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Bailing Out (Firms') Uninsured Deposits: A Quantitative Analysis

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Abstract: We document two novel stylized facts about uninsured deposits and bank failures: (i) firms hold more uninsured deposits than households, and (ii) uninsured depositors do not suffer losses in 94 percent of bank failures. We construct a quantitative general equilibrium model designed around these facts. We characterize the marginal benefits of increased insurance for firms' and households' deposits separately, finding higher benefits for household insurance. Quantitatively, the welfare gains from increasing insurance arise primarily from the reduction in bank runs driven by the higher limit on households' deposits. Reducing bailouts increases bank failures due to runs and generates severe macroeconomic effects.

JEL classification: E20, G21, G28, G32

Key words: uninsured deposits, deposit insurance, bailouts, firms' deposits, households' deposits

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1 Introduction

The failures of Silicon Valley Bank (SVB), Signature Bank, and First Republic Bank in 2023 have turned the spotlight back on the resilience of the financial sector, the effects of bank failures on the economy, and the design of banking regulation. Much has been made of the government's decision to invoke a systemic risk exception to ensure that depositors suffered no losses, even on their uninsured deposits. Importantly, a substantial fraction of the uninsured deposits at these failed banks was held by firms, and a key concern of policymakers was to "minimize any impact on businesses [...] and the economy."[1] Despite the significance of these events, open questions remain about ex-post interventions such as bailouts and ex-ante government guarantees such as deposit insurance—especially for firms' deposits.

In this paper, we make two main contributions. We first present novel stylized facts on who holds uninsured deposits, and how often uninsured depositors experience losses when banks fail. We then present a general equilibrium model of banking in which both firms and households hold insured and uninsured deposits, and uninsured deposits might be bailed in the event of bank failures. Using a simplified version of the model, we characterize the marginal benefits of increasing deposit insurance for firms' vs. households' deposits, and we show that such benefits are higher when increasing coverage for households. We validate these findings using a quantitative version of the model, and quantify the welfare gains from increasing deposit insurance limits to as high as $10 million. Finally, we show that not bailing out uninsured deposits in 2023 would have led to runs on other banks and large, negative macroeconomic effects.

We begin our analysis by documenting our novel facts: (i) firms hold more uninsured deposits than households, both as total stock and as a fraction of their own holdings, and (ii) uninsured depositors rarely face losses when banks fail, even when a systemic risk exception is not invoked. We derive fact (i) by combining the Survey of Consumer Finances with a variety of other public data sources. We find that, as of 2019, 56% of firms' deposits are uninsured, while only 21% of households' deposits are uninsured. Regarding fact (ii), we find that uninsured depositors faced no losses in 71% of bank failures from 1986 to 2008Q4, and in 94% between 2008Q4 and 2020. That is, out of over 500 bank failures after the collapse of Lehman Brothers in which the FDIC bore losses, uninsured depositors suffered losses only 30 times.

We then construct a structural model designed around the novel facts. In the model, (i) both firms and households hold insured and uninsured deposits, and (ii) uninsured deposits can be bailed out when a bank fails. Firms need deposits to pay wages because they face a working capital constraint, and households need deposits to finance some of their consumption. Bank failures are driven by both fundamental shocks and runs. Increasing the probability of a bailout or the deposit insurance limit reduces the losses on uninsured deposits and the risk of panic-based runs, but at the cost of higher taxes to finance the government guarantees, as well as moral hazard for banks.

First, we work with a simplified version of the model that allows us to characterize analytically the marginal benefits of increasing deposit insurance for firms' and households' deposits. We find two primary channels through which increased deposit insurance affects welfare: (i) it reduces the losses on uninsured deposits, thereby improving their liquidity value, and (ii) it reduces the stock of uninsured deposits, which

[1] See https://www.federalreserve.gov/newsevents/pressreleases/monetary20230312a.htm.

promote financial stability by decreasing the risk of runs. We show that for both of these channels, an increase in the household insurance limit is more effective than an increase in the firm insurance limit. For the first channel, this result arises because the benefits of household liquidity are more concave than for firm liquidity, and deposit insurance—like any insurance—matters more for more concave payoffs. For the second channel, which operates through the reduction in the stock of uninsured deposits, the effects depend on the number of uninsured accounts, as increasing insurance by e.g. $\$1$ reduces the stock of uninsured deposits by $\$1$ times the number of uninsured accounts. We infer, from the facts we document, that the number of uninsured accounts is higher for households, and thus, this second effect is again stronger when we increase insurance for households' deposits.

We then use a calibrated version of our model to quantify the effects of increasing deposit insurance on welfare as well as on macroeconomic and financial outcomes. Motivated by the "Main Street Depositor Protection Act" proposed in 2025 that would increase deposit insurance to $10 million if approved, we consider insurance limits as high as $10 million and find that welfare is monotonically increasing. Consistent with our analytical results, most of the welfare effects of increased insurance come from increasing the household insurance limit, rather than the firm limit. Furthermore, our quantitative model suggests that the most important benefit of increased deposit insurance is related to the reduction in bank runs.

We also use the calibrated model to analyze the March 2023 banking crisis. We find that the macroeconomic effects of not bailing out depositors in 2023 would have been large: had the government not bailed out depositors in response to the banking crisis, the bank default rate would have increased by 1.3 percentage points because of panic-based runs. The amplified banking panic would then have lead to a drop in GDP of about 2/3 of a percent, a decline in employment of about half a percent, and a decline in investment of 2.5%.

Our quantitative results highlight the importance of considering government bailouts and deposit insurance policy jointly. First, in a version of the model that abstracts from bailouts, uninsured deposits have higher risk of losses, and the model attributes nearly all bank failures to panic-based runs. Thus, since higher deposit insurance reduces run risk, it generates implausibly high welfare gains. Second, bailouts mute the importance of considering banks' moral hazard in response to higher insurance. Because of bailouts, an increase in banks' default rate by 1 percentage point raises the risk of losses on uninsured deposits by only $1\times(1-94\%) = 0.06$ percentage points, where 94% is the fraction of depositors that do not face losses when a bank fails post-2008, based on the second fact that we document. Hence, the link between bank default risk and depositors' losses is weakened by bailouts, and a version of the model that includes monitoring by uninsured depositors behaves very similarly to a version that does not include this element. Finally, we show that eliminating deposit insurance entirely leads to smaller welfare losses than eliminating bailouts entirely.

Our work is closely related to four recent papers: Egan et al. (2017), Dávila and Goldstein (2023), Begenau et al. (2024), and Pancost and Robatto (2023). Egan et al. (2017) distinguish between insured and uninsured deposits in a structural model of the U.S. banking sector with run-type equilibria, and Dávila and Goldstein (2023) develop a framework that provides guidance for the determination of the degree of deposit insurance using sufficient statistics. Begenau et al. (2024) rationalize the cross-sectional distribution of banks' assets and uninsured deposit holdings, and derive regulatory implications. Relative to these three papers, we distinguish between households' and firms' deposits, which allows us to answer how bailouts affect firms—and through firms, the macroeconomy—and to study the welfare effects of changing the deposit insurance limit for firms and households separately. Pancost and Robatto (2023) also use a model with both households' and firms' deposits, but assume that all deposits are fully insured and focus on capital requirements.

Our analysis builds on a growing literature that uses structural models to study financial regulation (Van den Heuvel, 2008; Davydiuk, 2019; Begenau, 2020; Begenau and Landvoigt, 2022; Corbae and D'Erasmo, 2021; Elenev et al., 2021; Dempsey, 2022; Choi, 2022; Meehl, 2022). Relative to this literature, our focus is on deposit insurance and bailouts—differently from these papers that typically study capital requirements—and our model distinguishes between households' and firms' deposits.[2]

More generally, our paper is related to the broader literature about bank runs, deposit insurance, and bailouts (Diamond and Dybvig, 1983; Gorton and Pennacchi, 1990; Allen and Gale, 1998; Cooper and Ross, 2002; Rochet and Vives, 2004; Goldstein and Pauzner, 2005; Keister, 2016; Allen et al., 2018; Mitkov, 2020). A strand of the literature has focused on the pricing of deposit insurance, and includes Merton (1977), Pennacchi (1987, 2006), Chan et al. (1992), Duffie et al. (2003), Acharya et al. (2009), and Shoukry (2024). Other papers focus on the effects of deposit insurance on the banking system, and include Demirgüç-Kunt and Detragiache (2002), Cucic et al. (2024), Iyer and Puri (2012), Kim and Rezende (2023), Martin et al. (2022), and Shy et al. (2016). Kim et al. (2024) study a recent innovation in deposit markets that allows depositors to easily increase their coverage beyond the current $250,000 limit. Other papers, including Kelly et al. (2016) and Berndt et al. (2025), estimate the probability of government bailouts using option prices; Falasconi (2025) analyzes government bailouts of bank creditors using CDS spreads and equity options, focusing on the bailouts of bank creditors other than depositors.

Our paper is also part of a growing literature related to the 2023 U.S. banking crisis, which include Benmelech et al. (2023), Chang et al. (2023), Jiang et al. (2023), Allen et al. (2023), Drechsler et al. (2023), Haddad et al. (2023), and Cipriani et al. (2024).

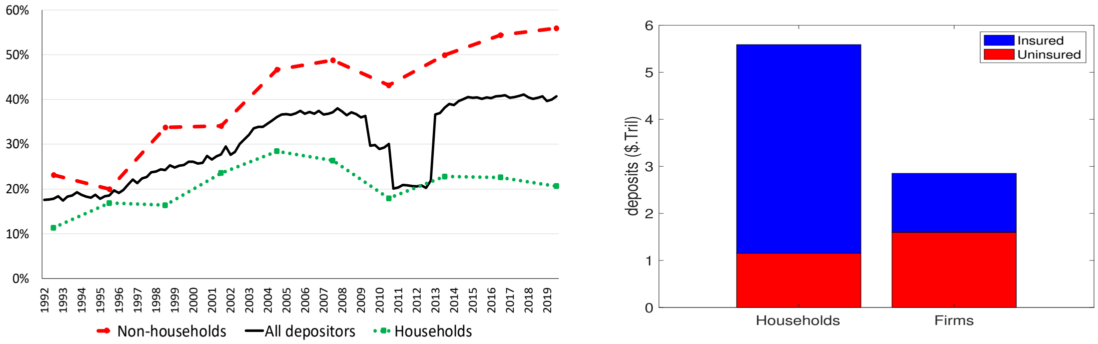
2 Uninsured deposits: institutional details and stylized facts

We begin by providing some institutional details and novel facts about the FDIC insurance of bank deposits and resolution of failed banks. We summarize our discussion in two novel facts. First, firms and other non-household depositors hold more uninsured deposits than households, both as total stocks and as a share of their own holdings. Second, uninsured deposits rarely realize losses when their banks fail, especially since 2008. This section considers these two facts in turn.

2.1 Fact 1: Non-Households Hold Most Uninsured Deposits

Our first stylized fact is that firms hold more uninsured deposits than households, both as a total stock and as a fraction of their own holdings. To establish this fact, we use data from the Flow of Funds, the FDIC, and the Survey of Consumer Finance (SCF). The design of the SCF in particular allows us to compute the

[2] Meehl (2022) compares capital requirements with imposing a bail-in for holders of banks' unsecured debt, other than depositors.



(a) Uninsured share (b) Uninsured and insured stock in 2019

Figure 1. Uninsured deposits
The left panel plots the holdings of uninsured deposits for all depositors (black solid line), households (green dotted line), and non-households (red dashed line), as a percent of the total holdings of the respective group. The right panel plots the stock of total deposits for households and firms in 2019, and breaks them down between insured (blue area) and uninsured (red area).

fraction of households' deposits that are insured and uninsured, as we explain below. For the other classes of depositors, we cannot separate firms from other non-household deposit holders, which include financial institutions, foreigners, and governments (see Appendix A.1 for details). Furthermore, because there are no systematic micro-level data that can be used to precisely disentangle firms' deposits into insured and uninsured, we estimate the insurance coverage for firms and other non-household depositors from aggregate data, subtracting out total insured deposits held by households as computed from the SCF.

We compute total uninsured deposits held by households using the SCF. Uninsured deposits, which are typically held by wealthy households, are observable in the SCF because it includes not only a random sample of U.S. households but also a second sample of wealthy households identified on the basis of tax returns, as well as weights to combine the two samples (see e.g. Heathcote et al., 2010). For each household surveyed by the SCF, we use account-level data, including dollars amounts, the identity of the bank, and of information on which household member owns each account. Because the FDIC insurance coverage depends on amount, bank, and owner(s), the SCF data allows us to estimate the amount of households' deposits that are insured and those that are uninsured. Additional details about the data construction are provided in Appendix A.2.

The left panel of Figure 1 plots the share of uninsured deposits for households and non-household depositors, relative to their own total deposit holdings. The figure also shows the average share of uninsured deposits. Non-household depositors hold a much higher share of uninsured deposits, and the gap increases over time. At the end of our sample, 56% of non-households' deposits are uninsured, but only 21% of households' deposits are uninsured.

The right panel of Figure 1 plots the stock of deposits held by households and firms at the end of our sample (i.e., 2019), and breaks them down by insured and uninsured.[3] Even though households hold nearly

[3] We focus on the last year of the sample because of the trend in the left panel of Figure 1. Note also that, because the right panel of Figure 1 focuses only on firms, it does not include deposits held by other non-household depositors such as the financial sector,

twice as many deposits as firms, their holdings of uninsured deposits are slightly smaller than those of firms. For households, the result is based on the SCF analysis. For firms, we use the Flow of Funds data on total deposit holdings, and we assume that firms' own share of uninsured deposits is the same as that of all non-household deposits plotted in the left panel of Figure 1, that is, 56% in 2019.

We conclude this section with a comment on the accuracy of our estimates. Balloch and Richers (2023) show that the SCF does not provide a full picture of ultrarich households, which could lead us to underestimate aggregate households' uninsured deposits and—because we compute firms' uninsured deposits as a residual—overestimate aggregate firms' uninsured deposits. On the other hand, our approach combines firms and other non-households' deposits, including government deposits; and because local governments can often insure *more* than \$250,000, our method might in fact underestimate firms' uninsured deposits.[4] Regarding the precision of the estimates based on the SCF, we note that Cooperman et al. (2025) show that, for the largest bank holding companies in the United States, the fraction of retail deposits that are uninsured in 2019 is 21.5%, and thus, almost identical to our 21% estimate. Their sample includes only a subset of banks, but because they use regulatory data, the figure for such banks is likely very accurate. In any case, the availability of more precise disaggregated data is important to make further progress in the design of optimal deposit insurance, as noted also by Dávila and Goldstein (2023).

2.2 Fact 2: Losses on Uninsured Deposits

Despite the attention paid to the recent wave of depositor bailouts, uninsured depositors rarely realize losses when their banks fail, especially since the 2008 financial crisis. To understand why, we consider the FDIC's resolution process for failed banks.

When a bank fails, the FDIC is tasked with its resolution. Unless a systemic risk exception is invoked—as in the case of SVB and Signature—the FDIC is legally required to choose the least-cost option for the Deposit Insurance Fund (see Figure 2 for details). The resolution options available to the FDIC are either a sale to another institution or liquidation, and because of the least-cost mandate, liquidation occurs only if no bids are submitted by potential acquirers or if the cost of all submitted bids exceeds the cost of liquidation.

The resolution method determines whether uninsured depositors face losses. Uninsured deposits experience losses if the bank is resolved via *purchase and assumption of insured deposits only*, in which only the insured deposits are transferred to an acquirer, or via *liquidation*. Conversely, in a standard *purchase and assumption* where all deposits are transferred, or if the FDIC invokes the systemic risk exception, uninsured deposits are fully protected.[5]

Figure 3 shows that resolution methods imposing losses on uninsured deposits are rare. The figure plots the deposit-weighted failure rate, distinguishing between liquidations (black), insured-only transfers (gray), and resolutions with no losses on uninsured deposits (dotted). While used to some extent during the Savings and Loan crisis, liquidation has since declined due to the operational strain it imposed on the FDIC (FDIC,

the government, or the rest of the world.

[4]For local governments, time and savings deposits are insured separately from demand deposits in some cases, so that the limit can reach \$500,000 per bank, and uninsured deposits might be collateralized by assets held by the banks.

[5]In an insured-only transfer, uninsured depositors receive a receivership certificate representing a claim on future dividends from asset liquidations. We thank the FDIC Division of Resolutions & Receiverships for clarifying these procedures.

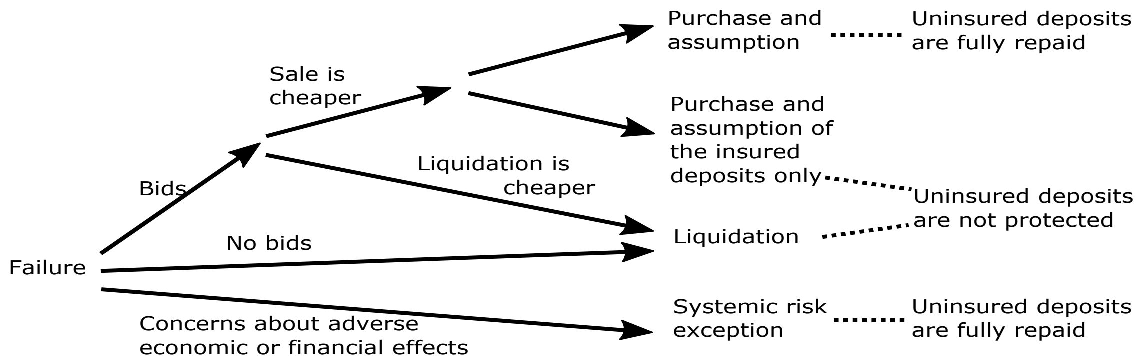


Figure 2. Resolution process of failed banks.
The figure shows how the FDIC resolves failed banks. Liquidation can be implemented in various ways such as deposit payouts (in which the FDIC pays the depositors directly), insured deposit transfer (in which a bank serves as a paying agent for the FDIC), or through the setup of a deposit insurance national bank.

2017). Similarly, purchase and assumptions of insured deposits only are infrequent and have also decreased over time (Ohlrogge, 2023).

To formalize the result that uninsured deposits rarely experience losses when banks fail, we consider bank failures between 1986 and 2022 in which the FDIC experiences a loss—thereby excluding cases in which uninsured deposits experienced no losses just because there were enough junior liabilities (see Appendix A.3 for more details about the sample construction). We then run the following regression:

$$y_{i,t} = \beta_0 + \beta_1 \text{Post}_t + \beta_2 \text{Size}_{i,t} + \beta_3 \text{Size}_{i,t} \times \text{Post}_t + \varepsilon_{i,t} \tag{1}$$

where $y_{i,t}$ is an indicator variable equal to one if uninsured depositors face no loss in bank failure i in quarter t, and zero otherwise; Post_t is an indicator variable equal to one for 2008Q4 and after; and $\text{Size}_{i,t}$ is a measure of bank size at the time of default. We include the Post_t indicator to account for possible changes in the risk of uninsured deposit losses over time, such as those stemming from the reduction in the use of liquidation. The coefficient β_0 represents the average probability that uninsured deposits of failed banks are fully repaid before the 2008 crisis, while $\beta_0 + \beta_1$ represents the average probability afterwards.

The first column of Table 1 shows that uninsured deposits experienced no losses in 71% of bank failures between 1986 and 2008, and in 94% thereafter. This result is robust to controlling for bank size—using log assets (Column 2) or log deposits (Column 3)—and to splitting the sample by asset size (Columns 4–6). Across these specifications, we find no evidence that the probability of uninsured losses relates to bank size within our sample. Note, however, that because none of the largest U.S. banks failed during our sample period, our analysis is silent about "too-big-to-fail" guarantees. While the literature provides evidence for such guarantees for equity holders and bondholders of the largest banks (e.g., Gandhi and Lustig 2015; Berndt et al. 2025; Falasconi 2025), the message of Table 1 is that uninsured depositors of small- and medium-size banks have also been largely protected from losses in the event of bank failures.

Taken together, the results show that uninsured deposits rarely experience losses at banks that have failed in our sample, regardless of size. This outcome typically arises not from the systemic risk exception

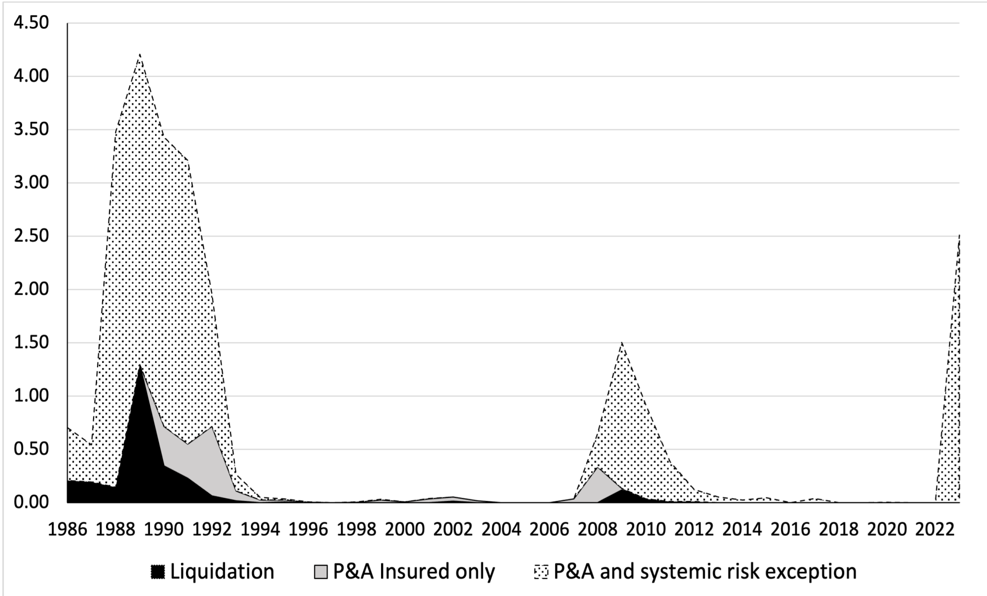


Figure 3. Default rate by resolution

The figure plots the bank default rate (in %) between 1986 and 2023 weighted by deposits, distinguishing between liquidation (black area), purchase and assumption of insured deposits only (gray area), and resolutions in which uninsured deposits do not experience any losses, that is, purchase and assumption and systemic risk exception (dotted area).

but from the standard process of selling failed banks to other financial institutions.

3 Baseline model

In this section, we present the baseline model and discuss some key forces that generate a different optimal level of deposit insurance for firms versus households. We then extend the model the model in Section 4 to provide a full quantitative analysis.

Time is discrete and infinite. There are four types of agents in the economy: firms, banks, households, and the government. In the baseline model, bank failures are driven only by fundamental risk. In the quantitative analysis of Section 4, we extend the model to allow for bank failures driven by panic-based runs and to include additional negative effects of bank failure on the economy.

The government provides two types of deposit guarantees: insurance and bailouts. Deposits are insured up to a dollar limit $\bar{d}^f$ and $\bar{d}^h$ for firms and households, respectively. These limits are identical in our baseline calibration, but we allow them to differ in the welfare analysis. Regarding bailouts, we assume that uninsured deposits at a failed bank are bailed out and thus fully repaid with probability f, and face an endogenous haircut with probability $1 - f$. The probability f captures the resolution methods discussed in Section 2 that guarantee full repayment—namely, a purchase and assumption or a systemic risk exception. The $1 - f$ case corresponds to a liquidation or a purchase and assumption of insured deposits only, both of which impose losses on uninsured depositors. The government funds these guarantees by taxing households, which entails deadweight losses.

	(1)	(2)	(3)	(4)	(5)	(6)
Constant	0.714***	0.679***	0.686***	0.704***	0.721***	0.775***
	(76.15)	(25.05)	(24.62)	(59.15)	(42.60)	(22.68)
Post	0.228***	0.294***	0.289***	0.244***	0.224***	0.133**
	(16.31)	(5.294)	(5.083)	(10.85)	(10.57)	(2.534)
Log Assets		0.00817				
		(1.384)				
Log Assets × Post		-0.0140				
		(-1.297)				
Log Deposits			0.00649			
			(1.054)			
Log Deposits × Post			-0.0128			
			(-1.145)			
Bank size ($ bn)	All	All	All	< 0.1	0.1-1	> 1
Observations	2,842	2,842	2,842	1,608	1,029	205
R-squared	0.042	0.042	0.042	0.023	0.065	0.022

Table 1. Coverage of Uninsured Deposits
The table reports the results of estimating equation (1) on quarterly bank failure data from the FDIC from 1986Q1 to 2022Q4. The dependent variable is an indicator variable equal to 1 if uninsured depositors face no losses at a failed bank, and 0 otherwise. "Post" is an indicator variable equal to 1 from quarters on or after 2008Q4. "Bank size" denotes the size of the failed bank. Robust t-statistics are in parentheses. *** p <0.01, ** p <0.05, * p <0.1.

A key feature of our model is that uninsured deposits are risky, as each depositor can have an account at only one bank. Consider a firm i with deposits d_t^i exceeding the insurance limit $\bar{d}^f$. If the bank remains solvent, or if it fails but uninsured deposits are bailed out, the full amount d_t^i is available at $t+1$. Conversely, if the bank fails and no bailout occurs, the available funds are limited to the insured portion $\bar{d}^f$ plus the recovered value of the uninsured balance, $(d_t^i - \bar{d}^f)(1-\nu_{t+1})$, where ν_{t+1} denotes the haircut.

Thus, bailouts and deposit insurance are distinct policies for depositors who cannot diversify across banks. A bailout increases the probability that deposits are repaid in full, whereas deposit insurance increases the payoff in the state where a bank is insolvent and no bailout occurs.

3.1 Banks

A continuum of banks is founded each period t with equity n_t. Banks issue deposits d_t to households and firms, investing the total resources $n_t + d_t$ into physical capital b_t, which they lend to firms. Each bank's investment is subject to an idiosyncratic shock ε at $t+1$, captures imperfect asset diversification. Due to limited liability, banks with low realizations of ε fail. Deposit insurance protects insured deposits at all failed banks, while bailouts protect uninsured deposits with probability f. While all failures here are driven by fundamentals, Section 4 extends the model by incorporating panic-based runs.

When a bank is set up at time t, it lends its physical capital b_t to firms. After production takes place at $t+1$, firms return the undepreciated fraction of capital $1-\delta$ plus a return r_t. The resources $b_t\,(1-\delta+r_t)$

returned by firms are then hit by the idiosyncratic shock ε, which is distributed according to the cumulative distribution function $F(\varepsilon)$, with $\mathbb{E}(\varepsilon) = 1$. We assume that $F(\varepsilon)$ is lognormal with scale parameter σ. As a result, banks' profits at $t+1$ are given by the cash flow $\varepsilon b_t(1-\delta+r_t)$ net of the repayment $R_t^d d_t$ to depositors, where d_t are total bank's deposits and R_t^d is the gross return on deposits. Thus, banks solve the problem

$$\max_{b_t,\, d_t} \; \mathbb{E}_t \int_{\varepsilon_{t+1}^{FUN}}^{\infty} \left[\varepsilon b_t (1-\delta+r_t) - R_t^d d_t\right] dF(\varepsilon) \tag{2}$$

where ε_{t+1}^{FUN} is the threshold for ε above which banks are solvent:[6]

$$\varepsilon_{t+1}^{FUN} b(1-\delta+r_t) = R_t^d d_t. \tag{3}$$

That is, for a bank that receives the shock $\varepsilon = \varepsilon_{t+1}^{FUN}$ the assets $\varepsilon_{t+1}^{FUN} b(1-\delta+r_t)$ are just enough to pay the liabilities $R_t^d d_t$.

The maximization problem (2) is subject to the budget and capital requirement constraints:

$$b_t = d_t + n_t \tag{4}$$

$$n_t \geq \zeta b_t \tag{5}$$

where ζ is the capital requirement. Because the return on deposits will always be less than the return on bank's capital, the capital requirement constraint (5) always binds.

Households choose the investment in equity n_t (see Section 3.3). To characterize the return on equity, we note that households can diversify their equity holdings across banks, and failed banks return zero to their equity holders. Thus, the return on bank equity R_{t+1}^n is given by

$$R_{t+1}^n = \frac{1}{n_t} \int_{\varepsilon_{t+1}^{FUN}}^{\infty} \left\{\varepsilon b_t(1-\delta+r_t) - R_t^d d_t\right\} dF(\varepsilon). \tag{6}$$

The bank default rate is given by

$$p_{t+1}^{default} = \int_0^{\varepsilon_{t+1}^{FUN}} dF(\varepsilon). \tag{7}$$

Note, however, that for uninsured depositors, the probability of facing losses on their uninsured deposits is lower than the default rate, because of the possible bailouts. To this end, we define the probability p_{t+1}^{full} that an uninsured depositor is repaid in full (i.e., experiences no losses) as

$$p_{t+1}^{full} = \left(1 - p_{t+1}^{default}\right) + p_{t+1}^{default} f. \tag{8}$$

That is, an uninsured depositor is fully repaid if the bank is solvent (i.e., with probability $1 - p_{t+1}^{default}$), or if the bank fails but the government bails out uninsured deposits (i.e., with probability $p_{t+1}^{default} f$).

[6] We index ε_{t+1}^{FUN} with the $t+1$ subscript to emphasize that ε_{t+1}^{FUN} is the threshold that determine solvency at $t+1$, although ε_{t+1}^{FUN} is measurable with respect to the time-t information set.

