Bank Runs in the Digital Era*

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Abstract

The Digital Era has introduced advanced communication technologies, such as social media and the internet. These changes have transformed the banking industry. Not only has the accessibility and spread of information (not always accurate) about banks' conditions expanded, but online banking has further enabled swift depositor responses to this information. We show that while these technological advancements accelerate the speed and intensity of bank runs, they may also reduce their likelihood. Although depositors are more inclined to withdraw prematurely because others are simultaneously paying attention to information, they tend to be less concerned about the risk of withdrawing too late if they choose to wait.

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1 Introduction

Bank runs have been a ubiquitous phenomenon throughout the history of banking systems. They are typically triggered when depositors lose confidence in their bank's financial standing and, perhaps more critically, by the fear that other depositors are losing confidence, too.

Historically, such episodes unfolded gradually over several days or weeks, as panic spread through word of mouth, visible queues at bank branches, and intermittent media coverage. In recent years, however, developments associated with the Digital Era have profoundly transformed the dynamics of financial systems. The proliferation of real-time news sources, the viral nature of social media, and the ability to withdraw funds instantly via mobile apps have dramatically accelerated the speed at which information circulates and the pace at which depositors can act on it.[1]

The failures of Silicon Valley Bank, Signature Bank, and First Republic Bank in the United States, and of Credit Suisse in Switzerland, during the spring of 2023 provide stark examples of unprecedented withdrawals, in terms of speed and volume, driven by digital technologies (see Financial Stability Board (2024)). In response, regulators have expressed concerns about digital technologies spreading information (and misinformation) rapidly, increasing the intensity and the likelihood of bank runs.[2]

What role do new technologies of the Digital Era play in shaping financial stability? We show that despite progress in communication technologies speed and intensify bank runs, their effect on the likelihood of observing runs is more nuanced: while initially, the Digital Era tends to trigger more bank runs, eventually, information technologies may develop to the point that makes them less likely to occur. This trade-off matters for regulation: should capital or liquidity requirements be tightened because runs are faster and larger, or relaxed because runs become less likely?

We propose a model of dynamic bank runs where the value of a bank's assets changes continuously, influencing depositors' incentives to withdraw. When agents receive bad news about the bank's assets, they are more inclined to withdraw because they are worried other agents may have the same concerns. We assume, however, that depositors' attention to the evolution of a bank's financial health is intermittent: at any moment, inattentive agents may start paying attention, while conversely, attentive agents may become inattentive. We model the role of digital technologies in enhancing information spreading by increasing the rate at which depositors become attentive to the bank's asset value.

Enhanced communication technologies that increase the rate of attentiveness have two effects. On the one hand, an increase in attentiveness raises the number of informed depositors at any given moment, thereby increasing the scale of the run when it occurs and the likelihood of it (by heightening coordination pressures).[3] On the other hand, the incentive to withdraw funds out of fear of being inattentive when others start a run diminishes when depositors understand that they are unlikely to remain inattentive for long.

While the first effect is more relevant as coordination failures become more common, the second effect dominates once the number of informed investors becomes large. The natural

[1] Pew Research Center (2021a,b,c,d) report the extent of digital penetration in how U.S. adults (particularly young) access news and information.

[2] For instance, the Basel Committee on Banking Supervision (2023) raised concerns of "liquidity runs on banks in an age characterised by easy access to information as well as banking services via various digital tools."

[3] For empirical evidence of coordination pressures among depositors, consider Artavanis et al. (2019).

implication is that digital technologies may eventually reduce financial fragility. In other words, there is an extent of digital progress or, in particular, media penetration that maximizes financial fragility. Despite the non-linear impact of improved communication technologies on the likelihood of a crisis, their advancement accelerates the pace of a run as depositors become aware of the bank's health quickly. In other words, these technological developments affect two dimensions of fragility differentially; while digital technologies such as social media increase the *magnitude of runs*, they may decrease the *frequency of runs*.

This aligns with the pattern observed by Rose (2023) for the U.S., who documented that the most severe runs in recent history before 2022 occurred at Continental in 1984 (with 30% of depositors withdrawing in 10 days) and at Wachovia and Washington Mutual in 2008 (with 4.4% and 10% of deposits withdrawn, respectively, over more than 15 days). In contrast, the most severe run in 2023, with a much larger presence of social media and banking apps, occurred at Silicon Valley Bank (SVB), where 25% of deposits were withdrawn in a single day (an additional 62% were scheduled to flow out the next day before the bank was closed). Likewise, Cipriani et al. (2024) show that runs on other banks in March 2023 were fast and large, concentrated in two days and with net outflows reaching 10% of assets in a single day for some banks. Consistently, the Financial Stability Board (2024), drawing on data from Europe, North America, and Asia, reported that recent bank runs have been characterized by accelerated withdrawal rates and significantly larger outflows compared to historical precedents.

Further, it is consistent with the evidence presented by Cookson et al. (2023), who study the role of social media in the recent SVB run. The paper suggests that social media had exacerbated the impact on banks during runs, reporting that the stocks of banks with higher Twitter coverage suffered more than those with less social media exposure, even when risk levels were similar. Since stock returns were a significant predictor of liquidity outflows (Cipriani et al., 2024), this highlights the role of public signals and social media activity in coordinating runs.[4]

We begin the analysis with a two-period, perfect-foresight model to isolate how anticipated future inaction shapes depositors' ex ante run incentives. A higher future attentiveness rate has two effects: it increases *running intensity* (more depositors can withdraw during distress) but it reduces *inattention risk* (depositors are less likely to be caught dormant). When future attentiveness is low, the run-intensity channel dominates because depositors expect to be inactive and therefore fear being late. When future attentiveness is high, the second force dominates: precisely because many others will be able to run, the value of being able to react on time is greatest, and higher running intensity is less worrisome since the depositor expects to be active as well. The interaction of these forces generates an inverted-U relationship between run incentives and future attentiveness.

We then develop a continuous-time version with stochastic fundamentals, which ties inaction directly to the absence of new information and provides a novel way to address equilibrium multiplicity. This model confirms the main results obtained with the discrete-time version. In addition, we show that greater attentiveness raises depositors' tolerance for failure risk by increasing the option value of waiting, so banks can sustain a given run likelihood at higher levels of liquidity risk. This matters for liquidity-buffer design. Although higher attention can amplify outflows conditional on a run, attempting to fully offset that amplification by expanding liquidity access makes runs considerably less likely to occur than before the attention change.

