserve shortfall is positive, hence

$$\frac{x_0^{SB}}{n_0^{SB}} = \tau - \kappa + \rho\psi_{d,0}^{SB} \geq 0. \tag{S73}$$

Therefore,

$$\frac{\partial}{\partial R_{b,0}}\left[\frac{\mu_{e,0}^{SB} - \theta}{\omega\left(\theta - \mu_{d,0}^{SB}\right)}\right] < 0. \tag{S74}$$

We next consider the deposit response. The household deposit-demand condition gives

$$\psi_{d,0}^{SB} = \left[\frac{R_{d,0}^{SB} - R_{b,0}}{\xi(\eta^{SB} - 1)R_{b,0}}\right]^{\frac{1}{\eta^{SB}-1}}. \tag{S75}$$

Given $R_{d,0}^{SB}$, differentiating (S75) yields

$$\begin{aligned}\frac{\partial\psi_{d,0}^{SB}}{\partial R_{b,0}} = &-\frac{R_{d,0}^{SB}}{\xi(\eta^{SB} - 1)^2 R_{b,0}^2} \\ &\times\left[\frac{R_{d,0}^{SB} - R_{b,0}}{\xi(\eta^{SB} - 1)R_{b,0}}\right]^{\frac{1}{\eta^{SB}-1}-1} < 0.\end{aligned} \tag{S76}$$

Furthermore,

$$\lim_{\eta^{SB}\to\infty}\left(-\frac{\partial\psi_{d,0}^{SB}}{\partial R_{b,0}}\right) = 0. \tag{S77}$$

Thus, the first term on the right-hand side of (S67) is positive but converges to zero as η^{SB} becomes large. By contrast, the second term is strictly negative by (S74). Because all other prices

and continuation values are held fixed in this partial-equilibrium exercise, this negative term does not vary with η^{SB}. Therefore, there exists a sufficiently large value of η^{SB} such that

$$\frac{\partial \psi_{ib,0}^{SB}}{\partial R_{b,0}} < 0. \tag{S78}$$

Since $ib_0^{SB} = n_0^{SB}\psi_{ib,0}^{SB}$ and $n_0^{SB} > 0$ is given,

$$\frac{\partial ib_0^{SB}}{\partial R_{b,0}} = n_0^{SB}\frac{\partial \psi_{ib,0}^{SB}}{\partial R_{b,0}} < 0. \tag{S79}$$

Finally, since the SB balance-sheet condition is

$$Q_0 k_0^{SB} = \left[1 - \kappa - r_{b,0}(\tau - \kappa)\right] n_0^{SB} + \left(1 - \rho r_{b,0}\right) d_0^{SB} + ib_0^{SB}. \tag{S80}$$

we have

$$\frac{\partial d_0^{SB}}{\partial R_{b,0}} = n_0^{SB}\frac{\partial \psi_{d,0}^{SB}}{\partial R_{b,0}} < 0. \tag{S81}$$

Using $x_0^{SB} \geq 0$, $1 - \rho r_{b,0} > 0$, $\partial d_0^{SB}/\partial R_{b,0} < 0$, and (S79), equation (S80) implies

$$\frac{\partial (Q_0 k_0^{SB})}{\partial R_{b,0}} < 0. \tag{S82}$$

Since $Q_0 > 0$ is held fixed, it follows that

$$\left.\frac{\partial k_0^{SB}}{\partial R_{b,0}}\right|_{Q_0} < 0. \tag{S83}$$

Therefore, when η^{SB} is sufficiently large, a marginal decrease in the policy rate increases both SB interbank borrowing and SB capital demand. □

Proof of Lemma S2. In the run equilibrium, the interbank market collapses, $IB_1 = 0$, and SBs liquidate their capital. LBs therefore absorb the entire capital stock, so each LB purchases

$$(k_1^{LB})^* = \bar{k} \equiv \frac{\bar{K}}{s(1-\varsigma)}. \tag{S84}$$

The LB balance-sheet condition and binding incentive constraint in the run state are

$$\left(Q_1^* + \alpha^{LB}\bar{K}\right)(k_1^{LB})^* = (n_1^{LB})^* + (d_1^{LB})^* - \kappa(n_1^{LB})^* - \chi^*\left((x_1^{LB})^*\right), \tag{S85}$$

$$\theta\left((n_1^{LB})^* + (d_1^{LB})^*\right) = (\mu_{e,1}^{LB})^*(n_1^{LB})^* + (\mu_{d,1}^{LB})^*(d_1^{LB})^*. \tag{S86}$$

Solving (S86) for LB deposits gives

$$(d_1^{LB})^* = \frac{\theta - (\mu_{e,1}^{LB})^*}{(\mu_{d,1}^{LB})^* - \theta}(n_1^{LB})^*. \tag{S87}$$

Substituting (S87) into (S85), we obtain

$$\left(Q_1^* + \alpha^{LB}\bar{K}\right)(k_1^{LB})^* = F(Q_1^*)(n_1^{LB})^*, \tag{S88}$$

$$F(Q_1^*) \equiv 1 + \frac{\theta - (\mu_{e,1}^{LB})^*}{(\mu_{d,1}^{LB})^* - \theta}(1 - \rho r_{b,1}) - \kappa - r_{b,1}(\tau - \kappa). \tag{S89}$$

Because $Z_2 = \bar{Z}$ is fixed and all other prices and continuation values are held fixed, F has no direct dependence on Z_1. It may nevertheless depend on Q_1^* through the LB continuation returns. At the fire-sale equilibrium, (S84) and (S88) imply

$$\left(Q_1^* + \alpha^{LB}\bar{K}\right)\bar{k} = F(Q_1^*)(n_1^{LB})^*. \tag{S90}$$

Since $Q_1^* + \alpha^{LB}\bar{K} > 0$, $\bar{k} > 0$, and $(n_1^{LB})^* > 0$, equation (S90) also implies

$$F(Q_1^*) > 0. \tag{S91}$$

The SB recovery rate is

$$u^{SB} = \frac{(Z_1 + Q_1^*)k_0^{SB} + a_0^{SB}}{R_{ib,0}ib_0^{SB} + R_{d,0}^{SB}d_0^{SB}}. \tag{S92}$$

Holding the other argument fixed, (S92) gives

$$\left.\frac{\partial u^{SB}}{\partial Z_1}\right|_{Q_1^*} = \left.\frac{\partial u^{SB}}{\partial Q_1^*}\right|_{Z_1} = \frac{k_0^{SB}}{R_{ib,0}ib_0^{SB} + R_{d,0}^{SB}d_0^{SB}} > 0. \tag{S93}$$

The run-state net worth of an LB is

$$(n_1^{LB})^* = a_0^{LB} + (Z_1 + Q_1^*)k_0^{LB} - u^{SB}R_{ib,0}ib_0^{LB} - R_{d,0}^{LB}d_0^{LB}. \tag{S94}$$

Using (S93), we obtain

$$\begin{aligned}\left.\frac{\partial (n_1^{LB})^*}{\partial Z_1}\right|_{Q_1^*} &= \left.\frac{\partial (n_1^{LB})^*}{\partial Q_1^*}\right|_{Z_1} \\ &= k_0^{LB} - \frac{R_{ib,0}ib_0^{LB}k_0^{SB}}{R_{ib,0}ib_0^{SB} + R_{d,0}^{SB}d_0^{SB}} > 0.\end{aligned} \tag{S95}$$

The last inequality follows from $ib_0^{LB} < 0$.

Equation (S88) implies that LB capital demand satisfies

$$(k_1^{LB})^* = \frac{F(Q_1^*)(n_1^{LB})^*}{Q_1^* + \alpha^{LB}\bar{K}}. \tag{S96}$$

Differentiating (S96) with respect to Q_1^*, holding Z_1 fixed, gives

$$\left.\frac{\partial (k_1^{LB})^*}{\partial Q_1^*}\right|_{Z_1} = \frac{F\left.\frac{\partial (n_1^{LB})^*}{\partial Q_1^*}\right|_{Z_1} + F_Q(n_1^{LB})^* - (k_1^{LB})^*}{Q_1^* + \alpha^{LB}\bar{K}}, \tag{S97}$$

where $F_Q \equiv \partial F/\partial Q_1^*$. Under the uniform local regularity condition, LB residual capital demand is strictly downward sloping at the local interior equilibrium. Therefore, using $(k_1^{LB})^* = \bar{k}$,

$$F \left.\frac{\partial (n_1^{LB})^*}{\partial Q_1^*}\right|_{Z_1} + F_Q (n_1^{LB})^* - \bar{k} < 0. \tag{S98}$$

We now differentiate the fire-sale equilibrium condition (S90) with respect to Z_1. Because F has no direct dependence on Z_1,

$$\begin{aligned} \bar{k}\frac{dQ_1^*}{dZ_1} &= F_Q (n_1^{LB})^* \frac{dQ_1^*}{dZ_1} \\ &\quad + F\left[\left.\frac{\partial (n_1^{LB})^*}{\partial Z_1}\right|_{Q_1^*} + \left.\frac{\partial (n_1^{LB})^*}{\partial Q_1^*}\right|_{Z_1} \frac{dQ_1^*}{dZ_1}\right]. \end{aligned} \tag{S99}$$

Collecting the terms involving dQ_1^*/dZ_1 gives

$$\frac{dQ_1^*}{dZ_1} = \frac{F \left.\dfrac{\partial (n_1^{LB})^*}{\partial Z_1}\right|_{Q_1^*}}{\bar{k} - F \left.\dfrac{\partial (n_1^{LB})^*}{\partial Q_1^*}\right|_{Z_1} - F_Q (n_1^{LB})^*} > 0. \tag{S100}$$

The inequality follows from (S91), (S95), and (S98). Thus, a higher Z_1 increases the fire-sale price Q_1^*.

Taking the total derivative of (S92) with respect to Z_1, and using (S93) and (S100), gives

$$\begin{aligned} \frac{du^{SB}}{dZ_1} &= \left.\frac{\partial u^{SB}}{\partial Z_1}\right|_{Q_1^*} + \left.\frac{\partial u^{SB}}{\partial Q_1^*}\right|_{Z_1} \frac{dQ_1^*}{dZ_1} \\ &= \frac{k_0^{SB}}{R_{ib,0} ib_0^{SB} + R_{d,0}^{SB} d_0^{SB}} \left(1 + \frac{dQ_1^*}{dZ_1}\right) > 0. \end{aligned} \tag{S101}$$

Hence P is weakly decreasing in Z_1, with a strictly negative derivative whenever run risk is active.