3.2 Firms

Each period, a mass m_t^f of firms operate, where m_t^f is chosen by households. Each firm i is set up at time t with wealth a^i, and we assume that a^i is distributed according to the exogenous CDF $F^a(a^i)$. Firms set up at time t will produce at $t+1$ and then will return all their wealth to households at $t+1$.

At time t, firm i allocates its wealth a^i to productive investments k_t^i (i.e., physical capital) or to deposits d_t^i at one bank:[7]

$$k_t^i + d_t^i \leq a^i. \tag{9}$$

The firm also borrows b_t^i from banks, in the form of a loan with interest rate r_t subject to the borrowing constraint

$$b_t^i \leq \xi k_t^i, \tag{10}$$

where $0 < \xi < 1$ is the firms' collateral constraint. Bank loans are used for productive investments, so that the total physical capital used for production by firm i is $k_t^i + b_t^i$.

At $t+1$, after the realization of aggregate productivity A_{t+1}, the firm chooses labor l_{t+1}^i with wage w_{t+1} (subject to the working capital constraint described below), and then production takes place. Output is given by

$$y_{t+1}^i = A_{t+1}\left(k_t^i + b_t^i\right)^\gamma \left(l_{t+1}^i\right)^{1-\gamma}. \tag{11}$$

Firms require liquidity to finance wage payments. Specifically, liquidity is provided by their deposits (plus the return R_t^d) and by a fraction $\theta \in [0,1]$ of their output y_{t+1}^i, where θ parameterizes firms' ability to use their revenues to cover some of their operating expenses, either directly or by pledging future cash flows. Deposits up to the insurance limit $\bar{d}^f$ are always available. However, for balances exceeding $\bar{d}^f$, firms face the risk of losses on their deposits. With probability p_{t+1}^{full}, the bank is either solvent or failure is followed by a bailout, making all deposits available. Conversely, if the bank is insolvent and no bailout occurs, available funds are limited to the insured portion $\bar{d}^f$ and the recovered value $(1-\nu_{t+1})$ of the uninsured balance $d_t^i - \bar{d}^f$. The liquidity constraint is thus:

$$w_{t+1} l_{t+1}^i \leq \begin{cases} R_t^d d_t^i + \theta y_{t+1}^i & \text{if } d_t^i \leq \bar{d}^f \\ R_t^d d_t^i + \theta y_{t+1}^i & \text{if } d_t^i > \bar{d}^f, \text{with probability } p_{t+1}^{full} \\ R_t^d \left[\bar{d}^f + (1-\nu_{t+1})\left(d_t^i - \bar{d}^f\right)\right] + \theta y_{t+1}^i & \text{if } d_t^i > \bar{d}^f, \text{with probability } 1 - p_{t+1}^{full}. \end{cases} \tag{12}$$

The first line in (12) refers to the case in which the firm's deposits are below the insurance limit. The second line refers to the case in which the firm has uninsured deposits which are repaid in full, either because the bank is solvent or because there is a bailout. And the third line refers to the case in which the bank is insolvent and uninsured deposits are not bailed out. Note that (12) is a restriction on l_{t+1}^i: firms have already chosen how much to invest in deposits d_t^i, and losses on the firm's deposit will restrict the firm's ability to hire labor and produce output.

To state the firm's maximization, recall that firms return all their resources to households at $t+1$. Thus,

[7] The choice of capital and deposits are, in equilibrium, a time-varying function of the level of wealth a^i. For simplicity, we write such choices as k_t^i and d_t^i and omit, for notational convenience, their dependence on the level of wealth a^i.

the firms' problem is given by

$$\max_{k_t^i, d_t^i, b_t^i} \mathbb{E}\left\{\frac{\Lambda_{t+1}}{\Lambda_t}\left[\max_{l_{t+1}^i} \pi_{t+1}^i\right]\right\}$$

where

$$\begin{aligned}\pi_{t+1}^i \equiv &\underbrace{y_{t+1}^i}_{\text{output}} + \underbrace{(1-\delta)\,k_t^i}_{\text{undepreciated capital}} - \underbrace{w_{t+1} l_{t+1}^i}_{\text{wage bill}} - \underbrace{r_t b_t^i}_{\text{interest on loan}} + \underbrace{\mathbb{I}_{d_t^i \le \bar{d}^f} R_t^d d_t^i}_{\text{deposits, if below insurance limit}} \\ &+ \left(1 - \mathbb{I}_{d_t^i \le \bar{d}^f}\right) \underbrace{R_t^d \left(p_{t+1}^{full} d_t^i + (1 - p_{t+1}^{full})\left[\bar{d}^f + (1-\nu_{t+1})\left(d_t^i - \bar{d}^f\right)\right]\right)}_{\text{deposits, if above insurance limit}},\end{aligned} \tag{13}$$

subject to the budget constraint (9), the borrowing constraint (10), and the working capital constraint (12). The term Λ_t in in the firm's problem is the households' marginal utility (defined in Section 3.3), which firms use to discount future cash flows because households are the owners of the firms and we assume no agency frictions.

To solve the firms' problem, we first analyze the choice of labor l_{t+1}^i at time $t+1$. The first-order condition with respect to l_{t+1}^i is

$$\frac{\partial y_{t+1}^i}{\partial l_{t+1}^i}\left(1 + \theta \lambda_{t+1}^i\right) = w_{t+1}\left(1 + \lambda_{t+1}^i\right). \tag{14}$$

where λ_{t+1}^i is the Lagrange multiplier of the working capital constraint (12). Note that without the term λ_{t+1}^i, this would be a standard condition that equates the marginal productivity of labor to the wage, and the multiplier λ_{t+1}^i accounts for the role of the working capital constraint.

Next, we turn to the choices of capital k_t^i, deposits d_t^i, and bank loans b_t^i at time t. First, we conjecture that the borrowing constraint (10) is binding because, in equilibrium, the interest rate on loans will be less than the firms' own cost of capital. This result arises because banks fund part of their balance sheet with deposits, which include a liquidity premium, and pass this low funding costs onto a lower loan rate. Second, we conjecture that there are two endogenous thresholds $\underline{a}_t$ and $\overline{a}_t$ that affect firms' choices at time t, with $\underline{a}_t < \overline{a}_t$. Firms with little wealth (i.e., $a^i < \underline{a}_t$) will chose an amount of deposits below the insurance limit, and thus, all their deposits will be insured. Firms with an intermediate level of wealth (i.e., with a^i such that $\underline{a}_t < a^i < \overline{a}_t$) will choose deposits equal to the insurance limit, that is, $d_t^i = \bar{d}^f$. And firms with large wealth (i.e., $a^i > \overline{a}_t$) choose a level of deposits above the insurance limit and, thus, hold uninsured deposits. We first solve for the choice of capital vs. deposits in each region, and then we explain how we solve for the thresholds.

For firms with low wealth, that is, $a^i < \underline{a}_t$, the first-order condition that governs the allocation of wealth to capital and (fully insured) deposits is

$$0 = \mathbb{E}_t\left\{\frac{\Lambda_{t+1}}{\Lambda_t}\left[\frac{\partial y_{t+1}^i}{\partial k_t^i}\left(1 + \theta\lambda_{t+1}^i\right) + 1 - \delta - r_t \xi - R_t^d\left(1 + \lambda_{t+1}^i\right)\right]\right\}, \tag{15}$$

Equation (15) trades off the expected marginal benefits of investing in capital with the expected marginal benefits of deposits. The marginal benefits of capital are the expected marginal product of capital, the undepreciated capital $1-\delta$, and the effect of relaxing the working capital constraint (12) since the firm can pledge a fraction θ of its output. The marginal cost includes both the cost of borrowing from banks, $r_t\xi_t$, and the foregone benefits of investing in deposits, which include the deposit return R_t^d and the shadow value λ_{t+1}^i of relaxing the working capital constraint (12).

For firms with high wealth, that is, $a^i > \overline{a}_t$, the first-order condition at time t is similar to (15), but it accounts for the fact that the marginal dollar of deposit is uninsured and, thus, subject to the risk of losses, given by the haircut ν_{t+1} with probability $1-p_{t+1}^{full}$. That is, the first-order condition is

$$0 = \mathbb{E}_t\left\{\frac{\Lambda_{t+1}}{\Lambda_t}\left[\frac{\partial y_{t+1}^i}{\partial k_t^i}\left(1+\bar{\theta}\lambda_{t+1}^i\right)+1-\delta-r_t\xi-R_t^d\left(1+\lambda_{t+1}^i\right)\left(1-(1-p_{t+1}^{full})\nu_{t+1}\right)\right]\right\}. \quad (16)$$

Finally, we solve for the two thresholds $\underline{a}_t$ and $\overline{a}_t$. To solve for $\underline{a}_t$, we use the first-order condition of firms in the insured-deposits region, (15), and compute the level of wealth a^i such that firm i would choose $d_t^i = \overline{d}^f$. To compute $\overline{a}_t$, we instead use the first-order condition in the uninsured-deposit region, (16), and again compute the level of wealth a^i such that firm i would choose $d_t^i = \overline{d}^f$. Because uninsured deposits are risky (i.e., $p_{t+1}^{full} < 1$ and $\nu_{t+1} > 0$), the threshold $\underline{a}_t$ computed using (15) is lower than the threshold $\overline{a}_t$ computed using (16).

3.3 Households

There is a mass $m^h > 0$ of households—infinitely-lived agents who consume, supply labor, and invest in firms, bank deposits, and bank equity. That is, all sources of income accrue to households, and thus, welfare analysis can be conducted by studying how households' utility is affected by policy changes. Households need deposits to finance some of their consumption expenditures, and we refer to such expenditures as *liquid consumption*. All other expenditure finance *other consumption*.

To maintain tractability of the households' side of the model while allowing households' deposit holdings to be heterogeneous, we make the following assumptions. First, each household is composed of (infinitely) many members indexed by ψ, where ψ is distributed according to the CDF $F^\psi(\psi)$. At time t, the household gives to member ψ an amount $d_t^h(\psi)$ of deposits, which are deposited in a single bank and can be used to finance ψ's liquid consumption $c_{t+1}^{liq}(\psi)$ at $t+1$, yielding utility $\psi \log\left(c_{t+1}^{liq}(\psi)\right)$. The household also consumes other consumption c_t^{oth} and supplies labor l_t, so that the utility of the overall household is

$$U\left(c_t^{oth}, \left\{c_t^{liq}(\psi)\right\}, l_t\right) = \log\left(c_t^{oth}\right) + \int \psi \log\left(c_t^{liq}(\psi)\right) dF^\psi(\psi) - \chi\frac{l_t^{1+1/\eta}}{1+1/\eta}, \quad (17)$$

where $\chi > 0$ parametrizes the disutility of labor, and η is the Frisch elasticity of labor supply.

Under the above assumptions, the households' building block of the model produces three key results. First, because the parameter ψ acts a shifter in the marginal utility of consumption of the household member, the household will assign more deposits to members with a higher value of ψ, so that they can consume more.

Hence, household members with a low ψ will have deposits below the insurance limit, but members with a high ψ will have deposits above the insurance limit. In the calibration, we can parametrize the CDF $F^{\psi}(\psi)$ to match the empirical distribution of households' deposit holdings in the Survey of Consumer Finance. Second, because all the deposits of member ψ are at one bank, household members with deposits above the insurance limit are exposed to the risk of losses on their uninsured deposits. Nonetheless, different household members can deposit at different banks, and thus, the fraction of members facing losses on uninsured deposits is equal to the fraction of banks that go bankrupt and whose uninsured deposits are not bailed out, so that the model has a representative household and remains tractable. Third, all the deposits will be used to finance liquid consumption, so losses on uninsured deposits will have no impact on households' wealth.[8]

To solve the household problem, consider a household with wealth a_t^h after the consumption of liquid goods $c_t^{liq}(\psi)$ has taken place. The household allocates a_t^h among consumption of other goods c_t^{oth} and savings, where the saving instruments are (i) deposits $d_t^h(\psi)$ for each member ψ, (ii) total wealth a_t^f to be invested in firms, and (iii) bank equity n_t. Hence, the household's budget constraint at $t+1$ is

$$c_t^{oth} + \int d_t^h(\psi) dF^{\psi}(\psi) + a_t^f + n_t \leq a_t^h + w_t l_t, \tag{18}$$

where w_t is the wage earned from supplying labor l_t, and the total wealth a_t^f invested in firms pins down the mass of firms m_t^f: $a_t^f = m_t^f \int a^i dF^a(a^i)$. At $t+1$, the household members' consumption of liquid goods c_{t+1}^{liq} is subject to the liquidity constraint

$$c_{t+1}^{liq} \leq \begin{cases} R_t^d d_t^h(\psi) & \text{if } d_t^h(\psi) \leq \bar{d}^h \\ R_t^d d_t^h(\psi) & \text{if } d_t^h(\psi) > \bar{d}^h \text{, with probability } p_{t+1}^{full} \\ R_t^d \left[\bar{d}^h + (1-\nu_{t+1})\left(d_t^h(\psi) - \bar{d}^h\right)\right] & \text{if } d_t^h(\psi) > \bar{d}^h \text{, with probability } 1 - p_{t+1}^{full}. \end{cases} \tag{19}$$

The three cases on the right-hand side mirror equation (12) for firms. Namely, consumption c_{t+1}^{liq} is constrained by deposits $d_t^h(\psi)$ if deposits are fully insured (i.e., below the insurance limit $\bar{d}^h$), or if the deposits are above the insurance limit but the uninsured deposits are fully repaid (i.e., with probability p_{t+1}^{full}). If instead the member has uninsured deposits that experience losses (i.e., with probability $1-p_{t+1}^{full}$), consumption c_{t+1}^{liq} can be financed only by the insured deposits $\bar{d}^h$ plus the value $(1-\nu_{t+1})\left(d_t^h(\psi) - \bar{d}^h\right)$ recovered on the uninsured deposits, which depends on the haircut ν_{t+1}. We conjecture (and verify) that the liquidity constraint (19) is always binding.[9]

The law of motion of households' wealth is

$$a_{t+1}^h = n_t R_{t+1}^n + a_t^f R_{t+1}^a - T_{t+1} - \Omega(T_{t+1}), \tag{20}$$

[8]We leave for future research how the impact of bank failure on households' wealth accumulation affects the design of the deposit insurance regulation.

[9]We also assume that the choice of $c_{t+1}^{liq}(\psi)$ is made before the household observes the time-$t+1$ aggregate state—the household only knows whether its bank is solvent or fails when it chooses $c_{t+1}^{liq}(\psi)$. With this assumption, the deposit-in-advance constraint is always binding.

where R^n_{t+1} is the return on bank equity, $R^a_{t+1} \equiv m^f_t \int \pi^i_{t+1} dF^a\left(a^i\right)/a^f_t$ is the return on the investments in firms, and $T_{t+1} + \Omega(T_{t+1})$ are lump-sum taxes—the government raises T_{t+1} to finance deposit insurance and bailouts and $\Omega(T_{t+1})$ to cover the deadweight losses of taxation, where the function $\Omega(\cdot)$ satisfies $\Omega', \Omega'' > 0$.

We can now state the household maximization problem:

$$V_t(a^h_t) = \max_{c^{oth}_t, l_t, n_t, a^f_t, \{d^h_t(\psi), c^{liq}_{t+1}(\psi)\}} \log\left(c^{oth}_t\right) - \chi \frac{l_t^{1+\frac{1}{\eta}}}{1+\frac{1}{\eta}} + \beta\, \mathbb{E}_t\left[\int \psi \log\Big(c^{liq}_{t+1}(\psi)\Big)\, dF^\psi(\psi) + V_{t+1}(a^h_{t+1})\right]$$

subject to the budget constraint (18), the liquidity constraint (19), and the law of motion of wealth (20).

The framework gives rise to standard asset-pricing conditions for the supply of banks' net worth n_t and of the wealth a^f_t for new firms,

$$1 = \mathbb{E}_t\left\{\beta \frac{\Lambda_{t+1}}{\Lambda_t} R^n_{t+1}\right\}, \quad 1 = \mathbb{E}_t\left\{\beta \frac{\Lambda_{t+1}}{\Lambda_t} R^a_{t+1}\right\}, \tag{21}$$

(where $\Lambda_t \equiv {}^1/_{c^{oth}_t}$ is the marginal utility of consumption of c^{oth}_t) and to a standard first-order condition that determines labor supply l_t,

$$\Lambda_t w_t = \chi l_t^{1/\eta}, \tag{22}$$

The choice of deposits $d^h_t(\psi)$ mirrors what we described for firms in Section 3.2. That is, the first-order condition with respect to $d^h_t(\psi)$ depends on whether their ψ is large enough to induce them to hold deposits below or above the insured level $\bar{d}^h$. In particular, there are two thresholds $\underline{\psi}_t < \overline{\psi}_t$ such that (i) household members with $\psi < \underline{\psi}_t$ have deposits $d^h_t(\psi) < \bar{d}^h$, that is, below the insurance limit; (ii) household members with $\underline{\psi}_t < \psi < \overline{\psi}_t$ have deposits exactly equal to the insurance limit $\bar{d}^h$; and (iii) household members with $\psi > \overline{\psi}_t$ have deposits above the insurance limit.

The first-order condition for deposits for household members with $\psi < \underline{\psi}$ (i.e., with fully insured deposits) is

$$\Lambda_t = \beta\, \psi\, \frac{1}{d^h_t(\psi)}. \tag{23}$$

For household members with $\psi > \overline{\psi}_t$ (i.e., with deposits above the insurance limit), the first-order condition for deposits accounts for the risk of losses on uninsured deposits, which happen with probability $1 - p^{full}_{t+1}$:

$$\Lambda_t = \beta\psi\, \mathbb{E}_t\left\{p^{full}_{t+1} \frac{1}{d^h_t(\psi)} + \left(1 - p^{full}_{t+1}\right) \frac{(1-\nu_{t+1})}{\bar{d}^h + (1-\nu_{t+1})\left(d^h_t(\psi) - \bar{d}^h\right)}\right\}. \tag{24}$$

Finally, household members with ψ such that $\underline{\psi} < \psi < \overline{\psi}_t$ hold deposits equal to the insurance limit, that is, $d^h_t(\psi) = \bar{d}^h$, and we solve for $\underline{\psi}$ and $\overline{\psi}_t$ by evaluating (23) and (24) at $d^h_t(\psi) = \bar{d}^h$.

3.4 Government

Following the literature that studies financial regulation in quantitative general equilibrium models, we assume that the government consists of a bank resolution mechanism that is financed by lump-sum taxes. Our novelty is that when a bank fails and is taken over by the government, we distinguish between insured deposits that are fully repaid, and uninsured deposits which might be fully repaid (i.e., bailed out) or subject to losses. Specifically, as discussed in Section 3.1, the government bails out the uninsured deposits that are left in failing banks with probability f. The bailout of uninsured deposits corresponds to the case, in practice, in which a failed bank is resolved with a purchase and assumption or a systemic risk exception is invoked.

To calculate the losses for uninsured deposits at a failed bank that is not bailed out, we note that in practice, the FDIC and uninsured deposits have the same priority, meaning that losses must be shared equally by these two groups of claimants. We define ν_{t+1} to be the haircut imposed on the uninsured deposits that are not bailed out, and we assume that the haircut is the same for all the banks that fail—as if we were considering an "average" failed bank. Thus, ν_{t+1} is pinned down by the expression that equates the defaulted value of deposits to the value of assets at failed banks:

$$(1-\nu_{t+1})\int_0^{\underline{\varepsilon}_{t+1}^{FUN}} R_t^d d_t \; dF(\varepsilon) = \int_0^{\underline{\varepsilon}_{t+1}^{FUN}} \varepsilon b_t \left(1-\delta+r_t\right) dF(\varepsilon). \tag{25}$$

The left-hand side of equation (25) denotes all the liabilities of failed banks. Note that the haircut is applied to all the deposits—including the insured ones—because of the equal seniority among depositors. However, the FDIC (implicitly) reimburses insured deposits for the haircut they experience. The right-hand side of equation (25) denotes the value of the assets at failed banks.

The government uses lump-sum taxes T_{t+1} to finance the costs of deposit insurance and to make insured deposits whole. Its budget constraint is

$$T_{t+1} = p_{t+1}^{default}\; \nu_{t+1} R_t^d \left[d_t^{ins} + f\left(d_t - d_t^{ins}\right)\right]. \tag{26}$$

That is, for the mass $p_{t+1}^{default}$ of banks that fail, the government covers the losses ν_{t+1} for the insured deposits d_t^{ins} and for the fraction f of the uninsured deposits $d_t - d_t^{ins}$ that are bailed out. The stock d_t^{ins} of insured deposits is given by

$$d_t^{ins} \equiv \underbrace{\int_0^{\bar{a}_t} d_t^i \; dF^a\left(a^i\right) + \int_{\bar{a}_t}^{\infty} \bar{d}^f \; dF\left(a^i\right)}_{\text{total insured firm deposits}} + \underbrace{\int_0^{\bar{\psi}_t} d_t^h\left(\psi\right)\; dF\left(\psi\right) + \int_{\bar{\psi}_t}^{\infty} \bar{d}^h \; dF\left(\psi\right)}_{\text{total insured household deposits}}. \tag{27}$$

That is, for each class of depositor—firms and households—the stock of insured deposits is the sum of accounts below the insurance limit, plus the insured part of accounts that exceed the limit.

3.5 Aggregate Resource Constraint and Risk

The aggregate resource constraint is given by

$$c_t + i_t + \Omega(T_t) \leq Y_t, \tag{28}$$

where total consumption c_t is defined as $c_t = c_t^{liq} + c_t^{oth}$, i_t denotes investments $i_t = (k_t + b_t) - (1 - \delta)(k_{t-1} + b_{t-1})$, and Y_t is gross output defined as $Y_t = \int y_t^i di$. We follow the standard practice of defining the gross domestic product as the sum of consumption and investments.

There is a single aggregate shock to total factor productivity A_t, which follows an AR(1) in logs:

$$\log A_t = (1 - \rho_A) \log \bar{A} + \rho_A \log A_{t-1} + \sigma_A \varepsilon_{A,t}.$$

3.6 Analytical Results on the Effects of Deposit Insurance

In this section, we use the baseline model to provide intuition for the benefits of higher deposit insurance. Under some simplifying assumptions, we show analytically that the benefits derive from two primary channels. First, a higher insurance limit reduces losses on uninsured deposits, thereby improving their liquidity value and directly increasing household welfare. Second, a higher insurance limit also reduces the stock of uninsured deposits. While this second channel has no direct impact on welfare in the baseline model, it is a key determinant of run risk in the full model (Section 4).

We find higher benefits for increasing insurance for households' deposits, in comparison to increasing insurance for firms' deposits. This result holds across both the channels we identify. The quantitative analysis in Sections 4 and 5 confirms these findings, even when accounting for other forces such as general equilibrium effects and bank moral hazard. In particular, the reduction in run risk triggered by higher insurance for households' deposits plays the most prominent role in the quantitative results.

We begin by characterizing the benefits and costs of the loss-shielding effect of deposit insurance. We do so by computing how household welfare changes as we increase deposit insurance for firms and households—welfare is given by the present discounted value of households' utility in equation (17). To characterize the result analytically, we consider the limit as the bank failure probability goes to zero, so that changes in deposit insurance have no impact on depositors' choices and, thus, no general equilibrium feedback. Nonetheless, we can characterize the benefits and cost of higher insurance *per failed bank*, even in the limit as failures are arbitrarily small.

Proposition 1. *Consider the steady-state of an economy described in Sections 3.1-3.5 in which:*[10]

- *The bank default rate is arbitrarily close to zero:* $p^{default} \to 0$.
- *The deposit premium is arbitrarily close to zero:* $\frac{1}{\beta} - R^d \approx 0$.

[10]We state the first two assumptions in terms of equilibrium values, rather than restrictions on parameters. However, the first item can be obtained by assuming that the scale parameter σ of the distribution $F(\varepsilon)$ of the idiosyncratic shock is arbitrarily close to zero (i.e., $\sigma \approx 0$), and the second item can be obtained by imposing a restriction on the parameter ξ of the firms' borrowing constraint.

- *The pledgeability of cash flows in the firms' working capital constraint is $\theta = 0$.*

Then the marginal benefit of changing deposit insurance $\bar{d}^f$ and $\bar{d}^h$, per depositor at banks who fail and are not bailed out, can be expressed as

$$MB\left(\bar{d}^f\right) = R^d\nu\left(\mathbb{E}_i\left\{\left(\nu\frac{\bar{d}^f}{d^i} + (1-\nu)\right)^{-\gamma}\middle| d^i > \bar{d}^f\right\} - 1\right) \tag{29}$$

$$MB\left(\bar{d}^h\right) = R^d\nu\left(\mathbb{E}_\psi\left\{\left(\nu\frac{\bar{d}^h}{d\left(\psi\right)} + (1-\nu)\right)^{-1}\middle| d^h\left(\psi\right) > \bar{d}^h\right\} - 1\right) \tag{30}$$

for firms' and households' deposit, respectively. The marginal costs can be expressed as

$$MC\left(\bar{d}^f\right) = MC\left(\bar{d}^h\right) = R^d\nu\Omega'(T)$$

for firms' and households' deposits, respectively.

Proposition 1 characterizes the direct marginal benefits and costs of deposit insurance on households' welfare. The marginal costs depend on the deadweight losses of taxation Ω', similar to Dávila and Goldstein (2023). To understand the marginal benefits of deposit insurance in Proposition 1, consider the firms' marginal benefits, in equation (29). If the bank of firm i fails and the deposits are not bailed out, the firm experiences a haircut ν on uninsured deposits that results in a tightening of the working capital constraint and leads to lower employment. The marginal product of labor (MPL) is thus higher, relative to an identical firm whose deposits are fully repaid, and increasing deposit insurance reduces this labor misallocation. Because $MPL = (1-\gamma)Ak^\gamma l^{-\gamma}$, and because capital is chosen before knowing whether deposits are fully repaid or not, the labor misallocation can be expressed as

$$\frac{MPL^{losses\ on\ uninsured}}{MPL^{no\ losees}} - 1 = \left(\nu\frac{\bar{d}^f}{d^i} + (1-\nu)\right)^{-\gamma} - 1,$$

where the equality follows from the liquidity constraint (12) and the assumption $\theta = 0$ of the proposition. To compute the aggregate welfare effect, we integrate this ratio over the distribution of firms' deposits for firms with holdings above the insurance limit—to get the average marginal benefit of raising firms' insurance $\bar{d}^f$—and multiply by the haircut on uninsured deposits ν and the return on deposit R^d. The marginal benefits for households in (30) is constructed similarly, but uses the curvature of the log utility function of liquid consumption rather than the parameter γ of the production function, and thus, the term inside the integral is raised to the power of -1.[11]

If firms and households have the same cross-sectional distribution of deposits, the marginal benefit in Proposition 1 is higher for households. Under the same deposit distribution, the only difference between equations (29) and (30) is the curvature of the marginal payoff function (i.e., the marginal product of labor for firms, and the marginal utility function for households). This curvature is closer to zero for firms because

[11]If the household had a more general CRRA utility function with risk aversion σ_d, the argument of the expectation in equation (30) would be raised to the power of $-\sigma_d$.

the parameter γ of the production function is less than one (i.e., less than households' risk aversion under log utility). Note that if households had a general CRRA utility with risk aversion σ_d, the condition $\gamma < \sigma_d$ would still hold for standard parameterizations, and this result would be even stronger.

Accounting for differences in the cross-sectional distribution of deposits for households and firms does not change the result that the marginal benefit in Proposition 1 is higher for households. When we calibrate the full model to match the data in Section 5.1, household deposits are approximately lognormal and firm deposits are approximately Pareto. Numerically evaluating (29) and (30) under these distributions has a negligible effect on the results that would arise if firms and households had the same deposit distribution. (see Appendix C for details).

Next, we characterize how a higher insurance limit reduces the stock of uninsured deposits. This channel is central to the full model of Section 4, as a smaller stock of uninsured deposits reduces runs, and with it, bank failures. Indeed, this mechanism proves to be the primary driver of the quantitative results presented in Section 5.

Proposition 2. *Let $d^{unins} = d^{h,unins} + d^{f,unins}$ be the total stock of uninsured deposits, where $d^{h,unins}$ and $d^{f,unins}$ denote uninsured deposits held by households and firms, respectively. Then, in the limit as $p^{default} \to 0$:*

$$\frac{\partial d^{unins}}{\partial \bar{d}^h} = -m^h \Pr\left\{d^h\left(\psi\right) > \bar{d}^h\right\}, \quad \frac{\partial d^{unins}}{\partial \bar{d}^f} = -m^f \Pr\left\{d^i > \bar{d}^f\right\}. \tag{31}$$

If, in addition:

- *Households and firms hold the same amount of uninsured deposits: $d^{h,unins} = d^{f,unins}$*
- *The average holdings of uninsured deposits are greater for firms than for households:* $\mathbb{E}\left\{d^i - \bar{d}^f \,\middle|\, d^i > \bar{d}^f\right\} > \mathbb{E}\left\{d^h\left(\psi\right) - \bar{d}^h \,\middle|\, d^h\left(\psi\right) > \bar{d}^h\right\}$

Then

$$\left|\frac{\partial d^{unins}}{\partial \bar{d}^h}\right| > \left|\frac{\partial d^{unins}}{\partial \bar{d}^f}\right|. \tag{32}$$

The first part of Proposition 2 states that the marginal impact of raising the deposit insurance limit on the aggregate stock of uninsured deposits depends on the number of deposit accounts with balances over the limit (i.e., the mass $m^h \Pr\left\{d^h\left(\psi\right) > \bar{d}^h\right\}$ of household members with uninsured deposits, and similarly for firms). Intuitively, if we raise the insurance limit by \$1, and there are a million depositors (whether firm or household) with accounts above the limit, then the aggregate stock of uninsured deposits goes down by \$1 million. If there were 1,000 such accounts, it would only go down by \$1,000.