[4]Additional evidence on the predictive power of social media sentiment, alongside traditional news sources, for explaining depositor behavior is provided in Hasan et al. (2013) and Accornero and Moscatelli (2018).

This trade-off between intensity and frequency will determine optimal liquidity buffers.

We conclude discussing testable implications, and relegate remaining extensions to the appendix, including heterogeneity, the distinction between information frequency and reach, and the role of improved withdrawal technologies.

We contribute to models of dynamic runs, (He and Xiong, 2012; Gertler and Kiyotaki, 2015; He and Manela, 2016; Schliephake and Shapiro, 2021; Amador and Bianchi, 2024), introducing a dimension of heterogeneity across depositors that we call *asymmetric inattention*. As in He and Xiong (2012) and He and Manela (2016), we use a conpredict the frequency of bank runs, capturing a novel mechanism in which a higher likelihood of receiving future information decreases the incentive to runbut on whether they pay attention to such information. We also extend the discussion of equilibrium multiplicity, emphasizing that continuous-time modeling can serve as a route to equilibrium uniqueness in bank run models.

The two papers closer to ours are He and Manela (2016) and Schliephake and Shapiro (2021). He and Manela (2016) study optimal information acquisition during rumor-based bank-runs. They show that information acquisition via heterogeneous signals can provoke runs on otherwise safe banks, driven by depositors' concerns that others will receive negative signals. In contrast, we abstract from endogenous information acquisition and instead assume homogeneous signals in a setting with time-varying fundamentals. This mechanism enables us to make predictions about the frequency of bank runs, capturing a novel mechanism through which a higher chance of receiving information in the future decreases running incentives. Moreover, Schliephake and Shapiro (2021) study learning in a discrete time multi-period model of bank runs. Their main result is that allowing uninformed depositors to obtain more precise information in the future or increasing the share of informed depositors increases the likelihood of runs. However, we find that learning, in the form of a higher fraction of informed depositors, can reduce the frequency of runs. The key difference arises for two reasons: in their model, runs by informed depositors are only fundamental-based, whereas coordination failures play a central role in ours.

In addition, we contribute to an emerging empirical literature that studies the impact of new technologies on running behavior and competition in the banking industry (Ziebarth, 2013; Koont et al., 2023; Liu et al., 2023; Koont, 2023; Rainone, 2024). Ziebarth (2013) shows that high levels of county-level radio penetration led to larger deposit outflows during the Great Depression. Koont et al. (2023) show that banks with digital platforms that allow for instantaneous withdrawals as well as potentially providing brokerage services have deposits that are less sticky in the sense that they respond more to changes in the Fed Funds Rate. They argue that digitalization has reduced the franchise value of banks, which explains why SVB was insolvent even before the run. In a related paper, Koont (2023) shows that the adoption of digital banking platforms has increased competition in the deposit and loan markets by allowing banks to branchlessly enter local markets and, as a result, a larger share of surplus is captured by consumers. However, she argues that digitalization may alter financial stability as it leads to a higher share of uninsured deposits in banks' balance sheets and a greater market share of less-regulated mid-sized banks. Liu et al. (2023) dissect the Terra-LUNA crash in 2022 and show how the blockchain technology allowed investors to closely monitor others' behavior, increasing the speed of the run. Further, they argue that the complexity of the system put less sophisticated and poorer investors at a greater informational disadvantage, resulting in delayed withdrawals and larger loses. Rainone (2024) introduces a method for real-time identification of sudden deposit outflows and finds that approximately half of the transfers during distress

episodes are processed through real-time settlement systems, significantly straining the bank's liquidity. Our paper contributes to this literature by rationalizing how new communication and withdrawal technologies influence run incentives, with a particular focus on the Digital Era.

From a theoretical perspective, Ding and Pennacchi (2024) use a simple one-period model to argue that social media activity, by aggregating depositors' information, provides new information on a bank's financial health. With otherwise inactive depositors, this increases the likelihood of runs but also reduces ex-ante funding costs through enhanced monitoring capabilities. The main difference with our approach is that we consider a dynamic setting with *asymmetric inattention*, where technologies such as social media do not increase the amount of information available but instead facilitate access to it, raising the share of attentive depositors at all times. This allows us to study how social media affects both the likelihood and the intensity of bank runs.

In this paper, we focus on the role of new technologies in influencing depositors' decisions. Still, it's important to note that these technologies can also affect the asset side and banks' risk management, as noted in Koont (2023). For instance, AI tools could be developed to improve liquidity management and monitor withdrawal patterns, potentially lowering the risk of bank runs. However, we do not explore this dimension in our analysis.

The rest of the paper is organized as follows. Section 2 describes the two-period model and analyzes the effects of greater attention on depositors' incentives. Section 3 analyses the continuous time model, starting with a discussion on equilibria multiplicity. Section 4 discusses the main testable implications that are unique to our model. Finally, section 5 concludes.

2 A Two-Period Dynamic Model of Runs

Advances in communication technologies affect the frequency and reach of information as well as the ease of withdrawal. In the following sections, we will focus on information frequency, while we leave the discussion about reach and withdrawal frictions to Appendices B and C, respectively. For simplicity, we treat signals as perfectly informative.

We first consider a two-period, perfect-foresight environment to highlight the core mechanism. We later move to a continuous-time framework that links information and inaction more explicitly and delivers a form of equilibrium uniqueness. All proofs and extra derivations can be found in Appendix A.

Environment and Timing

Consider a discrete-time environment with two periods, $t \in \{0, 1\}$. There is a continuum of mass 1 depositors, indexed by $i \in [0, 1]$, each holding one unit of wealth deposited in a bank at the beginning of period $t = 0$. Depositors are risk-neutral and discount future payoffs with a factor $\beta \in (0, 1)$.

There is a bank investing in a diversified portfolio that yields a safe, constant return $r > \rho := \beta^{-1} - 1$ per period. Let y_t denote the (market) value of the portfolio in period t, which is assumed to be perfectly foreseen by all agents. The bank pays depositors a rent r per unit of wealth at the end of each period, provided it remains solvent. If the bank fails to roll over its short-term debt, it is liquidated. In this event, the remaining depositors recover the portfolio's liquidation value, which is a fraction $\alpha \in (0, 1]$ of its market value.