□

Proof of Lemma S3. The SB recovery rate can be written as

$$u^{SB} = \frac{R_k^{SB,*} \mathcal{H}^{SB} + \kappa}{\mathcal{L}}, \tag{S102}$$

where

$$R_k^{SB,*} = \frac{Z_1 + Q_1^*}{Q_0}, \tag{S103}$$

$$\mathcal{H}^{SB} = 1 + \psi_{ib,0}^{SB} + (1 - \rho r_{b,0}) \psi_d^{SB} - \kappa - r_{b,0}(\tau - \kappa), \tag{S104}$$

$$\mathcal{L} = R_{ib,0} \psi_{ib,0}^{SB} + R_{d,0}^{SB} \psi_d^{SB}. \tag{S105}$$

We first derive the direct balance-sheet effect. Holding Q_1^* fixed and differentiating (S102) with respect to $\psi_{ib,0}^{SB}$ gives

$$\left.\frac{\partial u^{SB}}{\partial \psi_{ib,0}^{SB}}\right|_{Q_1^*} = \frac{R_k^{SB,*}\mathcal{L} - R_{ib,0}\left(R_k^{SB,*}\mathcal{H}^{SB} + \kappa\right)}{\mathcal{L}^2}$$
$$= -\frac{B}{\mathcal{L}^2}, \tag{S106}$$

where

$$B \equiv R_{ib,0}\mathcal{A}^* - \psi_d^{SB} R_k^{SB,*}\left[R_{d,0}^{SB} - R_{ib,0}(1-\rho r_{b,0})\right], \tag{S107}$$

and

$$\mathcal{A}^* \equiv \kappa + R_k^{SB,*}\left[1 - \kappa - r_{b,0}(\tau - \kappa)\right]. \tag{S108}$$

The funding-cost inequality used below follows directly from the SB no-arbitrage condition $\mu_{ib,0}^{SB} = \omega\mu_{d,0}^{SB}$. In particular, evaluating the equivalent return condition (S58) at $t = 0$ and using (S56) gives

$$\begin{aligned} &R_{ib,0}(1-\rho r_{b,0}) - R_{d,0}^{SB} \\ &\quad = \left[1 - \omega(1-\rho r_{b,0})\right]\left[(1-\rho r_{b,0})\frac{E_0\left[\Omega_1^{SB} R_{k,1}^{SB}\right]}{E_0\left[\Omega_1^{SB}\right]} - R_{d,0}^{SB}\right] \\ &\quad = \left[1 - \omega(1-\rho r_{b,0})\right]\frac{\mu_{d,0}^{SB}}{E_0[\Omega_1^{SB}]} \geq 0. \end{aligned} \tag{S109}$$

The last inequality uses $0 < \omega \leq 1$. Hence, $R_{d,0}^{SB} \leq R_{ib,0}(1-\rho r_{b,0})$. Together with the maintained run-state condition $\mathcal{A}^* > 0$, this implies $B > 0$ and therefore $\partial u^{SB}/\partial \psi_{ib,0}^{SB}\Big|_{Q_1^*} < 0$.

We next derive the endogenous fire-sale-price response. LB run-state net worth is

$$N^{LB,*} = A_0^{LB} + (Z_1 + Q_1^*)K_0^{LB} + u^{SB} R_{ib,0}\psi_{ib,0}^{SB} N_0^{SB} - R_{d,0}^{LB} D_0^{LB}. \tag{S110}$$

Run-state capital-market clearing requires

$$\left(Q_1^* + \alpha^{LB}\bar{K}\right)\bar{K} = F^{LB,*}N^{LB,*}, \tag{S111}$$

where

$$F^{LB,*} = 1 + (1-\rho r_{b,1})\psi_d^{LB,*} - \kappa - r_{b,1}(\tau - \kappa). \tag{S112}$$

Differentiating (S111) with respect to $\psi_{ib,0}^{SB}$ gives

$$\left[\bar{K} - F^{LB,*}\frac{\partial N^{LB,*}}{\partial Q_1^*} - F_Q^{LB,*}N^{LB,*}\right]\frac{dQ_1^*}{d\psi_{ib,0}^{SB}}$$
$$= F^{LB,*}\left.\frac{\partial N^{LB,*}}{\partial \psi_{ib,0}^{SB}}\right|_{Q_1^*}. \tag{S113}$$

Holding $\psi_{ib,0}^{SB}$ fixed and using the SB balance sheet $Q_0 K_0^{SB} = N_0^{SB}\mathcal{H}^{SB}$, equations (S102)–(S105) imply

$$\frac{\partial u^{SB}}{\partial Q_1^*} = \frac{\mathcal{H}^{SB}}{Q_0\mathcal{L}} = \frac{K_0^{SB}}{N_0^{SB}\mathcal{L}} > 0. \tag{S114}$$

Differentiating (S110) with respect to Q_1^*, holding $\psi_{ib,0}^{SB}$ fixed, and using (S114) gives

$$\begin{aligned}\frac{\partial N^{LB,*}}{\partial Q_1^*} &= K_0^{LB} + R_{ib,0}\psi_{ib,0}^{SB}N_0^{SB}\frac{\partial u^{SB}}{\partial Q_1^*} \\ &= K_0^{LB} + \frac{R_{ib,0}\psi_{ib,0}^{SB}}{\mathcal{L}}K_0^{SB}.\end{aligned} \tag{S115}$$

Differentiating the same SB balance sheet and $K_0^{SB} + K_0^{LB} = \bar{K}$ with respect to $\psi_{ib,0}^{SB}$ gives

$$\begin{aligned}\frac{\partial K_0^{SB}}{\partial \psi_{ib,0}^{SB}} &= \frac{N_0^{SB}}{Q_0}, \\ \frac{\partial K_0^{LB}}{\partial \psi_{ib,0}^{SB}} &= -\frac{N_0^{SB}}{Q_0}.\end{aligned} \tag{S116}$$

The LB balance-sheet condition gives

$$\psi_{d,0}^{LB} = \frac{\dfrac{(Q_0 + \alpha^{LB}K_0^{LB})K_0^{LB}}{N_0^{LB}} - [1 - \kappa - r_{b,0}(\tau - \kappa)] + \dfrac{N_0^{SB}}{N_0^{LB}}\psi_{ib,0}^{SB}}{1 - \rho r_{b,0}}. \tag{S117}$$

Differentiating (S117) and using (S116) yields

$$\begin{aligned}\frac{\partial D_0^{LB}}{\partial \psi_{ib,0}^{SB}} &= N_0^{LB}\frac{\partial \psi_{d,0}^{LB}}{\partial \psi_{ib,0}^{SB}} \\ &= -\frac{2\alpha^{LB}K_0^{LB}N_0^{SB}}{Q_0(1 - \rho r_{b,0})} < 0.\end{aligned} \tag{S118}$$

Equations (S102)–(S107) imply

$$R_{ib,0}u^{SB} - R_k^{SB,*} = \frac{B}{\mathcal{L}}. \tag{S119}$$

Differentiating (S110) with respect to $\psi_{ib,0}^{SB}$, holding Q_1^* fixed, and using (S106), (S116), (S118), (S119), and $Z_1 + Q_1^* = Q_0 R_k^{SB,*}$, gives

$$\left.\frac{\partial N^{LB,*}}{\partial \psi_{ib,0}^{SB}}\right|_{Q_1^*} = \frac{N_0^{SB}R_{d,0}^{SB}\psi_d^{SB}B}{\mathcal{L}^2} + \frac{2\alpha^{LB}K_0^{LB}R_{d,0}^{LB}N_0^{SB}}{Q_0(1 - \rho r_{b,0})} > 0. \tag{S120}$$

The strict regularity condition maintained in the proof of Lemma S2 is

$$F^{LB,*}\frac{\partial N^{LB,*}}{\partial Q_1^*} + F_Q^{LB,*}N^{LB,*} - \bar{K} < 0. \tag{S121}$$

For the present comparative static, maintain the following uniform local regularity condition, which incorporates the deposit adjustment required by the LB balance sheet:

$$\bar{K}(F^{LB,*} - 1) + F_Q^{LB,*}N^{LB,*} + \frac{2\alpha^{LB}K_0^{LB}K_0^{SB}R_{d,0}^{LB}F^{LB,*}\mathcal{L}}{Q_0(1 - \rho r_{b,0})B} < 0. \tag{S122}$$

Equations (S113), (S120), and (S121) imply

$$\frac{dQ_1^*}{d\psi_{ib,0}^{SB}} = \frac{F^{LB,*}\left.\frac{\partial N^{LB,*}}{\partial \psi_{ib,0}^{SB}}\right|_{Q_1^*}}{\bar{K} - F^{LB,*}\frac{\partial N^{LB,*}}{\partial Q_1^*} - F_Q^{LB,*}N^{LB,*}} > 0. \tag{S123}$$

The total effect on recovery is

$$\frac{du^{SB}}{d\psi_{ib,0}^{SB}} = \frac{\partial u^{SB}}{\partial Q_1^*}\frac{dQ_1^*}{d\psi_{ib,0}^{SB}} + \left.\frac{\partial u^{SB}}{\partial \psi_{ib,0}^{SB}}\right|_{Q_1^*}. \tag{S124}$$

Substituting (S106), (S114), (S115), (S120), and (S123) into (S124), and using $K_0^{SB} + K_0^{LB} = \bar{K}$ and $\mathcal{L} = R_{ib,0}\psi_{ib,0}^{SB} + R_{d,0}^{SB}\psi_d^{SB}$, yields

$$\frac{du^{SB}}{d\psi_{ib,0}^{SB}} = \frac{B\left[\bar{K}(F^{LB,*}-1) + F_Q^{LB,*}N^{LB,*}\right] + \dfrac{2\alpha^{LB}K_0^{LB}K_0^{SB}R_{d,0}^{LB}F^{LB,*}\mathcal{L}}{Q_0(1-\rho r_{b,0})}}{\mathcal{L}^2\left[\bar{K} - F^{LB,*}\frac{\partial N^{LB,*}}{\partial Q_1^*} - F_Q^{LB,*}N^{LB,*}\right]}. \tag{S125}$$

The denominator in (S125) is strictly positive by (S121). Since $B > 0$, (S122) makes the numerator strictly negative. Equation (S125) therefore gives

$$\frac{du^{SB}}{d\psi_{ib,0}^{SB}} < 0. \tag{S126}$$

Because

$$\frac{\partial \psi_{ib,0}^{SB}}{\partial IB_0} = \frac{1}{N_0^{SB}} > 0,$$

we obtain

$$\frac{\partial u^{SB}}{\partial IB_0} = \frac{du^{SB}}{d\psi_{ib,0}^{SB}}\frac{\partial \psi_{ib,0}^{SB}}{\partial IB_0} < 0,$$

which proves (S31).

Finally,

$$P(u^{SB}) = \left[1 - \min\{u^{SB}, 1\}\right]^{\delta_p}$$

is weakly decreasing in u^{SB}. Together with $\partial u^{SB}/\partial IB_0 < 0$, this implies that P is weakly increasing in IB_0, and strictly increasing wherever run risk is active.