The second half of Proposition 2 allows us to easily compare the marginal impact of increasing insurance coverage for firms vs. households. To this end, we leverage our empirical analysis of Section 2.1 showing that the stock of uninsured deposits held by firms is roughly the same size as the stock of uninsured deposits held by households (right panel of Figure 1). If we also assume that the average uninsured firm depositor has a larger deposit balance than the average uninsured household—which is likely the case in practice—then there must be more uninsured households than uninsured firms, because

$$(\text{total uninsured deposits}) = (\#\text{ uninsured depositors}) \times (\text{avg uninsured balance})\,.$$

It follows from Proposition 2 that an increase in the household insurance limit $\bar{d}^h$ will have a greater effect on the total stock of uninsured deposits, than an increase in the firm insurance limit $\bar{d}^f$.

Taken together, both Propositions 1 and 2 show higher benefits for expanding insurance for households' deposits, in comparison to expanding insurance for firms' deposits. We confirm this result in the quantitative analysis of Sections 4 and 5, where we relax the assumptions of Proposition 1 and include other forces, such as general equilibrium effects on employment, investment, and output triggered by a change in deposit insurance, as well as the moral hazard of banks induced by subsidized deposit insurance.

4 Quantitative Model

In this section, we extend the baseline model, and then we use this full model to provide a quantitative analysis in Section 5. In particular, we add two ingredients to the model: first, we introduce panic-based runs, a primary motivation for deposit insurance and a key driver of its optimal design (Dávila and Goldstein, 2023). Second, we endogenize run-induced output losses to capture the empirical severity of systemic banking crises. We consider the moral hazard induced by subsidized deposit insurance in the robustness analysis of Section 5.4.

4.1 Runs: Environment and Timing

We now describe the environment of the extended model. We first highlight the two key ingredients that we add to baseline model, and we then describe the timing of the model in detail.

The first ingredient we add to the model generates panic-based runs. Specifically, we allow depositors to withdraw early if they anticipate bank failure, forcing banks to incur fire-sale costs to liquidate assets. As in Dávila and Goldstein (2023), the model features a *run region* for intermediate idiosyncratic shocks, where banks are susceptible to panic-based runs.

The second ingredient we add generates quantitatively meaningful effects of bank runs on real outcomes. To this end, we assume that banks can recall loans to build liquidity buffers, which directly reduces firms' productive capacity. This mechanism is motivated by two observations. First, loan covenant violations can trigger accelerated repayments, especially during crises; this channel reduced bank lending by 5% in 2008-2009 (Chodorow-Reich and Falato, 2022; Bidder et al., 2024). Second, banks typically expand liquidity buffers during run-prone episodes, such as the Great Depression (Robatto, 2019) and the 2023 regional banking crisis (Cipriani et al., 2024).

To link bailouts and bank runs, we assume that depositors must decide whether to run before the bailout decision is revealed, and that running entails a fixed cost Ξ. Thus, if a depositor runs but a bailout eventually occurs, then running was unnecessary ex post, and the cost need not have been paid. Consequently, a higher bailout probability f reduces the expected payoff of running, thereby lowering the volume of run-prone deposits. For quantitative realism, we also assume that only a fraction $\kappa < 1$ of running depositors successfully withdraw their funds.[12]

A key outcome of the quantitative model is that deposit insurance and government bailouts mitigate runs and, by extension, curtail loan recalls and their negative impact on output. A higher deposit insurance limit protects a larger share of depositors, reducing the proportion of run-prone deposits in the system. Furthermore, a higher bailout probability increases the opportunity cost of participating in a run, further reducing run risk. Consequently, deposit insurance and bailouts safeguard both the liquidity-provision role of deposits and the banks' role in providing credit to the economy.

The timing within the period is as follows:

(i) **Loan Recall Decision.** Each bank observes its idiosyncratic shock ε and chooses to either recall a fraction τ of its loans or none. Recalled loans do not earn the return r_t.[13]

(ii) **Depositor Choice.** Depositors observe the deposit insurance level, the bailout probability, a sunspot, and the bank's balance sheet (including ε and the recall decision). They then choose whether to incur the fixed cost Ξ to attempt a withdrawal.[14]

(iii) **Early Withdrawals and liquidation.** In banks subject to runs, a fraction κ of running deposits are withdrawn before the government closes the bank. Early withdrawals are paid by banks using recalled loans and, if not enough, by liquidating additional assets at a fire-sale cost $\Upsilon^{tot} > 0$. That is, banks need to sell $1/(1-\Upsilon^{tot}) > 1$ units of assets to raise one dollar.

(iv) **Bailout Realization.** For a fraction f of failing banks, the government bails out the remaining uninsured deposits. At the remaining fraction $1-f$ of failing banks, uninsured depositors receive a haircut ν_{t+1}.

(v) **Production and Settlement.** Firms hire labor and produce, households consume and save, and the government levies taxes to fund bailouts and deposit insurance.

The fixed cost Ξ ensures that only depositors with sufficiently large balances run, leading to simple threshold rules. Specifically, firms run only if their wealth exceeds an endogenous threshold $\bar{a}_t^{RUN}$, reflecting a monotonic relationship between wealth and deposits as in the model of Section 3. Similarly, household members run only if their liquidity preference parameter ψ exceeds an endogenous threshold $\bar{\psi}_t^{RUN}$.[15] We

[12]The assumption $\kappa < 1$ is consistent with stylized facts from banking crises; for example, during the run on Silicon Valley Bank (SVB), only a fraction of withdrawal requests were fulfilled.

[13]We also assume that recalling loans reduces the sunspot probability from one to $\pi < 1$. Without this assumption, banks in the run region would not recall loans, as the recall incurs a loss of the return r_t without an offsetting decrease in run probability. An alternative formulation would be to assume a negligible recall cost while allowing all loans—including those recalled—to earn the return r_t.

[14]We assume that depositors with uninsured funds that are able to take their money out of the bank withdraw their entire balance, including the insured portion.

[15]Note that, because of Item (ii), depositors observe only ε and their bank's recall decision when they decide whether to run or not at $t+1$, but no aggregate variables at $t+1$. Thus, the thresholds $\bar{a}_t^{RUN}$ and $\bar{\psi}_t^{RUN}$ can be computed together with other time-t equilibrium objects. If we instead had assumed that the run decisions depend on the aggregate state at $t+1$, the run cutoffs would be random variables at time t, and simulating the model would require solving for the endogenous distribution of such a random variables, which would substantially complicate the analysis. We also argue that the assumption about the lack of information about

can then define total runnable deposits as

$$d_t^{RUN} \equiv m_t^f \int \mathbb{I}\left\{a^i \geq \bar{a}_t^{RUN}\right\} d_t^i \, di + m^h \int \mathbb{I}\left\{\psi \geq \bar{\psi}_t^{RUN}\right\} d_t^h(\psi) \, dF^\psi(\psi). \tag{33}$$

In the following subsections we consider the bank's, firm's, and household's decisions, respectively.

4.2 Banks

The bank's problem includes an additional decision relative to the baseline model of Section 3: the choice to recall a fraction τ of its loans. Recalled loans do not earn the return r_t, but they provide liquidity that can be used to pay for withdrawals without incurring the fire-sale cost Υ^{tot}.

The decision to recall loans interacts with a bank's susceptibility to runs (Figure 4). As in typical models of panic-based runs (e.g., Dávila and Goldstein 2023), this susceptibility depends on the idiosyncratic shock ε. The key difference here is that for some banks, recalling loans provides sufficient liquidity to withstand a run, allowing them to become run-proof. We summarize these regions and the recall decisions below:

- **Run-Proof Region ($\varepsilon > \underline{\varepsilon}_{t+1}^{RUN}$):** These banks are healthy and never experience a run. This region contains two subregions:
  - Banks with $\varepsilon > \underline{\varepsilon}_{t+1}^{REC}$ do not recall any loans.
  - Banks with $\varepsilon \in (\underline{\varepsilon}_{t+1}^{RUN}, \underline{\varepsilon}_{t+1}^{REC})$ recall a fraction τ of their loans to ensure they are run-proof.
- **Run Region ($\varepsilon \in [\underline{\varepsilon}_{t+1}^{FUN}, \underline{\varepsilon}_{t+1}^{RUN}]$):** These banks recall their loans but remain vulnerable to panics. A fraction π of these banks is subject to runs; total failures due to panic-based runs are $\pi \int_{\underline{\varepsilon}_{t+1}^{FUN}}^{\underline{\varepsilon}_{t+1}^{RUN}} dF(\varepsilon)$.
- **Fundamental Default Region ($\varepsilon < \underline{\varepsilon}_{t+1}^{FUN}$):** These banks recall their loans but are fundamentally insolvent; total failures due to fundamentals are $\int_0^{\underline{\varepsilon}_{t+1}^{FUN}} dF(\varepsilon)$. Note that depositors run on fundamentally insolvent banks, too.

For $\varepsilon > \underline{\varepsilon}_{t+1}^{REC}$, banks remain solvent during a run without relying on recalling loans—which is costly because of the forfeited return r_t. The threshold $\underline{\varepsilon}_{t+1}^{REC}$ defines the shock value where a non-recalling bank is exactly solvent if all run-prone deposits d_t^{RUN} are withdrawn:

$$\underline{\varepsilon}_{t+1}^{REC} b_t(1 - \delta + r_t) = R_t^d \left(d_t - d_{t+1}^{RUN} + \frac{d_{t+1}^{RUN}}{1 - \Upsilon^{tot}} \right). \tag{34}$$

Equation (34) equates total assets on the left-hand side to the sum of (i) the deposits remaining after the run, $R_t^d(d_t - d_{t+1}^{RUN})$, and (ii) the deposits successfully withdrawn, $R_t^d d_{t+1}^{RUN}$. Due to the fire-sale cost Υ^{tot}, each dollar withdrawn requires liquidating $1/(1 - \Upsilon^{tot})$ units of assets.

the aggregate state at $t + 1$ is reasonable, as depositors who are facing a distressed bank need to decide quickly whether to run or not, whereas macroeconomic data typically become available with a lag.

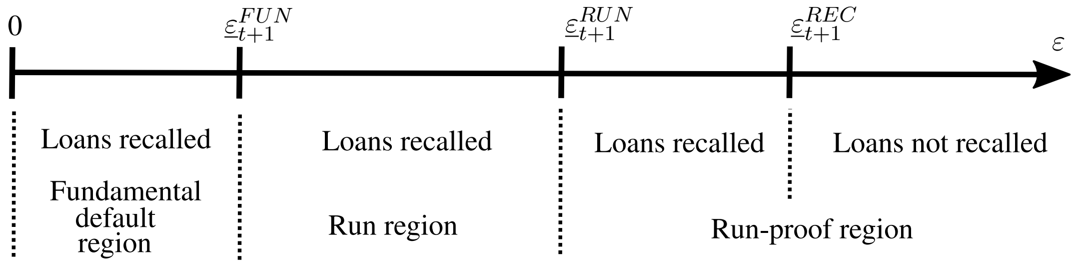


Figure 4. Banks' Recall Decisions and Runs

The figure describes the cutoff regions in ε-space for banks' loan recall decision and runs. Banks recall loans if and only if $\varepsilon < \varepsilon_{t+1}^{REC}$. Banks with $\varepsilon \in \left(\varepsilon_{t+1}^{RUN}, \varepsilon_{t+1}^{REC}\right)$ are able to avoid a run by recalling loans. Banks with $\varepsilon \in \left(\varepsilon_{t+1}^{FUN}, \varepsilon_{t+1}^{RUN}\right)$ experience a run with probability π. Banks with $\varepsilon < \varepsilon_{t+1}^{FUN}$ fail regardless of runs.

For $\varepsilon \in (\varepsilon_{t+1}^{RUN}, \varepsilon_{t+1}^{REC})$, banks eliminate run risk by recalling loans to obtain immediate liquidity and avoid fire-sale costs.[16] The threshold ε_{t+1}^{RUN} defines the shock value where a bank remains exactly solvent during a run after recalling loans:

$$(1-\tau)\varepsilon_{t+1}^{RUN} b_t(1-\delta+r_t) = R_t^d(d_t - d_{t+1}^{RUN}) + \frac{R_t^d d_{t+1}^{RUN} - \tau\varepsilon_{t+1}^{RUN} b_t(1-\delta)}{1-\Upsilon^{tot}}. \tag{35}$$

In equation (35), the left-hand side reflects the fact that a fraction τ of loans has been recalled, while on the right-hand side the fire sales necessary to meet the withdrawals have been reduced by the recalled loans (which do no earn r_t).

Banks with $\varepsilon \in (\varepsilon_{t+1}^{FUN}, \varepsilon_{t+1}^{RUN})$ remain susceptible to panic-based runs despite recalling loans. These banks are solvent only if a run does not occur. The lower bound, ε_{t+1}^{FUN}, is defined by:

$$(1-\tau)\varepsilon_{t+1}^{FUN} b_t(1-\delta+r_t) + \tau\varepsilon_{t+1}^{FUN} b_t(1-\delta) = R_t^d d_t. \tag{36}$$

Equation (36) differs from the baseline (3) by incorporating the effect of the banks' loan recalls.

Finally, banks with $\varepsilon < \varepsilon_{t+1}^{FUN}$ are fundamentally insolvent. We assume these banks adopt the same strategy as those in the run and recall regions and likewise implement a loan recall.[17]

Given these results, the bank default rate $p_{t+1}^{default}$ extends the baseline definition (7) by including the fraction π of banks in the run region that experience panics,

$$p_{t+1}^{default} = \int_0^{\varepsilon_{t+1}^{FUN}} dF(\varepsilon) + \pi \int_{\varepsilon_{t+1}^{FUN}}^{\varepsilon_{t+1}^{RUN}} dF(\varepsilon), \tag{37}$$

and total loans recalled are $\tau b_t \int_0^{\varepsilon_{t+1}^{REC}} dF(\varepsilon)$.

[16] The binary choice for τ has a negligible impact, as this region is quantitatively small.

[17] This approach is standard (e.g., Caballero and Simsek 2013), and it can be microfounded by allowing banks to gamble for resurrection; see Appendix E of Robatto (2019).

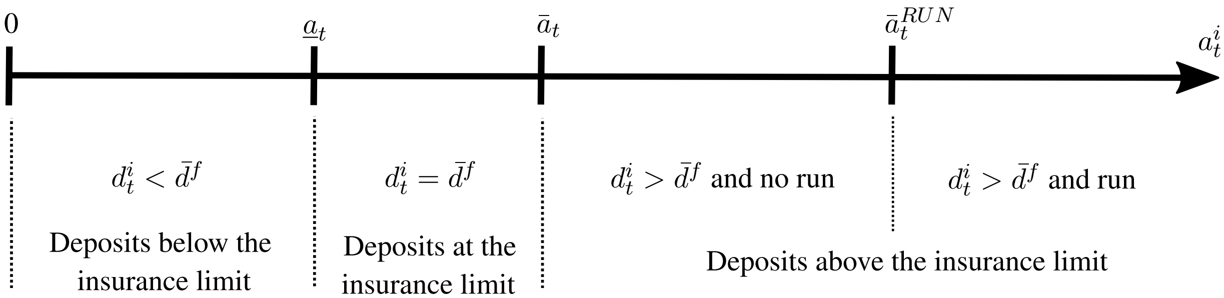


Figure 5. Firms: deposits and run decisions

The figure describes the cutoff regions in a^i-space (i.e., as a function of firms' wealth a^i) for firms' deposit and run choices. Firms with $a^i < \underline{a}_t$ choose $d_t^i < \bar{d}^f$; firms with $a^i \in (\underline{a}_t, \overline{a}_t)$ choose $d_t^i = \bar{d}^f$. Thus, deposits at firms with $a^i < \overline{a}_t$ are fully insured. Firms with $a^i > \overline{a}_t$ choose $d_t^i > \bar{d}^f$ and thus are partially uninsured. For firms with $a^i \in \left(\overline{a}_t, \overline{a}_t^{RUN}\right)$ it is not optimal top pay Ξ and attempt to withdraw; firms with $a^i > \overline{a}_t^{RUN}$ do pay Ξ and attempt to withdraw.

4.3 Selling Failed Banks

Following a bank failure (caused by runs or fundamentals), the government liquidates assets to partially cover the costs of deposit insurance and bailouts, incurring a proportional cost Υ^{tot}.[18] While Υ^{tot} represents a loss to the government of resolving failed banks, a portion of that loss may represent a windfall for the acquirer of the failed bank's assets. Thus, following Elenev et al. (2021), we assume a fraction $\Upsilon^{dwl} \leq \Upsilon^{tot}$ is a deadweight loss to society, while the remainder $\Upsilon^{tot} - \Upsilon^{dwl}$ is a gain to the acquirers. The total gains Π_t^{acq} are given by

$$\Pi_t^{acq} \equiv \left(\Upsilon^{tot} - \Upsilon^{dwl}\right) \int_{\{\text{failed banks}\}} (1-\tau)\varepsilon b_{t-1} \left(1 - \delta + r_{t-1}\right) dF(\varepsilon) \tag{38}$$

and are distributed lump-sum to households. Note that setting $\Upsilon^{dwl} \in [0, \Upsilon^{tot}]$ allows for a flexible parameterization: $\Upsilon^{dwl} = 0$ implies that fire sales and bankruptcy costs are just a transfer from sellers to buyers, whereas $\Upsilon^{dwl} = \Upsilon^{tot}$ implies that all such costs are deadweight losses.

4.4 Firms: Run Decision and Time-t Choices

Firms' decisions differ from the baseline in Section 3 in three ways. First, firms choose whether to run; the fixed cost Ξ makes this optimal only for deposits sufficiently above the insurance limit. Second, this run choice alters the ex-ante trade-off between deposits and capital. Third, firms' productive capacity is subject to the bank's loan recall decisions.

As in Section 3.2, firms' decisions depend on their wealth a^i. While the baseline features three regions, the quantitative model introduces a fourth to account for run behavior (Figure 5). As in the baseline, low-wealth firms ($a^i < \underline{a}_t$) hold deposits below the insurance limit $\bar{d}^f$, those with $a^i \in (\underline{a}_t, \overline{a}_t)$ hold deposits exactly at the limit $\bar{d}^f$, and high-wealth firms ($a^i > \overline{a}_t$) choose to be partially uninsured. Among these

[18] Note that the liquidation cost Υ^{tot} is the same as the fire-sale cost faced by banks subject to runs (Section 4.2).

uninsured firms, those with $a^i \in (\overline{a}_t, \overline{a}_t^{RUN})$ choose not to run to avoid the fixed cost Ξ, while the wealthiest ($a^i > \overline{a}_t^{RUN}$) find it optimal to incur Ξ and attempt withdrawal if their bank is failing.

The run threshold $\bar{a}_t^{RUN}$ is defined by the indifference condition between attempting a run and not. The following result characterizes this threshold.

Proposition 3. *Let $y_{t+1}^{full}(a^i)$ denote the output of a firm with wealth a^i when its uninsured deposits are fully recovered (via a successful run or a government bailout), and $y_{t+1}^{partial}(a^i)$ denote the output when uninsured deposits are subject to a haircut. The run threshold $\bar{a}_t^{RUN}$ satisfies*

$$\Xi = \kappa(1-f)(1-\theta)\mathbb{E}_t\left\{y_{t+1}^{full}\left(\bar{a}_t^{RUN}\right) - y_{t+1}^{partial}\left(\bar{a}_t^{RUN}\right)\right\}. \tag{39}$$

Equation (39) equates the fixed cost Ξ with the expected benefit of running. This benefit only accrues if the depositor successfully withdraws, which occurs with probability κ, and the bank is not subsequently bailed out, which occurs with probability $1-f$. The $1-f$ term in equation (39) reflects the fact that there is only an incremental benefit to running if the failed bank is *not* bailed out. The payoff is the fraction $1-\theta$ of the incremental output $y_{t+1}^{full}\left(\bar{a}_t^{RUN}\right) - y_{t+1}^{partial}\left(\bar{a}_t^{RUN}\right)$ that is obtained by avoiding losses on uninsured deposits, where $1-\theta$ accounts for the portion of production allocated to labor via the working capital constraint (12).

Proposition 3 shows that the run threshold is sensitive to the bailout probability f. An increase in f reduces the benefit of running, as uninsured deposits are more likely to be recovered without incurring the fixed cost Ξ. Consequently, a higher bailout probability f raises the threshold $\bar{a}_t^{RUN}$ above which running is optimal, and it reduces the aggregate volume of run-prone deposits. This reduction in turn shrinks the size of the run region (Section 4.2).

Next, we examine how the run decision affects the firms' allocation of resources between capital and deposits. For firms with wealth below the run threshold $\bar{a}_t^{RUN}$, the optimal choices remain identical to the baseline in Section 3.2. For firms above the threshold, the optimal choices are adjusted to reflect a higher expected recovery of uninsured funds. Specifically, the ability to withdraw early in a run increases the probability that deposits are fully repaid, and for firms that run, this probability is

$$p_{t+1}^{fr} = (1 - p_{t+1}^{default}) + p_{t+1}^{default}\big[\kappa + (1-\kappa)f\big]. \tag{40}$$

Note that as the withdrawal success probability κ increases, p_{t+1}^{fr} increases too; in the limit in which $\kappa \to 1$, the withdrawal probability converges to one as well, regardless of the default rate or bailout probability. The first-order condition governing the choice of capital and deposits for these firms is thus:

$$0 = \mathbb{E}_t\left\{\frac{\Lambda_{t+1}}{\Lambda_t}\left[\frac{\partial y_{t+1}^i}{\partial k_t^i}(1+\bar{\theta}\lambda_{t+1}^i) + 1 - \delta - r_t\xi_{t+1} - R_t^d(1+\lambda_{t+1}^i)\left(1-(1-p_{t+1}^{fr})\nu_{t+1}\right)\right]\right\}, \tag{41}$$

where $1-(1-p_{t+1}^{fr})\nu_{t+1}$ is the expected recovery rate per dollar of deposits. See Figure 12 in Appendix E.1 for a stylized depiction of firm's deposit choice as a function of their wealth a^i.

Finally, we describe how loan recalls affect firms. We assume that recalled loans affect equally all the firms in the economy—as if a firm were borrowing from a "representative" bank. This implies that the production function (11) is replaced by

$$y_{t+1}^i = A_{t+1}\left[k_t^i + \left(1 - \tau\int_0^{\varepsilon_{t+1}^{REC}} dF(\varepsilon)\right)b_t^i\right]^{\gamma}\left(l_{t+1}^i\right)^{1-\gamma}$$

because an amount τ of loans from the mass $\int_0^{\varepsilon_{t+1}^{REC}} dF(\varepsilon)$ of banks that recall their lending is not available for production. In addition, the term $r_t b_t^i$ in (13) is replaced by $r_t\left(1-\tau\int_0^{\varepsilon_{t+1}^{REC}} dF(\varepsilon)\right)b_t^i$ because firms do not pay any interest on recalled loans.

4.5 Households: Run Decision and Time-t choices

Household decisions depend on their liquidity preferences ψ and mirror the four-region structure of firms in Section 4.4. As in the baseline, households with low liquidity needs ($\psi < \underline{\psi}_t$) hold deposits below the insurance limit $\bar{d}^h$, while those with $\psi \in (\underline{\psi}_t, \overline{\psi}_t)$ hold deposits exactly at the limit. For households choosing to be partially uninsured ($\psi > \overline{\psi}_t$), the quantitative model introduces a run decision: those with $\psi \in (\overline{\psi}_t, \overline{\psi}_t^{RUN})$ forgo running to avoid the fixed cost Ξ, while only those with the highest liquidity needs ($\psi > \overline{\psi}_t^{RUN}$) find it optimal to pay the cost Ξ to attempt withdrawal.

The run cutoff $\overline{\psi}_t^{RUN}$ can be defined similarly to that of firms in equation (39). However, households compare the run cost Ξ with the utility of liquid consumption, and thus, the cost Ξ needs to be converted to utils using the marginal utility of consumption Λ_{t+1}:

$$\Xi\Lambda_{t+1} = \kappa(1-f)\overline{\psi}_t^{RUN}\left(\log\left(R_t^d d_t^h(\overline{\psi}_t^{RUN})\right) - \log\left(R_t^d\left[\bar{d}^h + \left(d_t^h(\overline{\psi}^{RUN}) - \bar{d}^h\right)(1-\nu_{t+1})\right]\right)\right). \tag{42}$$

Similar to the firm's problem, the choice of deposits for household members with $\psi > \bar{\psi}_t^{RUN}$ (i.e., those that choose to run) is analogous to the baseline expression (24), but with the probability of full repayment p_{t+1}^{full} replaced by p_{t+1}^{fr} as defined in (40). The first-order condition is thus

$$\Lambda_t = \beta\psi\,\mathbb{E}_t\left\{p_{t+1}^{fr}\frac{1}{d_t^h(\psi)} + \left(1-p_{t+1}^{fr}\right)\frac{(1-\nu_{t+1})}{\bar{d}^h + (1-\nu_{t+1})\left(d_t^h(\psi) - \bar{d}^h\right)}\right\}. \tag{43}$$

4.6 Labor Market

To capture short-term labor market dynamics, we incorporate wage rigidities following the macro-labor literature (Shimer, 2005; Gertler and Trigari, 2009; Gertler et al., 2020). The labor market is competitive, but wages adjust sluggishly according to:

$$w_t = \omega w_{t-1} + (1-\omega)w_t^f, \tag{44}$$

where ω governs the degree of rigidity and $w_t^f = \chi l_t^{1/\eta}/\Lambda_t$ is the flexible wage determined by the households' marginal rate of substitution. Equation (44) provides a reduced-form representation of the infrequent wage renegotiations microfounded in Gertler et al. (2020).

4.7 Government

The government operates as in the baseline model of Section 3, but the haircut ν_{t+1} and the taxes T_{t+1} are based on the deposit balances remaining after accounting for runs and loan recalls. Replacing the baseline formulation in (25), the haircut ν_{t+1} is implicitly defined by:

$$\begin{aligned} p_{t+1}^{default}\ R_t^d\left[(1-\nu_{t+1})\left(d_t-\kappa d_t^{RUN}\right)+\kappa d_t^{RUN}\right] = \\ \int_{\{\text{failed banks}\}}\left[\tau\varepsilon b_t\left(1-\delta\right)+(1-\tau)\varepsilon b_t\left(1-\delta+r_t\right)\left(1-\Upsilon^{tot}\right)\right]dF\left(\varepsilon\right). \end{aligned} \tag{45}$$

Equation (45) equates failed banks' liabilities to their liquidated assets. The haircut ν_{t+1} applies only to the deposits remaining in the bank d_t net of the amount κd_t^{RUN} withdrawn during runs, while the assets reflect the liquidation cost Υ^{tot} applied to the non-recalled portion $1-\tau$ of loans.

The taxes required to finance the costs of deposit insurance and bailouts are

$$T_{t+1} = p_{t+1}^{default}\nu_{t+1}R_t^d\left(f\left(d_t-\kappa d_t^{RUN}\right)+(1-f)\underbrace{\left[d_t^{ins}-\kappa\left(\int_{\overline{a}_t^{RUN}}^{\infty}\bar{d}^f dF^a\left(a^i\right)+\int_{\overline{\psi}_t^{RUN}}^{\infty}\bar{d}^h dF^{\psi}(\psi)\right)\right]}_{\text{insured deposits not withdrawn}}\right) \tag{46}$$

For the fraction f of failed banks that are bailed out, the government covers the haircut ν_{t+1} on all deposits remaining after the runs, $d_t-\kappa d_t^{RUN}$. For the fraction $1-f$ that are not bailed out, the government covers only the insured deposits that were not withdrawn. This amount is the total stock of insured deposits d_t^{ins} minus the insured portion of deposits successfully withdrawn in runs; recall that depositors that run withdraw all their deposits, and not just the deposits that were above the limit.

4.8 Aggregate Resource Constraint

The aggregate resource constraint is given by

$$\begin{aligned} c_t+i_t+\Omega\left(T_t\right)+\Upsilon^{dwl}\int_{\{\text{failed banks}\}}\varepsilon(1-\tau)b_{t-1}\left(1-\delta+r_{t-1}\right)\ dF_t\left(\varepsilon\right) \\ +\ \Xi\ p_t^{default}\left[\int_{\overline{a}_t^{RUN}}^{\infty}dF\left(a^i\right)+\int_{\overline{\psi}_t^{RUN}}^{\infty}dF\left(\psi\right)\right]\leq Y_t. \end{aligned} \tag{47}$$

The first three terms are the same as in Section 3.5—total consumption $c_t = c_t^{liq}+c_t^{oth}$, investments $i_t = (k_t+b_t)-(1-\delta)\left(k_{t-1}+b_{t-1}\right)$, and the deadweight loss of taxation $\Omega(T)$. The fourth term is the deadweight loss arising from bank defaults and fire sales. The fifth term accounts for the costs incurred by firms and households that choose to run. Finally, $Y_t=\int y_t^i di$ denotes gross output.