In each period, depositors who are able to act choose whether to withdraw (run) or roll over their claims. After running, they exit the game and we normalize the value of a dollar outside the bank to one. Withdrawals are not financed by selling the underlying portfolio, but instead through short-term interbank borrowing, for instance, because the bank's project is nondivisible.[5] These interbank loans are senior and must be rolled over each period unless they are repaid with net deposit inflows. Absent conditions for a run, we assume that the bank recovers its deposits fully.

From the depositors' perspective, runs create an exogenous refinancing risk in interbank markets. In period t, if the bank must finance withdrawals corresponding to a fraction $N_t \in [0,1]$ of deposits, it fails during that period with probability θN_t, where $\theta \in (0,1)$ captures the fragility of funding markets. Although banks can access short-term credit lines from other private entities or the Central Bank, this liquidity may dry up if depositors keep running.

Conditional on failure, depositors who choose to withdraw at the beginning of the period are able to recover their deposits with probability $\zeta \in (0,1)$. This reflects random processing times and the sequential servicing of withdrawal requests: even if the bank fails during the day, some early movers may be fully repaid before insolvency.[6] This recovery rate will typically be affected by technologies that change accesibility (i.e. that reduce the time it takes to place a withdrawal order) and processing times (i.e. that reduce the time it takes the bank to deliver the money), as well as on how these withdrawal dynamics interact with interbank liquidity and the timing of failure. If instead the bank survives through $t = 1$, it repays all remaining deposits at gross return $1 + r$, and the game ends.[7]

In each period t, a measure $\lambda_t \in (0,1)$ of depositors is *attentive*: they observe y_t and can choose whether to withdraw or roll over. The remaining depositors are dormant in period t and take no action. The attentiveness rate λ_t is the key parameter capturing our mechanism: technological changes that improve accessibility (e.g., banking apps) or increase the frequency of information exposure (e.g., social media) raise the rate at which depositors revisit their withdrawal decision, thereby shaping equilibrium dynamics. Attentiveness is i.i.d. across depositors and over time.

Equilibrium Characterization

This model admits a trivial equilibrium in which no agents ever run on the bank. We are instead interested in conditions under which there exists a non-trivial run equilibrium where attentive agents coordinate to withdraw if the value of the bank's portfolio falls below a critical threshold.

Given a measure of deposit outflows $N_1 \in [0,1]$, an attentive depositor at time $t = 1$ compares the expected utility from running early versus waiting. A depositor who runs at $t = 1$ receives:

$$V_1^{\text{run}}(y_1; N_1) := (1 - \theta N_1) \cdot 1 + \theta N_1 \cdot [\zeta + (1 - \zeta) \min\{1, \alpha y_1\}],$$

[5] That banks finance sudden withdrawals with credit instead of selling their assets is supported by the evidence in Cipriani et al. (2024).

[6] In Diamond and Dybvig (1983) the sequential-service constraint implies that running depositors get their funds with probability $1/N_t$ during a fully fledged panic. In our model we make that probability independent of the measure of withdrawers, highlighting that once conditioning on failure throughout the whole day, which happens at rate θN_t, whether a running depositor receives its money on time depends instead on the withdrawal technology and the particularities of the interbank credit market.

[7] Equivalently, bank owners retain any residual asset value. Alternative terminal payoffs would not affect the main results; in the continuous-time, infinite-horizon version, the terminal rule is immaterial.

With probability θN_1, the bank fails, but early movers may still recover either their full deposit (with probability ζ).

By contrast, a depositor who does not run at $t = 1$ receives:

$$V_1^{\text{wait}}(y_1; N_1) := (1 - \theta N_1) \cdot \beta(1 + r) + \theta N_1 \cdot \min\{1, \alpha y_1\}.$$

If the depositor waits and the bank fails, they recover only the liquidation value. If the bank survives, they earn the promised return.[8]

A depositor will choose to run if and only if:

$$(1 - \theta N_1) + \theta N_1 \left[\zeta + (1 - \zeta) \min\{1, \alpha y_1\}\right] \geq (1 - \theta N_1)\beta(1 + r) + \theta N_1 \min\{1, \alpha y_1\}.$$

Since all attentive depositors behave identically in equilibrium, we can set

$$N_1 = \lambda_1 (1 - N_0) + N_0,$$

the mass of new deposit outflows added to previously acquired interbank loans that must be rolled over. Substituting and simplifying gives the threshold condition under which a run equilibrium can be sustained:

$$(1 - \theta N_1(\lambda_1, N_0))(1 - \beta(1 + r)) + \theta N_1(\lambda_1, N_0)\zeta(1 - \min\{1, \alpha y_1\}) \geq 0.$$

This highlights the key trade-off: running helps protect wealth in the event of failure, but to lose valuable rents should the bank remain alive for another period. This inequality implicitly defines a threshold $\bar{y}$ such that attentive depositors run if and only if $y_1 \leq \tilde{y}_1$, or

$$y_1 \leq \frac{1}{\alpha}\left(1 - \frac{(1 - \theta N_1(\lambda_1, N_0))(\beta(1 + r) - 1)}{\theta N_1(\lambda_1, N_0)\zeta}\right) =: \tilde{y}_1 \tag{1}$$

This cutoff characterizes the values of y_1 below which attentive depositors find it optimal to run when others do, thereby triggering a run equilibrium. This equilibrium exists as long as $\beta(1 + r) - 1 < \zeta\theta N_1(\lambda_1, N_0)/(1 - \theta N_1(\lambda_1, N_0))$ so that there is an incentive to run at least when $y \approx 0$. The threshold decreases in r and increases with ζ, which raises the payoff from running. In addition, the threshold increases in λ_1 (or θ) since a larger chance of failure makes agents more reluctant to keep their deposits in the bank.

The threshold $\tilde{y}_1$ is the lower bound of the upper-dominance region where all depositors stay in the bank irrespective of the behavior of others. However, attentive depositors may coordinate on running whenever $y_1 \leq \hat{y}_1$ for any $\hat{y}_1 \in (0, \tilde{y}_1)$. This is the typical type of equilibrium multiplicity found in bank run models with symmetric information. Since our focus is not on equilibria multiplicity nor on running behavior at $t = 1$, we make the simplistic assumption that agents coordinate on running below $\tilde{y}_1$.