□

Proof of Proposition 2. Consistent with the conditional comparative statics in the simple model, the private marginal conditions in this proof hold fixed the other date-0 and continuation prices. When computing the aggregate run-probability response, however, the run-state fire-sale price Q_1^* adjusts endogenously through run-state capital-market clearing. Because bankers are owned by households, the planner's objective is household utility. The relevant continuation values are

$$V_1(N_1) = u(C_1(N_1)) + \beta u(C_2(N_1)), \qquad V_1^*(N_1^*) = u(C_1^*(N_1^*)) + \beta u(C_2^*(N_1^*)).$$

We restrict attention to a parameter region in which the relevant interior DE and CSP solutions are unique for each policy rate considered. Write $P = P(IB_0, R_{b,0}, Z_1)$, where the reduced-form run probability incorporates the endogenous response of Q_1^*. All objects below are evaluated at the allocations implied by $(IB_0, R_{b,0}, Z_1)$. After substituting the equilibrium constraints, applying the relevant envelope conditions, and using market clearing, equilibrium-price feedback terms outside P cancel in aggregate household welfare. The partial derivatives entering $\mathcal{G}$ are therefore the common price-taking marginal derivatives, holding the run-probability schedule and equilibrium prices fixed; the endogenous Q_1^* response remains included in $\partial P/\partial IB_0$. Define this common marginal condition as

$$\begin{aligned}\mathcal{G}(IB_0, R_{b,0}) \equiv \beta E_0\left[(1-P)\frac{\partial V_1}{\partial IB_0} + P\frac{\partial V_1^*}{\partial IB_0}\right] \\ - u'(C_0)\frac{\partial}{\partial IB_0}\left[\alpha^{LB}(K_0^{LB})^2 + \sum_j f(D_0^j)\right].\end{aligned} \tag{S127}$$

This expression contains the direct effects of interbank borrowing on continuation values and date-0 resource costs. An individual SB accounts for these effects but takes the aggregate run-probability schedule as given. Hence, after aggregating the symmetric SB first-order conditions, the decentralized equilibrium satisfies

$$\mathcal{G}(IB_0^{DE}, R_{b,0}) = 0. \tag{S128}$$

By contrast, the constrained social planner internalizes the effect of aggregate interbank borrowing on the run probability. The planner's first-order condition (S47) can be written as

$$\mathcal{G}(IB_0^{CSP}, R_{b,0}) - \mathcal{M}(IB_0^{CSP}, R_{b,0}) = 0, \tag{S129}$$

where the externality wedge is

$$\mathcal{M}(IB_0, R_{b,0}) \equiv -\beta E_0\left[(V_1^* - V_1)\frac{\partial P}{\partial IB_0}\right]. \tag{S130}$$

The sign of $\mathcal{M}$ follows from the economics of the run state. A run weakly lowers household continuation utility, so $V_1^* \leq V_1$. Lemma S3 shows that u^{SB} is strictly decreasing in aggregate interbank borrowing and that P is therefore weakly increasing in IB_0. In active states with $u^{SB} < 1$, P is differentiable and $\partial P/\partial IB_0 > 0$; in interior inactive states with $u^{SB} > 1$, $P = 0$ locally and $\partial P/\partial IB_0 = 0$. Threshold realizations satisfying $u^{SB} = 1$ are assumed to have zero probability, and the derivative entering the expectation is understood almost surely. Therefore

$$\mathcal{M}(IB_0, R_{b,0}) \geq 0. \tag{S131}$$

The inequality is strict whenever $V_1^* < V_1$ and $\partial P/\partial IB_0 > 0$ jointly hold on a positive-probability set of adverse states. This is the nondegenerate run-risk externality invoked in Proposition 2.

It remains to compare the borrowing levels. A second-order condition imposed only at each optimum is not sufficient for this comparison. We therefore use the following common-neighborhood

version of the local curvature condition: for policy rates in a common neighborhood containing $\bar{R}_b$ and R_b^L, and for every IB_0 between the DE and CSP choices,

$$\frac{\partial}{\partial IB_0}\left[\mathcal{G}(IB_0, R_{b,0}) - \mathcal{M}(IB_0, R_{b,0})\right] < 0. \tag{S132}$$

Evaluating the planner's marginal condition at the decentralized choice and using (S128) gives

$$\begin{aligned}\mathcal{G}(IB_0^{DE}, R_{b,0}) - \mathcal{M}(IB_0^{DE}, R_{b,0}) \\ = -\mathcal{M}(IB_0^{DE}, R_{b,0}) \leq 0.\end{aligned} \tag{S133}$$

At IB_0^{CSP}, by contrast, the same expression equals zero by (S129). Since (S132) makes the expression strictly decreasing in IB_0 throughout the common neighborhood, (S133) implies

$$IB_0^{CSP}|_{R_{b,0}} \leq IB_0^{DE}|_{R_{b,0}}, \tag{S134}$$

with strict inequality whenever $\mathcal{M}(IB_0^{DE}, R_{b,0}) > 0$. This comparison is ex ante: IB_0 is selected before Z_1 is realized, while $\mathcal{M}$ integrates the state-contingent run externality over the distribution of Z_1.

We now turn to the finite comparison between the two initial-policy-rate cases in Proposition 2. When $R_{b,0} = \bar{R}_b$, run risk is inactive, so $P = 0$. It follows that $\mathcal{M} = 0$. Under the maintained uniqueness of the relevant interior solutions, the DE and CSP marginal conditions therefore coincide and imply

$$IB_0^{DE}|_{\bar{R}_b} = IB_0^{CSP}|_{\bar{R}_b}. \tag{S135}$$

Consider instead the case $R_{b,0} = R_b^L < \bar{R}_b$. By assumption, both endpoint allocations remain in the common neighborhood used in (S132), and this initial low-policy-rate case places a positive-probability set of sufficiently adverse realizations of Z_1 in the active region $u^{SB} < 1$. Hence $\mathcal{M} > 0$ in the $R_{b,0} = R_b^L$ case, so the strict level comparison in (S134) applies and gives

$$IB_0^{DE}|_{R_b^L} > IB_0^{CSP}|_{R_b^L}. \tag{S136}$$

Using the definition in (36), subtracting the common allocation at $R_{b,0} = \bar{R}_b$ in (S135) from the comparison at $R_{b,0} = R_b^L$ in (S136) gives

$$\begin{aligned}\Delta IB_0^{DE} - \Delta IB_0^{CSP} &= \left[IB_0^{DE}|_{R_b^L} - IB_0^{CSP}|_{R_b^L}\right] \\ &\quad - \left[IB_0^{DE}|_{\bar{R}_b} - IB_0^{CSP}|_{\bar{R}_b}\right] \\ &= IB_0^{DE}|_{R_b^L} - IB_0^{CSP}|_{R_b^L} > 0.\end{aligned} \tag{S137}$$

Therefore,

$$\Delta IB_0^{DE} > \Delta IB_0^{CSP}. \tag{S138}$$

No sign restriction on ΔIB_0^{CSP} is required. This proves Proposition 2. □

Proof of Proposition 3. We compare the two initial-policy-rate cases $R_{b,0} = \bar{R}_b$ and $R_{b,0} = R_b^L < \bar{R}_b$ defined in Proposition 2. Initial net worth is given. At each fixed endpoint $R \in \{\bar{R}_b, R_b^L\}$, hold fixed the other prices and continuation marginal values. The maintained interior active-region conditions used below hold throughout the interval between the two regulated borrowing levels at the $R_{b,0} = R_b^L$ endpoint. Under the proportional limit (39), actual aggregate interbank borrowing under the two rules is

$$\begin{aligned} IB_0^{\phi^l}|_R &= \phi^l(R) IB_0^{DE}|_R = IB_0^{DE}|_R, \\ IB_0^{\phi^*}|_R &= \phi^*(R) IB_0^{DE}|_R = IB_0^{CSP}|_R. \end{aligned} \tag{S139}$$

It follows from (36) that

$$\Delta IB_0^{\phi^l} - \Delta IB_0^{\phi^*} = \Delta IB_0^{DE} - \Delta IB_0^{CSP} > 0, \tag{S140}$$

where the strict inequality is Proposition 2.

We next establish how SB capital expenditure varies with interbank borrowing when deposits are endogenous. Interbank market clearing, symmetry, and the fact that n_0^{SB} is given imply

$$IB_0 = s_\varsigma \, ib_0^{SB} = s_\varsigma n_0^{SB} \psi_{ib,0}^{SB}. \tag{S141}$$

At a fixed policy rate R, the household deposit-demand schedule (16) can be inverted as

$$R_{d,0}^{SB} = R\left[1 + \xi(\eta^{SB} - 1)(\psi_{d,0}^{SB})^{\eta^{SB}-1}\right], \qquad \frac{\partial R_{d,0}^{SB}}{\partial \psi_{d,0}^{SB}} = R\xi(\eta^{SB} - 1)^2(\psi_{d,0}^{SB})^{\eta^{SB}-2} > 0. \tag{S142}$$

From the definition of the expected marginal value of deposits, holding the other prices and continuation marginal values fixed,

$$\frac{\partial \mu_{d,0}^{SB}}{\partial \psi_{d,0}^{SB}} = -E_0\left[\Omega_1^{SB}\right] \frac{\partial R_{d,0}^{SB}}{\partial \psi_{d,0}^{SB}} < 0. \tag{S143}$$

In the active region, the SB incentive constraint binds. Allowing $\mu_{d,0}^{SB}$ to vary with the endogenous deposit rate, it is

$$\mu_{e,0}^{SB} + \mu_{d,0}^{SB}(\psi_{d,0}^{SB})\psi_{d,0}^{SB} + \mu_{ib,0}^{SB}\psi_{ib,0}^{SB} = \theta\left(1 + \psi_{d,0}^{SB} + \omega\psi_{ib,0}^{SB}\right). \tag{S144}$$

Let $\varpi_0^{SB} > 0$ be the multiplier on this incentive constraint and let $\varpi_{\phi,0}^{SB} \geq 0$ be the multiplier on the upper limit on SB interbank borrowing. The price-taking first-order conditions for deposits and interbank borrowing are

$$(1 + \varpi_0^{SB})\mu_{d,0}^{SB} = \varpi_0^{SB}\theta, \tag{S145}$$

$$(1 + \varpi_0^{SB})\mu_{ib,0}^{SB} = \varpi_0^{SB}\theta\omega + \varpi_{\phi,0}^{SB}. \tag{S146}$$

Consequently,

$$\mu_{ib,0}^{SB} = \omega\mu_{d,0}^{SB} + \frac{\varpi_{\phi,0}^{SB}}{1 + \varpi_0^{SB}} \geq \omega\mu_{d,0}^{SB}, \tag{S147}$$

with equality when the limit is slack. Differentiating (S144) with respect to $\psi^{SB}_{ib,0}$, while holding the other prices and continuation marginal values fixed, gives

$$\left[\theta - \mu^{SB}_{d,0} - \psi^{SB}_{d,0}\frac{\partial \mu^{SB}_{d,0}}{\partial \psi^{SB}_{d,0}}\right]\frac{\partial \psi^{SB}_{d,0}}{\partial \psi^{SB}_{ib,0}} = -\left(\theta\omega - \mu^{SB}_{ib,0}\right). \tag{S148}$$