Panel A: Pre-Set Parameters							
Parameter	Value	Parameter	Value	Parameter	Value	Parameter	Value
β	0.95	η	1	δ	0.1	γ	0.3
$\bar{A}$	1	ρ_A	0.95	χ	171	ζ	0.0913
Υ^{tot}	0.1579	Υ^{dwl}	0.045	Ω_1	0.13	Ω_2	5.5
π	0.109	f	0.94	$\bar{d}^f$	0.35	$\bar{d}^h$	0.35

Panel B: Parameters chosen to match data moments			
Parameter	Value	Moment Target	Moment Value (Data & Model)
α_0	7.1769×10^{-4}	Firms' uninsured deposits, %	56%
α_1	1.06	Pareto tail, firm size	1.06
μ_ψ	-2.4973	Avg households' deposits, thous $	28.852
σ_ψ	1.8867	Households' uninsured deposits, %	21%
m^h	11.6474	Households' deposits/GDP	25%
ξ	0.2735	Firms' deposits/GDP	14%
Ξ	0.002536	Runnable/uninsured deposits	86%
κ	0.296	% of runs that are successful	42%
τ	0.2	Investment decline after loan recall	4%
σ	0.0258	Average bank default rate	0.64%
θ	0.55121	Deposit premium, $R^f - R^d$	0.91%
σ_A	0.00745	Volatility GDP	1.56%
ω	0.917	Vol(employment)/vol(GDP)	0.72

Table 2. Calibrated Parameter Values. Firms' and households' insured deposits are expressed as a fraction of the total deposit of the respective group. All second moments are computed by taking logs and applying the HP-filter with parameter 100, both in the model and in the data.

5 Quantitative Analysis: Deposit insurance, Bailouts, and the 2023 Crisis

In this section, we calibrate the quantitative model and conduct two counterfactuals. First, we perform a welfare analysis by increasing deposit insurance, allowing for different coverage levels for firms and households. Second, we ask what would have happened had regulators not bailed out uninsured deposits during the banking crisis of 2023. Finally, we assess the robustness of our results to alternative calibrations and model extensions.

5.1 Calibration

We calibrate the model using data from 1986 to 2019. The sample begins in 1986 because most regulations that prevented banks from paying interest on their deposits were phased out by 1985 (Gilbert, 1986), and ends in 2019 to avoid the effects of COVID-19. Because depositors are able to access the recovery value of their uninsured deposits at failed banks, we choose the length of a time period to be one year.[19] We simulate the model using standard first-order perturbation methods.

The top panel of Table 2 lists pre-set parameters. We adopt standard values for the discount factor β, Frisch elasticity η, depreciation δ, capital share γ, and productivity average $\bar{A}$ and persistence ρ_A, while χ is set to normalize aggregate labor to unity. We set the capital requirement ζ to 9.13%, which matches the average equity-to-assets ratio in our sample. Following Elenev et al. (2021) and Bennett and Unal (2015), we set the liquidation cost Υ^{tot} to 15.79% and the deadweight loss Υ^{dwl} to 4.5%, reflecting asset-weighted resolution and receivership expenses. For the deadweight loss of taxation, we adopt the functional form $\Omega(T) = (\Omega_1/\Omega_2)\left(e^{\Omega_2 T} - 1\right)$ and parameters $\Omega_1 = 0.13$ and $\Omega_2 = 5.5$ from Dávila and Goldstein (2023), which align with the marginal cost of public funds in Kleven and Kreiner (2006). The sunspot probability π is 10.9%, matching the likelihood of a run among banks with identical observables during the SVB crisis (Cipriani et al., 2024).[20] The bailout probability f is 94% (Section 2.2).

To set the insurance limits for households and firms, $\bar{d}^h$ and $\bar{d}^f$, we note that in the model these limits represent the average holdings of insured deposits for depositors with a positive uninsured balance. In the SCF data, we find these insured holdings to be about \$350,000 (see Appendix C). Hence, we set $\bar{d}^h$ and $\bar{d}^f$ to 0.35. In the robustness analysis of Section 5.4, we show that the results are essentially unchanged when we set $\bar{d}^h$ and $\bar{d}^f$ to 0.25 based on the \$250,000 FDIC limit.

The bottom panel of Table 2 lists parameters calibrated to match selected moments. We describe the calibration targets here, and provide additional details in Appendix C.

We assume that the firm wealth distribution a^i follows a Pareto distribution with scale parameter α_0 and tail parameter α_1, allowing us to match the employment distribution in the Census Business Dynamic Statistics (see also Luttmer 2007). We set α_0 and α_1 to match the 56% share of uninsured firm deposits (Section 2.1) and a Pareto tail coefficient of 1.06. For households, consistent with the lognormal distribution of deposits in the SCF, we assume that the liquidity preferences ψ are lognormally distributed with parameters μ_ψ and σ_ψ. We calibrate these parameters to match the 21% share of uninsured household deposits (Section 2.1) and the average holdings of households' deposits in the 2019 wave of the SCF. We calibrate the household measure m^h and firm leverage constraint ξ to match the household and firm deposit-to-GDP ratios, respectively.

We calibrate the run cost Ξ and the fraction κ of successful withdrawals in a run using evidence from the 2023 SVB crisis. During the run on SVB, depositors attempted to withdraw \$142 billion, representing approximately 86% of uninsured deposits, but only 29.6% of these requests were fulfilled before regulators closed the bank (Board of Governors, 2023; Gruenberg, 2023). Accordingly, we set Ξ such that 86% of uninsured deposits are runnable in equilibrium and set $\kappa = 0.296$. These values imply that running is optimal only for firms and households with at least \$1.30 million and \$1.26 million in deposits, respectively.

We set the loan-recall parameter $\tau = 0.2$. This matches the investment decline following covenant

[19] In practice, the FDIC repays uninsured depositors over time as resources are recovered, though it often provides an "advanced dividend" based on estimated recovery values. Furthermore, historical precedents—such as the 1992 California budget crisis where banks honored state-issued IOUs as regular checks (Reinhold, 1992)—suggest that markets for recovery-value claims can emerge quickly.

[20] This matches our model's definition of π as the fraction of run-prone banks that actually experience a run.

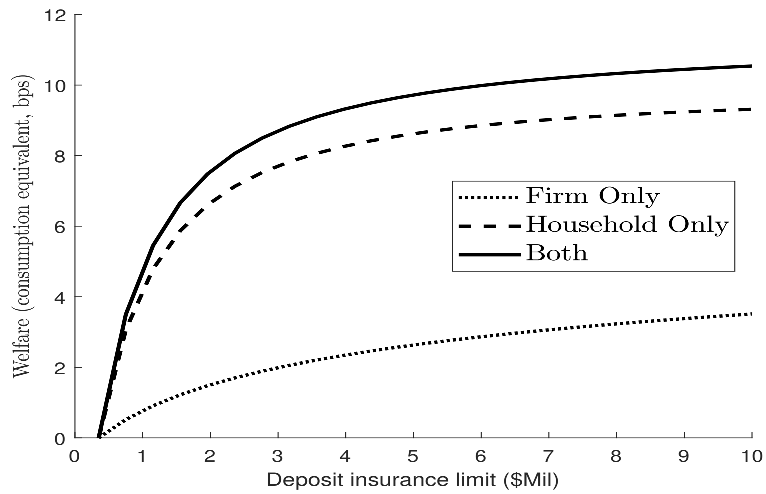


Figure 6. Welfare as a Function of Households' and Firms' Insurance Limit

The figure plots household welfare as a function of the level of deposit insurance insurance coverage in millions of dollars. The dotted line assumes that only the firms' insurance limit $\bar{d}^f$ changes to the value plotted on the x axis, the dashed line assumes only the households' limit $\bar{d}^h$ changes, and the solid line assumes that both limits change together. Welfare is expressed in consumption equivalent units, in annualized basis points, relative to the baseline economy in which $\left(\bar{d}^f, \bar{d}^h\right) = (0.35, 0.35)$.

violations during periods of lender distress (Chodorow-Reich and Falato, 2022).

We calibrate the remaining parameters—σ, θ, σ_A, and ω—to match the bank default rate, the deposit premium, and the volatilities of GDP and employment.

Appendix D provides a list of untargeted moments and compares the model's behavior with the data. The model matches reasonably well several untargeted business cycle and banking moments.

5.2 Changing Deposit Insurance: Welfare Analysis

In this section, we first examine the welfare effects of increasing deposit insurance limits while fixing the bailout probability at $f = 94\%$. Motivated by the 2025 "Main Street Depositor Protection Act," we consider insurance levels as high as \$10 million. Across this range, we obtain modest welfare gains, the majority of which stem from household coverage. In a second exercise, we find that reducing coverage—either by lowering insurance limits or the bailout probability f—results in significant welfare losses.

We compute welfare using the standard approach of calculating the expected present-discounted utility of households. Our primary analysis focuses on the stochastic steady state, though our results are similar when we account for the transitional dynamics as the economy converges to a new stochastic steady state (see Section 5.4).

Figure 6 plots welfare, in consumption-equivalent units, as insurance coverage expands to \$10 million. When we increase insurance for both households' and firms' deposits (solid line), the welfare gain reaches 10.5 basis points (i.e., 0.105% of consumption). To put this magnitude in context, Begenau (2020), Begenau and Landvoigt (2022), and Pancost and Robatto (2023) find that optimal capital requirements increase

	Baseline	$10 million insurance		
		All Deposits	Household only	Firm only
Default Rate:	0.64%	0.40%	0.43%	0.56%
Default Rate (from runs)	0.28%	0.005%	0.03%	0.18%
Uninsured Deposits	34%	17%	21%	30%
Runable Deposits	29%	18%	21%	28%
Welfare Gains (bps):		10.5	9.31	3.51
Change in GDP (bps):		6.73	5.96	2.26
from Δl:		-0.24	-0.21	-0.07
from Δk:		1.97	1.74	0.67
from Δloan recalls:		4.50	3.97	1.49
from Δdeadweight losses:		0.50	0.45	0.17
from Δtaxes:		0.14	0.12	0.05
from Δbank failure:		0.36	0.32	0.13
from Δwithdrawal costs:		0.003	0.002	0.001

Table 3. Decomposing Welfare Gains

The table reports various bank outcomes (top panel), welfare gains in basis points (middle panel), and changes in GDP in basis points (bottom panel) for three alternative deposit insurance policies: a $10 million limit for both households and firms (second column), a $10 million limit for households but no change in the limit for firms (third column), and a $10 million limit for firms with no change in the limit for households (last column). The first column reports the bank outcome variables in the baseline model without the policy change.

welfare by approximately 3, 5, and 20 bps, respectively. The dashed and dotted lines plot the result when we increase insurance only for households' or firms' deposits, respectively. The gains arising from increasing coverage for households' deposits are substantially higher, in line with the analysis of Section 3.6.

Table 3 shows that the main effects of increasing insurance are to reduce bank defaults due to runs, and to increase GDP. We estimate that increasing the insurance limit to $10 million would boost GDP by 6.73 bps, of which 4.50 bps are due to a reduction in loan recalls. Only about half of a basis point of the increase in GDP is attributable to a reduction in other deadweight losses associated with runs and bank failures. The last two columns of Table 3 show that these results are qualitatively identical when changing just the household or firm insurance limits separately, but much larger for the increase in the household insurance limit.

Table 4 explores the welfare consequences of eliminating deposit insurance and government bailouts.[21] Removing insurance while maintaining the baseline bailout probability ($f = 0.94$) lowers welfare by 6 bps—a smaller magnitude, in absolute terms, than the gain from increasing insurance to $10 million. In contrast, removing bailouts has a much larger impact of 36 bps. Finally, eliminating both deposit insurance and bailouts produces an extremely severe welfare loss, as households would forgo 1.5% of annual consumption to avoid such a regime.

[21] For computational reasons, we approximate zero insurance coverage with a $500 limit.

Policy	Parameter	Welfare (consumption equivalent, bps)
No deposit insurance	$\bar{d}^f = \bar{d}^h = \$500$	-6
No bailout	$f = 0$	-36
No deposit insurance and no bailouts	$\bar{d}^f = \bar{d}^h = \$500$ and $f = 0$	-149

Table 4. Welfare Costs of Reducing Coverage

The table reports the welfare losses, in consumption equivalent units relative to the baseline, of eliminating various forms of government guarantees.

5.3 The 2023 Banking Crisis and the Reduction in Bailouts

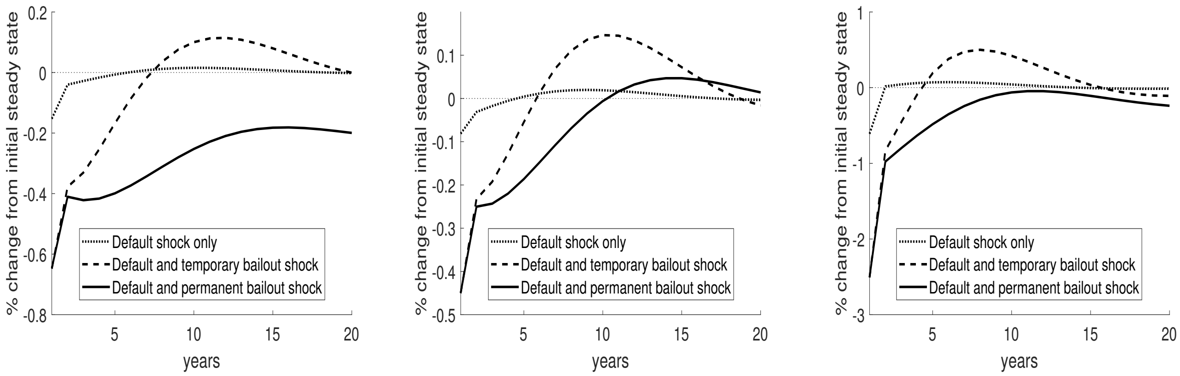
To study what would have happened had regulators not bailed out uninsured deposits during the banking crisis of 2023, we use the calibrated model to compute the impulse responses to two shocks: a *default shock* that temporarily increases the default rate of banks, to produce the 2023 banking crisis, and a *reduced bailout shock* that lowers the probability f that the government bails out the uninsured deposits of failed banks. We find that reducing bailouts during the crisis would have generated substantial macroeconomic consequences: bank failures would have increased by 1.3 percentage points because of an increase in panic-based runs, and GDP would have declined by 0.65%.

We model the 2023 banking crisis as an unexpected, one-period increase in σ—the parameter governing the size of the idiosyncratic bank shock. We set σ to induce a 2.3% default rate among banks, matching the asset-weighted failure rate of FDIC-insured institutions in the first half of 2023. We consider three scenarios for the bailout probability f: (i) f remains constant at 0.94; (ii) a transitory shock in which f drops to zero, and then reverts to 0.94 with an autocorrelation of 0.5, and (iii) a permanent shock where f drops to zero but then reverts to 0.35 over time over time.[22] This latter value represents the historical asset-weighted percentage of banks receiving bailouts from 2008 to 2023, assuming no bailouts had occurred during the 2023 crisis.

Figure 7 plots the real consequences of these shocks over time. We find small responses to the shock to σ that generates the 2.3% bank default rate observed in 2023, when we keep the bailout probability unchanged at $f = 94\%$. Panel (a) shows a very modest reduction on GDP on impact, of about 0.15%, that quickly reverts to zero. The effects on employment and investment in Panels (b) and (c) are likewise small.

The shock to the bailout probability f leads to more bank failures and a significant reduction in real economic activity. The bank default rate increases by 1.3 percentage points on impact—from the 2.3% level observed in 2023 to 3.6%—because the lower value of f reduces the cost to depositors of running. Figure 7 shows that, on impact, GDP drops by 0.65%, employment by about 0.45%, and and investment by 2.5%, regardless of whether the change in f is permanent. The long-term value of f affects the speed the of the recovery and the long-term effects: if the long-term value of f drops to 0.35, the recovery is slower and there are permanent effects. These long-term effects are especially pronounced for GDP, which is lower by more than 20 basis points. As we show in Section 5.4, the effects are mostly driven by loan recalls, in line

[22] Because we consider a large shock to f, we compute the impulse response using a perfect foresight solution method that solves the full set of non-linear equations.



(a) GDP (b) Employment (c) Investments

Figure 7. Response to the default and reduced bailout shocks

The figure plots the dynamics of GDP (panel a), employment (panel b), and investments (panel c) in response to exogenous shocks to bank default risk σ and the bailout probability f. In all three lines, σ increases at $t = 1$ to induce a 2.3% bank default rate in the absence of the shock to f. The dotted lines in each figure correspond to the shock to σ alone, holding f constant at 0.94; in the dashed lines, $f = 0$ at $t = 1$, but then f slowly mean-reverts to its previous steady-state value of 0.94 with auto-correlation 0.50; in the solid lines, f mean-reverts to a new steady-state value of 0.35. All figures report values in percent deviations from the initial steady-state.

with the welfare decomposition in Section 5.2.

5.4 Robustness

As a last step, we show that our results are robust to several extensions, alternative calibrations, and solution approaches. Table 5 summarizes these analyses, where the first row reports the baseline results comparison. We briefly describe these exercises here, and provide extensive details in Appendix F.

Rows 2 and 3 consider slight variations to our solution methods.[23] In row 2, we simulate the model using a second-order approximation. In row 3, we account for the transition path to the new steady state when computing welfare. Because the new steady state has a slightly higher level of physical capital, the change in welfare that accounts for the transition is slightly smaller.

Rows 4–6 consider alternative calibrations. In row 4, we set $\bar{d}^h = \bar{d}^f = 0.25$ to match the $250,000 FDIC statutory limit. In row 5, we increase the deadweight losses of default by 3 percentage points, consistent with the evidence on crisis-time costs (Bennett and Unal, 2014; Granja et al., 2017). In row 6, we lower the bailout probability f to 0.71, to match the pre-2008 data (Table 1, Column 1). In this last exercise, the effects of a bailout shock are mechanically smaller as the probability f drops to zero from a lower baseline. However, the welfare gains from expanding deposit insurance are unchanged, because the recalibrated model requires a higher run cost Ξ to match our target moments, offsetting the impact of the lower f.

Rows 7–10 analyze various model extensions. In row 7, we allow firms to hold risk-free liquid assets such as Treasury securities, which provide liquidity—albeit less than deposits. This additional liquidity is

[23]These alternative approaches apply only to the computation of welfare when changing deposit insurance. For the bailout shock, we compute the impulse responses using the full-nonlinear model as noted in Section 5.3.

Model	$10 million insurance All deposits		HH deposits	Bailout shock Section 5.3	
	ΔGDP	ΔWelfare	ΔWelfare	Δdefault	ΔGDP
1. Baseline calibration	0.07%	0.11%	0.09%	1.3 p.p.	-0.65%
2. Baseline with 2nd order simulations*	0.07%	0.10%	0.09%	1.3 p.p.	-0.65%
3. Baseline with transition*	0.07%	0.09%	0.08%	1.3 p.p.	-0.65%
4. Insurance limit $\bar{d}^h, \bar{d}^f$: $250,000	0.07%	0.11%	0.10%	1.3 p.p.	-0.68%
5. More deadweight losses: $\Upsilon^{dwl} = 0.075$	0.07%	0.11%	0.10%	1.3 p.p.	-0.68%
6. Lower bailout probability: $f = 0.71$	0.07%	0.11%	0.09%	0.7 p.p.	-0.42%
7. Other liquid assets for firms	0.07%	0.11%	0.09%	1.3 p.p.	-0.63%
8. Banks with negative equity	0.06%	0.12%	0.10%	2.2 p.p.	-0.73%
9. Risk-shifting	0.04%	0.06%	0.05%	1.2 p.p.	-0.70%
10. Risk-shifting & monitoring	0.03%	0.04%	0.04%	1.2 p.p.	-0.70%
11. No loan recalls: $\tau = 0$	0.02%	0.03%	0.03%	1.7 p.p.	-0.14%
12. No bailouts: $f = \Xi = 0^{\dagger}$	0.20%	0.29%	0.28%	-	-

Table 5. Robustness

The table reports results for several robustness exercises, with the results of the baseline calibration reported on the first line for convenience. In lines 4-12, we recalibrate the model to match the same targets as in Table 2. Columns 1-2 report the results of increasing the deposit insurance limit to $10 million, either for all depositors (columns 1 and 2) or for households only (column 3). Columns 4 and 5 report the effect, on impact, of the impulse-response exercise of Section 5.3. ΔGDP is the change in GDP in percent, and Δdefault is the change in bank default rate in percentage points. *: the second-order simulations and transition apply only to the welfare analysis of changing deposit insurance, as the effects of the bailout shocks are computed by solving the full non-linear model. †: we consider increasing the limit only to $2 million, at which point bank default risk is essentially zero.

offset by a lower calibrated value of θ in the working capital constraint (12) to match the deposit premium, leaving the results essentially unchanged. In row 8, we allow banks to operate with negative equity, reflecting accounting rules that create a wedge between market and regulatory capital (FDIC 2017; Jiang et al. 2023; Begenau et al. 2021; Kim et al. 2019; Orame et al. 2023). This version generates slightly larger effects because delayed liquidation requires higher bank-default parameters to match our targeted moments.

Rows 9–10 introduce risk-shifting (Jensen and Meckling, 1976) via a negative-NPV technology that increases idiosyncratic risk, following the "bad risk-taking" approach of Pancost and Robatto (2023). Row 10 further adds a "monitoring" element where risk-shifting increases the return demanded by uninsured depositors. Although welfare gains are lower, they remain monotonic for insurance limits up to $10 million for two reasons. First, higher insurance curbs runs and bank defaults, thereby diminishing risk-shifting incentives. Second, the high bailout probability ($f = 0.94$) mutes the impact of monitoring: each percentage point increase in bank default risk raises the risk to uninsured depositors by only $1 \times (1 - 0.94) = 0.06$ percentage points, rendering the results with and without monitoring nearly identical. To further highlight the importance of bailouts in muting the impact of depositor monitoring, in Appendix F.6.3 we assume that an increase in bank default risk due to risk-shifting is fully transmitted to uninsured deposits; in that extension, welfare is not monotonically increasing and is instead maximized at $5 million, with welfare gains of only 1.87 bps.

We also extend the model to allow banks to hold safe liquid assets alongside loans. We provide all the details in Appendix F.7, as some rich transitional dynamics arise in response to higher insurance. Safe liquid assets provide a liquidity buffer for banks, which can protect them from runs. A potential concern is that higher insurance might induce banks to reduce these holdings, thereby offsetting the direct reduction in run risk. We find that while banks do scale back their liquidity buffers, they reallocate their assets toward lending. This shift allows for more liquidity access through loan recalls, keeping run frequency slightly below the baseline.

In the last two rows of Table 5, we highlight the quantitative importance of two key elements: loan recalls and the effects of bailouts on runs. Without these elements, the qualitative results are unchanged but the magnitudes are very different. Removing loan recalls substantially reduces the impact of changing deposit insurance and bailouts because recalls drive the large macroeconomic costs of bank runs. Conversely, removing bailouts and their effect on runs (i.e., setting $f = 0$ and $\Xi = 0$, so that all uninsured deposits are runnable) sharply increases the impact of higher insurance. Under this calibration, nearly all bank failures are run-driven. Thus, by precluding runs, higher insurance virtually eliminates all bank defaults. Furthermore, without bailouts, the liquidity benefits described in Proposition 1 apply to all uninsured deposits at failed banks, rather than just the $1 - f = 6\%$ of failed banks that are not bailed out, as in the baseline calibration. Thus, the results in the final row of Table 5 illustrate the importance of modeling both bailouts and the endogeneity of runs jointly.

6 Conclusion

This paper makes two primary contributions. First, we provide novel stylized facts showing that firms hold more uninsured deposits than households, and that uninsured deposits rarely incur losses. Second, we incorporate these facts into a quantitative general equilibrium model, showing—both analytically and quantitatively—that expanding deposit insurance for households' deposits yields higher welfare gains than expanding insurance for firms' deposits. In addition, our model indicates that failing to bail out depositors in March 2023 would have triggered a severe spike in defaults and a large macroeconomic contraction.

Our analysis points to several directions for future research. While we focus on deposits as liquidity providers, accounting for their function as a primary saving instrument for households (Cirelli, 2023) could enrich the welfare analysis of government guarantees. More broadly, the optimal joint design of insurance, bank resolution, and capital requirements remains an open question. Finally, our results suggest that refining the design of deposit insurance will require more granular data on the distribution of deposits across firms and households and how these distributions vary in the cross-section of banks.

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Appendix

A Deposits and Bank Failures Data Analysis: Details

A.1 Deposit Holdings by Owner

Figure 8 plots the evolution of the deposits held by households, firms, financial institutions, foreigners, as well as federal, state, and local governments, as a share of deposits at domestic branches of FDIC-insured banks, between 1992 and 2019.[24] Households typically hold between 40% and 60% of the total stock of deposits. The next largest group of depositors are firms (i.e., nonfinancial businesses), followed by financial institutions, foreigners, and government entities.[25] Firms' deposit holdings have nearly doubled from 12% in 1992 to 22% in 2019, in line with the increase in the holdings of cash-like assets documented by Bates et al. (2009).

A.2 Insured and Uninsured Households' Deposits in the Survey of Consumer Finance

We use the Survey of Consumer Finances (SCF) to compute the amount of deposits held by households and to break this quantity down into insured and uninsured deposits. For other groups of depositors, we obtain aggregate data from the Flow of Funds (FF). When we work with both the SCF and FF at the same time, we use FF data from the third quarter of the respective year to facilitate the comparison. In the rest of this subsection, we provide details about our data analysis using the SCF. Starting with the 1992 survey, the SCF asks each respondent to provide detailed information about checking accounts, saving accounts, money market accounts, and certificate of deposits.

Regarding checking accounts, all years include information about amount, bank, and ownership of six checking accounts, as well as the amount held in any remaining checking account. For the amount held in any remaining checking account, we lack information about the bank and ownership. Thus, we assume that the amount in these accounts is held in one bank (that is different from all the other banks the household is engaged with) and is owned by the respondent (see below how the SCF assigns ownerships of bank accounts).

Between 1992 and 2001, the SCF asks respondents about their money market deposit accounts, but this information is combined with savings accounts after 2001. Specifically, between 1992 and 2001, the survey asks about amount, bank, and ownership of up to three money market deposit accounts, as well as any amount held in additional money market deposit accounts. Similar to checking accounts, we assume that the amount held in additional accounts is in one bank (that is different from all the other banks with which the household is engaged) and is owned by the respondent.

Regarding savings accounts, the SCF asks about amount, bank, and ownership of up to five savings accounts between 1992 and 2001, and up to six savings/money market accounts after 2001. Similar to

[24] We exclude deposits held at foreign branches, which are not insured. We start our sample in 1992 because detailed SCF data that allows us to compute households' insured and uninsured deposits are not available in previous waves of the SCF.

[25] Other account holders (not shown) include nonprofit institutions, with holdings stable at about 4% throughout the entire sample, and domestic hedge funds, for which data are available only since the end of 2012, and whose holdings have been 1% or less.

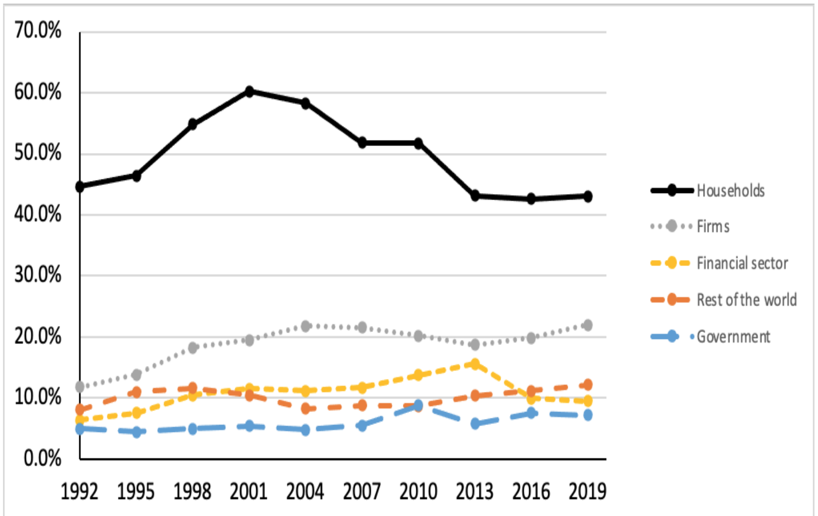


Figure 8. Ownership of deposits

The figure plots the holdings of deposits of households, firms, financial institutions, foreigners, and governments. For each group, the figure reports the holdings as a fraction of deposits at domestic branches of FDIC-insured banks.

checking accounts, the SCF also asks about the amount held in any remaining checking account, and we assume such an amount is held in one bank (that is different from all the other banks with which the household is engaged) and is owned by the respondent.

Regarding certificate of deposits (CDs), the SCF provides the total amount of all CDs held by the family, up to five institutions where the CDs are held in the 1992 survey and up to seven in the following ones, and one response about the ownership of all the CDs. If the respondent lists multiple institutions where the CDs are held, we assume that the household owns the same amount of CDs at each of the institutions that are listed.