We continue with the problem at $t = 0$. $\lambda_0 > 0$ depositors are attentive and decide whether to withdraw hoping for the chance to act in $t = 1$.

Given N_0, the continuation value at $t = 0$ is then:

$$V_0^{\text{wait}}(y_0) = \theta N_0 \min\{1, \alpha y_0\} + (1 - \theta N_0)\beta \left[r + \overbrace{\mathbb{I}_{y_1 \leq \tilde{y}_1}\left(\lambda_1 V_1^{\text{run}}(y_1; \lambda_1, N_0) + (1 - \lambda_1)V_1^{\text{wait}}(y_1; \lambda_1, N_0)\right) + \mathbb{I}_{y_1 > \tilde{y}_1}\beta(1 + r)}^{:= V_1^{\text{cont}}(y_1; \lambda_1, N_0)}\right]$$

[8] The fact that there is no discounting in the payoff when failure is without loss of generality.

The depositor compares this to the payoff from running immediately, which is:

$$V_0^{\text{run}}(y_0) = (1 - \theta N_0) + \theta N_0 \left(\zeta + (1-\zeta)\min\{1, \alpha y_0\}\right)$$

The unique threshold $\tilde{y}_0$ that characterizes the region where runs can occur in equilibrium is then implicitly defined by setting $V_0^{run}(\tilde{y}_0) = V_0^{\text{wait}}(\tilde{y}_0)$ with $N_0 := \lambda_0$. It is given by[9]

$$\tilde{y}_0 := \begin{cases} \frac{1}{\alpha}\left(1 - \frac{(1-\theta\lambda_0)\left(\beta(V_1^{\text{cont}}(y_1;\lambda_1,\lambda_0)+r)-1\right)}{\theta\lambda_0\zeta}\right) & \text{if } \beta(V_1^{\text{cont}}(y_1;\lambda_1,\lambda_0)+r) - 1 > 0 \\ \infty \quad \text{ow.} \end{cases}$$

where the unbounded case is the equilibrium where, even without failure, it is not profitable to stay in the bank. In that case, the foresight about future runs makes agents today unwilling to stay on the bank for every value of y_0.

Comparative Statics: *inattention risk*

How does future attentiveness, λ_1, shift V_1^{cont} for a given y_1? This is important because it represents the channel through which future *inattention risk* affects the threshold to run in period 0.

First, conditional on being in the running region, a higher λ_1 reduces both V_1^{run} and V_1^{wait}: greater attentiveness makes runs larger and thus raises the probability of failure. This is the conventional force stressed in policy discussions: technologies that increase accessibility and information exposure expand the set of depositors who become aware of problems during a run, amplifying fragility in both periods. Further, a higher λ_1 expands the running region at $t = 1$ by raising $\tilde{y}_1$.

Second, a higher λ_1 increases the probability that a depositor is able to act during a run, which raises V_1^{cont}. This is a less intuitive force: depositors expecting to decide again in the future are less willing to run in the present, as there is a "wait and see" value. In other words, depositors who anticipate being unable to react in real time when trouble hits are more likely to withdraw at the first sign of distress.

These channels are central to our analysis. Formally, the trade-off is captured as follows,

$$\frac{\partial}{\partial\lambda_1}\left[\lambda_1 V_1^{\text{run}} + (1-\lambda_1) V_1^{\text{wait}}\right] = \overbrace{V_1^{\text{run}} - V_1^{\text{wait}}}^{\text{gain from attentiveness}} + \overbrace{\lambda_1 \frac{\partial V_1^{\text{run}}}{\partial\lambda_1} + (1-\lambda_1)\frac{\partial V_1^{\text{wait}}}{\partial\lambda_1}}^{\text{expected marginal loss from } \uparrow N_1}$$

The first term captures that depositors benefit from a higher chance of being able to act and run when $y_1 < \tilde{y}_1$. This gain is increasing in λ_1, because the cost of being unable to act during a run is larger when runs are more severe.[10] The second term captures the expected loss the depositor suffers regardless of whether it runs. Importantly, it approaches zero as λ_1 increases, since the loss is smaller when the agent knows it will most likely be able to act against a higher failure rate.[11] As a result, for sufficiently high λ_1 the gain from attentiveness dominates the loss from larger withdrawals, as shown formally below,

[9] The iid assumption for y is key in determining a closed-form expression for $\tilde{y}_0$.

[10] Formally, $V_1^{\text{run}} - V_1^{\text{wait}} = (1 - \theta N_1(\lambda_1,\lambda_0))[1 - \beta(1+r)] + \theta N_1(\lambda_1,\lambda_0)\zeta(1-\alpha y_1)$

[11] This result comes from the fact that $\frac{U_1^{\text{run}}}{\partial\lambda} - \frac{U_1^{\text{wait}}}{\partial\lambda} \geq 0$, which is trivial, and that failure rates are concave in

Lemma 1 ($V^{cont}(\lambda_1)$'s Inverted U-Shape). *For any fixed $y_1 < \tilde{y}_1$, the continuation value $V_1^{cont}(y_1;\lambda_1)$ decreases in λ_1 if and only if $\lambda_1 < \bar{\lambda}(y_1)$, with*

$$\bar{\lambda}(y_1) := \frac{\beta(1+r)(1+\theta(1-2\lambda_0)) - 1 + \lambda_0\theta(1-\zeta) - \theta\alpha y_1(1-\lambda_0(1+\zeta))}{2\theta(1-\lambda_0)\left[\beta(1+r) - 1 + \zeta(1-\alpha y_1)\right]} \in \mathbb{R}$$

Moreover, $\bar{\lambda}'(y_1) > 0 \iff \zeta > \theta(1-\lambda_0)(1+\theta(1-\lambda_0))^{-1}$ and $\frac{\partial^2 V_1^{cont}}{\partial\lambda_1\partial y_1} < 0 \iff 1 < \zeta\left(2\lambda_1 + \lambda_0(1-\lambda_0)^{-1}\right)$. Likewise, $\bar{\lambda}$ decreases with θ.