The maintained active-region conditions imply $\theta > \mu^{SB}_{d,0}$ and $\theta\omega > \mu^{SB}_{ib,0}$. Together with (S143), the denominator in (S148) is strictly positive. Moreover,

$$\begin{aligned}\omega\left[\theta - \mu^{SB}_{d,0} - \psi^{SB}_{d,0}\frac{\partial \mu^{SB}_{d,0}}{\partial \psi^{SB}_{d,0}}\right] - \left(\theta\omega - \mu^{SB}_{ib,0}\right)& \\ = \mu^{SB}_{ib,0} - \omega\mu^{SB}_{d,0} - \omega\psi^{SB}_{d,0}\frac{\partial \mu^{SB}_{d,0}}{\partial \psi^{SB}_{d,0}} > 0,&\end{aligned} \tag{S149}$$

where the last inequality follows from (S147), $\psi^{SB}_{d,0} > 0$, and (S143). Therefore,

$$0 < -\frac{\partial \psi^{SB}_{d,0}}{\partial \psi^{SB}_{ib,0}} = \frac{\theta\omega - \mu^{SB}_{ib,0}}{\theta - \mu^{SB}_{d,0} - \psi^{SB}_{d,0}(\partial \mu^{SB}_{d,0}/\partial \psi^{SB}_{d,0})} < \omega. \tag{S150}$$

Dividing the SB balance sheet by given net worth yields

$$\frac{Q_0 k^{SB}_0}{n^{SB}_0} = 1 - \kappa - r_{b,0}(\tau - \kappa) + (1 - \rho r_{b,0})\psi^{SB}_{d,0} + \psi^{SB}_{ib,0}. \tag{S151}$$

Using (S150), $0 < \omega \leq 1$, and $0 \leq \rho r_{b,0} < 1$,

$$\begin{aligned}\frac{\partial}{\partial \psi^{SB}_{ib,0}}\left(\frac{Q_0 k^{SB}_0}{n^{SB}_0}\right) &= 1 + (1 - \rho r_{b,0})\frac{\partial \psi^{SB}_{d,0}}{\partial \psi^{SB}_{ib,0}} \\ &> 1 - \omega(1 - \rho r_{b,0}) \geq 0.\end{aligned} \tag{S152}$$

Thus SB capital expenditure is strictly increasing in individual and aggregate interbank borrowing, even though additional interbank borrowing partially crowds out deposits.

When $R_{b,0} = \bar{R}_b$, Proposition 2 gives the common allocation $IB^{\phi^l}_0|_{\bar{R}_b} = IB^{\phi^*}_0|_{\bar{R}_b}$. In the $R_{b,0} = R^L_b$ case, the same proposition and (S140) give $IB^{\phi^l}_0|_{R^L_b} > IB^{\phi^*}_0|_{R^L_b}$. Applying the strict monotonicity in (S152) at $R_{b,0} = R^L_b$, while noting equality at $R_{b,0} = \bar{R}_b$, yields

$$\Delta\left(Q_0 k^{SB}_0\right)^{\phi^l} > \Delta\left(Q_0 k^{SB}_0\right)^{\phi^*}. \tag{S153}$$

This proves (40).

It remains to establish the LB comparison. Since aggregate capital supply is fixed and the simple model has no direct household capital holdings,

$$K^{LB}_0 = \bar{K} - K^{SB}_0. \tag{S154}$$

The strict SB expenditure ordering in the $R_{b,0} = R^L_b$ case implies $K^{SB,\phi^l}_0 > K^{SB,\phi^*}_0$, and therefore $K^{LB,\phi^l}_0 < K^{LB,\phi^*}_0$. For a representative LB, symmetry gives $k^{LB}_0 = K^{LB}_0/[s(1-\varsigma)]$, and its capital

expenditure is strictly increasing in aggregate LB capital because

$$\frac{\partial}{\partial K_0^{LB}}\left[(Q_0+\alpha^{LB}K_0^{LB})k_0^{LB}\right]=\frac{Q_0+2\alpha^{LB}K_0^{LB}}{s(1-\varsigma)}>0. \tag{S155}$$

The two regulatory rules coincide when $R_{b,0}=\bar{R}_b$, whereas the looser rule leaves LBs with strictly less capital when $R_{b,0}=R_b^L$. Hence,

$$\Delta\left[(Q_0+\alpha^{LB}K_0^{LB})k_0^{LB}\right]^{\phi^l}<\Delta\left[(Q_0+\alpha^{LB}K_0^{LB})k_0^{LB}\right]^{\phi^*}. \tag{S156}$$

□

Proof of Proposition 4. By the definitions of the two regulatory rules in (39),

$$IB_0^{\phi^l}=IB_0^{DE}|_{R_b^L},\qquad IB_0^{\phi^*}=IB_0^{CSP}|_{R_b^L}. \tag{S157}$$

When $R_{b,0}=\bar{R}_b$, decentralized and planner borrowing coincide. Hence Proposition 2 implies

$$\begin{aligned}IB_0^{\phi^l}-IB_0^{\phi^*}&=\left[IB_0^{DE}|_{R_b^L}-IB_0^{DE}|_{\bar{R}_b}\right]-\left[IB_0^{CSP}|_{R_b^L}-IB_0^{CSP}|_{\bar{R}_b}\right]\\&=\Delta IB_0^{DE}-\Delta IB_0^{CSP}>0.\end{aligned} \tag{S158}$$

Lemma S3 incorporates the endogenous response of Q_1^* and, under the strict uniform regularity condition maintained there, establishes

$$\frac{du^{SB}}{dIB_0}<0 \tag{S159}$$

throughout the interval between the two borrowing levels in (S157). Combining (S158) and (S159) gives

$$u^{SB,\phi^l}-u^{SB,\phi^*}=\int_{IB_0^{\phi^*}}^{IB_0^{\phi^l}}\frac{du^{SB}}{dIB_0}\,dIB_0<0. \tag{S160}$$

For the sufficiently low realizations of Z_1 specified in the proposition, run risk is active under the looser regime, so

$$u^{SB,\phi^l}<1. \tag{S161}$$

Recall that

$$P(u^{SB})=\left[1-\min\{u^{SB},1\}\right]^{\delta_p} \tag{S162}$$

is weakly decreasing in u^{SB} and strictly decreasing whenever $u^{SB}<1$. Therefore,

$$P^{\phi^l}>P^{\phi^*}. \tag{S163}$$

□

Appendix D. Technical Details of the Quantitative Model

A. *Additional details for the environment in Section V*

Section V in the main text provides a high-level description of the rich quantitative model and emphasizes the key frictions. This appendix collects the formal definitions and derivations that underpin that discussion (reserve-management timing, the household problem, and the bankers' recursive formulation), using the same notation as in Section V.

A.1. *Aggregate shock processes.* Productivity follows a mean-reverting process driven by the one-time adverse innovation specified below, while the gross policy rate follows a stationary AR(1) process:

$$Z_{t+1} - Z = \rho_z \left(Z_t - Z\right) + \epsilon_{z,t+1}, \tag{S164}$$

$$R_{b,t+1} - R_b^{ss} = \rho_{R_b} \left(R_{b,t} - R_b^{ss}\right) + \epsilon_{R_b,t+1}, \tag{S165}$$

where Z and R_b^{ss} denote their steady-state levels. In the policy experiment, $\epsilon_{R_b,t}$ is the one-time unexpected policy innovation at the impact date. The impact innovation lowers the net policy rate $r_{b,t} = R_{b,t} - 1$ by 50%, from 1.15% to 0.575%, which is a decline of 0.575 percentage points, or approximately 0.58 percentage points (58 basis points). Until the adverse productivity shock arrives, the policy rate follows its mean-reverting path. Conditional on no previous productivity shock, a one-time innovation $\epsilon_{z,T_Z} = -0.025Z$ arrives from period 7 onward with probability $h = 0.081$ in each period and can occur only once; before and after that first arrival, $\epsilon_{z,t} = 0$. Once the productivity shock arrives, the conditional path sets the policy rate at R_b^{ss}, and productivity subsequently mean-reverts according to ρ_z. Accordingly, the model does not separately calibrate a continuous-innovation volatility. The variable Z_{t+1} is the exogenous per-unit return component of capital; the total gross capital return remains the endogenous object in (S169).

A.2. *Technology and heterogeneous intermediation efficiency.* There are two goods: a nondurable consumption good and capital. Each agent of type j—where $j \in \{LB, SB, h\}$ denotes an LB, an SB, or the household—uses both goods as inputs to produce output and new capital. If k_t^j units of capital are employed in period $t+1$, the agent receives $Z_{t+1}k_t^j$ units of output in period $t+1$ plus undepreciated capital, where Z_{t+1} is an aggregate productivity shock.

To capture heterogeneity in screening and credit allocation efficiency, we assume that each type faces a different capital-management cost when allocating capital. This cost is paid directly by the agent and is not rebated to the household. The cost function is

$$F^j(k_t^j; K_t^j) = \alpha^j K_t^j k_t^j, \tag{S166}$$

where $\alpha^j \geq 0$ and K_t^j is aggregate capital managed by type j. Each atomistic agent takes aggregate K_t^j as given, so the marginal management cost entering its capital decision is $\alpha^j K_t^j$, and its expenditure per unit of capital is $Q_t + \alpha^j K_t^j$. We normalize SBs to be the most efficient and households to be the least efficient:

$$\alpha^{SB} = 0 < \alpha^{LB} < \alpha^h. \tag{S167}$$

For simplicity, capital does not depreciate, and aggregate capital is fixed at $\bar{K} = 1$:

$$K^{LB} + K^{SB} + K^h = \bar{K} = 1, \tag{S168}$$

where K^{LB}, K^{SB}, and K^h denote aggregate capital held by LBs, SBs, and households. The (gross) return to capital for a type-j agent is

$$R_{k,t+1}^j = \frac{Q_{t+1} + Z_{t+1}}{Q_t + \alpha^j K_t^j}, \tag{S169}$$

where Q_t is the relative price of capital.

A.3. *Reserve requirement and reserve-management cost.* As in the simple model, we represent reserve-management costs in reduced form. For a bank of type $j \in \{LB, SB\}$, the expected net reserve-management need is

$$x_t^j = \tau n_t^j + \rho d_t^j - a_t^j, \tag{S170}$$

where $\rho d_t^j - a_t^j$ is the expected net reserve gap associated with the reserve requirement and τn_t^j captures an additional component of reserve-management needs proportional to bank net worth. The associated reserve-management cost is

$$\chi(x_t^j) = r_{b,t} x_t^j = r_{b,t}\big(\tau n_t^j + \rho d_t^j - a_t^j\big), \qquad r_{b,t} = R_{b,t} - 1, \tag{S171}$$

which corresponds to (19). Appendix C.A provides a detailed analysis of this reduced-form cost and its insurance interpretation.

A.4. *The Household's Problem.* There is a representative household with a unit measure of members. A fraction s are bankers and $1 - s$ are workers. Among bankers, a fraction ς manages SBs and $1 - \varsigma$ manages LBs. The household receives an endowment W each period, and there is full consumption insurance within the household. Each banker of type j survives to the next period with probability σ^j and exits with probability $1 - \sigma^j$. Upon exit, the banker transfers residual net worth to the household as dividends. Exiting bankers are replaced by workers so that the measure of bankers of each type is constant.