When information about the bank is provided, the public version of the SCF contains an identifier of the bank (rather than the name) for up to seven financial institutions with which the household is engaged. The identifier allows us to determine if any two bank accounts are at the same bank or at different banks, which allows us to construct the FDIC insurance coverage, as we explain below. For each additional institution, we have information about the broad category of the institution (e.g. "commercial bank," "brokerage," "person or other non-institution,"...). We remove accounts held at non-bank institutions such as stores, insurance companies, churches, unions, etc. Note that the bank identifier is household-specific, and thus, we cannot construct bank-level holdings of insured and uninsured deposits using the public version of the SCF.

When information about ownership is provided, each account is assigned one of the following options: respondent, spouse, child or grandchild, other family member, unrelated person, respondent and spouse, respondent/spouse and child/grandchild, respondent/spouse and other relative, and respondent/spouse and unrelated person. We treat "child/grandchild" as one single owner. For joint ownership, we assume that the account is owned by three people; for instance, if the ownership is recorded as "respondent/spouse and child/grandchild," we assign equal ownership to the respondent, the spouse, and the child/grandchild. The SCF question about ownership includes, as possible responses, also "personal business account" and "trust

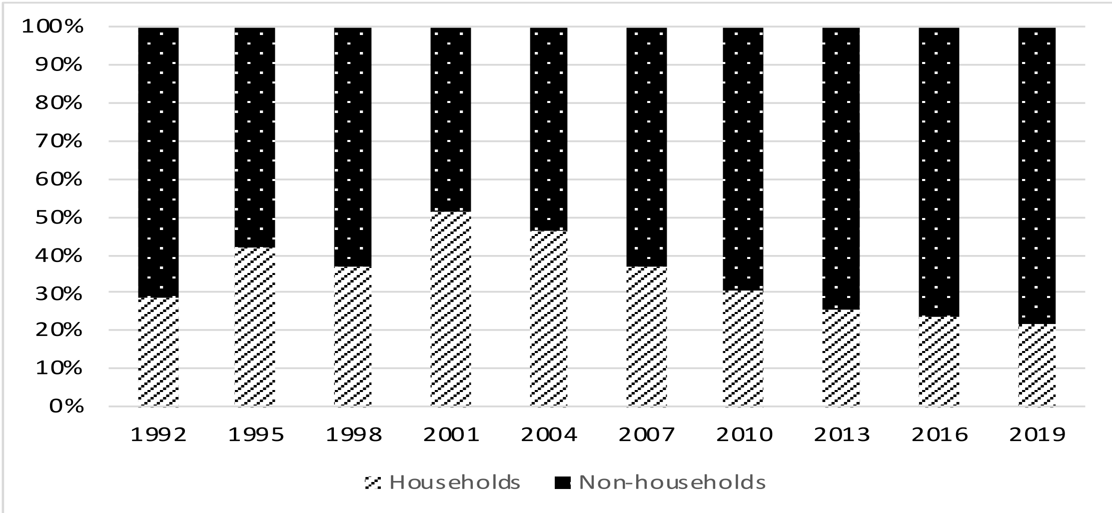


Figure 9. Uninsured deposits by owner

The figure plots the fraction of total uninsured deposits that are held by household and non-household depositors.

account." We exclude personal business accounts, and we use the "trust account" to compute holdings in the trust ownership category. We assign the ownership of trust accounts entirely to the respondent.

The FDIC insurance is computed separately *per depositor*, *per FDIC-insured bank*, and *per ownership category*. The qualifiers *per depositor* and *per FDIC-insured bank* are rather straightforward. If a bank account has multiple owners, the insurance limit is applied per depositor. For instance, since 2008, a married couple that jointly owns a single deposit account at a bank is insured up to $500,000 (i.e., $250,000 per depositor). Similarly, the $250,000 is computed per bank, so that a single depositor with accounts at two banks can insure $500,000 by splitting her deposits across both banks. The qualifier *ownership category* means that the FDIC considers single accounts, joint accounts, trust accounts, and certain retirement accounts separately.[26] Consider as an example a married couple with deposits at a single bank. The couple can obtain insurance up to $1,000,000 in total, or $500,000 each, by opening three separate accounts: two individual accounts ($250,000 insurance per depositor, or $500,000 in total) and a single joint account (another $500,000, as explained above).

Using the SCF, we can thus calculate the amount held by each owner in any given bank, distinguishing between three ownership categories: single accounts, joint accounts, and (only for the respondent) trust accounts. We then compute the amount of uninsured deposits, if any, as those that exceeds the FDIC insurance limit for each depositor, bank, and ownership category.

Thus, for each wave of the SCF, we arrive at a dataset in which each observation describes the deposit holdings of an individual household member, and for each member, we have total deposit holdings, total insured deposits, and total uninsured deposits. To obtain aggregate data, we use the weights provided in the SCF.

We can then compute the holdings of uninsured deposits held by non-household depositors residually,

[26]Revocable and irrevocable trust accounts are separate ownership categories in our sample, but all trust accounts are part of a single ownership category as of April 1, 2024; for additional details, see https://www.fdic.gov/news/press-releases/2022/pr22004.html.

that is, by subtracting households' holdings (computed from the SCF) from total uninsured deposits (from the FDIC). Figure 9 shows that firms and other non-household depositors hold most of the uninsured deposits. Uninsured deposits held by households were about 30% of total uninsured deposits in 1992, increased to about 50% in 2001 as households' share of total deposits increased (see Figure 8), and then decreased after. As of 2019, households held only 22% of the stock of uninsured deposits, despite holding 43% of the stock of total deposits.

A.3 Bank Failures

We use FDIC data to construct our sample of failed banks. We exclude banks for which the FDIC bore no resolution cost, those for which the resolution cost is not available, or those that are recorded to have a negative resolution cost. Finally, we exclude banks for which data about assets or deposits as of the last filed Call Report before failure are not available.

For each failed bank, we then determine whether uninsured deposits experienced losses, based on the resolution method used by the FDIC. We drop 16 observations categorized as "MGR" (i.e., in which the resolution was handled by the Federal Savings and Loan Insurance Corporation by taking over management and generally providing financial assistance) because we cannot determine if uninsured deposits experienced losses. In our sample, uninsured depositors experienced no losses if the bank is resolved with a purchase and assumption transaction or if it is an assisted transaction, and experience losses in all other cases.

B Proofs

B.1 Proof of Proposition 1

Because we are studying the steady state of the model, maximizing the present-discounted value of households' utility is equivalent to maximizing:

$$\begin{aligned}\mathcal{W} &= \log\left(c^{oth}\right) + p^{full}\int \psi\ \log\left(R^d d^h\left(\psi\right)\right) dF^{\psi}\left(\psi\right) \\ &\quad + \left(1-p^{full}\right)\int \psi\ \log\left(R^d \max\left\{d^h\left(\psi\right), \nu\bar{d}^h + (1-\nu)d^h\left(\psi\right)\right\}\right) dF^{\psi}\left(\psi\right) - \chi\frac{l^{1+1/\eta}}{1+1/\eta},\end{aligned}$$

The labor market clearing condition is

$$l = m^f \int l^i di,$$

where m^f is the mass of firms. Denoting $l^{i,full}$ and $l^{i,part}$ to be the labor hired by firm i when its deposits are fully and partially repaid, respectively, the aggregate resource constraint (28) becomes

$$\begin{aligned}c^{oth} &= m^f\ p^{full}\int A\left(k^i\right)^{\gamma}\left(l^{i,full}\right)^{1-\gamma} di + m^f\left(1-p^{full}\right)\int A\left(k^i\right)^{\gamma}\left(l^{i,part}\right)^{1-\gamma} di \\ &\quad - p^{full}\int R^d d^h\left(\psi\right)\ dF^{\psi}(\psi) - \left(1-p^{full}\right)\int R^d \max\left\{d^h\left(\psi\right), \nu\bar{d}^h + (1-\nu)d^h\left(\psi\right)\right\} dF^{\psi}\left(\psi\right) \\ &\quad - i - \Omega\left(T\right)\end{aligned}$$

where taxes T are defined by (26). Because $\theta = 0$, the firms' working capital constraints are

$$wl^{i,full} = R^d d^i, \qquad wl^{i,part} = R^d \max\left\{d^i, \nu \bar{d}^f + (1-\nu) d^i\right\}$$

for firms with fully and partially repaid deposits, respectively.

Next, we compute the derivative of the welfare function $\mathcal{W}$ with respect to $\bar{d}^h$ and we scale it by the numbers of banks $1 - p^{full}$ that fail and are not bailed out and by the fraction of household members with uninsured deposits $Pr\left\{d^h(\psi) > \bar{d}^h\right\}$. We also use the first assumption of the Proposition and take the limit as the probability of default goes to zero, which implies that $p^{full} \to 1$ because of (8), and that the planner's choices do not affect the choices of households and firms. We have

$$\begin{aligned}
&\lim_{p^{default}\to 0} \frac{\partial \mathcal{W} / \partial \bar{d}^h}{\left(1 - p^{full}\right) Pr\left\{d^h(\psi) > \bar{d}^h\right\}} \\
= \quad & \nu \frac{\int_{\bar{\psi}}^{\infty} \psi \, \frac{1}{\nu \bar{d}^h + (1-\nu) d^h(\psi)} dF^{\psi}(\psi)}{\int_{\bar{\psi}}^{\infty} dF^{\psi}(\psi)} - \frac{1}{c^{oth}} R^d \nu \left[1 + \Omega'(T)\right] \\
= \quad & \nu \frac{\frac{1}{\beta} \int_{\bar{\psi}}^{\infty} \frac{\beta\psi}{d^h(\psi)} \frac{d^h(\psi)}{\nu \bar{d}^h + (1-\nu) d^h(\psi)} dF^{\psi}(\psi)}{\int_{\bar{\psi}}^{\infty} dF^{\psi}(\psi)} - \frac{1}{c^{oth}} R^d \nu \left[1 + \Omega'(T)\right] \\
= \quad & \frac{1}{c^{oth}} \nu R^d \left(\mathbb{E}_{\psi} \left\{ \left(\nu \frac{\bar{d}^h}{d^h(\psi)} + 1 - \nu \right)^{-1} \middle| \, d^h(\psi) > \bar{d}^h \right\} - 1 - \Omega'(T) \right) \qquad (48)
\end{aligned}$$

where the third line multiplies and divide by $\beta d^h(\psi)$ in the integral in the numerator, and the last line uses the first-order condition (24) evaluated at $p^{full} \to 1$ to obtain $\beta\psi\left(1/d^h(\psi)\right) = 1/c^{oth}$ and rearranges using $R^d \to 1/\beta$. The result in the Proposition follows from defining the marginal benefits and costs in dollars (i.e., in terms of consumption) by dividing (48) by the marginal utility $1/c^{oth}$.

We then repeat the same analysis for $\bar{d}^f$:

$$\begin{aligned}
&\lim_{p^{default}\to 0} \frac{\partial \mathcal{W} / \partial \bar{d}^f}{\left(1 - p^{full}\right) Pr\left\{d^i > \bar{d}^f\right\}} \\
= \quad & \frac{\frac{1}{c^{oth}} \int_{\bar{a}}^{\infty} \frac{\partial A \left(k^i\right)^{\gamma} \left(l^{i,part}\right)^{1-\gamma}}{\partial l^{i,part}} \frac{\partial l^{i,part}}{\partial \bar{d}^f} di}{\int_{\bar{a}}^{\infty} di} - \frac{\chi l^{1/\eta} \int_{\bar{a}}^{\infty} \frac{\partial l^{i,part}}{\partial \bar{d}^f} di}{\int_{\bar{a}}^{\infty} di} - \frac{1}{c^{oth}} \nu R^d \, \Omega'(T) \\
= \quad & \frac{1}{c^{oth}} \nu R^d \left(\frac{\int_{\bar{a}}^{\infty} \frac{1}{w} (1-\gamma) A \left(k^i\right)^{\gamma} \left(l^{i,part}\right)^{-\gamma} di}{\int_{\bar{a}}^{\infty} di} - 1 - \Omega'(T) \right) \\
= \quad & \frac{1}{c^{oth}} \nu R^d \left(\frac{\int_{\bar{a}}^{\infty} \left(\frac{l^{i,part}}{l^{i,full}} \right)^{-\gamma} di}{\int_{\bar{a}}^{\infty} di} - 1 - \Omega'(T) \right) \\
= \quad & \frac{1}{c^{oth}} \nu R^d \left(\frac{\int_{\bar{a}}^{\infty} \left(\nu \frac{\bar{d}^f}{d^i} + 1 - \nu \right)^{-\gamma} di}{\int_{\bar{a}}^{\infty} di} - 1 - \Omega'(T) \right) \qquad (49)
\end{aligned}$$

The third line uses the household's first-order condition for the choice of labor, (22) and the liquidity constraint (12) evaluated at $\theta = 0$, which implies ${\partial l^{i,part}}/{\partial \bar{d}^f} = \frac{\nu R^d}{w}$, and rearranges. The fourth line uses the firm's first-order condition for labor when deposits are fully repaid, (14), evaluated at $\theta = 0$ (by assumption of the proposition) and $\lambda^i = 0$ (because the assumption $R^d \to 1/\beta$ implies that liquidity constraints are not binding), that is, $(1-\gamma)A\left(k^i\right)^\gamma \left(l^{i,full}\right)^{-\gamma} = w$. The last line rearranges using the liquidity constraint (12) evaluated at $\theta = 0$, which allows us to obtain $\left({l^{i,part}}/{l^{i,full}}\right) = \nu\left({\bar{d}^f}/{d^i}\right) + (1-\nu)$. As before, we obtain the result of the Proposition by defining marginal benefits and costs in dollars (i.e., in terms of consumption) by dividing by the marginal utility $1/c^{oth}$.

B.2 Proof of Proposition 2

The stock of uninsured deposits for households is the integral of the deposits $d^h(\psi)$ that exceed the insurance limit $\bar{d}^h$ (i.e., the deposits for household members with $\psi > \overline{\psi}$, multiplied by the mass m^h):

$$d^{h,unins} = m^h \int_{\overline{\psi}}^{\infty} (d^h(\psi) - \bar{d}^j) F^\psi(\psi).$$

As $p^{default} \to 0$, the distribution of deposits is not affected by a change in the deposit insurance limit, but the threhold $\overline{\psi}$ changes because, at $p^{default} \to 0$ it reflects the depositor with holdings equal to the insurance limit. Hence,

$$\begin{aligned}
\frac{\partial d^{h,unins}}{\partial \bar{d}^h} &= m^h \left[\int_{\overline{\psi}} \frac{\partial}{\partial \bar{d}^h}\left[d^h(\psi) - \bar{d}^h\right] dF^\psi(\psi) - \frac{\partial \overline{\psi}}{\partial \bar{d}^h}\left[d^h(\overline{\psi}) - \bar{d}^h\right] f\left(\overline{\psi}\right)\right] \\
&= m^h \int_{\overline{\psi}} (-1)\, dF^\psi(\psi) \\
&= -m^h \text{Pr}\left\{d^h(\psi) > \bar{d}^h\right\}
\end{aligned}$$

where the second line uses $d^h(\overline{\psi}) = \bar{d}^h$. The derivation of $\partial d^{f,unins}/\partial \bar{d}^f$ follows identical steps.

To prove the second result, note that the stock of households' uninsured deposits can be written as the mass of household members with uninsured deposits, $m^h \Pr\{d^h(\psi) > \bar{d}^h\}$, times the average uninsured deposits held by such depositors, $\mathbb{E}[d^h(\psi) - \bar{d}^h \mid d^h(\psi) > \bar{d}^h]$:

$$d^{h,unins} = m^h \Pr\{d^h(\psi) > \bar{d}^h\}\mathbb{E}[d^h(\psi) - \bar{d}^h \mid d^h(\psi) > \bar{d}^h]. \tag{50}$$

A similar expression holds for firms' uninsured deposits:

$$d^{f,unins} = m^f \Pr\{d^i > \bar{d}^f\}\mathbb{E}[d^i - \bar{d}^f \mid d^i > \bar{d}^f]. \tag{51}$$

Under the assumption $d^{h,unins} = d^{f,unins}$ and $\mathbb{E}[d^i - \bar{d}^f \mid d^i > \bar{d}^f] > \mathbb{E}[d^h(\psi) - \bar{d}^h \mid d^h(\psi) > \bar{d}^h]$, we can combine (50) and (51) to obtain

$$m^h \Pr\{d^h(\psi) > \bar{d}^h\} > m^f \Pr\{d^i > \bar{d}^f\},$$

which implies (32) using (31).

B.3 Proof of Proposition 3

We begin by defining the profits that a firm obtains when its uninsured deposits are fully repaid (because the firm runs and is able to withdraw, or the bank is bailed out) and the profits when the uninsured deposits are subject to an haircut (because the bank fails and is not bailed out). We define the profits if the uninsured deposits are fully repaid as:

$$\pi_{t+1}^{i(1)} \equiv y_{t+1}^{i(1)} + (1-\delta)\, k_t^i - r_t b_t^i - w_{t+1} l_{t+1}^{i(1)} + R_t^d d_t^i,$$

where the superscript "(1)" refers to the value when the uninsured deposits are fully repaid. We define the profits when the uninsured deposits are subject to a haircut similarly:

$$\pi_{t+1}^{i(0)} \equiv y_{t+1}^{i(0)} + (1-\delta)\, k_t^i - r_t b_t^i - w_{t+1} l_{t+1}^{i(0)} + R_t^d \left[\bar{d}^f + (1-\nu_{t+1})\left(d_t^i - \bar{d}^f\right)\right],$$

where the superscript "(0)" refers to the case in which the haircut is applied. Note that we define both $\pi_{t+1}^{i(1)}$ and $\pi_{t+1}^{i(0)}$ before accounting for the cost Ξ of running. The cutoff $\overline{a}_t^{RUN}$ is then pinned down by equating the payoff from running to the payoff from not running:

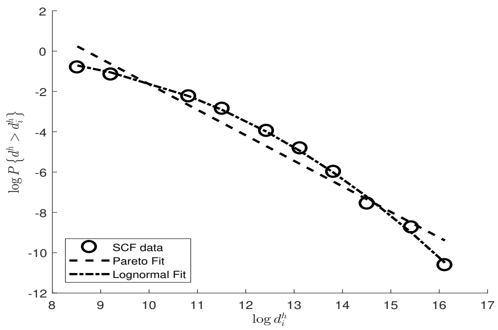
$$-\Xi + \mathbb{E}_t\left\{\pi_{t+1}^{i(1)}\right\}[\kappa + (1-\kappa)\, f] + \mathbb{E}_t\left\{\pi_{t+1}^{i(0)}\right\}(1-\kappa)(1-f) = f\,\mathbb{E}_t\left\{\pi_{t+1}^{i(1)}\right\} + (1-f)\,\mathbb{E}_t\left\{\pi_{t+1}^{i(0)}\right\}. \tag{52}$$

The left-hand side of equation (52) states the payoff if the firm runs: the firm pays the cost Ξ; it earns the profits $\mathbb{E}_t\{\pi_{t+1}^{i(1)}\}$ with probability $\kappa + (1-\kappa)\, f$ (i.e., it either successfully withdraws its deposits—probability κ—or it fails to withdraw them but is bailed out—probability $(1-\kappa)\, f$); and it earns the profits $\mathbb{E}_t\{\pi_{t+1}^{i(0)}\}$ with probability $(1-\kappa)(1-f)$ (i.e., if it is unable to withdraw its deposits—probability $1-\kappa$—and the bank is not bailed out—probability $1-f$). On the right-hand side, the firm does not pay the cost Ξ to run, in which case the probability of earning $\mathbb{E}_t\{\pi_{t+1}^{i(1)}\}$ is only f (i.e., if the bank is bailed out).

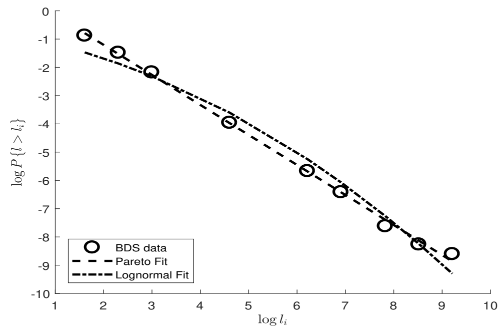
The result of the proposition follows from rearranging (52).

C Numerical Evaluation of the Results in Proposition 1 and Calibration of the Quantitative Model: Additional Details

In this appendix, we describe in more detail how we arrive at some of the values discussed in Section 3.6, and we provide additional details about the calibration of the model described in Section 5.1 and the computation of the target moments in the data. For most of these moments, we follow the approach of Pancost and Robatto (2023) and extend their data sample to 2019.



(a) Household Deposits



(b) Firm Employment

Figure 10. Right Tails of Deposit Distributions
The left panel plots the log probability of household deposits being greater than the (log) value on the x-axis, using the 2019 Survey of Consumer Finance data. The right panel plots the log probability of a firm having employment greater than the (log) value on the x-axis, using data from the Census Business Dynamic Statistics. In both panels, data values are plotted as circles, the best fits assuming a Pareto distribution are plotted as dotted lines, and the best fits assuming a lognormal distribution are plotted as dash-dotted lines.

C.1 Distribution of Households' and Firms Deposits in the Data

We argue that households' and firms' deposits have different empirical distributions. For households, we observe the distribution of uninsured based on our analysis of the SCF. For firms, we do not have direct evidence about the distribution of uninsured deposits. However, our model implies that the distribution of firms' deposits is approximately the same as the distribution of firms' employment, because deposits are used to finance labor as a result of the working capital constraint. Hence, for firms, we focus on the distribution of employment.

Figure 10 plots the far right tails of the household deposit distribution (from the SCF) and the firm employment distribution (from the Census Business Dynamic Statistics). In particular, the left panel of Figure 10 plots the log anti-CDF of household deposits from the 2019 SCF (as circles) against two approximate distributions: Pareto (straight, dashed line) and lognormal (curved, dash-dotted line). The figure shows that the distribution of deposits for very large household depositors is well approximated by a lognormal distribution, and has thinner tails than a Pareto distribution. On the other hand, firm employment—and with it, firms' holdings of deposits—is better approximated by a Pareto distribution, as shown by the right panel of Figure 10.[27] For comparison, Figure 11 plots the distribution of deposits for the top 10 depositors at SVB. While Figure 11 is based on a limited number of depositors, it is consistent with a Pareto distribution for firms' deposits.

[27] A large literature argues that the firm size distribution is roughly Pareto, and not lognormal (e.g. Luttmer 2007; see Gabaix 2009 for a comprehensive review).

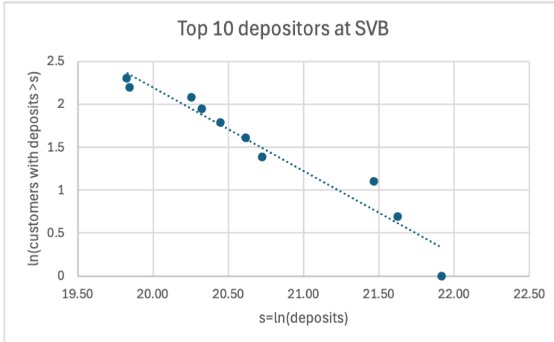


Figure 11. Top depositors at SVB

The figure plots the distribution of deposits holdings for the top 10 depositors at SVB, using data from "SVB's biggest customers, revealed. Kinda" Financial Times, May 24, 2023.

C.2 Quantifying the Marginal Benefits of Insurance in Proposition 1

To compute the marginal benefits in Proposition 1, we set the distribution of firms' and households' deposits to be Pareto and lognormal, in line with the discussion in Appendix C.1.

The Pareto distribution for firms implies that equation (29) can be expressed in closed form as

$$MB(\bar{d}^f) = R^d \nu \left[(1-\nu)^{-\gamma} \, {}_2F_1 \left(\alpha, \gamma, 1+\alpha, \frac{\nu}{\nu-1} \right) - 1 \right], \tag{53}$$

where ${}_2F_1$ is the hypergeometric function and α is the tail parameter of the Pareto distribution, which we set to 1.06 in our calculations based on the slope of the line in the right panel of Figure 10. Note that the marginal benefit is independent of $\bar{d}^f$ itself. Thus, if the marginal cost of taxation $\Omega'(T)$ is also independent of $\bar{d}^f$, then equation (53) can be used to pin down the cutoff for Ω' such that the optimal insurance under the assumption of Proposition 1 switches from zero to full. We also note as the haircut $\nu \to 1$ (i.e., complete loss on uninsured deposits) (53) simplifies even further to $R^d \nu \left(\frac{\alpha}{\alpha-\gamma} - 1 \right)$.

For households, we set the location parameter and scale parameter of the lognormal distribution to 8.22 and 2.15, respectively, based on the mean and standard deviation of log deposits greater than \$1 in the 2019 SCF.

We also need to parameterize R^d, ν, and γ. We set R^d to the steady-state value we obtain when calibrating the quantitative version of the model, that is, 1.04353 (see Section 5.1). We set $\nu = 0.17$ based on the haircut on uninsured deposits at failed banks in which no losses on uninsured deposits occur—these are the great majority, as discussed in Section 2.2. We compute the haircut as the average ratio of the costs to the insurance fund relative to the assets of the failed banks. We set the parameter γ of the production function to 0.3, which is the same value we use in the calibration of Section 5.1.

With these assumptions, we can quantify $MB(\bar{d}^f)$ and $MB(\bar{d}^h)$ derived in Proposition 1. The marginal benefit of increasing the insurance limit for firms' deposits is 0.0047, while the marginal benefit for increasing the insurance limit for households' deposits 0.0156 (i.e., more than three times bigger). Furthermore, the difference in distribution plays only a small role: if the distribution of deposits for households were Pareto with the same tail coefficient as firms, then the marginal benefit of increasing $\bar{d}^h$ would only increase to

Year	FDIC limit ($)	Effective limit ($)
1992	100,000	145,937
1995	100,000	163,290
1998	100,000	149,240
2001	100,000	140,215
2004	100,000	156,727
2007	100,000	142,307
2010	250,000(*)	392,958
2013	250,000	341,665
2016	250,000	356,061
2019	250,000	354,891

Table 6. Deposit insurance limit.
The table displays the FDIC insurance limit and the effective insurance limit for households. The latter is calculated as the average amount of insured deposits for household members with positive holdings of uninsured deposits. (*): Between October 14, 2008, and December 31, 2012, the Transaction Account Guarantee Program provided full insurance on non-interest bearing transaction accounts.

0.0165. Thus, as noted in Section 3.6, the curvature of the depositors' objective function is the key element that drives a wedge between the marginal benefit of insuring firms' vs. households' deposits.

C.3 Other Calibration Targets

We now provide additional details on how we measure some other calibration targets in the data.

Equity-to-asset ratio. We compute this target moment using FDIC data.

Insured deposits held by households with a positive uninsured balance. After we compute the deposit holdings of each household members (see Appendix A.2), we restrict attention to household members with positive holdings of uninsured deposits, and we compute the average holdings of insured deposits for such depositors. Table 6 shows that the average holdings of insured deposits (Column 2) is higher than the statutory limit (Column 1). To arrive at our calibration target $\bar{d}^h = \bar{d}^f = 0.35$, we consider the average of Column 2 for the last 3 waves of the SCF (i.e., 2013, 2016, and 2019). We exclude the earlier year in the sample because of the change in insurance limit, and we exclude 2010 because of the possible effects of the Transaction Account Guarantee Program that provided full insurance on non-interest bearing transaction accounts.

Firms' and households' deposits as a fraction of GDP. Firms' deposit holdings are from the flow of funds, and households' deposit holdings are from the SCF (see Appendix 2.1). Firms' deposits as a fraction of GDP display a trend throughout the entire sample, and thus, we use the last observation of the sample as the target. For households' deposits, there is trend that ends around 2001, so we start the sample in 2001 to compute this target.

Deposit premium. We measure the deposit premium in the data as the difference between the rate on 3-month AA commercial paper, which proxies safe illiquid assets as in Davydiuk (2019) and Pancost and Robatto (2023), and the rate paid by banks on deposits. We measure the interest rate on deposits as the ratio of interest expense on domestic deposits relative to the stock of such deposits, using FDIC data. We compute the ratio between expenses on deposits in domestic offices divided by the amount of deposits in domestic offices at the end of the previous quarters. Both the commercial paper and deposit rates in the data are computed first at a quarterly frequency, and from that, we calculate the average liquidity premium in our sample.

Fraction of loans recalled. As discussed in the calibration section (Section 5.1), we set τ to match the reduction in investments following the reduction in loan supply that results from covenant violations when banks are in poor health. Chodorow-Reich and Falato (2022) find that when a firm violates a covenant and the lender is in poor health, the firm reduces investments by 4% of total assets, or 4%/0.31 = 12.9% of physical assets—using the fact that physical assets are about 31% of total assets (Lugo 2025). Because only about 1/3 of firms face covenant violations every year (Chodorow-Reich and Falato 2022; Bidder et al. 2024), a 12.9% reduction in investments by 1/3 of firms corresponds to 12.9%*(1/3)=4.3% reduction in investments by a representative firm. In our model, the effect of the loan being recalled is a reduction in productive capital by τb_{t-1}, and we can scale this effect by total physical assets $k_{t-1} + b_{t-1}$. We thus set τ so that $\tau b_{t-1}/(k_{t-1} + b_{t-1}) = 4.3\%$, which simplifies to $\tau\xi/(1 + \xi) = 4.3\%$ using Equation (10). Given the calibration of ξ, the resulting value of τ is 0.2.