Intuitively, when attention is low, the option to act has little value and an increase in run severity is especially costly because the depositor is likely to be dormant if trouble arises, making her more prone to withdraw when λ_1 rises. When attention is high, instead, the depositor is less concerned about larger runs because she expects to be able to respond quickly, and she values even more the ability to act swiftly since runs are severe, making her less prone to withdraw when λ_1 rises.

Importantly, the proposition also shows that banks with weak fundamentals suffer less from rising attention if the recovery rate ζ is high enough. Intuitively, while a lower recovery value αy_1 increases the losses from a higher failure rate, it also makes lowering *inattention risk* crucial, and a high ζ favors the latter effect. Similarly, we obtain that lower liquidity access in the interbank market (i.e. high θ) makes decreasing the exposure to *inattention risk* the dominant effect for lower values of λ_1, highlighting the importance of this channel for fragile banks.

Proposition 1 shows how this dynamic mechanism feeds back into initial withdrawal decisions, mapping the non-monotonicity of continuation values into the threshold $\tilde{y_0}$. When depositors anticipate higher future attentiveness, they coordinate on a higher withdrawal threshold only when attention rates are sufficiently low. By contrast, when future attention is already high, additional increases in expected attentiveness raise the option value of waiting and thus reduce run incentives, resulting in a lower equilibrium threshold $\tilde{y_0}$. Notably, this non-monotonicity contrasts with the standard increasing effect λ_0 has on $\tilde{y}_0$, through raising rollover concerns in $t = 0$ and $t = 1$.

Proposition 1 ($\tilde{y}_0(\lambda_1)$'s Inverted U-Shape). *While $\tilde{y}_0$ increases with λ_0, for any fixed $y_1 < \tilde{y}_1$, it exhibits the same non-monotonic dependence on λ_1 as V_1^{cont}.*

3 Continuous Time and Equilibrium Multiplicity

As usual in bank-run models, our previous section showed a case with multiple equilibria. This complicates making predictions and comparative statics. In this section we propose a continuous time view of bank runs that can deliver a type of equilibrium uniqueness under certain mild restrictions.

λ_1. Specifically, with linear failure rates, we get

$$\begin{aligned}\lambda\frac{\partial V_1^{\text{run}}}{\partial\lambda_1} + (1-\lambda_1)\frac{\partial V_1^{\text{wait}}}{\partial\lambda_1} &= \lambda_1\cdot(1-\lambda_0)\left(-\theta + \theta[\zeta + (1-\zeta)\alpha y_1]\right) + (1-\lambda_1)\cdot(1-\lambda_0)\left(-\theta\beta(1+r) + \theta\alpha y_1\right)\\ &= \theta\,(1-\lambda_0)\Big[\alpha y_1 - \beta(1+r) + \lambda_1\Big[\beta(1+r) - 1 + \zeta(1-\alpha y_1)\Big]\Big]\end{aligned}$$

which increases in λ_1.

Environment and Timing

We extend the two-period model to have an arbitrary number of periods, each of length $\Delta > 0$, so that time is indexed by $t \in \{0, \Delta, 2\Delta, \ldots, T\}$. Depositors are risk-neutral and discount future payoffs using a rate $\rho > 0$, which corresponds to a discrete-time discount factor of $\beta := e^{-\rho\Delta} \in (0, 1)$ per period.

To capture the link between information arrival and depositor inaction, we introduce uncertainty about the evolution of fundamentals. The bank's investment technology is as before and delivers a flow return $r > \rho$ per unit of time as long as it remains solvent. The portfolio value y_t follows a geometric Brownian motion, discretized as

$$\log y_{t+\Delta} = \log y_t + \left(\mu - \frac{\sigma^2}{2}\right)\Delta + \sigma\sqrt{\Delta}\,\varepsilon_{t+\Delta}, \quad \varepsilon_{t+\Delta} \sim \mathcal{N}(0,1),$$

with $\sigma > 0$.

In addition, when depositors place a withdrawal request, these are not processed immediately: each request is fulfilled at a Poisson rate ζ, so within a period of length $\Delta \approx 0$, the probability of receiving the deposit back is $\zeta\Delta$. If the bank fails before the withdrawal is processed, the depositor receives a liquidation payout. If the order is not fulfilled and the bank does not fail within the period, the depositor becomes a decision-maker again next period and receives the accrued rents in the meantime.

Bank failure now occurs with probability $\theta \cdot N_t \cdot \Delta$ in period t, where $N_t \in [0, 1]$ is the new borrowing at time t, covering current withdrawal orders and refinancing interbank borrowing incurred in the past. We maintain the assumption that banks recover all deposits and, hence, N_t becomes zero the instant the run stops.

At last, we assume that depositors exit the "attentive" state, where they observe y and can make withdrawal decisions, with probability $\Delta\delta$ for the next period. Similarly, they exit the "inattentive" state, where depositors are assumed to be inactive, with probability $\Delta\lambda$. Making attentiveness persistent this way simplifies computations, keeping λ as our key parameter that determines the expected length of the inattentiveness window $1/\lambda$. Denote the measure of attentive depositors in the bank at any time t as $\mathcal{A}_t$.

3.1 Equilibria in Markov Strategies: Uniqueness

As before, this model will always feature an equilibrium in which depositors do not run on the bank ever. Absent withdrawals there is no bank failure risk and depositors are guaranteed a return $r > \rho$ per unit of time, which justifies staying in the bank.[12]

In the discrete case above, we have characterized an indeterminacy of equilibria given by any threshold $y < \bar{y}$. We show this continuous time extension has a unique threshold in equilibrium. We restrict attention to Markov strategy equilibria with monotone strategies, were the relevant states are y and the remaining measure of deposits $1 - N$. Let W_t be the measure of new withdrawal requests at time t. Consider the decision to withdraw at time t, given future behavior and strategies of other agents, which we assume to be monotone in y_t. An attentive depositor's value function at time t is given by

[12]This would not necessarily be true in a finite version of the continuous time game, where the equilibria include the possibility of runs depending on the last period's asset distribution rule.