New bankers receive a one-time individual startup transfer w^j from the household, where

$$w^j = \frac{\zeta}{(1 - \sigma^j)s}.$$

Deposits in both LBs and SBs are fully guaranteed by the government. To capture the segmented deposit market, households incur a convex cost when depositing into SBs:

$$f(D_t^{SB}) = \frac{\xi(\eta^{SB}-1)}{\eta^{SB}}\left(\frac{D_t^{SB}}{N_t^{SB}}\right)^{\eta^{SB}} N_t^{SB}, \qquad \eta^{SB}>1,\ \xi>0,$$

where D_t^{SB} and N_t^{SB} denote aggregate SB deposits and net worth.

The household chooses consumption and saving, and portfolio allocation among bank deposits, direct capital holdings, and foreign government bonds. Let C_t denote consumption, B_t foreign bond holdings, and K_t^h household capital, and let R denote the gross return on foreign bonds. The household chooses $\{C_t, D_t^{LB}, D_t^{SB}, B_t, K_t^h\}_{t\geq 0}$ to maximize

$$E_0\sum_{t=0}^{\infty}\beta^t \log C_t$$

subject to the budget constraint

$$\begin{aligned} &C_t + \sum_{j\in\{SB,LB\}} D_t^j + f(D_t^{SB}) + \zeta + B_t + g(B_t) + (Q_t + \alpha^h K_t^h)K_t^h \\ &= W + \sum_{j\in\{SB,LB\}} R_{d,t-1}^j D_{t-1}^j + (Z_t + Q_t)K_{t-1}^h + \Pi_t + RB_{t-1} + T_t, \end{aligned}$$

where $g(B_t) \equiv \frac{\upsilon}{2}B_t^2$ is a convex adjustment cost for foreign bond holdings, Π_t are dividends from exiting bankers, and T_t is the transfer from the public sector. The household takes aggregate K_t^h as given when choosing its own capital holdings, so the marginal capital expenditure entering its Euler equation is $Q_t + \alpha^h K_t^h$.

The household first-order conditions are

$$(R_{d,t}^{LB})^{-1} = E_t\Lambda_{t,t+1}, \tag{S172}$$

$$\big(1 + f'(D_t^{SB})\big)(R_{d,t}^{SB})^{-1} = E_t\Lambda_{t,t+1}, \tag{S173}$$

$$\big(1 + g'(B_t)\big)R^{-1} = E_t\Lambda_{t,t+1}, \tag{S174}$$

$$1 = E_t\Big(\Lambda_{t,t+1}R_{k,t+1}^h\Big), \tag{S175}$$

where the household stochastic discount factor is $\Lambda_{t,t+1} \equiv \beta\frac{C_t}{C_{t+1}}$. The function $f(D_t^{SB})$, the transaction cost of depositing into SBs, follows the same functional form as in (8). Π_t is the total dividend payout from the exiting bankers, B_t denotes foreign bond holdings, and $g(B_t) \equiv \frac{\upsilon}{2}B_t^2$ is a reduced-form adjustment cost.

Combining the deposit first-order conditions (S172)–(S173) with the bond first-order condition (S174), we obtain the household's non-arbitrage conditions between SB and LB deposits and between LB deposits and foreign bonds

$$\frac{R_{d,t}^{SB} - R_{d,t}^{LB}}{R_{d,t}^{LB}} = \xi(\eta^{SB}-1)\left(\frac{D_t^{SB}}{N_t^{SB}}\right)^{\eta^{SB}-1} \tag{S176}$$

and

$$R_{d,t}^{LB} = \frac{R}{1 + g'(B_t)}, \tag{S177}$$

To allow for anticipated (but potentially unrealized) systemic events, agents at t know the law governing next-period productivity and run risk. Let P_{t+1} denote the state-contingent run probability evaluated after Z_{t+1} and the other period-$t+1$ state variables are realized. It is a conditional probability, not the zero-one realization of the run itself. Agents integrate P_{t+1} over the next-period state distribution when making decisions at t. Let asterisks denote allocations when the run is realized. The household capital Euler equation (S175) can then be written as

$$1 = E_{R_b,Z}\left[(1 - P_{t+1})\Lambda_{t,t+1}\left(\frac{Q_{t+1} + Z_{t+1}}{Q_t + \alpha^h K_t^h}\right) + P_{t+1}\Lambda_{t,t+1}^*\left(\frac{Q_{t+1}^* + Z_{t+1}}{Q_t + \alpha^h K_t^h}\right)\right]. \tag{S178}$$

A.5. *Bankers: value functions and net worth dynamics under run risk.* Bankers act on behalf of the household and face an exit probability $1 - \sigma^j$. Since bankers are financially constrained, they optimally delay dividend payouts until exit. Let V_t^j denote the value of a continuing banker of type j at the end of period t. The recursive formulation is

$$V_t^j = \max E_t\Big[\Lambda_{t,t+1}\big((1 - \sigma^j)n_{t+1}^j + \sigma^j V_{t+1}^j\big)\Big] = \max E_t\Big[\Omega_{t+1}^j n_{t+1}^j\Big], \tag{S179}$$

where

$$\Omega_{t+1}^j = \Lambda_{t,t+1}\left(1 - \sigma^j + \sigma^j \frac{V_{t+1}^j}{n_{t+1}^j}\right) \tag{S180}$$

is the banker stochastic discount factor.

We focus on runs on SBs only. The value function can be written as a weighted average of no-run and run values:

$$V_t^j = \max E_{R_b,Z}\Big[(1 - P_{t+1})\Omega_{t+1}^j n_{t+1}^j + P_{t+1}\Omega_{t+1}^{j*} n_{t+1}^{j*}\Big], \tag{S181}$$

where $\Omega_{t+1}^{j*} = \Lambda_{t,t+1}^*\left(1 - \sigma^j + \sigma^j \frac{V_{t+1}^{j*}}{n_{t+1}^{j*}}\right)$. The evolution of the banker's net worth is

$$n_t^j = a_{t-1}^j + R_{k,t}^j(Q_{t-1} + \alpha^j K_{t-1}^j)k_{t-1}^j - R_{ib,t-1} ib_{t-1}^j - R_{d,t-1}^j d_{t-1}^j. \tag{S182}$$

The flow-of-funds constraint is

$$(Q_t + \alpha^j K_t^j)k_t^j = n_t^j + ib_t^j + d_t^j - a_t^j - \chi(x_t^j). \tag{S183}$$

In the interbank market, creditors restrict funding so that the banker's diversion payoff does not exceed franchise value, with the pledgeability of interbank positions captured by ω and γ in the following incentive constraint:

$$\begin{aligned} &\theta\big[(Q_t + \alpha^j K_t^j)k_t^j + a_t^j + \chi(x_t^j) - (1 - \omega)ib_t^j\big] \le V_t^j, \text{ if } ib_t^j > 0, \\ &\theta\big[(Q_t + \alpha^j K_t^j)k_t^j + a_t^j + \chi(x_t^j) + \gamma(-ib_t^j)\big] \le V_t^j, \text{ if } ib_t^j < 0, \end{aligned} \tag{S184}$$

where V_t^j is the banker's franchise value. We also impose a liquidity constraint

$$a_t^j \geq \kappa n_t^j, \tag{S185}$$

where $\kappa > 0$. This liquidity requirement, proportional to bank net worth, binds in equilibrium.

The banker solves (S181) by choosing $(a_t^j, k_t^j, ib_t^j, d_t^j)$ subject to the budget constraint (S183), the incentive constraint (S184), and the liquidity constraint (S185).

A.6. *Central bank transfers and deposit guarantees.* The central bank is owned by the household. It issues reserves to both types of banks and makes interest and principal payments on previously issued reserves. It also collects insurance premiums from banks to cover reserve shortfalls. In the absence of bank runs, it rebates its net receipts to the household as a lump-sum transfer

$$T_t = \sum_{j\in\{LB,SB\}} \left[a_t^j - a_{t-1}^j + \chi(x_t^j)\right].$$

In the event of an SB run, the government additionally taxes households to honor deposit guarantees. The transfer becomes

$$T_t^* = \sum_{j\in\{LB,SB\}} \left[a_t^j - a_{t-1}^j + \chi(x_t^j)\right] - (1-u_t^{SB})R_{d,t-1}^{SB} D_{t-1}^{SB},$$

where u_t^{SB} is the recovery rate during a run (defined in Appendix D.C). This expression records the fiscal cost of the run-state deposit guarantee. It is distinct from the SRISK measure defined in Section V.A, which is the expected SB net worth shortfall.

B. *Characterization of Banks' Problem*

From (19), (S183), (S181), (S180) and (S182), we get

$$\begin{aligned}
\frac{V_t^j}{n_t^j} &= E_t(\Omega_{t+1}^j \frac{n_{t+1}^j}{n_t^j}) \\
&= E_t\{\Omega_{t+1}^j[\big(1 - R_{k,t+1}^j(1-r_{b,t})\big)\frac{a_t^j}{n_t^j} + (R_{k,t+1}^j(1-\rho r_{b,t}) - R_{d,t}^j)\frac{d_t^j}{n_t^j} \\
&\quad + (R_{k,t+1}^j - R_{ib,t})\frac{ib_t^j}{n_t^j} + R_{k,t+1}^j(1-r_{b,t}\tau)]\}
\end{aligned} \tag{S186}$$

$R_{k,t+1}^j$, $R_{d,t}^j$, and $R_{ib,t}$ are the return on capital and the costs of deposits and interbank borrowing, respectively. The term $R_{k,t+1}^j(1-r_{b,t}\tau)$ is the effective return to non-financial loans funded by net worth, net of the fixed reserve-insurance cost. The coefficient $1 - R_{k,t+1}^j(1-r_{b,t})$ is the effective marginal return from holding reserves, and $R_{k,t+1}^j(1-\rho r_{b,t}) - R_{d,t}^j$ is the effective net return from deposit funding. Finally, $R_{k,t+1}^j - R_{ib,t}$ is the effective net return from interbank borrowing. Since interbank borrowing is not subject to reserve requirements, unlike deposits, it does not carry the reserve cost.

We can express the value per unit of net worth as

$$\frac{V_t^j}{n_t^j} = \mu_{e,t}^j + \mu_{d,t}^j \psi_{d,t}^j + \mu_{ib,t}^j \psi_{ib,t}^j,$$

where

$$\mu_{e,t}^j = E_t\{\Omega_{t+1}^j[\kappa + R_{k,t+1}^j(1 - \kappa - r_{b,t}(\tau - \kappa))]\} \tag{S187}$$

$$\mu_{d,t}^j = E_t\{\Omega_{t+1}^j[R_{k,t+1}^j(1 - \rho r_{b,t}) - R_{d,t}^j]\} \tag{S188}$$

$$\mu_{ib,t}^j = E_t\{\Omega_{t+1}^j[R_{k,t+1}^j - R_{ib,t}]\} \tag{S189}$$

$$[\psi_{ib,t}^j, \psi_{d,t}^j] = \frac{[ib_t^j, d_t^j]}{n_t^j} \tag{S190}$$

$\psi_{d,t}^j$ and $\psi_{ib,t}^j$ are deposits and interbank funding per unit of net worth. It is easy to see that $\frac{V_t^j}{n_t^j}$ depends only on aggregate variables for each bank type and not on individual bank variables (such as net worth).