Volatility of GDP and employment. We calibrate σ_A and ω to match the volatility of real GDP and labor. Real GDP is from FRED (series GDPC1). We measure labor as one minus the unemployment rate (FRED series UNRATE).

Bank default rate. We measure bank default as the fraction of banks that are taken over by the FDIC (weighted by deposits) and for which the FDIC incurred a positive resolution cost.

D Untargeted Moments

In this section we validate the model by comparing model-implied moments to the data. In particular, the moments discussed here were not used to calibrate the model parameters reported in Table 2. We provide a list of untargeted moments in Table 7 for both the data and the model. Unless noted otherwise, the data moments are computed as in Pancost and Robatto (2023) but extending their sample up to 2019.

Moment	Data	Model
Volatilities, ratios to volatility of log GDP, HP-filtered		
log(investment)	4.23	3.50
log(consumption)	0.68	0.64
log(wages)	0.84	0.29
log(bank assets)	2.29	0.69
log(deposits)	1.83	0.69
log(1 + deposit premium)	0.66	0.57
Correlations with log GDP, HP-filtered		
log(investment)	0.94	0.88
log(consumption)	0.80	0.74
log(labor)	0.85	0.98
log(wages)	0.44	0.30
log(bank assets)	0.67	0.82
log(firm deposits)	0.71	0.65
log(1 + deposit premium)	0.70	0.66
Other Moments, not HP-filtered		
Corr(bank default rate, $\Delta \log \text{GDP}$)	-0.13	0.00
Bank assets, share of capital stock	0.24	0.27
Bank assets, share of GDP	0.41	0.43
Haircut on deposits at failed banks	17%	14%
% of employment, top 10% of firms	76%	88%
% of employment, top 1% of firms	52%	77%

Table 7. Untargeted Moments

The table reports values of untargeted moments for both the data (second column) and the model (third column). The top panel reports volatility moments as a ratio to the volatility of log GDP. The middle panel reports correlations with log GDP. The bottom panel reports other moments. All moments in the top and middle panels are computed by applying the HP-filter both to the data and model-simulated series, using a smoothing parameter of 100.

The model matches well business cycle moments such as the volatilities of investment and consumption, and the correlation of GDP with investment, consumption, and labor. Regarding wages, the model's volatility and correlation with GDP is lower than in the data. The model produces a zero correlation between bank default and GDP growth, though in the data this correlation is negative; however the correlation in the data is not statistically different from zero, and thus, the performance of the model in this regard is good.

In terms of banking moments, the model matches well the ratio of bank assets to GDP and the ratio of bank assets to the stock of capital—the latter is measured as nonfinancial assets of nonfinancial firms. The model does not match the volatilities of bank assets or deposits, likely because in the model bank assets are perfectly correlated with the stock of capital. To match these moments we would need to considerably enrich the asset side of the banks in the model. The model does match the volatility of the deposit premium, however, which is difficult in many macro-banking models (Davydiuk, 2019; Pancost and Robatto, 2023).

The model matches quite well the average haircut on deposits at failed banks. In the model, this is the haircut ν_t that would be applied to the deposits at all failed banks absent government interventions. At nearly all such banks, uninsured deposits are bailed out, and thus, the losses are borne by the government. In the data, we restrict attention to the bank failures with no losses on uninsured deposits—which are again the great majority—and compute the haircut as the average ratio of the costs to the insurance fund relative to the assets of the failed banks.

Finally, we report some untargeted moments related to the firm size distribution. The last two lines of Table 7 show that the model does a reasonable good job; in the data, the top 10% of firms account for 76% of aggregate employment, while the corresponding number in the model is 88%. Going further into the right tail, the top 1% of firms make up about 52% of employment in the data and 77% in the model. Thus, if anything the firm size distribution in the model is a bit thicker-tailed than the data.

E Computation

In this section, we describe how we aggregate firms' and households' decisions (which are not homothetic because deposits are guaranteed up to a dollar limit), how we numerically compute welfare (which requires an integration over the distribution of households' deposits), and how we compute the impulse response in Section 5.3. Specifically, to aggregate firms' and households' decisions and to compute welfare, we need to numerically integrate over the distribution of deposits, and we do so using Gaussian quadrature. We then use the method of Winberry (2018) and treat each quadrature node and weight for each endogenous distribution as a separate endogenous state variable.

E.1 Firm Aggregates

As discussed in the calibration of the model (Section 5.1), we assume that the distribution of firms' assets a is Pareto:

$$\phi\left(a;\alpha_0,\alpha_1\right)=\alpha_1\alpha_0^{\alpha_1}a^{-(1+\alpha_1)}. \tag{54}$$

The density in equation (54) implies an exact linear relationship between $\log a^*$ and the log probability that $a>a^*$, which well describes the firm size distribution in the data (see right panel of Figure 10).

The model implies three endogenous values $\underline{a}_t<\overline{a}_t^{FUN}<\overline{a}_t^{RUN}$ which define four regions over which we need to integrate over the distribution of assets a: region 0, where $a<\underline{a}_t$ and firms' deposits are 100% insured; region 1, where $a\in\left(\underline{a}_t,\overline{a}_t^{FUN}\right)$ and firms set $d_t^f=\bar{d}^f$; region 2, where $a\in\left(\overline{a}_t^{FUN},\overline{a}_t^{RUN}\right)$ and firms optimally choose deposits over the insurance limit but do not pay the Ξ cost to attempt to run, and region 3, where $a>\overline{a}_t^{RUN}$ and firms do pay Ξ.

Figure 12 plots firms' deposit demand as a function of assets a_t^i. Deposit demand jumps discontinuously at $\bar{a}^{RUN}$ because that is the point where firms endogenously pay Ξ. When they do, the probability of being fully repaid jumps discontinuously because running and successfully withdrawing allows them to recover the full value of their deposits, even if the bank is insolvent. Hence, their demand for deposits rises at $\bar{a}^{RUN}$. The regions in the figure are exaggerated to make them easier to see; a factual representative of the

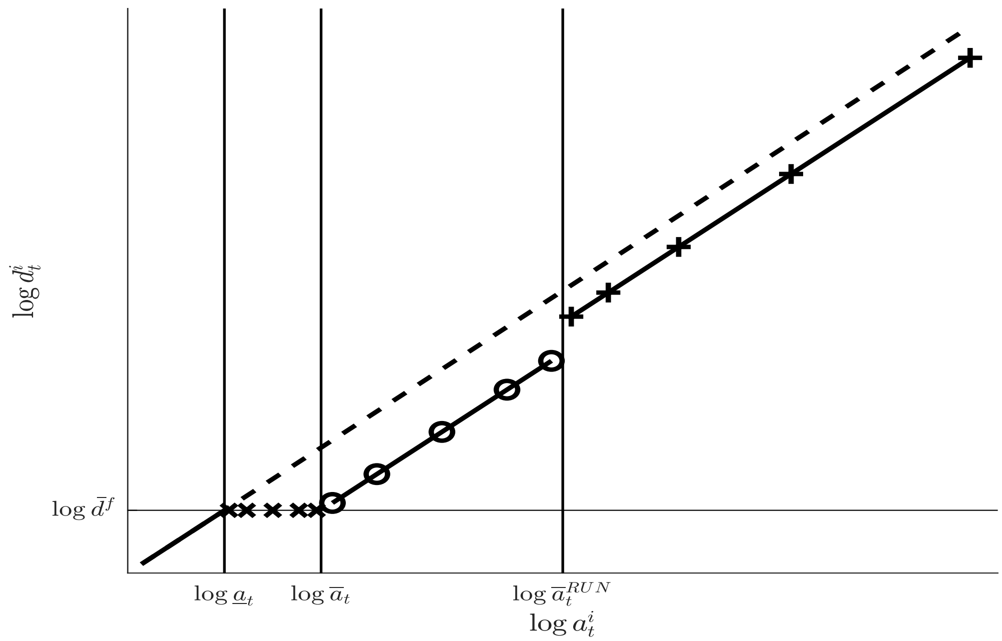


Figure 12. Firm Deposit Demand as a Function of Assets

The figure depicts a stylized solution to equations (15), (16), and (41), by plotting $\log d_t^i$ on the y-axis against $\log a^i$ on the x-axis. The horizontal line denotes the log deposit insurance limit $\log \bar{d}^f$. Firms with $a^i < \underline{a}_t$ choose $d_t^i < \bar{d}^f$; firms with $a^i \in (\underline{a}_t, \overline{a}_t)$ choose $d_t^i = \bar{d}^f$. Thus, deposits at firms with $a^i < \overline{a}_t$ are fully insured. Firms with $a^i > \overline{a}_t$ choose $d_t^i > \bar{d}^f$ and thus are partially uninsured. For firms with $a^i \in \left(\overline{a}_t, \overline{a}_t^{RUN}\right)$ it is not optimal to pay Ξ and attempt to withdraw; firms with $a^i > \overline{a}_t^{RUN}$ do pay Ξ and attempt to withdraw. The solid diagonal lines denote the firm's optimal choice of $\log d_t^i$, while the dashed diagonal line denotes what the firm would choose when $a^i > \underline{a}_t$ if there were full deposit insurance.

quantitative deposit demand curve in the calibrated model would be nearly indistinguishable from a straight line, because the probability of losses on uninsured deposits is very close to zero. Likewise, region 1 in the calibrated model (where firms set $d_t^i = \bar{d}^f$) is so small as to be barely visible.

Let firm deposit holdings in region i be given by $d_t^f(i)$. Deposit holdings of the average firm are given by $d_t^f(0) + d_t^f(1) + d_t^f(2) + d_t^f(3)$, while aggregate firms' deposits are given by

$$d_t^f = m_t^f \left[d_t^f(0) + d_t^f(1) + d_t^f(2) + d_t^f(3) \right]$$

where m_t^f is the endogenous measure of firms in the economy, chosen by households to satisfy right-hand first-order condition equation in equation (21); see Sections 3.2 and 3.3.

We use Gaussian quadrature to approximate functions of firm assets, such as deposits and employment, over the distribution of a given by equation (54). In regions 0 and 2, we use Gauss-Legendre quadrature, which approximates integrals of the form

$$\int_{-1}^{1} f(u)\, du \approx \sum_{i=1}^{N} w_i^{(0)} f\left(u_i^{(0)}\right) \tag{55}$$

where the weights $w_i^{(0)}$ and node-points $u_i^{(0)}$ are known functions of the number of node-points N (Judd, 1998). Below we define the function $f(\cdot)$ to incorporate three things: (1) the policy function being integrated; (2) the density function $\phi(a)$ in equation (54); and (3) the change of support from $(-1,1)$ to $(0, \underline{a}_t)$ in region 0, and to $\left(\overline{a}_t, \overline{a}_t^{RUN}\right)$ in region 2.

In region 3, we use Gauss-Laguerre quadrature, which approximates integrals of the form

$$\int_{0}^{\infty} f(u)\, e^{-u} du \approx \sum_{i=1}^{N} w_i^{(3)} f\left(u_i^{(3)}\right) \tag{56}$$

where again the weights $w_i^{(3)}$ and node-points $u_i^{(3)}$ are known functions of the number of node-points N. Applying equation (56) requires a change of variables to (1) convert the power of a in the denominator of (54) into e^{-u}, and (2) to shift the support from $(0,\infty)$ to $\left(\overline{a}_t^{RUN}, \infty\right)$. Quadrature is only necessary over regions 0, 2 and 3; region 1 is small enough (since $p_{t+1}^{full} \approx 1$, which implies that $\underline{a}_t \approx \overline{a}_t$) that simply taking the average value of $f(a)$ at $\underline{a}_t$ and $\overline{a}_t$ is more than sufficient.

To apply equation (55) to integrals over the density (54) for $a \in (0, \underline{a}_t)$, we use the change of variables

$$u = g(a) \equiv 2\left(\frac{a}{\underline{a}_t}\right)^{\alpha_1 - 1} - 1 \tag{57}$$

so that integrals of any function $f(a)$ in region 0 can be written as

$$\begin{aligned}
\int_0^{\underline{a}_t} f(a)\, \phi(a; \alpha_0, \alpha_1)\, da &= \int_0^{\underline{a}_t} \frac{f(a)}{g'(a)} \phi(a; \alpha_0, \alpha_1)\, g'(a)\, da \\
&= \int_{-1}^{1} \frac{f\left(g^{-1}(u)\right) \phi\left(g^{-1}(u); \alpha_0, \alpha_1\right)}{g'\left(g^{-1}(u)\right)} du \\
&\approx \sum_{i=1}^{N} w_i^{(0)} \frac{f\left(a_i^{(0)}\right) \phi\left(a_i^{(0)}; \alpha_0, \alpha_1\right)}{g'\left(a_i^{(0)}\right)} \\
&= \sum_{i=1}^{N} \exp\left\{\log \hat{w}_i^{(0)} + \log f\left(a_i^{(0)}\right)\right\}
\end{aligned}$$

where

$$\begin{aligned}
\log a_i^{(0)} &= \log g^{-1}\left(u_i^{(0)}\right) = \log \underline{a}_t + \frac{1}{\alpha_1 - 1}\left[\log\left(u_i^{(0)} + 1\right) - \log 2\right], \\
\log \hat{w}_i^{(0)} &\equiv \log w_i^{(0)} + \log \phi\left(a_i^{(0)}; \alpha_0, \alpha_1\right) + (\alpha_1 - 1)\log \underline{a}_t - (\alpha_1 - 2)\log a_i^{(0)} - \log(\alpha_1 - 1) - \log 2,
\end{aligned}$$

ϕ is the log Pareto pdf given in equation (54), and $u_i^{(0)}$ and $w_i^{(0)}$ are the Gauss-Legendre nodes and weights, respectively.

To apply equation (55) to integrals over the density (54) for $a \in \left(\overline{a}_t, \overline{a}_t^{RUN}\right)$, we use the change of variables

$$u = g(a) \equiv 2\left(\frac{a^{\alpha_1 - 1} - (\overline{a}_t)^{\alpha_1 - 1}}{\left(\overline{a}_t^{RUN}\right)^{\alpha_1 - 1} - (\overline{a}_t)^{\alpha_1 - 1}}\right) - 1 \tag{58}$$

so that integrals of any function $f(a)$ in region 2 can be written as

$$\begin{aligned}
\int_{\overline{a}_t}^{\overline{a}_t^{RUN}} f(a)\,\phi(a;\alpha_0,\alpha_1)\,da &= \int_{\overline{a}_t}^{\overline{a}_t^{RUN}} \frac{f(a)}{g'(a)}\phi(a;\alpha_0,\alpha_1)\,g'(a)\,da \\
&= \int_{-1}^{1} \frac{f\left(g^{-1}(u)\right)\phi\left(g^{-1}(u);\alpha_0,\alpha_1\right)}{g'\left(g^{-1}(u)\right)}du \\
&\approx \sum_{i=1}^{N} w_i^{(2)} \frac{f\left(a_i^{(2)}\right)\phi\left(a_i^{(2)};\alpha_0,\alpha_1\right)}{g'\left(a_i^{(2)}\right)} \\
&= \sum_{i=1}^{N} \exp\left\{\log \hat{w}_i^{(2)} + \log f\left(a_i^{(2)}\right)\right\}
\end{aligned}$$

where

$$\begin{aligned}
\log a_i^{(2)} &= \log g^{-1}\left(u_i^{(2)}\right) = \frac{1}{\alpha_1 - 1}\log\left[(\overline{a}_t)^{\alpha_1 - 1} + \left[\left(\overline{a}_t^{RUN}\right)^{\alpha_1 - 1} - (\overline{a}_t)^{\alpha_1 - 1}\right]\frac{u_i^{(2)} + 1}{2}\right] \\
\log \hat{w}_i^{(2)} &\equiv \log w_i^{(2)} + \log\phi\left(a_i^{(2)};\alpha_0,\alpha_1\right) + \log\left[\left(\overline{a}_t^{RUN}\right)^{\alpha_1 - 1} - (\overline{a}_t)^{\alpha_1 - 1}\right] \\
&\quad - (\alpha_1 - 2)\log a_i^{(2)} - \log(\alpha_1 - 1) - \log 2,
\end{aligned}$$

ϕ is the log Pareto pdf given in equation (54), and $u_i^{(2)}$ and $w_i^{(2)}$ are the Gauss-Legendre nodes and weights, respectively.

To apply equation (56) to integrals over the density (54) for $a > \overline{a}_t^{RUN}$, we use the change of variables

$$u = g(a) \equiv (\alpha_1 - 1)\left(\log a - \log \overline{a}_t^{RUN}\right) \tag{59}$$

so that integrals of any function $f(a)$ in region 3 can be written as

$$\begin{aligned}
\int_{\overline{a}_t^{RUN}}^{\infty} f(a)\,\phi(a;\alpha_0,\alpha_1)\,da &= \int_{\overline{a}_t^{RUN}}^{\infty} \frac{f(a)}{g'(a)} e^{g(a)} \phi(a;\alpha_0,\alpha_1)\, e^{-g(a)} g'(a)\,da \\
&= \int_0^{\infty} \frac{g^{-1}(u)}{\alpha_1 - 1} e^{u} f\left(g^{-1}(u)\right) \phi\left(g^{-1}(u);\alpha_0,\alpha_1\right) e^{-u} du \\
&\approx \sum_{i=1}^{N} w_i^{(3)} \frac{a_i^{(3)}}{\alpha_1 - 1} e^{u_i^{(3)}} f\left(a_i^{(3)}\right) \phi\left(a_i^{(3)};\alpha_0,\alpha_1\right) \\
&= \sum_{i=1}^{N} \exp\left\{\log \hat{w}_i^{(3)} + \log f\left(a_i^{(3)}\right)\right\}
\end{aligned}$$

where

$$\begin{aligned}
\log a_i^{(3)} &= \frac{u_i^{(3)}}{\alpha_1 - 1} + \log \overline{a}_t^{RUN} \\
\log \hat{w}_i^{(3)} &\equiv \log w_i^{(3)} + \log \phi\left(a_i^{(3)};\alpha_0,\alpha_1\right) + \alpha_1 \log a_i^{(3)} - (\alpha_1 - 1)\log \overline{a}_t - \log(\alpha_1 - 1),
\end{aligned}$$

ϕ is the log Pareto pdf given in equation (54), and $u_i^{(3)}$ and $w_i^{(3)}$ are the Gauss-Laguerre nodes and weights, respectively.

Using the value $\alpha_1 - 1$ in equations (57), (58), and (59) ensures that the quadrature approximation is exact when $f(a)$ is proportional to a, as it nearly is in practice, even for α_1 close to 1. Notice also that although we specified the distribution $\phi(\cdot;\alpha_0,\alpha_1)$ in equation (54), these formulas work for any density on the positive real line, though they work best for densities with a Pareto tail of α_1.

We implement the quadrature rules described above with $N = 5$, and verify that changing N has no appreciable effect on our results.

E.2 Household Aggregates and Welfare

As with firms, we compute household deposits and utility from liquid consumption across four regions in ψ-space, defined by thresholds $\underline{\psi}_t < \overline{\psi}_t < \overline{\psi}_t^{RUN}$. In region 0, when $\psi < \psi_t$, deposits are strictly below the insurance limit $\bar{d}^h$; in region 1, $\psi \in \left(\underline{\psi}_t, \overline{\psi}_t\right)$ households set $d_t^h(\psi) = \bar{d}^h$; in region 2, $\psi \in \left(\overline{\psi}_t, \overline{\psi}_t^{RUN}\right)$ households have some deposits above the limit, but choose not to pay Ξ to attempt to withdraw funds when their bank fails; and in region 3, where households with $\psi > \overline{\psi}_t^{RUN}$ have enough uninsured deposits that they do choose to pay Ξ and attempt to withdraw.

Let total deposit holdings in region i be given by $d_t^h(i)$. Deposit holdings of the average household are given by $d_t^h(0) + d_t^h(1) + d_t^h(2) + d_t^h(3)$, while aggregate household deposits are given by

$$d_t^h = m^H \left[d_t^h(0) + d_t^h(1) + d_t^h(2) + d_t^h(3)\right]$$

where m^H is the measure of households in the economy, as defined in Section 3.3.

Let $d_t^{h*}(\psi)$ be the deposit holdings that would be chosen by the household with ψ assuming full insurance. Because we assume that ψ is log-normal with mean μ_ψ and variance σ_ψ^2 (Section 5.1), households' deposits holdings absent risk of losses are also log-normal, using equation (23):

$$d_t^{h*}(\psi) = \frac{\beta\psi}{\Lambda_t}. \tag{60}$$

For $\psi \leq \underline{\psi}_t$, deposits are fully insured, and so deposits equal the full-insurance value given in equation (60). For $\psi \in \left(\underline{\psi}_t, \overline{\psi}_t\right)$, deposits are equal to $\bar{d}^h$. Thus for regions 0 and 1, we can compute total deposit holdings in closed form, using the following result:

Truncated Lognormal Integral: If $\varepsilon \sim \mathbb{N}\left(\mu, \sigma^2\right)$, then for any real number c we have

$$\int_a^b e^{c\,\varepsilon}\phi\left(\varepsilon; \mu, \sigma^2\right) d\,\varepsilon = \exp\left\{c\mu + \frac{1}{2}(c\sigma)^2\right\}\left[\Phi\left\{\frac{b-\mu}{\sigma} - c\sigma\right\} - \Phi\left\{\frac{a-\mu}{\sigma} - c\sigma\right\}\right] \tag{61}$$

where $\Phi\{\cdot\}$ is the standard normal CDF.

Thus, total household deposits in region 0 are given by

$$\begin{aligned} d_t^h(0) &\equiv \int_0^{\underline{\psi}_t} d^h(\psi)\, dF(\psi) \\ &= \frac{\beta}{\Lambda}\int_0^{\underline{\psi}_t} \psi^{\frac{1}{\sigma_d}}\, dF(\psi) \\ &= \frac{\beta}{\Lambda}\exp\left\{\frac{\mu_\psi}{\sigma_d} + \frac{1}{2}\frac{\sigma_\psi^2}{\sigma_d^2}\right\}\Phi\left\{\frac{\log\underline{\psi}_t - \mu_\psi}{\sigma_\psi} - \frac{\sigma_\psi}{\sigma_d}\right\}, \end{aligned} \tag{62}$$

while total household deposits in region 2 are given by

$$\begin{aligned} d_t^h(1) &\equiv \int_{\underline{\psi}_t}^{\overline{\psi}_t} d^h(\psi)\, dF(\psi) \\ &= \bar{d}^h\int_{\underline{\psi}_t}^{\overline{\psi}_t} dF(\psi) \\ &= \bar{d}^h\left[\Phi\left\{\frac{\log\overline{\psi}_t - \mu_\psi}{\sigma_\psi}\right\} - \Phi\left\{\frac{\log\underline{\psi}_t - \mu_\psi}{\sigma_\psi}\right\}\right]. \end{aligned} \tag{63}$$

To compute the utility from deposits in regions 0 and 1 we use the following result:

Truncated Lognormal × Normal Integral: If $\varepsilon \sim \mathbb{N}\left(\mu, \sigma^2\right)$, then for any real number c we have

$$\begin{aligned} &\int_a^b \varepsilon\, e^{c\,\varepsilon}\phi\left(\varepsilon; \mu, \sigma^2\right) d\,\varepsilon = \\ &\qquad \exp\left\{c\mu + \frac{1}{2}(c\sigma)^2\right\}\left[\left(c\sigma^2 + \mu\right)\Big(\Phi\left(b'\right) - \Phi\left(a'\right)\Big) - \sigma\Big(\phi\left(b'\right) - \phi\left(a'\right)\Big)\right]. \end{aligned} \tag{64}$$

where

$$a' \equiv \frac{a-\mu}{\sigma} - c\sigma, \quad b' \equiv \frac{b-\mu}{\sigma} - c\sigma$$

and $\phi(\cdot)$ is the standard normal PDF.

Total household utility from liquid consumption is thus

$$\begin{aligned}
U^h &= \int \psi \log\left(c_t^{liq}(\psi)\right) dF(\psi) \\
&= \log R_t^d \int \psi dF(\psi) + \int \psi \log\left(d_t^h(\psi)\right) dF(\psi) \\
&= \exp\left\{\mu_\psi + \frac{1}{2}\sigma_\psi^2\right\} \log R_t^d + u_t^h(0) + u_t^h(1) + u_t^h(2) + u_t^h(3)
\end{aligned}$$

where the bottom line defines notation for deposit utility in each region. Then we have that

$$\begin{aligned}
u_t^h(0) &= e_1\left(\log \underline{\psi}_t\right) \log\left(\frac{\beta}{\Lambda_t}\right) + e_2\left(\log \underline{\psi}_t\right) \\
u_t^h(1) &= \left[e_1\left(\overline{\psi}_t\right) - e_1\left(\log \underline{\psi}_t\right)\right] \log\left(\bar{d}^h\right)
\end{aligned}$$

where

$$\begin{aligned}
e_1(x) &\equiv \exp\left\{\mu_\psi + \frac{1}{2}\sigma_\psi^2\right\} \Phi\left\{\frac{x-\mu_\psi}{\sigma_\psi} - \sigma_\psi\right\} \\
e_2(x) &\equiv \exp\left\{\mu_\psi + \frac{1}{2}\sigma_\psi^2\right\} \left[\left(\mu_\psi + \sigma_\psi^2\right) \Phi\left\{\frac{x-\mu_\psi}{\sigma_\psi} - \sigma_\psi\right\} - \sigma_\psi \phi\left(\frac{x-\mu_\psi}{\sigma_\psi} - \sigma_\psi\right)\right].
\end{aligned}$$

To compute deposits and utility from liquid consumption in regions 2 and 3, we use Gaussian quadrature. In order to minimize approximation error, rather than numerically integrate deposits and utility directly, we integrate only the difference between full-insurance deposits (e.g. equation 60) and utility and the actual values chosen by households. To do so, note that we can rewrite the first-order condition for deposits in region 2, equation (24), as

$$\begin{aligned}
d_t^h(\psi) &= \frac{\beta\psi}{\Lambda_t} \mathbb{E}_t \left\{ p_{t+1}^{full} + \frac{\left(1 - p_{t+1}^{full}\right)(1-\nu_{t+1})}{1 - \nu_{t+1}\left(1 - \frac{\bar{d}^h}{d_t^h(\psi)}\right)} \right\} \\
&= \frac{\beta\psi}{\Lambda_t} \mathbb{E}_t^*(\psi) \qquad (65)
\end{aligned}$$

where the last line defines $\mathbb{E}_t^*(\psi)$, which is 1 in the absence of bank failure risk. The first-order condition for deposits in region 3 can be written similarly, with p_{t+1}^{fr} replacing p_{t+1}^{full} (see Section 4.5).

In region 2, we approximate deposit holdings using Gauss-Legendre quadrature with a linear change of variables to change the interval $\left(\log \overline{\psi}_t, \log \overline{\psi}_t^{RUN}\right)$ to $(-1, 1)$. because region 3 is unbounded, there we use Gauss-Laguerre quadrature with a quadratic change of variables. In both cases, we compute the nodes and weights to incorporate the change of variables, the multiplication by ψ, and lognormal density as follows: for any function $f_t(\psi)$, we approximate its integral in region 2 as

$$\int_{\underline{\psi}_t}^{\overline{\psi}_t^{RUN}} \psi f_t(\psi)\, dF(\psi) = \sum_i \exp\left\{\log \hat{v}_i^{(2)} + \log f_t\left(\psi_i^{(2)}\right)\right\} \tag{66}$$

where

$$\log \psi_i^{(2)} = \frac{u_i^{(2)}+1}{2}\left(\log \overline{\psi}_t^{RUN} - \log \underline{\psi}_t\right) + \log \underline{\psi}_t$$
$$\log \hat{v}_i^{(2)} = \log w_i^{(2)} + \log \psi_i^{(2)} + \log \phi\left(\log \psi_i^{(2)}; \mu_\psi, \sigma_\psi^2\right) + \log\left(\log \overline{\psi}_t^{RUN} - \log \underline{\psi}_t\right) - \log 2,$$

$\phi\left(\cdot; \mu, \sigma^2\right)$ is the pdf of a normal random variable with mean μ and variance σ^2, and $u_i^{(2)}$ and $w_i^{(2)}$ are the Gauss-Legendre nodes and weights, respectively.

Thus, household deposits in region 2 can be approximated as

$$\begin{aligned} d_t^h(2) &\equiv \int_{\underline{\psi}_t}^{\overline{\psi}_t^{RUN}} d_t^h(\psi)\, dF(\psi) \\ &= \frac{d_t^{h*}(2)}{d_t^{h*}(2)} \int_{\underline{\psi}_t}^{\overline{\psi}_t^{RUN}} d_t^h(\psi)\, dF(\psi) \\ &= d_t^{h*}(2) \frac{\int_{\underline{\psi}_t}^{\overline{\psi}_t^{RUN}} \frac{\beta}{\Lambda_t} \psi\, \mathbb{E}_t^*(\psi)\, dF(\psi)}{\int_{\underline{\psi}_t}^{\overline{\psi}_t^{RUN}} \frac{\beta}{\Lambda_t} \psi dF(\psi)} \\ &\approx d_t^{h*}(2) \frac{\sum_i \exp\left\{\log \hat{v}_i^{(2)} + \log \mathbb{E}_t^*\left(\psi_i^{(2)}\right)\right\}}{\sum_i \exp\left\{\log \hat{v}_i^{(2)}\right\}}, \end{aligned}$$

where

$$d_t^{h*}(2) \equiv \int_{\underline{\psi}_t}^{\overline{\psi}_t^{RUN}} d^h(\psi)\, dF(\psi) = \frac{\beta}{\Lambda_t}\left[e_1\left(\overline{\psi}_t^{RUN}\right) - e_1\left(\underline{\psi}_t\right)\right]$$

is household deposits in region 2 under full insurance.