$$
\begin{aligned}
V_t^A(y,N) &= \max\{V_t^{run}(y,N), V_t^{wait}(y,N)\} \\
\text{with } V_t^{wait}(y,N) &= (1-\theta N_t\Delta)e^{-\rho\Delta}\left(r\Delta + \mathbb{E}_t\left[\Delta\delta V_{t+\Delta}^I(y_{t+\Delta},N_t) + (1-\Delta\delta)V_{t+\Delta}^A(y_{t+\Delta},N_t)\right]\right) \\
&\quad + \theta N_t\Delta\min\{1,\alpha y_t\} \\
V_t^{run}(y,N) &= \zeta\Delta + (1-\zeta\Delta)\left[(1-\theta N_t\Delta)e^{-\rho\Delta}\left(r\Delta + \mathbb{E}_t\left[\Delta\delta V_{t+\Delta}^I(y_{t+\Delta},N_t) + (1-\Delta\delta)V_{t+\Delta}^A(y_{t+\Delta},N_t)\right]\right)\right. \\
&\quad \left. +\theta N_t\Delta\min\{1,\alpha y_t\}\right] \\
V_t^I(y,N) &= (1-\theta N_t\Delta)e^{-\rho\Delta}\left(r\Delta + \mathbb{E}_t\left[\Delta\lambda V_{t+\Delta}^A(y_{t+\Delta},N_t) + (1-\Delta\lambda)V_{t+\Delta}^I(y_{t+\Delta},N_t)\right]\right) \\
&\quad + \theta N_t\Delta\min\{1,\alpha y_t\} \\
N_t &= N + \Delta\zeta W_t
\end{aligned}
$$

which assumes that within-period successful processing times precede bank failure. This assumption simplifies the computations and is innocuous to our argument since $\Delta \to 0$ makes the double coincidence happen with probability zero.

A depositor waits if and only if

$$
\begin{aligned}
&\left[(1-\theta N_t\Delta)e^{-\rho\Delta}\left(r\Delta + \mathbb{E}_t\left[\Delta\delta V_{t+\Delta}^I(y_{t+\Delta},N_t) + (1-\Delta\delta)V_{t+\Delta}^A(y_{t+\Delta},N_t)\right]\right) + \theta N_t\Delta\min\{1,\alpha y_t\}\right]\zeta\Delta > \zeta\Delta \\
&\iff (1-\theta N_t\Delta)e^{-\rho\Delta}\left(r\Delta + \mathbb{E}_t\left[\Delta\delta V_{t+\Delta}^I(y_{t+\Delta},N_t) + (1-\Delta\delta)V_{t+\Delta}^A(y_{t+\Delta},N_t)\right]\right) + \theta N_t\Delta\min\{1,\alpha y_t\} > 1
\end{aligned}
$$

The left-hand-side is increasing in y_t through time t's failure payoff and expectations about future payoffs.[13] Given future behavior and a value for N_t, the previous inequality defines a threshold $\tilde{y}_t$ below which the attentive depositor will place a withdrawal order at time t. Let $\tilde{N}_t = N + \zeta\Delta\mathcal{A}_t$ be the refinancing the bank needs if all attentive depositors withdraw at time t. The following equation defines the largest equilibrium threshold $\tilde{y}_t(\tilde{N}_t)$ below which all attentive depositors run on the bank:

$$
(1-\theta\tilde{N}_t\Delta)e^{-\rho\Delta}(r\Delta + \mathbb{E}_t\left[\Delta\delta V_{t+\Delta}^I(y_{t+\Delta},\tilde{N}_t) + (1-\Delta\delta)V_{t+\Delta}^A(y_{t+\Delta},\tilde{N}_t)\right]) + \theta\tilde{N}_t\Delta\min\{1,\alpha\tilde{y}_t\} = 1
$$

As in the two-period model, and most bank run models since Diamond and Dybvig (1983), for any finite Δ, within-period multiplicity arises because the measure of withdrawal orders at time t affects current and future bank failure risk through the value of N_t. For example, there is another equilibrium in which current attentive depositors coordinate on running only when $y_t < \tilde{y}_t - \varepsilon$ for $\varepsilon > 0$ close to zero. This behavior justifies using the same threshold as for $y_t \in (\tilde{y}_t - \varepsilon, \tilde{y}_t]$ the depositor prefers staying in the bank given a failure risk below $\theta\tilde{N}_t$. Typically, there would be a continuum of equilibrium running thresholds bounded above by $\tilde{y}_t$.

Continuous time eliminates intra-period multiplicity by reducing the relevance of intra-period decisions. First, as Δ approaches zero we see that the failure rate vanishes, making depositors focus their decision on whether their expected continuation value under survival is higher than one. Intuitively, a depositor expects the chance of failure in the next instant to be zero irrespective of other depositors' decisions at time t. In the limit, the decision rule becomes to withdraw whenever $V_{t^+}^A < 1$.

Second, even with inter-period failure rates that are negligible, intra-period multiplicity can remain if expected continuation values depend on current depositors' actions. Proposition 2 shows that plausible assumptions on the failure rate structure lead to unique intra-period

[13] The value functions will trivially be increasing in y, and our stochastic process for it provides first-order stochastic dominance for distributions with a higher conditional.

monotone equilibria as $\Delta \to 0$. For instance, if withdrawals increase refinancing risk but evolve continuously. This way depositors at time t do not care about other's behavior in the current period as it gets infinitesimal. Intuitively, not only is the chance of failure in the next instant small, but a negligible amount of withdrawal orders will be processed. For this reason depositors do not take into account the behavior of others at the instant in which they make their withdrawal decision. The key object governing decisions becomes the instantaneous comparison of continuation values, and within-period coordination multiplicity disappears.

Another possible route is to assume that the failure rate is $\theta \cdot N_t$ is constant over time. Then intra-period strategic complementarities are eliminated as the failure rate vanishes. This is motivated by a deep pockets assumption in the interbank market: whether a bank receives funding in a given period does not depend on the amount of credit needed but on other primitives governing the bank's health.

Proposition 2. *For any finite horizon T, if $V^A_{t^+}$ does not directly depend on behavior at time t, intra-period equilibria multiplicity vanishes as $\Delta \to 0$ and, hence, we obtain a unique Markov strategy equilibrium through backward induction. Conditions that guarantee this include:*

(i) Deep Pockets: failure rates are independent on the measure of withdrawals.

(ii) Continuous Withdrawal Paths: new withdrawals arrive at exogenous Poisson rates.