The incentive constraint in Equation (S184) can be written as

$$V_t^j \geq \theta[n_t^j + d_t^j + \omega ib_t^j \cdot I_{ib_t^j>0} + (1-\gamma) ib_t^j \cdot I_{ib_t^j<0}] \tag{S191}$$

where $I_{ib_t^j>0} = 1$ if $ib_t^j > 0$ and $I_{ib_t^j>0} = 0$ otherwise (and $I_{ib_t^j<0} = 1$ if $ib_t^j < 0$ and $I_{ib_t^j<0} = 0$ otherwise).

Then, a bank's problem becomes

$$\Psi = \max_{\psi_{d,t}, \psi_{ib,t}} (\mu_{e,t} + \mu_{d,t}\psi_{d,t} + \mu_{ib,t}\psi_{ib,t}) \tag{S192}$$

subject to

$$\theta[1 + \psi_{d,t} + \omega\psi_{ib,t} \cdot I_{ib_t>0} + (1-\gamma)\psi_{ib,t} \cdot I_{ib_t<0}] \leq \mu_{e,t} + \mu_{d,t}\psi_{d,t} + \mu_{ib,t}\psi_{ib,t}$$

$$0 \leq \psi_{d,t} \leq \overline{\psi}_{d,t}$$

$$(1 - \rho r_{b,t})\psi_{d,t} + \psi_{ib,t} + [1 - \kappa - r_{b,t}(\tau - \kappa)] \geq 0$$

where $\overline{\psi}_{d,t}$ is the maximum deposit-to-net-worth ratio implied by the deposit-rate ceiling:

$$\overline{\psi}_{d,t} \equiv \left(\frac{\overline{R}_{d,t} - R_{d,t}^{LB}}{\xi(\eta^{SB} - 1) R_{d,t}^{LB}} \right)^{\frac{1}{\eta^{SB}-1}}$$

Let ϖ_t, $\varpi_{k,t}$, and $\varpi_{d,t}$ denote the Lagrange multipliers on the incentive constraint, the capital non-negativity constraint, and the deposit-rate ceiling constraint, respectively. The Lagrangian is

$$\begin{aligned}\mathscr{L} &= (1+\varpi_t)(\mu_{e,t}+\mu_{d,t}\psi_{d,t}+\mu_{ib,t}\psi_{ib,t})\\ &\quad -\varpi_t\theta[1+\psi_{d,t}+\omega\psi_{ib,t}\cdot I_{ib_t>0}+(1-\gamma)\psi_{ib,t}\cdot I_{ib_t<0}]\\ &\quad +\varpi_{k,t}\big[(1-\rho r_{b,t})\psi_{d,t}+\psi_{ib,t}+1-\kappa-r_{b,t}(\tau-\kappa)\big]-\varpi_{d,t}(\psi_{d,t}-\overline{\psi}_{d,t})\end{aligned}$$

For the case of $\psi_{ib,t}\geq 0$, it is easy to check that capital investment is positive, so $\varpi_{k,t}=0$. Intuitively, SBs get funds from deposits and interbank borrowing in order to invest in capital and earn the return spread. If capital is not profitable, then SBs will not operate actively.

The first-order conditions are

$$\begin{gathered}(1+\varpi_t)\mu_{ib,t}\leq\varpi_t\theta\omega\\ where = \ \ holds\ if\ \psi_{ib,t}>0, and <\ implies\ \psi_{ib,t}=0.\end{gathered}\tag{S193}$$

$$\begin{gathered}(1+\varpi_t)\mu_{d,t}\leq\varpi_t\theta+\varpi_{d,t}\\ where = \ \ holds\ if\ \psi_{d,t}>0, and <\ implies\ \psi_{d,t}=0.\end{gathered}\tag{S194}$$

Thus, for the case of $\psi_{d,t}>0$, we learn

$$\begin{aligned}&\psi_{ib,t}>0,\ \ if\ \mu_{ib,t}=\omega\left(\mu_{d,t}-\frac{\varpi_{d,t}}{1+\varpi_t}\right),\\ &\psi_{ib,t}=0,\ \ if\ \mu_{ib,t}<\omega\left(\mu_{d,t}-\frac{\varpi_{d,t}}{1+\varpi_t}\right).\end{aligned}\tag{S195}$$

In the special case in which the deposit rate ceiling is not binding (or in the absence of a deposit rate ceiling), the above conditions become

$$\begin{aligned}&\psi_{ib,t}>0,\ \ if\ \frac{\mu_{ib,t}}{\mu_{d,t}}=\omega;\\ &\psi_{ib,t}=0,\ \ if\ \frac{\mu_{ib,t}}{\mu_{d,t}}<\omega.\end{aligned}$$

Therefore, when $\mu_{ib,t}=\omega\left(\mu_{d,t}-\frac{\varpi_{d,t}}{1+\varpi_t}\right)<\omega\mu_{d,t}$, $\psi_{ib,t}>0$ when the deposit rate ceiling is binding, but $\psi_{ib,t}=0$ without deposit rate ceiling.

For the case of $ib\leq 0$ and $\varpi_{d,t}=0$,[23] the first-order conditions are

$$\begin{gathered}(1+\varpi_t)\mu_{ib,t}+\varpi_{k,t}\geq\varpi_t\theta(1-\gamma)\\ where = holds\ if\ \psi_{ib,t}<0, and >\ implies\ \psi_{ib,t}=0.\end{gathered}\tag{S196}$$

$$\begin{gathered}(1+\varpi_t)\mu_{d,t}+\varpi_{k,t}(1-r_{b,t}\rho)\leq\varpi_t\theta\\ where = holds\ if\ \psi_{d,t}>0, and <\ implies\ \psi_{d,t}=0.\end{gathered}\tag{S197}$$

[23]For LBs, the deposit rate ceiling is always nonbinding. Thus, we only consider the case $\varpi_{d,t}=0$.

Thus for the case of $\psi_{d,t} > 0$ and $\psi_{ib,t} < 0$, we learn

$$\begin{aligned} &\psi_{k,t} > 0, \ \textit{if} \ \frac{\mu_{ib,t}}{\mu_{d,t}} = 1-\gamma; \\ &\psi_{k,t} = 0 \ \textit{and} \ \varpi_{k,t} > 0, \ \textit{if} \ \frac{\mu_{ib,t}}{\mu_{d,t}} < 1-\gamma. \end{aligned} \tag{S198}$$

where $\psi_{k,t} = \frac{(Q_t+\alpha K_t)k_t}{n_t}$.

Based on market clearing for interbank loans and the assumption that banks operate actively[24], we have only the following possible patterns of equilibrium in the neighborhood of the steady state:

(A) Perfect specialization with active interbank market: $\psi_{k,t}^{LB} = 0, \psi_{d,t}^{SB} = 0, \psi_{ib,t}^{SB} > 0 > \psi_{ib,t}^{LB}$

(B) Perfect specialization by LBs with an active interbank market: $\psi_{k,t}^{LB} = 0, \psi_{d,t}^{SB} > 0, \psi_{ib,t}^{SB} > 0 > \psi_{ib,t}^{LB}$

(C) Perfect specialization by SBs with an active interbank market: $\psi_{k,t}^{LB} > 0, \psi_{d,t}^{SB} = 0, \psi_{ib,t}^{SB} > 0 > \psi_{ib,t}^{LB}$

(D) Imperfect specialization with an active interbank market: $\psi_{k,t}^{LB} > 0, \psi_{d,t}^{SB} > 0, \psi_{ib,t}^{SB} > 0 > \psi_{ib,t}^{LB}$

(E) Inactive interbank market: $\psi_{k,t}^{LB} > 0, \psi_{d,t}^{SB} > 0, \psi_{ib,t}^{SB} = 0 = \psi_{ib,t}^{LB}$.

C. *Conditions for a Bank Run Equilibrium*

We model SB runs as a rollover panic. A self-fulfilling bank run equilibrium exists if an individual lender correctly believes that when all other lenders do not roll over their lending, the lender would lose money by rolling over. In our model, if one LB believes that all other LBs will not roll over their interbank lending because SBs cannot fulfill their debt obligations, then there may be a run on interbank funding. This condition is met if SBs' net worth goes to zero in the event of a run.

In a normal equilibrium where a run does not occur, SBs have sufficient assets to pay their promised obligations; in the run equilibrium, SBs are forced to liquidate, and the value of assets is below their promised obligations. Suppose the liquidation price of capital is Q^*, which is lower than the price Q at which capital trades normally, because of LBs' and the household's limited ability to absorb capital. Therefore, a run on the SB sector is possible if the liquidation value, $(Z_{t+1}+Q_{t+1}^*)K_t^{SB}+A_t^{SB}$, is smaller than their outstanding liabilities to interbank creditors, $R_{ib,t}IB_t$, and to depositors, $R_{d,t}^{SB}D_t^{SB}$. In this instance, the recovery rate in the event of an SB run, u_{t+1}^{SB}, is the ratio of $(Z_{t+1}+Q_{t+1}^*)K_t^{SB}+A_t^{SB}$ to $R_{ib,t}IB_t+R_{d,t}^{SB}D_t^{SB}$, and the condition for an SB run equilibrium to exist is that the recovery rate is less than unity, i.e.,

$$u_{t+1}^{SB} = \frac{(Z_{t+1}+Q_{t+1}^*)K_t^{SB}+A_t^{SB}}{R_{ib,t}IB_t+R_{d,t}^{SB}D_t^{SB}} < 1.$$

[24]Active operation means that banks have at least one liability or one asset other than reserves. For example, when $ib^{SB} = 0$, d^{SB} must be positive; otherwise, SBs do not operate actively.