Likewise, the utility from liquid consumption in region 2 is

$$\begin{aligned}
u_t^h(2) &= u_t^{h*}(2) + u_t^h(2) - u_t^{h*}(2) \\
&\approx u_t^{h*}(2) + p_{t+1}^{FUN} \sum_i \hat{v}_i^{(2)} \log d_t^h\left(\psi_i^{(2)}\right) \\
&\quad + \left(1 - p_{t+1}^{FUN}\right) \sum_i \hat{v}_i^{(2)} \log\left[\nu_{t+1}\bar{d}^h + (1-\nu_{t+1})\, d_t^h\left(\psi_i^{(2)}\right)\right]. \\
&\quad - p_{t+1}^{FUN} \sum_i \hat{v}_i^{(2)} \log \frac{\beta\psi_i^{(2)}}{\Lambda_{t+1}} - \left(1 - p_{t+1}^{FUN}\right) \sum_i \hat{v}_i^{(2)} \log \frac{\beta\psi_i^{(2)}}{\Lambda_{t+1}} \\
&= u_t^{h*}(2) + \sum_i \hat{v}_i^{(2)} \log \mathbb{E}_t^*\left(\psi_i^{(2)}\right) + \left(1 - p_{t+1}^{FUN}\right) \sum_i \hat{v}_i^{(2)} \log\left[1 - \nu_{t+1}\left(1 - \frac{\bar{d}^h}{d_t^h\left(\psi_i^{(2)}\right)}\right)\right],
\end{aligned}$$

where $u_t^{h*}(2)$ is utility in region assuming no bank failure risk:

$$u_t^{h*}(2) \equiv \left[e_1\left(\overline{\psi}_t^{RUN}\right) - e_1\left(\overline{\psi}_t\right)\right] \log \frac{\beta}{\Lambda_t} + e_2\left(\overline{\psi}_t^{RUN}\right) - e_2\left(\log \overline{\psi}_t\right).$$

To compute deposits and utility in region 3, we use Gauss-Laguerre quadrature with a quadratic change of variables. Specifically, we want to compute

$$\Pi \equiv \int_{\underline{\varepsilon}}^{\infty} f(\varepsilon)\, e^{\varepsilon} \phi\left(\varepsilon; \mu, \sigma^2\right) d\varepsilon \tag{67}$$

when $\varepsilon \sim \mathbb{N}\left(\mu, \sigma^2\right)$, for some arbitrary function $f(\cdot)$. The inclusion of the ε term reflects the fact that even with $\nu_{t+1} < 1$, equation (24) will still result in values of $d_t^h(\psi)$ that are approximately log-linear in ψ.

If we define the change of variables as

$$u \equiv g(\varepsilon) = \frac{1}{2}\left(\frac{\varepsilon - \mu}{\sigma}\right)^2 + b, \quad b = -\frac{1}{2}\left(\frac{\underline{\varepsilon} - \mu}{\sigma}\right)^2$$

then

$$g'(\varepsilon) = \frac{\varepsilon - \mu}{\sigma^2}$$

and as long as $\underline{\varepsilon} > \mu$ we will have $g'(\varepsilon) > 0$ and g will be invertible, with inverse

$$g^{-1}(u) = \mu + \sigma\sqrt{2(u-b)}.$$

Of course, $\underline{\varepsilon} = \log \overline{\psi}_t^{RUN}$ is endogenous, and so we ensure ex post that $\log \overline{\psi}_t^{RUN} > \mu_\psi$ so that $g' > 0$ in our simulations. We apply the change of variables formula to get

$$
\begin{aligned}
\Pi &= \frac{e^{b}}{\sigma\sqrt{2\pi}}\int_{\underline{\varepsilon}}^{\infty} f\left(\varepsilon\right)\frac{\exp\left\{\varepsilon\right\}}{\frac{\varepsilon-\mu}{\sigma^{2}}}\underbrace{\exp\left\{-\left[\frac{1}{2}\left(\frac{\varepsilon-\mu}{\sigma}\right)^{2}+b\right]\right\}}_{\exp\{-g(\varepsilon)\}}\underbrace{\left[\frac{\varepsilon-\mu}{\sigma^{2}}\right]}_{g'(\varepsilon)}d\,\varepsilon \\
&= \frac{e^{b}}{\sigma\sqrt{2\pi}}\int_{0}^{\infty} f\left(g^{-1}\left(u\right)\right)\frac{\exp\left\{g^{-1}\left(u\right)\right\}}{\frac{1}{\sigma}\sqrt{2\left(u-b\right)}}e^{-u}du \\
&\approx \frac{e^{b}}{\sqrt{2\pi}}\sum_{i=1}^{N} w_{i}^{(3)} f\left(g^{-1}\left(u_{i}^{(3)}\right)\right)\frac{\exp\left\{g^{-1}\left(u_{i}^{(3)}\right)\right\}}{\sqrt{2\left(u_{i}^{(3)}-b\right)}} \qquad (68)
\end{aligned}
$$

where $w_i^{(3)}$ and $u_i^{(3)}$ are the N Gauss-Laguerre weights and node-points.

We can then apply equation (68) to approximating integrals of the form (67) using

$$
\int_{\overline{\psi}_{t}^{RUN}}^{\infty} \psi f_{t}\left(\psi\right)dF\left(\psi\right) \approx \sum_{i} \exp\left\{\log\hat{v}_{i}^{(3)}+\log f_{t}\left(\psi_{i}^{(3)}\right)\right\}, \qquad (69)
$$

where

$$
\begin{aligned}
\log\psi_{i}^{(3)} &\equiv \mu_{\psi}+\sigma_{\psi}\sqrt{2\left(u_{i}^{(3)}-b_{t}\right)} \\
\log\hat{v}_{i}^{(3)} &\equiv \log w_{i}^{(3)}+\log\psi_{i}^{(3)}+b_{t}-\frac{1}{2}\log\left(2\pi\right)-\frac{1}{2}\log\left[2\left(u_{i}^{(3)}-b_{t}\right)\right] \\
b_{t} &\equiv -\frac{1}{2}\left(\frac{\log\overline{\psi}_{t}^{RUN}-\mu_{\psi}}{\sigma_{\psi}}\right)^{2}
\end{aligned}
$$

and $w_i^{(3)}$ and $u_i^{(3)}$ are the N Gauss-Laguerre weights and node-points.

It remains to find the proper function $f_t(\psi)$ in order to approximate household deposits and utility, taking note that equation (69) already incorporates a multiplication by ψ. Using equations (60) and (65) we have that

$$
\begin{aligned}
d_{t}^{h}\left(3\right) &\equiv \int_{\overline{\psi}_{t}^{RUN}}^{\infty} d_{t}^{h}\left(\psi\right)dF\left(\psi\right) \\
&= \frac{d_{t}^{h*}\left(3\right)}{d_{t}^{h*}\left(3\right)}\int_{\overline{\psi}_{t}^{RUN}}^{\infty} d_{t}^{h}\left(\psi\right)dF\left(\psi\right) \\
&= d_{t}^{h*}\left(3\right)\frac{\int_{\overline{\psi}_{t}^{RUN}}^{\infty}\frac{\beta}{\Lambda_{t}}\psi\,\mathbb{E}_{t}^{*}\left(\psi\right)dF\left(\psi\right)}{\int_{\overline{\psi}_{t}^{RUN}}^{\infty}\frac{\beta}{\Lambda_{t}}\psi dF\left(\psi\right)} \\
&\approx d_{t}^{h*}\left(3\right)\frac{\sum_{i}\exp\left\{\log\hat{v}_{i}^{(3)}+\log\mathbb{E}_{t}^{*}\left(\psi_{i}^{(3)}\right)\right\}}{\sum_{i}\exp\left\{\log\hat{v}_{i}^{(3)}\right\}}
\end{aligned}
$$

where

$$
\begin{aligned}
d_t^{h*}(3) &\equiv \int_{\overline{\psi}_t^{RUN}}^{\infty} d^h(\psi)\, dF(\psi) \\
&= \frac{\beta}{\Lambda_t}\left[e_1(\infty) - e_1\left(\overline{\psi}_t^{RUN}\right)\right]
\end{aligned}
$$

is the full-insurance value for household deposits in region 3. Likewise to approximate utility from household deposits in region 3 we use

$$
\begin{aligned}
u_t^h(3) &= u_t^{h*}(3) + u_t^h(3) - u_t^{h*}(3) \\
&\approx u_t^{h*}(3) + p_{t+1}^{FUN} \sum_i \hat{v}_i^{(3)} \log d_t^h\left(\psi_i^{(3)}\right) \\
&\quad + \left(1 - p_{t+1}^{FUN}\right) \sum_i \hat{v}_i^{(3)} \log\left[\nu_{t+1}\bar{d}^h + (1-\nu_{t+1})\, d_t^h\left(\psi_i^{(3)}\right)\right]. \\
&\quad - p_{t+1}^{FUN} \sum_i \hat{v}_i^{(2)} \log \frac{\beta\psi_i^{(3)}}{\Lambda_{t+1}} - \left(1 - p_{t+1}^{FUN}\right) \sum_i \hat{v}_i^{(2)} \log \frac{\beta\psi_i^{(3)}}{\Lambda_{t+1}} \\
&= u_t^{h*}(3) + \sum_i \hat{v}_i^{(3)} \log \mathbb{E}_t^*\left(\psi_i^{(3)}\right) \\
&\quad + \left(1 - p_{t+1}^{FUN}\right) \sum_i \hat{v}_i^{(3)} \log\left[1 - \nu_{t+1}\left(1 - \frac{\bar{d}^h}{d_t^h\left(\psi_i^{(3)}\right)}\right)\right]
\end{aligned}
$$

where

$$
u_t^{h*}(3) \equiv \left[e_1(\infty) - e_1\left(\overline{\psi}_t^{RUN}\right)\right] \log \frac{\beta}{\Lambda_t} + e_2(\infty) - e_2\left(\overline{\psi}_t^{RUN}\right).
$$

E.3 Impulse Response Functions

To compute the impulse-response functions plotted in Figure 7, we assume that the economy is in steady-state at $t = 0$ and receives an unexpected shock at time $t = 1$. In particular, at $t = 1$ the exogenous idiosyncratic bank risk variable σ is unexpectedly high for one period, leading to a large number of bank failures. When we incorporate the bailout shock, we also set $f = 0$ on impact. We assume that there are no further shocks to the economy, and that f mean-reverts to its steady-state level with an autocorrelation coefficient of 0.5.

Formally, we assume that the bailout probability and the scale parameter of the distribution ε are time varying, f_t and σ_t, and we assume an exogenous path from $t = 1$ to $t = T$ for the vector $z_t \equiv [f_t, \sigma_t]'$, and solve for the implied path of the vector of endogenous variables x_t from $t = 1$ to T. At $t = 0$ all variables are at their steady-state values. From $t = 1$ to T agents know the entire path of all variables, and we solve non-linearly for the values of x_t that satisfy all the equations described in Section 4. We use $T = 100$ and verify ex post that this value is large enough for the system to have converged back to steady-state.

Solving for x_t at $t = 1$, however, is not as straightforward. When simulating the model with constant f, the run thresholds $\overline{a}_t^{RUN}$ and $\overline{\psi}_t^{RUN}$ are measurable with respect to the time-t information set, and thus, we compute them at time t, even though they represent the thresholds for running at $t+1$. When we include the shock to the bailout probability f, however, these variables react to the change in f at $t+1$ (see Section 4.1), affecting the measure of runnable deposits. We thus need to recompute these thresholds on impact, when the shock to f is realized. To do so, we re-compute the node points for households and firms on impact, taking as given the distribution of deposits and of the other households' and firms' choices before the shock (i.e., the distributions in steady state), and re-compute the thresholds using the value of f_t on impact (i.e., $f_t = 0$). We can then compute the mass of runnable deposits, which increases substantially when the bailout probability drops to zero.

F Robustness Analyses: Additional Details

In this section we provide additional details about some of the robustness exercises discussed in Section 5.4 and presented in Table 5.

F.1 Baseline with Second Order Simulation

We simulate the model using a second-order approximation. To avoid explosive solutions, we use a pruning method; see Andreasen et al. (2018).

F.2 Baseline with Transition

To compute welfare accounting for the transition to the new steady state, we assume that the economy was in the non-stochastic steady state before the new limit was announced, and that the new limit applies immediately when it is announced. This is in line with the last increase in deposit insurance that took place in the United States, in 2008. Thus, for some depositors with holdings of uninsured deposits in steady state, their deposits become fully insured after the limit is increased.

To solve for the transition, we face a problem similar to the one discussed when describing the impulse response to the bailout shock (Appendix E.3). That is, on impact after the new insurance limit is announced, the run threshold changes (and specifically, increases) because more deposits become insured. We thus proceed along the lines of Appendix E.3 by recomputing the run thresholds $\overline{a}_t^{RUN}$ and $\overline{\psi}_t^{RUN}$ given the new level of deposit insurance, and then recomputing the measure of runnable deposits accordingly.

F.3 More Deadweight Losses of Bank Default

Deadweight losses of bank default are likely higher in crises times—when many banks fail at the same time—possibly because buyers of failed banks are constrained (Granja et al. 2017; Acharya and Yorulmazer 2008). The evidence in Bennett and Unal (2014) and Granja et al. (2017) show that resolution costs increase by about 3 percentage points during crises. In particular, Granja et al. (2017) report that the average cost of resolving failed banks between 2007 and 2013 is 28% of assets, but only 25% if acquirers are better capitalized. The difference between the two figures is thus 3 percentage points. To provide a simple and transparent result, we increase the deadweight loss of default Υ^{dwl} at all times by 3 percentage points—this provide an upper bound on the effects.

F.4 Adding Other Liquid Assets Held by Firms

In this extension, we allow firms to invest in assets s_t^i, which are risk-free and also provide some liquidity benefits, so that the firm's budget constraint becomes

$$k_t^i + d_t^i + s_t^i \leq a^i.$$

These other liquid assets pay a gross return R_t^s and provide some liquidity to finance wages. However, other liquid assets such as Treasury securities are likely less liquid than deposits in practice, as they need to be sold first before the resulting liquidity can be used to pay wages and other expenses. Hence, we assume that the liquidity provided by other liquid assets is lower than deposits. We also assume that the liquidity declines as a function of the liquidity holdings s_t^i scaled by the firm wealth a_t^i, as managing a large portfolio of securities can be costly or time consuming for smaller firms. The second assumption is also crucial to solve the model, as it implies that the firms' objective function is concave in s_t^i after we plug the liquidity constraint into the objective function. Specifically, we replace the working capital constraint (12) with

$$w_{t+1} l_{t+1}^i \leq R_{t+1}^d d_t^i + \theta y_{t+1}^i + R_t^s s_t^i \left(1 - \frac{\zeta^s}{2} \frac{s_t^i}{a^i}\right), \tag{70}$$

where ζ^s parameterizes the extent to which the marginal liquidity benefit decreases in s_t^i.[28]

We calibrate ζ^s to obtain a 0.13% liquidity premium on other liquid assets (i.e., the average spread between the rate on a risk-free illiquid asset and R_t^s), which we compute by using the approach of Krishnamurthy and Vissing-Jorgensen (2012) and extending their sample up to 2019. We set the supply of other liquid assets to 5.25% of GDP by considering firms' holdings of a broad set of other liquid assets: Treasury securities, money market funds, reverse repos, commercial paper munis, and agency securities. To compute these holdings, we consider the average between 2001 and the end of our sample in 2019 because of a trend in the initial part of the sample.

F.5 Allowing Banks to Operate with Negative Equity

In this extension, we enrich the bank's problem by allowing banks with negative equity to operate for some time, rather than being immediately shut down. Similar to the baseline model, a bank created at time t collects deposits and makes loans in that period, and then it receives a shock ε at $t+1$ that affects the cash flow from loan repayments. If the shock is large enough and the bank is solvent at $t+1$, it returns its resources after repaying depositors to shareholders (i.e., households), provided that it is not subject to a run: this is the same as in the baseline model. But if the bank has negative equity at $t+1$, and provided it is not subject to a run, we allow it to operate for another period, that is, take deposits and issue loans at

[28]Equation (70) reports the liquidity constraint for the case where the deposits are paid in full; the case in which the bank fails and is not bailed out is similar and is constructed by adding the term $R_t^s s_t^i \left(1 - \frac{\zeta^s}{2} \frac{s_t^i}{a^i}\right)$ to the baseline working capital constraint.

$t+1$. Operating with negative equity at $t+1$ is valuable for shareholders because the bank can "gamble for resurrection": the bank receives another shock ε at $t+2$ that can make the bank solvent again. At that point, we assume for simplicity that the bank is always shut down by the regulator: if it is insolvent, its uninsured depositors are either bailed out or experience losses, and if it is solvent, the uninsured depositors are fully repaid and any additional resource is used to repay shareholders.

The extension is motivated by both the 2023 banking crisis and the Savings & Loans crisis, and the fact that the regulation used in practice does not force banks to mark-to-market their equity every period. Specifically, banks can use historical cost accounting to value some of their securities (Kim et al., 2019; Orame et al., 2023), they can evaluate loans at book value rather than discounting their cash flow in case the interest rates changes (Jiang et al., 2023), and delayed loss accounting rules might keep banks' regulatory capital artificially high (Begenau et al., 2021).

At time t, households invest $n_t^{pos} > 0$ in the banking sector, creating a unit mass of positive-equity banks. These banks issue deposits d_t^{pos} and invest in assets b_t^{pos}, subject to the same capital requirement and budget constraint as the baseline model:

$$n_t^{pos} \geq \zeta b_t^{pos}$$
$$b_t^{pos} = d_t^{pos} + n_t^{pos}.$$

Likewise, the thresholds for fundamental and run defaults, which only affect positive-equity banks, are the same as in the baseline model (i.e., equations (34)-(36) in Section 4.2) but in which we replace banks' assets with b_t^{pos}, deposits with d_t^{pos}, and running deposits with $d_t^{RUN} \times d_t^{pos}/d_t$, that is, positive-equity banks have a fraction of the economy-wide running deposits, and the fraction equals their holdings of deposits d_t^{pos} relative to the economy-wide total d_t.

For a positive-equity bank, there are four possibilities at $t+1$, depending on the realization of its shock ε at $t+1$.

(i) If $\varepsilon > \underline{\varepsilon}_{t+1}^{REC}$, the bank is outside the run region and the recall region, so it does not recall loans and will not be subject to runs. The bank pays a dividend for sure, as in the baseline model.

(ii) If $\underline{\varepsilon}_{t+1}^{RUN} < \varepsilon < \underline{\varepsilon}_{t+1}^{REC}$, the bank is outside the run region, but it recall loans, as in the baseline model.

(iii) If $\underline{\varepsilon}_{t+1}^{FUN} < \varepsilon < \underline{\varepsilon}_{t+1}^{RUN}$, the bank is in the run region. If the bank is subject to a run, it is taken over by the regulator and liquidated immediately. If is not subject to a run, it pays a dividend. These outcomes are again the same as in the baseline model.

(iv) If $\varepsilon < \underline{\varepsilon}_{t+1}^{FUN}$, the bank's liabilities exceed the assets. With probability π, a bank in this region is subject to a run, and in this case, it is taken over by the regulator and liquidated immediately. But if it is not subject to a run, it operates again at $t+1$ (i.e., it takes deposits and issues loans) as a negative-equity bank.

At the beginning of $t+1$, the measure of banks of type (iv) not subject to runs (i.e., negative-equity banks) is given by

$$m_{t+1}^{neg} = (1-\pi)\int_0^{\underline{\varepsilon}_{t+1}^{FUN}} dF(\varepsilon).$$

The total net worth of negative-equity banks at time $t+1$ is n_{t+1}^{neg}, given by

$$n_{t+1}^{neg} = (1-\pi)\int_0^{\underline{\varepsilon}_{t+1}^{FUN}} \left[\varepsilon b_t^{pos}(1-\delta+r_t) - R_t^d d_t^{pos}\right] dF(\varepsilon) < 0,$$

where $n_{t+1}^{neg} < 0$ follows from the definition of $\underline{\varepsilon}_{t+1}^{FUN}$.

We assume that negative-equity banks operate together as a single representative bank.[29] We denote the total assets and total deposits at $t+1$ of the mass m_{t+1}^{neg} of negative-equity banks as b_{t+1}^{neg} and d_{t+1}^{neg}, respectively. Negative equity banks cannot be subject to the same capital requirement as positive-equity banks—if they did, they could not have any assets, because their equity is negative. Thus, we assume that they invest in the same assets as the previous period, so that the total stock of assets at negative equity banks is $b_{t+1}^{neg} = m_{t+1}^{neg} b_t^{pos}$. This is equivalent to assuming that the capital requirement of these banks depend on the lagged value of their capital, consistent with the motivation discussed earlier about regulation that allows banks to use historical cost accounting and other accounting rules based on book values. Deposits at negative-equity banks are then set by the budget constraint $d_{t+1}^{neg} = b_{t+1}^{neg} - n_{t+1}^{neg}$. Thus, negative-equity banks finance their losses for one period by issuing more deposits.

At $t+2$, negative equity banks pay a dividend and exit (if they are fundamentally solvent at $t+2$) or are resolved by the government (if they are insolvent)—the solvency depends on the value of ε they receive at $t=2$. For simplicity, we assume that there are no panic-based runs on negative equity banks, and that such banks do not recall loans. These simplifications are not crucial as the mass of negative-equity banks is small and, thus, has limited impact on the quantitative results. The cutoff that determines if a negative-equity bank becomes solvent at $t+2$ is denoted by $\underline{\varepsilon}_{t+2}^{NEG}$; that is, negative-equity banks at $t+1$ that receive a value of $\varepsilon_{t+2} > \underline{\varepsilon}_{t+2}^{NEG}$ pay out a dividend $div_{t+2}^{neg} > 0$, and the remainder are insolvent and, thus, are resolved by the government. The cutoff $\underline{\varepsilon}_{t+2}^{NEG}$ is defined by

$$\underline{\varepsilon}_{t+2}^{NEG} b_{t+1}^{neg}(1-\delta+r_{t+1}) = R_{t+1}^d d_{t+1}^{neg}.$$

Note that the investment of n_t^{pos} at the beginning of time t results in dividends in both $t+1$ and $t+2$. Dividends from positive-equity banks at $t+1$, including banks both inside and outside the run region, are

[29] This implies that there is no heterogeneity in the leverage of negative-equity banks, and allows us to compute one single cutoff for ε to determine which bank is solvent at $t+2$.

given by

$$
\begin{aligned}
div_{t+1}^{pos} \quad = \quad & (1-\pi)\int_{\underline{\varepsilon}_{t+1}^{FUN}}^{\underline{\varepsilon}_{t+1}^{RUN}} \left[\varepsilon b_t^{pos}(1-\tau)\left(1-\delta+r_t\right)+\tau\varepsilon b_t^{pos}(1-\delta)-R_t^d d_t^{pos}\right] dF\left(\varepsilon\right) \\
& +\int_{\underline{\varepsilon}_{t+1}^{RUN}}^{\underline{\varepsilon}_{t+1}^{REC}} \left[\varepsilon b_t^{pos}(1-\tau)\left(1-\delta+r_t\right)+\tau\varepsilon b_t^{pos}(1-\delta)-R_t^d d_t^{pos}\right] dF\left(\varepsilon\right) \\
& +\int_{\underline{\varepsilon}_{t+1}^{REC}}^{\infty} \left[\varepsilon b_t^{pos}\left(1-\delta+r_t\right)-R_t^d d_t^{pos}\right] dF\left(\varepsilon\right),
\end{aligned}
$$

and dividends from negative-equity banks at $t+2$ are given by

$$
div_{t+2}^{neg}=\int_{\underline{\varepsilon}_{t+2}^{NEG}}^{\infty}\left[\varepsilon b_{t+1}^{neg}\left(1-\delta+r_{t+1}\right)-R_{t+1}^d d_{t+1}^{neg}\right] dF\left(\varepsilon\right).
$$

We can thus write the first-order condition that pins down the households' choice of n_t^{pos}:

$$
1=\beta\left\{\frac{\Lambda_{t+1}}{\Lambda_t}\left[\frac{div_{t+1}^{pos}}{n_t^{pos}}+\beta\frac{\Lambda_{t+2}}{\Lambda_{t+1}}\frac{div_{t+2}^{neg}}{n_t^{pos}}\right]\right\}.
$$

The total bank default rate at time $t+1$ includes positive-equity banks who began at time t and experience a run, as well as negative-equity banks who began at time $t-1$ and received a low value of ε_{t+1}:

$$
p_{t+1}^{default}=\frac{\pi\int_0^{\underline{\varepsilon}_{t+1}^{RUN}} dF\left(\varepsilon\right)+m_t^{neg}\int_0^{\underline{\varepsilon}_{t+1}^{NEG}} dF\left(\varepsilon\right)}{1+m_t^{neg}}.
$$

Notice that this default probability uses m_t^{neg} and $\underline{\varepsilon}_{t+1}^{NEG}$, since at time $t+1$ the government closes negative-equity banks that were begun at time $t-1$.

Finally, the equation that pins down the haircut on deposits at failed banks at $t+1$, which is given by (45) in the main version of the quantitative model, is adjusted to account for the assets of the banks with positive and negative equity that fail. For failed banks with positive equity, the assets are the same as those in the integral on the right-hand side of (45), with b_t^{pos} replacing b_t. For failed banks with negative equity, the assets are $\int_0^{\underline{\varepsilon}_{t+1}^{NEG}} \varepsilon b_t^{neg}(1-\delta+r_t)(1-\Upsilon^{tot})dF(\varepsilon)$ because these banks do not recall loans.

F.6 Adding Risk-Shifting by Banks and Monitoring by Uninsured Depositors

To extend the model to include risk-shifting (rows 9 and 10 of Table 5), we allow banks to invest in projects with low net present value but higher idiosyncratic risk, along the logic of Jensen and Meckling (1976). The approach follows the bad risk-taking modeling in Pancost and Robatto (2023). We also describe how we incorporate monitoring by uninsured depositors to obtain the results in line 10 of Table 5.

For banks, increasing the variance of their investments is beneficial because limited liability and subsidized deposit insurance allow them to capture the upside of idiosyncratic risk while shifting the downside to the government. Consequently, banks may pursue riskier investments even if they entail a lower expected return.

The problem of banks now allows them to choose the degree of bad risk-taking $s_t \geq 0$. A choice of $s_t > 0$ increases the risk of the idiosyncratic shock ε, but leaves the mean unchanged. The cost to the bank of increasing s_t is a reduction in the return on bank loans. In row 9, this is the only cost to banks of risk-shifting. In row 10, we also assume that higher s_t increases the return the bank must pay on uninsured deposits.

We first describe the extension with only risk-shifting (i.e., no monitoring), and then we explain how we incorporate monitoring

F.6.1 Risk-Shifting Only (i.e., no Monitoring)

When we add risk-shifting, there are three differences in comparison to the quantitative model. First, the bad risk-taking decision s_t affects the distribution of the banks' idiosyncratic shock ε, which we now denote as $F(\varepsilon; s_t)$. We follow Pancost and Robatto (2023) by assuming that ε is distributed according to

$$\varepsilon \sim \begin{cases} 0 & \text{with probability } s_t \\ \frac{\tilde{\varepsilon}}{1-s_t} & \text{with probability } 1-s_t \end{cases} \tag{71}$$

where $\tilde{\varepsilon}$ is lognormal with scale parameter σ, and $\mathbb{E}(\tilde{\varepsilon}) = 1$. This implies, by construction, that $\mathbb{E}(\varepsilon) = 1$ for all s_t.

Second, bad risk-taking affects the bank's capital requirement constraint. Specifically, we replace (5) with

$$n_t \geq \zeta_n \frac{b_t}{1 - \zeta_{RWA} s_t}. \tag{72}$$

As extensively discussed in Pancost and Robatto (2023), the parameter ζ_{RWA} reflects the (imperfect) ability of regulators to tighten the effective capital requirement on banks that increase bad risk-taking s_t, using tools such as risk-weighted assets, inspections, and CAMELS ratings.

Third, for a bank set up at time t with loans b_t, the cash flow produced at $t+1$ is

$$(\text{cash flow})_{t+1} = \begin{cases} \varepsilon b_t \left[1 - \delta + r_t \left(1 - \frac{\lambda}{2} s_t^2\right)\right] & \text{if no loan is recalled} \\ (1-\tau)\,\varepsilon b_t \left[1 - \delta + r_t \left(1 - \frac{\lambda}{2} s_t^2\right)\right] + \tau \varepsilon b_t (1-\delta) & \text{if a fraction } \tau \text{ of loans are recalled.} \end{cases}$$

The parameter $\lambda > 0$ governs the lower return earned because of bad risk-taking.

To summarize, increasing bad risk-taking s_t has three effects for a bank: it increases the variance of its idiosyncratic risk, it reduces the leverage because of higher risk weights in the capital requirement, and it reduces the expected return on loans.