What Could Break This Result? Consider a scenario where failure rates depend on the measure of withdrawals and that withdrawal orders cannot be reversed. In such a world, the current behavior of depositors affects the future refinancing risk even though withdrawals do evolve continuously. Then the current behavior of depositors affects the continuation value $\mathbb{E}[V_{t+\Delta} \mid y_t]$ even for $\Delta \to 0$, and we can get intra-period multiplicity again.[14]

Finally, in the infinite horizon version of the model, a constant path for y allows agents to coordinate across periods. Since inter-period strategic complementarities do not disappear as $\Delta \to 0$ and there is no final period with unique outcome, multiplicity could arise once again.

3.2 Benchmark Continuous Time Model

In this section, we formalize the preceding analysis and comparative statics in continuous time. We work with the infinite horizon version of the previous model in the limit as $\Delta \to 0$ and $\zeta \to \infty$, and assume that failure occurs at a constant Poisson rate of the form $\theta \cdot N(\lambda)$, where $N(\cdot)$ is continuous, increasing, and $N(0) = 0$. This specification eliminates intra-period coordination issues and delivers equilibrium uniqueness, while also keeping the problem tractable and allowing for closed-form characterization.

On the liability side, risk-neutral depositors decide whether or not to instantly withdraw their deposits at every moment based on information about the bank's assets. This structure corresponds to a typical bank deposit that pays a stable interest rate and is redeemable at anytime, while capturing the improvement of new technologies for withdrawing funds at a moment's notice (i.e. high ζ). Importantly, depositors have limited information in the sense that they cannot observe the value of the bank's assets all the time. They observe y_t with exogenous Poisson rate $\lambda > 0$ for $\Delta \sim exp(\delta)$ periods.

[14] A way to avoid this is to assume that only a fraction $\Delta\lambda$ of depositors makes decisions in each period as in He and Xiong (2012). This trivially eliminates intra-period complementarities as $\Delta \to 0$ since the measure of agents making decisions at any time becomes negligible.

These assumptions are meant to describe an average depositor who is not constantly monitoring the bank but can do so occasionally when their jobs and other obligations allow her. Hence, the depositor is getting informed through the internet, friends, or social media outlets for an average of $1/\delta$ periods.[15] We assume that depositors do not see others run against the bank and are not allowed to signal their running behavior or intentions. These two assumptions are motivated by the advent of online banking, which allows people to instantly withdraw their deposits from their cell phones or computers without anyone else knowing.[16] We abstract here from agents using new technologies to strategically communicate their withdrawal decisions.

For simplicity, and following He and Manela (2016), we assume that depositors do not make withdrawals when they do not receive information about the bank's health (besides the fact that it still hasn't failed). This means that the attention window coincides with the decision window, where at any time the agent decides whether to keep waiting or not expecting to still be attentive for some time. We will later discuss the rationale and importance of this assumption.

Since interbank credit allows banks to survive during a run, depositors can withdraw their money instantly from their cellphones or computers, knowing that the probability that the bank fails the instant they decide to transfer their money out of the bank is zero.

In what follows, we solve the model and use it to understand how improvements in information technologies can affect equilibrium running behavior.

Equilibrium

Since $r > \rho$, the model consistently exhibits a no-run equilibrium where all depositors always keep their deposits in the bank. We show conditions under which they would withdraw if other depositors withdraw, in the spirit of standard bank runs as in Diamond and Dybvig (1983).

As before, we restrict our attention to monotone strategies and use a guess-and-verify approach to find a stationary equilibrium. Specifically, we guess that there will be an equilibrium threshold $\tilde{y}$ such that attentive depositors will run if and only if the value of the bank's assets is below or equal to this threshold.

Let $\mathcal{F}_t$ be the information available to an a depositor at time t, $\mathbb{F} = (\mathcal{F}_t)_{t\geq 0}$, and $\mathcal{T}$ be the set of $\mathbb{F}-$stopping times. Given the process for the random time at which the bank fails τ_θ, governed by the others' optimal stopping decisions, the problem of each agent that is attentive at t is given by

$$V^A = \max_{\tau\in\mathcal{T}} \mathbb{E}\left\{ \int_t^{\min\{\tau,\tau_\theta,\tau_\delta\}} e^{-\rho(s-t)} r ds + e^{-\rho(\min\{\tau,\tau_\theta,\tau_\delta\}-t)} \left[\min\left(1, \alpha y_{\tau_\theta}\right) I_{\{\min\{\tau,\tau_\delta\}>\tau_\theta\}} \right.\right.$$
$$\left.\left. + I_{\{\tau<\min\{\tau_\theta,\tau_\delta\}\}} + V^I\left(y_{\tau_\delta}\right) I_{\{\tau_\delta<\min\{\tau_\theta,\tau\}\}} \right] \mid \mathcal{F}_t \right\}$$

where $V^I(\cdot)$ reflects the value of becoming inattentive. Note that V^A reflects all relevant components for a depositor. First, as long as the bank remains alive an attentive depositor

[15] The assumption that the length of the attentive window Δ is random and exponentially distributed makes the model stationary since, at any time, the expected time until inattention is $1/\delta$. Further, it reflects the idea that people do not know how long they will be able to monitor the bank's assets since external random factors or shocks restrict their attention. The same logic applies for the inattentive window.

[16] Although this feature is more recent for the average depositor (certainly since the early 2000s), large corporations and corporate customers have already had this ability since the late 70s. Further, even for households, the technology available in the 80s (Rose, 2023) did not delay their withdrawals more than just a couple of hours or a day.

receives rents $r > \rho$ before withdrawing. Second, in case the depositor cashes out its deposits before it becomes inattentive or the bank fails, it recovers them fully. Third, if the bank fails before the depositor becomes inattentive or withdraws its money, it receives $\min\{1, \alpha y\}$, which could be significantly below 1. At last, the depositor faces the risk of becoming inattentive before withdrawing its deposits or the bank failing and thereby obtaining a payoff

$$V^I(y_t) = \mathbb{E}\left[\int_t^{\min\{\tau_\lambda,\tau_\theta\}} e^{-\rho(s-t)} r ds + e^{-\rho(\min\{\tau_\lambda,\tau_\theta\}-t)}\left[\min(1, \alpha y_{\tau_\theta})\, I_{\{\tau_\lambda > \tau_\theta\}} + I_{\{\tau_\lambda < \tau_\theta\}} V^A(y_{\tau_\lambda})\right] \mid \mathcal{F}_t\right]$$

which reflects that while an inattentive agent receives rents $r > \rho$ as long as the bank is alive and it does not have the option to withdraw, being considerably exposed to the risk of failure. In contrast with V^A, the entry rate into attention, λ, directly affects V^I.