D. *Aggregation and Equilibrium in the No-Run State with Anticipated Run Risk*

Given that the ratio of assets and liabilities to net worth is independent of individual bank-specific factors, we can aggregate across banks to obtain relations between total assets or liabilities and net worth for both LBs and SBs. For each individual variable of the two types of banks, we use the corresponding capital letter to denote its aggregate variable. Accordingly, for any individual variable l_t^j, the corresponding aggregate variable L_t^j is

$$L_t^j = \begin{cases} s\varsigma l_t^j & \text{if } j = SB \\ s\left(1-\varsigma\right) l_t^j & \text{if } j = LB \end{cases}$$

Let A_t^{SB} and A_t^{LB} be total reserves, D_t^{SB} and D_t^{LB} be total deposits, $\chi\left(X_t^{SB}\right)$ and $\chi\left(X_t^{LB}\right)$ be total reserve insurance costs, and $Q_t K_t^{SB}$ and $Q_t K_t^{LB}$ be total non-financial loans held by SBs and LBs, IB_t be total interbank funding, and N_t^{SB} and N_t^{LB} be total net worth in each respective banking sector. Then we have:

$$A_t^{SB} = \kappa N_t^{SB}, \tag{S199}$$

$$A_t^{LB} = \kappa N_t^{LB}, \tag{S200}$$

$$D_t^{SB} = \psi_{d,t}^{SB} N_t^{SB}, \tag{S201}$$

$$R_{d,t}^{LB} = \frac{R}{1+\upsilon B_t} \tag{S202}$$

$$R_{d,t}^{SB} = \lambda R_{d,t}^{LB} \tag{S203}$$

$$Q_t K_t^{SB} = N_t^{SB} + IB_t + D_t^{SB} - A_t^{SB} - \chi\left(X_t^{SB}\right), \tag{S204}$$

$$(Q_t + \alpha^{LB} K_t^{LB}) K_t^{LB} = N_t^{LB} - IB_t + D_t^{LB} - A_t^{LB} - \chi\left(X_t^{LB}\right), \tag{S205}$$

$$K_t^{LB} + K_t^{SB} + K_t^h = 1, \tag{S206}$$

$$E_t \Omega_{t+1}[R_{k,t+1}^{LB} - R_{ib,t}] = (1-\gamma) E_t \Omega_{t+1}[R_{k,t+1}^{LB}(1 - r_{b,t}\rho) - R_{d,t}^{LB}] \tag{S207}$$

Summing across both surviving and entering bankers yields the following expression for the evolution of N_t:

$$N_t^{SB} = \sigma^{SB}[A_{t-1}^{SB} + (Z_t + Q_t)K_{t-1}^{SB} - R_{ib,t-1} IB_{t-1} - R_{d,t-1}^{SB} D_{t-1}^{SB}] + W^{SB}, \tag{S208}$$

$$N_t^{LB} = \sigma^{LB}[A_{t-1}^{LB} + (Z_t + Q_t)K_{t-1}^{LB} + R_{ib,t-1} IB_{t-1} - R_{d,t-1}^{LB} D_{t-1}^{LB}] + W^{LB}, \tag{S209}$$

where $W^{SB} = (1-\sigma^{SB}) s\varsigma w^{SB}$ ($W^{LB} = (1-\sigma^{LB}) s(1-\varsigma) w^{LB}$) is the total endowment of entering SB (LB) bankers. The first term is the accumulated net worth of bankers that operated at $t-1$ and survived to t, which is equal to the product of the survival rate σ^j and the net earnings on bank assets. The total dividend to the household for exiting bankers at time t is given by

$$\Pi_t = \frac{N_t^{LB} - W^{LB}}{\sigma^{LB}}\left(1-\sigma^{LB}\right) + \frac{N_t^{SB} - W^{SB}}{\sigma^{SB}}\left(1-\sigma^{SB}\right),$$

and the total startup fund for the entering bankers is given by

$$\zeta = W^{LB} + W^{SB}.$$

We calculate net aggregate output, including the household endowment, as

$$Y_t = Z_t \bar{K} + W - \alpha^{LB} \left(K_t^{LB}\right)^2 - \alpha^h \left(K_t^h\right)^2 - f\left(D_t^{SB}\right) - g(B_t). \tag{S210}$$

As in the simple model, the household endowment is part of Y_t rather than a separate term in the aggregate resource constraint. Finally, the resource constraint is given by

$$C_t + B_t - B_{t-1} = Y_t + (R-1)\, B_{t-1}. \tag{S211}$$

where $B_t - B_{t-1}$ is the current account balance, and $Y_t + (R-1)\, B_{t-1}$ is gross national product.

The recursive competitive equilibrium in the no-run state with anticipated run risk consists of aggregate quantities,

$$(A_t^{SB}, A_t^{LB}, D_t^{SB}, D_t^{LB}, \chi(X_t^{SB}), \chi(X_t^{LB}), K_t^{SB}, K_t^{LB}, N_t^{SB}, N_t^{LB}, IB_t, Y_t, K_t^h, C_t, B_t)$$

prices

$$(Q_t, R_{d,t}^{SB}, R_{d,t}^{LB}, R_{ib,t})$$

as a function of the state variables $(A_{t-1}^j, D_{t-1}^j, K_{t-1}^j, IB_{t-1}, B_{t-1}, Z_t)_{j=LB,SB}$, which satisfy Equations (S199)-(S211), $(\text{S171})_{j=LB,SB}$, (S174), (S178), and $(\text{S184})_{j=LB,SB}$.

E. *Algorithms for a numerical solution*

We use the productivity shock Z with the deposit rate ceiling as an example; the computation for the policy-rate shock R_b is similar.

We define the ex-ante optimal values of surviving banks at time t:

$$\begin{aligned}
\bar{V}_t^{SB} &= [1 - \sigma^{SB} + \sigma^{SB}\theta(1 + \psi_{d,t}^{SB} + \omega\psi_{ib,t}^{SB})]\frac{N_t^{SB} - W^{SB}}{\sigma^{SB}} \\
&= \Omega_t^{SB}\frac{N_t^{SB} - W^{SB}}{\sigma^{SB}} \\
\bar{V}_t^{LB} &= [1 - \sigma^{LB} + \sigma^{LB}\theta(1 + \psi_{d,t}^{LB} + (1-\gamma)\psi_{ib,t}^{LB})]\frac{N_t^{LB} - W^{LB}}{\sigma^{LB}} \\
&= \Omega_t^{LB}\frac{N_t^{LB} - W^{LB}}{\sigma^{LB}}
\end{aligned}$$

Let the state of the economy if a run has not happened be denoted by $x = (N^{SB}, N^{LB}, Z, B)$, and the state in case a run has happened be denoted by $x^* = (0, N^{LB}, Z, B)$. We use iteration to approximate the functions

$$\{Q(x), C(x), \bar{V}^{SB}(x), \bar{V}^{LB}(x), \Gamma(x)\}$$

and

$$\{Q^*(x^*), C^*(x^*), \bar{V}^{*LB}(x^*), \Gamma^*(x^*)\}$$

where $\Gamma(x)$ and $\Gamma^*(x^*)$ are the laws determining the stochastic evolution of the state (see later).

The computational algorithm proceeds as follows:

(1) Determine a functional space to use for approximating equilibrium functions (we use piecewise linear approximation).

(2) Fix a grid of values for the states in the no-run case, G, and for the states in the run case, G^*.

(3) Set $i = 0$ and guess initial values for

$$NRF_{t,i} = \{Q(x), C(x), \bar{V}^{SB}(x), \bar{V}^{LB}(x), \Gamma(x)\}_{x\in G},$$
$$RF_{t,i} = \{Q^*(x^*), C^*(x^*), \bar{V}^{*LB}(x^*), \Gamma^*(x^*)\}_{x^*\in G^*}.$$

The guess of $\Gamma(x)$ involves guessing $\{P_{t,i}(x), N_{t,i}^{SB'}(x), N_{t,i}^{LB'}(x), N_{t,i}^{*LB'}(x), Z'(Z), B'(x)\}$, which implies

$$\Gamma_{t,i}(x) = \begin{cases} x_{t,i}^{NR'}(x) = (N_{t,i}^{SB'}(x), N_{t,i}^{LB'}(x), Z'(Z), B'(x)) & w.p. \quad 1 - P_{t,i}(x) \\ x_{t,i}^{R'}(x) = (0, N_{t,i}^{*LB'}(x), Z'(Z), B'(x)) & w.p. \quad P_{t,i}(x) \end{cases}$$

Similarly, the guess for $\Gamma^*(x^*)$ involves guessing $\{N_{t,i}^{\hat{L}B'}(x^*), Z'(Z), \hat{B}'(x^*)\}$, which implies $\Gamma_{t,i}^*(x^*) = ((1+\sigma^{SB})W^{SB}, N_{t,i}^{\hat{L}B'}(x^*), Z'(Z), \hat{B}'(x^*))$

(4) Iterate to find $NRF_{t,i+1}$ and $RF_{t,i+1}$ $(0 \le i < M = 10000)$ as follows:

- NO RUN SYSTEM At any point $x = (N_t^{SB}, N_t^{LB}, Z_t, B_t) \in G$, the system determining $\{\psi_{a,t}^{SB}, \psi_{d,t}^{SB}, \psi_{ib,t}^{SB}, \psi_{k,t}^{SB}, \psi_{\chi,t}^{SB}, \psi_{a,t}^{LB}, \psi_{d,t}^{LB}, \psi_{ib,t}^{LB}, \psi_{k,t}^{LB}, \psi_{\chi,t}^{LB}, Q_t, R_{d,t}^{SB}, R_{d,t}^{LB}, K_t^{SB}, K_t^{LB},$

$K_t^h, C_t, IB_t, D_t^{SB}, D_t^{LB}, A_t^{SB}, A_t^{LB}, Y_t\}$ is given by

$$\frac{1}{R_{d,t}^{LB}} = \beta[(1-P_i(x))\frac{C_t}{C_i(x_i^{'NR}(x))} + P_i(x)\frac{C_t}{C_i^*(x_i^{'R}(x))}]$$

$$1 = \beta[(1-P_i(x))\frac{C_t}{C_i(x_i^{'NR}(x))}\frac{Q_i(x_i^{'NR}(x)) + Z_{t+1}}{Q_t + \alpha^h K_t^h} + P_i(x)\frac{C_t}{C_i^*(x_i^{'R}(x))}\frac{Q_i^*(x_i^{'R}(x)) + Z_{t+1}}{Q_t + \alpha^h K_t^h}]$$

$$\psi_{a,t}^{SB} = \kappa$$

$$A_t^{SB} = \kappa N_t^{SB}$$

$$\psi_{a,t}^{LB} = \kappa$$

$$A_t^{LB} = \kappa N_t^{LB}$$

$$R_{d,t}^{LB} = \frac{R}{1+\upsilon B'(x)}$$

$$R_{d,t}^{SB} = \lambda R_{d,t}^{LB}$$

$$\psi_{d,t}^{SB} = \left(\frac{R_{d,t}^{SB} - R_{d,t}^{LB}}{\xi(\eta^{SB}-1)R_{d,t}^{LB}}\right)^{\frac{1}{\eta^{SB}-1}}$$

$$D_t^{SB} = \psi_{d,t}^{SB} N_t^{SB}$$

$$\theta(1 + \psi_{d,t}^{SB} + \omega\psi_{ib,t}^{SB})N_t^{SB} = \beta(1-P_i(x))\bar{V_i}^{SB}(x_i^{'NR}(x))$$

$$IB_t = \psi_{ib,t}^{SB} N_t^{SB}$$

$$\psi_{\chi,t}^{SB} = r_{b,t}(\tau + \rho\psi_{d,t}^{SB} - \psi_{a,t}^{SB})$$

$$\psi_{k,t}^{SB} = 1 + \psi_{ib,t}^{SB} + \psi_{d,t}^{SB} - \psi_{a,t}^{SB} - \psi_{\chi,t}^{SB}$$