We can write the bank's objective function, taking explicit account of the optimal loan recall policy described in Section 4.2 and the formulation of the idiosyncratic shock ε in (71):

$$\max_{b_t,\, d_t, s_t} \; (1-s_t)\,\mathbb{E}_t \int_{\widetilde{\varepsilon_{t+1}^{REC}}}^{\infty} \left\{ \frac{\tilde{\varepsilon}}{1-s_t} b_t \left[1-\delta + r_t\left(1-\frac{\lambda}{2}s_t^2\right)\right] - R_t^d d_t \right\} d\tilde{F}\left(\tilde{\varepsilon}\right)$$

$$+(1-s_t)\,\mathbb{E}_t \int_{\widetilde{\varepsilon_{t+1}^{RUN}}}^{\widetilde{\varepsilon_{t+1}^{REC}}} \left\{ \frac{\tilde{\varepsilon}}{1-s_t} b_t \left[1-\delta + (1-\tau)\, r_t\left(1-\frac{\lambda}{2}s_t^2\right)\right] - R_t^d d_t \right\} d\tilde{F}\left(\tilde{\varepsilon}\right) \quad (73)$$

$$+(1-s_t)\,(1-\pi)\,\mathbb{E}_t \int_{\widetilde{\varepsilon_{t+1}^{FUN}}}^{\widetilde{\varepsilon_{t+1}^{RUN}}} \left\{ \frac{\tilde{\varepsilon}}{1-s_t} b_t \left[1-\delta + (1-\tau)\, r_t\left(1-\frac{\lambda}{2}s_t^2\right)\right] - R_t^d d_t \right\} d\tilde{F}\left(\tilde{\varepsilon}\right),$$

subject to the budget constraint (4) and the capital requirement (72). The term $1-s_t$ appears in the objective function because the bank's idiosyncratic shock is zero with probability s_t, according to (71). In addition, when the shock is not zero, it takes value $\tilde{\varepsilon}/(1-s_t)$, again because of (71). We use $\tilde{F}$ to denote the CDF of the lognormal distribution with mean one and scale parameter σ, in line with the approach of denoting $\tilde{\varepsilon}$ to be the lognormally distributed shock.

Bad risk-taking also changes the thresholds at which banks recall loans, and are vulnerable to runs, and are fundamentally insolvent. Thus, we replace equations (34), (35), and (36) with

$$\frac{\widetilde{\varepsilon_{t+1}^{REC}}}{1-s_t} b_t \left[1-\delta + r_t\left(1-\frac{\lambda}{2}s_t^2\right)\right] = R_t^d\left(d_t - d_{t+1}^{RUN}\right) + \frac{R_t^d d_{t+1}^{RUN}}{1-\Upsilon^{tot}} \quad (74)$$

$$\frac{\widetilde{\varepsilon_{t+1}^{RUN}}}{1-s_t} b_t \left[(1-\tau)\left[1-\delta + r_t\left(1-\frac{\lambda}{2}s_t^2\right)\right] + \tau\frac{1-\delta}{1-\Upsilon}\right] = R_t^d(d_t - d_{t+1}^{RUN}) + \frac{R_t^d d_{t+1}^{RUN}}{1-\Upsilon^{tot}} \quad (75)$$

$$\frac{\widetilde{\varepsilon_{t+1}^{FUN}}}{1-s_t} b_t \left[(1-\tau)\left[1-\delta + r_t\left(1-\frac{\lambda}{2}s_t^2\right)\right] + \tau\frac{1-\delta}{1-\Upsilon}\right] = R_t^d d_t, \quad (76)$$

respectively.

The first-order condition for s_t is

$$\lambda r_t s_t \left[\int_{\varepsilon_{t+1}^{REC}}^{\infty} \tilde{\varepsilon} d\tilde{F}\left(\tilde{\varepsilon}\right) + (1-\tau)\int_{\varepsilon_{t+1}^{RUN}}^{\varepsilon_{t+1}^{REC}} \tilde{\varepsilon} d\tilde{F}\left(\tilde{\varepsilon}\right) + (1-\tau)\,(1-\pi)\int_{\varepsilon_{t+1}^{FUN}}^{\varepsilon_{t+1}^{RUN}} \tilde{\varepsilon} d\tilde{F}\left(\tilde{\varepsilon}\right)\right] \quad (77)$$

$$= R_t^d \left(1-\zeta_n \frac{1-\zeta_{RWA}}{\left(1-\zeta_{RWA}s_t\right)^2}\right)\left[\int_{\varepsilon_{t+1}^{RUN}}^{\infty} d\tilde{F}\left(\tilde{\varepsilon}\right) + (1-\pi)\int_{\varepsilon_{t+1}^{FUN}}^{\varepsilon_{t+1}^{RUN}} d\tilde{F}\left(\tilde{\varepsilon}\right)\right]$$

$$-\tau r_t\left(1-\frac{\lambda}{2}s_t^2\right)\varepsilon_{t+1}^{REC}\frac{\partial\widetilde{\varepsilon_{t+1}^{REC}}}{\partial s_t}\tilde{f}\left(\widetilde{\varepsilon_{t+1}^{REC}}\right)$$

$$-\pi\left[\widetilde{\varepsilon_{t+1}^{RUN}}\left(1-\delta + r\,(1-\tau)\left(1-\frac{\lambda}{2}s_t^2\right)\right) - (1-s_t)\left(1-\frac{\zeta_n}{1-\zeta_{RWA}s_t}\right)R_t^d\right]\frac{\partial\widetilde{\varepsilon_{t+1}^{RUN}}}{\partial s_t}\tilde{f}\left(\widetilde{\varepsilon_{t+1}^{RUN}}\right)$$

where $\tilde{f}\left(\cdot\right)$ is the PDF of the lognormal distribution with mean one

The left-hand side of equation (77) is the marginal cost of increasing s_t, which reduces the loan rate that banks charge to borrowers. The right-hand side is the marginal benefit: the first line represents the reduction, in expectation, of payments to depositors, incorporating both the leverage ratio of the bank and the fact that the leverage ratio itself changes with s_t because of the risk-weighting in the capital requirement constraint. The last two lines of equation (77) reflects the impact of s_t on the thresholds that define the loan recall region and the run region.

The marginal impacts of s_t on the threshold values $\widetilde{\varepsilon_{t+1}^{REC}}$ and $\widetilde{\varepsilon_{t+1}^{RUN}}$ are given by

$$\frac{\partial \widetilde{\varepsilon_{t+1}^{REC}}}{\partial s_t} = \widetilde{\varepsilon_{t+1}^{REC}} \left[\frac{\lambda r_t s_t}{1-\delta + r_t \left(1 - \frac{\lambda}{2} s_t^2\right)} + \frac{\zeta_n \zeta_{RWA}}{\left(1-\zeta_{RWA} s_t\right)^2 \left(1 - \frac{\zeta_n}{1-\zeta_{RWA} s_t}\right)} - \frac{1}{1-s_t} \right]$$

$$\frac{\partial \widetilde{\varepsilon_{t+1}^{RUN}}}{\partial s_t} = \widetilde{\varepsilon_{t+1}^{RUN}} \left[\frac{(1-\tau)\lambda r_t s_t}{(1-\tau)\left[1-\delta + r_t \left(1 - \frac{\lambda}{2} s_t^2\right)\right] + \tau \frac{1-\delta}{1-\Upsilon^{tot}}} + \frac{\zeta_n \zeta_{RWA}}{\left(1-\zeta_{RWA} s_t\right)^2 \left(1 - \frac{\zeta_n}{1-\zeta_{RWA} s_t}\right)} - \frac{1}{1-s_t} \right].$$

To calibrate this extension, we need to parameterize ζ_{RWA}, which governs the impact of s_t on capital requirements, and λ, which governs the lower return earned from increasing s_t. We set $\zeta_{RWA} = 0.8$ as in Pancost and Robatto (2023). We set λ so that a large fraction of bank failures due to fundamentals are attributable to bad risk-taking. Because this choice has the potential to generate a large negative impact of deposit insurance through moral hazard, we are essentially providing a lower bound for the welfare effect of increasing deposit insurance. Specifically, we choose $\lambda = 1569$ so that 86.9% of the non-run bank default is attributable to bad risk taking, or 72% of all defaults. The 86.9% target is based on the importance of bad risk-taking in Pancost and Robatto (2023), but more generally, it likely represents an upper bound on the default rate driven by banks' risk-shifting.

F.6.2 Risk-Shifting and Monitoring

In the extension with risk-shifting and monitoring (row 10 of Table 5), the asset side of banks is the same as that described in the risk-shifting extension of Appendix F.6.1. On the liability side, we link the rate that a bank pays on its uninsured deposits to its risk-shifting choice s_t. Banks continue to pay the return R_t^d on insured deposits.

Specifically, a bank pays a spread R_t^{spread} above R_t^d on deposits that are uninsured,

$$R_t^{spread} \equiv \Theta R_t^d \left(s_t - s_t^*\right), \tag{78}$$

where s_t^* is the average bad risk-taking of all other banks in the economy, and ≥ 0 is a parameter that governs the link between the bad-risk taking choice s_t and the spread R_t^{spread}.[30] In equilibrium, all banks are identical, so that $s_t = s_t^*$, ensuring that no banks actually pay such a spread. However, when the bank chooses its optimal bad risk-taking choice s_t, it internalizes that increasing s_t will affect the return paid on

[30]The spread is scaled by the return R_t^d for convenience, but the results are unchanged if one redefines the spread to be $\Theta \times (s_t - s_t^*)$. Also, we could in principle add higher order terms to the right-hand side of (78), such as $(s_t - s_t^*)^2$ and so on, to obtain a more precise approximation of the true function that links the return on uninsured deposits with bad risk-taking. Indeed, the true function can be approximated arbitrarily well by a polynomial function, according to the Stone-Weierstrass approximation theorem, provided that it is well-behaved. But as discussed in Section 5.4, adding monitoring using only a linear term as in (78) produces results that are very similar to the model with bad risk-taking but no monitoring. Hence, we expect higher-order approximations to generate essentially the same result.

uninsured deposits. This effect acts like a "monitoring" mechanism in the sense that the bank internalizes a return premium demanded by uninsured deposits for increasing bad risk-taking.

The total deposit bill paid by a bank that survives is

$$\begin{aligned} R^d d_t^{ins} + \left(R_t^d + R_t^{spread}\right) d_t^{unins} &= R_t^d \left[d_t^{ins} + (1+\Theta)\left(s_t - s_t^*\right) d_t^{unins}\right] \\ &= R_t^d d_t \left[\frac{d_t^{ins}}{d_t} + \left[1 + \Theta\left(s_t - s_t^*\right)\right] \frac{d_t^{unins}}{d_t}\right] \end{aligned} \tag{79}$$

where d_t^{ins} and d_t^{unins} denote the insured and uninsured deposits at the bank, respectively. The objective function of banks is similar to (73), but we replace all instances of $R_t^d d_t$ with the second line of (79). The first-order condition with respect to s_t is thus similar to (77), but we replace the second line by[31]

$$\left[R_t^d \left(1 - \zeta_n \frac{1-\zeta_{RWA}}{\left(1-\zeta_{RWA} s_t\right)^2}\right) - (1-s_t) R_t^d \left(1 - \frac{\zeta}{1-\zeta_{RWA} s_t}\right) \Theta \frac{d_t^{unins}}{d_t}\right] \times \\ \left[\int_{\underline{\varepsilon}_{t+1}^{RUN}}^{\infty} d\tilde{F}\left(\tilde{\varepsilon}\right) + (1-\pi) \int_{\underline{\varepsilon}_{t+1}^{FUN}}^{\underline{\varepsilon}_{t+1}^{RUN}} d\tilde{F}\left(\tilde{\varepsilon}\right)\right],$$

using the fact that, in equilibrium, $s_t^* = s_t$.

In the extension with risk-shifting and monitoring, we need to calibrate ζ_{BRT} and λ as in Appendix F.6.1, and we also need to calibrate Θ. As in Appendix F.6.1, we set $\zeta_{BRT} = 0.8$, and we set λ to generate 86.9% of non-run default attributable to bad risk-taking s_t. The calibrated value of λ is slightly lower than in Appendix F.6.1 (i.e., $\lambda = 1434$ in the version with monitoring vs. $\lambda = 1569$ in the version with no monitoring) because monitoring curbs the risk-shifting incentives, and thus, we can meet our target with a lower cost λ on the return on investments.

To discipline Θ, we use the model to price the spread on uninsured deposits that a bank has to pay when it increases its bad risk-taking s_t. Because all banks choose $s_t = s_t^*$, we consider an individual bank that chooses a higher (off-equilibrium) level of s_t, and we compute the spread R_t^{spread} that is demanded by a firm with large uninsured balances to hold deposits at such a bank.[32] Specifically, we consider an increase in s_t that produces a spread of 0.75 basis points, which is the spread for banks subject to FDIC enforcement action (Martin et al., 2022). The resulting value of Θ is 0.28.

F.6.3 Risk Shifting and Monitoring with Full Pass-Through of Risk Shifting on The Risk of Losses on Uninsured Deposits

In this subsection we consider a version of the model with risk-shifting and monitoring in which we discipline Θ so that a 1 percentage point increase in default rate due to risk shifting is fully transmitted to the default risk of uninsured deposits. That is, this version of the model ignores the effect that bailouts play in muting the transmission of bank default risk onto the default risk of uninsured deposits. We show that

[31] When deriving the first-order condition, we assume that the bank takes as given the fraction d_t^{unins}/d_t of uninsured deposits in its balance sheet.

[32] We focus on a firm with enough deposits to find it optimal to run if the bank is insolvent, as running decreases the effective risk; see Figure 12 and its discussion in Appendix E.

the calibrated version of this extended model overestimates the importance of market discipline, and thus, removing market discipline by increasing deposit insurance induces strong moral hazard, leading to welfare losses for high level of deposit insurance. This effect is instead much more muted in the correct calibration that accounts for the effect of bailouts.

We again consider an individual bank that chooses a higher (off-equilibrium) level of bad-risk taking, which we now denote by $\hat{s}_t$, leading to a default probability $\hat{p}_{t+1}^{default}$. We compute the spread R_t^{spread} that is demanded by a firm with large uninsured balances to hold deposits at such a bank (i.e., by a firm that finds it profitable to pay the cost to run if the bank is failing).

Because we are considering a full pass-through of bank default risk onto uninsured deposits default risk, we need to specify the probability that the uninsured deposits at the bank choosing $\hat{s}_t$ are fully repaid. We do so in a way that, when $\hat{s}_t$ converges to the average bad risk-taking s_t of the banking sector, the repayment probability also converges to the average banking-sector repayment probability. Absent runs, the probability that uninsured deposits are fully repaid for the bank choosing $\hat{s}_t$ would be $p_{t+1}^{fr} - (\hat{p}_{t+1}^{default} - p_{t+1}^{default}) < p_{t+1}^{fr}$, where p_{t+1}^{fr} is defined by (40). However, because we are considering a firm that does run if the bank is insolvent, the probability that the deposits are fully repaid is $p_{t+1}^{fr} - (1-\kappa)(\hat{p}_{t+1}^{default} - p_{t+1}^{default})$, as the firm is able to withdraw its deposits with probability κ by running.

We calibrate this extension similarly to the extension in Appendix F.6.2: we set $\zeta_{RWA} = 0.8$, but to match the the same target moments (the share of defaults due to bad risk-taking and the 0.75 bps deposit spread) we find that $\lambda = 1,290$ and $\Theta = 0.62$.

The parameter Θ captures the importance of market discipline, and thus, is related to the ability of depositors to "punish" bad risk-taking with higher deposit rates. Because the value of Θ in this extension is more than twice the value we obtained in Appendix F.6.2, this extension overestimates the importance of market discipline, and thus, removing market discipline by increasing deposit insurance induces strong moral hazard. As we increase deposit insurance, the stock of uninsured deposits drops, the discipline that such depositors impose through monitoring vanishes quickly, and banks increase bad risk-taking substantially. The higher bad risk-taking offsets the benefits of that deposit insurance produces through the reduction of runs; when we increase deposit insurance limits for both households and firms, we find that welfare is maximized at a \$5 million limit (rather than being monotonically increasing in the \$350,000-\$10 million range that we study in the main part of the paper), with welfare gains of only 1.87 bps (rather than 10.5 bps in the main part of the paper, when insurance is set at \$10 million).

F.7 Adding Liquid Assets Held by Banks

In this section, we extend the model to allow banks to hold risk-free liquid assets (or liquid assets for short), denoted by s_t. These assets are less profitable for banks in comparison to bank loans, but banks invest in them anyway because they can be used to pay for withdrawals in the event of a run, without incurring the fire-sale cost. Thus, in this extension, banks have two tools to protect themselves from runs: in addition to (ex-post) recalling a fraction τ of loans, they can also (ex-ante) hold liquid assets s_t.

We assume that liquid assets are supplied fully elastically at gross return R_t^s. The assumption that the supply is fully elastic allows us to evaluate how banks' liquid asset holdings react to changes in the deposit insurance limit, and in particular, if higher insurance creates a form of moral hazard by which banks respond to higher government guarantees by holding a less liquid portfolio. If this happens, the less liquid portfolio would counteract the reduction in runs driven by the higher insurance.

We also assume that banks face a cost $\phi(d)$ to raise deposits, with $\phi' > 0$ and $\phi'' > 0$. We need to introduce this cost because, in the data, the return on deposits is lower than the return on safe and liquid assets such as Treasuries, and holdings of such assets do not enter the capital requirement constraint.[33] Thus, absent a cost of raising deposits, a bank could earn unbounded profits by issuing more deposits and investing the proceeds in safe liquid assets. The cost $\phi(d)$ captures the expenses that a bank faces to provide services to depositors, such as ATMs, customer services at branches, payments, etc.

We next describe the problem of banks when they can hold liquid assets s_t, then we calibrate the extended model, and finally, we analyze how this extension affects welfare.

F.7.1 Banks' Problem When Banks Can Invest in Liquid Assets

The bank's objective function, taking explicit account of the optimal loan recall policy described in Section 4.2, is given by:

$$\begin{aligned} \max_{b_t,\, d_t, s_t} \; \mathbb{E}_t \int_{\varepsilon_{t+1}^{REC}}^{\infty} & \left[\varepsilon b_t \left(1-\delta+r_t\right)+R_t^s s_t-R_t^d d_t-\phi\left(d_t\right)\right] dF\left(\varepsilon\right) \\ +\mathbb{E}_t \int_{\varepsilon_{t+1}^{RUN}}^{\varepsilon_{t+1}^{REC}} & \left[\varepsilon b_t \left(1-\delta+\left(1-\tau\right) r_t\right)+R_t^s s_t-R_t^d d_t-\phi\left(d_t\right)\right] dF\left(\varepsilon\right) \\ +\left(1-\pi\right) \mathbb{E}_t \int_{\varepsilon_{t+1}^{FUN}}^{\varepsilon_{t+1}^{RUN}} & \left[\varepsilon b_t \left(1-\delta+\left(1-\tau\right) r_t\right)+R_t^s s_t-R_t^d d_t-\phi\left(d_t\right)\right] dF\left(\varepsilon\right) \end{aligned} \tag{80}$$

subject to the budget constraint

$$b_t + s_t = d_t + n_t$$

and the capital requirement constraint (5). The capital requirement constraint is the same as in the main part of the model because s_t are risk-free, and thus, can be interpreted as Treasury securities, which have zero risk-weight in practice. We assume, and verify ex post, that the capital requirement binds and banks choose $s_t > 0$ in equilibrium.

Because liquid assets s_t can be used to pay withdrawals in a run without incurring fire-sale costs, we

[33] An alternative would be to introduce a constraint akin to the supplementary leverage ratio. However, under such a constraint, holdings of liquid assets would be constrained by banks' equity, and they would likely not respond to changes in deposit insurance.

replace equations (34), (35), and (36) with

$$\underline{\varepsilon}_{t+1}^{REC} b_t(1-\delta+r_t) = R_t^d\left(d_t - d_{t+1}^{RUN}\right) + \frac{R_t^d d_{t+1}^{RUN} - R_t^s s_t}{1-\Upsilon^{tot}} + \phi\left(d_t\right) \tag{81}$$

$$(1-\tau)\underline{\varepsilon}_{t+1}^{RUN} b_t(1-\delta+r_t) = R_t^d(d_t - d_{t+1}^{RUN}) + \frac{R_t^d d_{t+1}^{RUN} - \tau\underline{\varepsilon}_{t+1}^{RUN} b_t(1-\delta) - R_t^s s_t}{1-\Upsilon^{tot}} + \phi\left(d_t\right) \tag{82}$$

$$(1-\tau)\underline{\varepsilon}_{t+1}^{FUN} b_t(1-\delta+r_t) = R_t^d d_t - \tau\underline{\varepsilon}_{t+1}^{FUN} b_t(1-\delta) - R_t^s s_t + \phi\left(d_t\right), \tag{83}$$

respectively. Notice that in all three equations, a higher stock of liquid assets s_t reduces each threshold all else equal, shrinking the probability that the bank will need to recall loans at all (equation 81), the region where the bank is exposed to run risk (equation 82), and the probability of a fundamental default (equation 83). The third effect does not matter to the bank because of limited liability, but the other two will affect their affect the returns they provide shareholders.[34]

The first-order condition that governs the choice of s_t is

$$\begin{aligned}\left(1-p_{t+1}^{default}\right)\left[R_t^s - R_t^d - \phi'\left(d_t\right)\right] &= \tau\varepsilon_{t+1}^{REC} b_t r_t \frac{\partial\underline{\varepsilon}_{t+1}^{REC}}{\partial d_t} f\left(\varepsilon_{t+1}^{REC}\right) \\ &+ \pi\left[\underline{\varepsilon}_{t+1}^{RUN} b_t\left(1-\delta-(1-\tau)\,r_t\right) + R_t^s s_t - R_t^d d_t - \phi\left(d_t\right)\right]\frac{\partial\varepsilon_{t+1}^{RUN}}{\partial d_t} f\left(\varepsilon_{t+1}^{RUN}\right)\end{aligned} \tag{84}$$

where

$$\frac{\partial\underline{\varepsilon}_{t+1}^{REC}}{\partial d} = \frac{R_t^d\left(1+\varphi\frac{\Upsilon^{tot}}{1-\Upsilon^{tot}}\right) - \frac{1}{1-\Upsilon^{tot}}R_t^s + \phi'\left(d_t\right)}{b_t\left(1-\delta+r_t\right)},$$

$$\frac{\partial\underline{\varepsilon}_{t+1}^{RUN}}{\partial d} = \frac{R_t^d\left(1+\varphi\frac{\Upsilon^{tot}}{1-\Upsilon^{tot}}\right) - \frac{1}{1-\Upsilon^{tot}}R_t^s + \phi'\left(d_t\right)}{b_t\left[(1-\tau)\left(1-\delta+r_t\right) + \tau\frac{1-\delta}{1-\Upsilon^{tot}}\right]},$$

$f\left(\cdot\right)$ is the PDF of ε, and $\varphi \equiv \mathbb{E}_t\, d_{t+1}^{RUN}/d_t$ is the fraction of runnable deposits in each bank, which banks take as given. The first-order condition equates the marginal cost and benefits of an additional dollar of deposits. On the margin, an additional dollar of deposits allows the bank to invest in an additional dollar of safe assets, because loans are pinned down by capital requirement. Thus, each additional dollar of deposits earns the bank the spread $R_t^d - R_t^s$ between safe assets and deposits, net of the marginal cost $\phi'(d)$, but only if the bank does not fail (i.e., with probability $1-p_{t+1}^{default}$). On the right-hand side of equation (84) are the marginal effects of raising deposits on the two thresholds $\underline{\varepsilon}_{t+1}^{REC}$ and $\underline{\varepsilon}_{t+1}^{RUN}$.

We replace the haircut equation (45) with

$$\begin{aligned}p_{t+1}^{default}\left[\left(1-\nu_{t+1}\right)R_t^d\left(d_t - \kappa d_t^{RUN}\right) + \kappa R_t^d d_t^{RUN} - R_t^s s_t + \phi\left(d_t\right)\right] &= \\ \int_{\{\text{failed banks}\}}\left[\tau\varepsilon b_t\left(1-\delta\right) + (1-\tau)\varepsilon b_t\left(1-\delta+r_t\right)\left(1-\Upsilon^{tot}\right)\right]dF\left(\varepsilon\right).\end{aligned} \tag{85}$$

[34]Formally, the value of the integrand in the third line of equation (80) is zero at $\underline{\varepsilon}_{t+1}^{FUN}$, canceling out the Leibniz rule term from the lower limit of integration in the first-order condition.

F.7.2 Calibration When Banks Can Hold Liquid Assets

To operationalize this extension we assume that

$$\phi\left(d_t\right) = \frac{\bar{\phi}}{2}\left[d_t - \frac{1-\zeta}{\zeta} n_t\right]^2,$$

which asymptotes to the baseline model as $\bar{\phi} \to \infty$.

We set $\bar{\phi} = 1.2252$ to match banks' holdings of Treasury securities over assets, which are 1.86% in our sample based on aggregate FDIC data. We consider only Treasuries as the empirical counterpart of s_t because they are the most liquid assets, and they can be easily liquidated during a crisis. Other securities held by banks, such as asset-backed securities or corporate bonds, have experienced fire sales during crises (Falato et al., 2021; Ma et al., 2022; Merrill et al., 2021). In addition, even if a large class of securities can be used as collateral to borrow from the central bank, the ability to borrow quickly requires banks to pre-position such collateral with the central bank. Crucially, Gorton et al. (2025) show that banks pre-position only a small fraction of of eligible collateral, likely because of the stigma associated with borrowing from the lender of last resort. As discussed in Gorton et al. (2025), the limited pre-positioning of collateral severely limited banks' ability to borrow from the central bank around the collapse of SVB.

F.7.3 Welfare Analysis When Banks Can Hold Liquid Assets

When the government raises the deposit insurance limit, the run region shrinks, and banks no longer need so many liquid assets s_t to protect themselves from runs. The direct effect of the lower holdings of s_t is to make banks' portfolios more illiquid, counteracting the reduction in runs driven by the higher insurance. However, in general equilibrium, the introduction of liquid assets actually amplifies the impact that higher insurance has on reducing runs.

In general equilibrium, the reduction in banks' holdings of liquid assets s_t leads to an increase in bank lending. To understand this result, note first that the contraction in banks' liquid asset holdings, s_t, reduces banks' funding requirements, lowering the demand for deposits and depressing the equilibrium deposit rate R^d. This lower return disincentivizes deposit holdings by firms, who shift their assets toward physical capital. The increased holdings of physical capital allow firms to borrow more from banks—because of the borrowing constraint (10). This result is reinforced by a boost in the supply of deposits by households and firms—which further reduces R^d—arising from the increase in output as a result of the higher investments by firms.

The general equilibrium effect is crucial to understanding the impact of higher deposit insurance on bank runs. Because of the higher stock of bank loans induced by the general equilibrium effect, banks have more loans that can be recalled to fend off runs ex-post. The increase in loans available for recall more than offsets the reduction in liquidity from the lower s_t. Hence, in this extension, the link between increasing insurance and lowering runs is stronger than in the main part of the paper.

Table 8 reports results for the baseline (first two columns), and the model with bank liquid assets (second two columns). The first and third column only compare steady-state values, while the second and fourth

	$10 million insurance			
	Baseline Calibration		Bank Liquid Assets	
	No transition	Transition	No transition	Transition
Welfare Gain (bps):	10.5	10.6	36.7	6.7
from Δc^{oth}:	6.83	8.8	35.7	24
from Δc^{liq}:	3.26	3.9	-10.7	-19
from Δl:	0.45	-2.1	11.4	1.1
Default Rate:	0.40%		0.38%	
Default Rate (from runs)	0.005%		0%	
Uninsured Deposits	17%		17%	
Runable Deposits	18%		18%	
Deposit Premium $R^f - R^d$	0.91%		1.51%	
Change in GDP (bps):	6.73		44	
from Δl:	-0.24		-6.4	
from Δk:	1.97		45.7	
from Δloan recalls:	4.50		3.73	
from Δdeadweight losses:	0.50		0.55	
from Δtaxes:	0.14		0.16	
from Δbank failure:	0.36		0.39	
from Δwithdrawal costs:	0.003		0.003	

Table 8. Decomposing Welfare Gains with Bank Liquid Assets
The table reports welfare gains in basis points (top panel), various bank outcomes (middle panel), and changes in GDP in basis points (bottom panel) for an increase to $10 million in the deposit insurance limits for both households and firms. Columns 1 and 3 do not account for the transition to the new steady-state in the welfare calculation, and report steady-state values in the bottom two panels; columns 2 and 4 do account for the transition to the new steady-state.

columns compute utility along the transition path to the new steady-state. Because the increase in the steady-state stock of capital triggered by higher deposit insurance is an order of magnitude larger than in the main part of the paper, comparing welfare across steady-state is somewhat misleading. That is, the actual welfare effects of increasing deposit insurance in this model are much more modest than comparing steady-states would suggest, because of the reduced consumption needed to finance investment on the path to the new steady-state.

When banks hold liquid assets, increasing insurance to $10 million is beneficial because it increases consumption of c_t^{oth}. Consumption of c_t^{liq}, which is financed by deposits, actually decreases because of the lower deposit return R_t^d. Overall, welfare increases, but the magnitude of the welfare gains when we account for the transition is lower than in the baseline calibration.

Finally, with $10 million insurance, banks' default rate due to runs is essentially zero in the extension with other liquid assets, versus 0.005% under the baseline calibration, because of the higher availability of loans to be recalled by banks.