$$Q_t K_t^{SB} = \psi_{k,t}^{SB} N_t^{SB}$$

$$\theta(1 + \psi_{d,t}^{LB} + (1-\gamma)\psi_{ib,t}^{LB})N_t^{LB} = \beta[(1-P_i(x))\bar{V_i}^{LB}(x_i^{'NR}(x)) + P_i(x)\bar{V_i}^{*LB}(x_i^{'R}(x))]$$

$$(\psi_{d,t}^{LB} + (1-\gamma)\psi_{ib,t}^{LB})N_t^{LB} = D_t^{LB} - (1-\gamma)IB_t$$

$$IB_t = -\psi_{ib,t}^{LB} N_t^{LB} > 0$$

$$\psi_{\chi,t}^{LB} = r_{b,t}(\tau + \rho\psi_{d,t}^{LB} - \psi_{a,t}^{LB})$$

$$(Q_t + \alpha^{LB} K_t^{LB})K_t^{LB} = N_t^{LB} + D_t^{LB} - IB_t - A_t^{LB} - \psi_{\chi,t}^{LB} N_t^{LB}$$

$$\psi_{k,t}^{LB} = \frac{(Q_t + \alpha^{LB} K_t^{LB})K_t^{LB}}{N_t^{LB}}$$

$$K_t^{SB} + K_t^{LB} + K_t^h = 1$$

$$Y_t = Z_t + W - \alpha^{LB}(K_t^{LB})^2 - \alpha^h(K_t^h)^2 - f(D_t^{SB}) - g(B'(x))$$

One can find $R_{ib,t}$ from

$$R_{ib,t} = \frac{E_i\{\tilde{\Omega}^{LB}(\Gamma_i(x))[\gamma\tilde{R}^{LB}_{k,t+1} + (1-\gamma)(R^{LB}_{d,t} + r_{b,t}\rho\tilde{R}^{LB}_{k,t+1})]\}}{E_i\{(1-P_i(x))\Omega^{LB}(x_i^{'NR}(x)) + P_i(x)\Omega^{*LB}(x_i^{'R}(x))u(x)\}}$$
$$= \frac{E_i\{\tilde{\Omega}^{LB}(\Gamma_i(x))[\gamma\frac{Z'(Z_t)+\tilde{Q}(\Gamma_i(x))}{Q_t+\alpha^{LB}K^{LB}_t} + (1-\gamma)(R^{LB}_{d,t} + r_{b,t}\rho\frac{Z'(Z_t)+\tilde{Q}(\Gamma_i(x))}{Q_t+\alpha^{LB}K^{LB}_t})]\}}{E_i\{(1-P_i(x))\Omega^{LB}(x_i^{'NR}(x)) + P_i(x)\Omega^{*LB}(x_i^{'R}(x))u(x)\}}$$

where

$$\tilde{\Omega}^{LB}(\Gamma_i(x)) = \begin{cases} \sigma^{LB}\dfrac{\bar{V}_i^{LB}(x_i^{'NR}(x))}{N_i^{'LB} - W^{LB}} & w.p. \qquad 1-P_i(x) \\ \sigma^{LB}\dfrac{\bar{V}_i^{*LB}(x_i^{'R}(x))}{N_i^{*'LB} - W^{LB}} & w.p. \qquad P_i(x) \end{cases}$$

and $B'(x)$ from:

$$B'(x) - RB(x) + C(x) - Y(x) = 0$$

and, finally, $\{\bar{V}_t^{SB}, \bar{V}_t^{LB}\}$ are given by

$$\bar{V}_t^{SB} = [1 - \sigma^{SB} + \theta\sigma^{SB}(1 + \psi^{SB}_{d,t} + \omega\psi^{SB}_{ib,t})]\frac{N_t^{SB} - W^{SB}}{\sigma^{SB}}$$
$$\bar{V}_t^{LB} = [1 - \sigma^{LB} + \theta\sigma^{LB}(1 + \psi^{LB}_{d,t} + (1-\gamma)\psi^{LB}_{ib,t})]\frac{N_t^{LB} - W^{LB}}{\sigma^{LB}}$$

where

$$N_t^{'SB} = \sigma^{SB}[A_t^{SB} + (Z'(Z_t) + Q(x_i^{'NR}(x)))K_t^{SB} - R_{ib,t}IB_t - R^{SB}_{d,t}D_t^{SB}] + W^{SB}$$
$$N_t^{'LB} = \sigma^{LB}[A_t^{LB} + (Z'(Z_t) + Q(x_i^{'NR}(x)))K_t^{LB} + R_{ib,t}IB_t - R^{LB}_{d,t}D_t^{LB}] + W^{LB}$$
$$N_t^{*'LB} = \sigma^{LB}[A_t^{LB} + (Z'(Z_t) + Q^*(x_i^{'R}(x)))K_t^{LB} + u(x)R_{ib,t}IB_t - R^{LB}_{d,t}D_t^{LB}] + W^{LB}$$
$$P_t(x) = [1 - \min\{1, \frac{(Z'(Z_t) + Q^*(x_i^{'R}(x)))K_t^{SB} + A_t^{SB}}{R_{ib,t}IB_t + R^{SB}_{d,t}D_t^{SB}}\}]^{\delta_p}$$

- RUN SYSTEM Analogously, at a point $x^* = (0, N_t^{LB}, Z_t, B_t) \in G^*$, the system determining $\{\psi^{*LB}_{a,t}, \psi^{*LB}_{d,t}, \psi^{*LB}_{k,t}, \psi^{*LB}_{\chi,t}, Q_t^*, K_t^{*LB}, K_t^{*h}, D_t^{*LB}, A_t^{*LB}, C_t^*, R^{*LB}_{d,t}, Y_t^*\}$ is given by

$$R_{d,t}^{*LB} = \frac{R}{1+\upsilon\hat{B}'}$$
$$1 = \beta\left[\frac{C_t^*}{C_i(x_i^*)}\frac{Q_i(x_i^*)+Z_{t+1}}{Q_t^*+\alpha^h K_t^{*h}}\right]$$
$$\psi_{a,t}^{*LB} = \kappa$$
$$A_t^{*LB} = \kappa N_t^{LB}$$
$$\theta(1+\psi_{d,t}^{*LB})N_t^{LB} = \beta\bar{V}_i^{LB}(x_i^*)$$
$$D_t^{*LB} = \psi_{d,t}^{*LB}N_t^{LB}$$
$$\psi_{\chi,t}^{*LB} = r_{b,t}(\tau+\rho\psi_{d,t}^{*LB}-\psi_{a,t}^{*LB})$$
$$(Q_t^*+\alpha^{LB}K_t^{*LB})K_t^{*LB} = N_t^{LB}+D_t^{*LB}-A_t^{*LB}-\psi_{\chi,t}^{*LB}N_t^{LB}$$
$$\psi_{k,t}^{*LB} = \frac{(Q_t^*+\alpha^{LB}K_t^{*LB})K_t^{*LB}}{N_t^{LB}}$$
$$K_t^{*LB}+K_t^{*h} = 1$$
$$Y_t^* = Z_t+W-\alpha^{LB}(K_t^{*LB})^2-\alpha^h(K_t^{*h})^2-g(\hat{B}')$$

and $\{\bar{V}_t^{*LB}, \hat{N}'^{LB}, \hat{B}'\}$ is given by

$$\bar{V}_t^{*LB} = [1-\sigma^{LB}+\theta\sigma^{LB}(1+\psi_{d,t}^{*LB})]\frac{N_t^{LB}-W^{LB}}{\sigma^{LB}}$$
$$\hat{N}'^{LB} = \sigma^{LB}[A_t^{LB}+(Z'(Z_t)+Q(\Gamma_{t,i}^*(x^*)))K_t^{*LB}-R_{d,t}^{*LB}D_t^{*LB}]+W^{LB}$$
$$\hat{B}'-RB_t+C_t^*-Y_t^* = 0$$

(5) Let $\widehat{NRF}_{t,i+1}$ and $\widehat{RF}_{t,i+1}$ denote the undamped functions newly obtained from the no-run and run systems. Define the difference between the $(i+1)$th candidate functions and the ith functions as $\Delta_{t,i+1}$. Iterate until $\Delta_{t,i+1} < 1\text{e}{-6}$; otherwise, set

$$NRF_{t,i+1} = (1-\alpha)NRF_{t,i}+\alpha\widehat{NRF}_{t,i+1},$$
$$RF_{t,i+1} = (1-\alpha)RF_{t,i}+\alpha\widehat{RF}_{t,i+1}$$

where $\alpha \in (0,1)$.

Table S7. Parameter Values

Parameter	Interpretation	Internal	Value
Households:			
β	Impatience	N	0.99
α^h	Households' capital management cost	Y	0.033
W	Household endowment	N	0.04
R	Quarterly foreign bond return	N	1.0101
υ	Households' foreign bond convex cost	N	0.03
LBs:			
κ	Liquidity constraint parameter	N	1.4
τ	Net-worth component of reserve-management needs	N	1.3
α^{LB}	LBs' capital management cost	Y	0.0058
σ^{LB}	LB bankers' survival probability	Y	0.98
θ	Bankers seizure rate	Y	0.15
W^{LB}	LB bankers' endowment	N	0.0003
γ	LB bankers' divertible proportion of interbank funding	Y	0.667
η^{LB}	Parameter for deposit transaction costs for LBs	N	1
SBs:			
ω	SB bankers' divertible proportion of interbank funding	N	1
ξ	Parameter for deposit demand function for SBs	Y	0.00035
σ^{SB}	SB bankers' survival probability	Y	0.93
W^{SB}	SB bankers' endowment	N	0.0003
α^{SB}	SBs' capital management cost	N	0
η^{SB}	Parameter for deposit transaction costs for SBs	N	1.5
Policy:			
r_b	Steady state policy net interest rate	N	0.0115
ρ_{R_b}	Serial correlation of R_b	N	0.95
λ	Annualized deposit rate ceiling ratio	N	1.0008
ρ	Required reserve ratio	N	0.2
Others:			
Z	Steady state productivity	Y	0.0161
δ_p	Power of the run probability function	N	0.5
h	Quarterly first-arrival hazard of the adverse productivity shock	N	0.081
ρ_z	Serial correlation of Z	N	0.95

Table S8. Targeted Moments in the Calibration

Moment	Empirical Value	Model Value
Annualized SBs' capital returns (%)	7.3	7.0
Annualized LBs' capital returns (%)	6.4	6.0
Annualized spread between interbank bond yield and policy rate (%)	0.8	1.0
Share of household's capital investment to non-financial institutions	0.2	0.2
LBs' ratio of deposit to total equity	9.7	9.9
Ratio of total assets between LBs and SBs	1.2	1.1
Ratio of total equity between LBs and SBs	2.8	3.8
SBs' ratio of total liability to equity	14.8	17.7