Given that others choose this common strategy, any particular agent will choose a threshold $\bar{y}$ to run the bank as long as $y \leq \bar{y}$ and will not run otherwise. Then the value function of an uninformed agent in the continuation region (i.e. when $y_t > \bar{y}$) is the unique C^2 solution to the following differential equation

$$\begin{aligned}\rho V^A(y_t;\tilde{y}) = r + \mu y_t V_1^A(y_t;\tilde{y}) + \frac{\sigma^2}{2} y_t^2 V_{11}^A(y_t;\tilde{y}) + \delta\left[V^I(y_t;\tilde{y}) - V^A(y_t;\tilde{y})\right] \\ + \theta N(\lambda) I_{\{y_t \leq \tilde{y}\}}\left[\min\{1, \alpha y_t\} - V^A(y_t;\tilde{y})\right]\end{aligned}$$

with $\lim_{y \to \bar{y}+} V^A(y;\tilde{y}) = 1$. This follows from applying Feynman-Kac's Theorem.[17] This differential equation perfectly captures the main benefits and risks of keeping your deposits in the bank. First, you earn a rate $r > \rho$ as long as you stay and the bank survives. Second, at a rate δ you can become inattentive, receiving a negative payoff of $\left[V^I(y_t;\tilde{y}) - V^A(y_t;\tilde{y})\right]$. Third, you are exposed to the risk of the bank failing-at rate θN-only if its asset value falls low enough to trigger a run by other depositors. In that case, you suffer a loss equal to $\left[\min\{1, \alpha y_t\} - V^A(y_t;\tilde{y})\right]$, which can be substantially negative when y_t is low.

Proposition 3 describes the unique equilibrium with runs.

Proposition 3. *Whenever an equilibrium with runs exists, it is unique and features a symmetric cutoff strategy: depositors run if and only if $y \leq \tilde{y}$. The equilibrium threshold $\tilde{y}$ is given by*

$$\tilde{y} = \frac{(\alpha_1 - \iota_3)\left(\frac{r}{\rho} - 1\right)\frac{\lambda+\delta}{\delta}\frac{\beta_2}{\beta_2 - \alpha_1} - \iota_3\left(1 - \frac{r+\lambda}{\rho+\lambda+\theta N(\lambda)}\right)}{(1-\iota_3)\frac{\theta N(\lambda)\alpha}{\rho+\lambda+\theta N(\lambda)-\mu}},$$

provided that $\tilde{y} < \alpha^{-1}$ (i.e., the liquidation payoff does not bind). Otherwise,

$$\tilde{y} = \left[\frac{(\alpha_1 - \iota_3)\left(\frac{r}{\rho} - 1\right)\frac{\lambda+\delta}{\delta}\frac{\beta_2}{\beta_2 - \alpha_1} - \iota_3\left(1 - \frac{r+\lambda+\theta N(\lambda)}{\rho+\lambda+\theta N(\lambda)}\right)}{\iota_3\frac{\theta N(\lambda)}{\rho+\lambda+\theta N(\lambda)} + (1-\iota_3)\frac{\theta N(\lambda)}{\rho+\lambda+\theta N(\lambda)-\mu}}\right]^{\frac{1}{\iota_4}} \alpha^{-1}.$$

The constants α_1, ι_3, ι_4, and β_2 are defined in Appendix A. Existence is determined by the first expression for $\tilde{y}$ being strictly positive, which holds for r low enough.

[17] To be more precise, in Feynman-Kac's terms, we define the optimal stopping time to be $\tau = \inf\{t > 0 : y_t \notin G\}$ where $G = (\bar{y}, \infty)$. Further, the only assumption needed for this is that $V^I(\cdot)$ be continuous, which will be the case in an equilibrium of this sort.

In figure 1 we can see three possible path's for the bank's assets and the corresponding equilibrium outcomes. This figure uses the fact that all agents decide to run if the bank's assets are below a certain threshold $\tilde{y}$, while the bank replaces its short-term credit obtained in a run for new depositors as soon as its assets recover. The shaded area marks the values of y for which agents decide to run and, hence, the bank faces the risk of failure. Once the bank's assets get valued below $\tilde{y}$, the depositors that are monitoring the bank decide to run. This is because they are concerned about the risk entailed by other depositors running in this region. This includes a measure $\lambda/(\lambda+\delta)$ of depositors who instantly withdraw their deposits as soon as y touches the threshold and a fraction λdt per unit of time of the remaining uninformed agents who continuously become aware of this situation and decide to run.[18] The latter is reflected in the second plot that shows how the bank's deposits evolve, decreasing gradually during the run after the initial sudden withdrawal and suddenly recovering as soon as the bank is in good standing again.

These paths show the three possible outcomes for the bank's assets. The green line is one where the bank's assets are almost always above the threshold, not being in distress for long and, hence, the bank survives. The golden path is where the bank's assets grow initially but then decrease, exposing the bank to a run. Nevertheless, the bank can obtain short-run financing to sustain itself during the run until the assets eventually recover, and then it manages to survive. The final path, shown in blue, represents a bank experiencing prolonged distress. Although there is a moment when it appears the bank might recover, its assets decline in value once more, ultimately leading to failure at τ_θ.

This illustrates the model's possible outcomes and hints at the main incentives that interplay in it. We proceed to do comparative statics, showing the main results of the paper.

3.3 Non-monotonic Bank Run Frequency

We are interested in understanding how the equilibrium running threshold changes with λ, the frequency with which information arrives to the general public. We focus on steady state outcomes. The following Proposition illustrates the key result, which is consistent with the logic in Proposition 1.

Proposition 4. *The equilibrium running threshold is non-monotonic in λ. For low enough values of λ, $\tilde{y}$ increases with λ. For high enough values of λ, $\tilde{y}$ decreases with λ.*

This proposition shows that under any calibration which provides a strictly positive equilibrium threshold $\tilde{y}$, the effect of changes in λ on it is non-monotonic. Decreasing λ eventually leads to the threshold getting closer and closer to 0, while increasing it will ultimately result in the same endpoint as λ becomes large. This is illustrated in Figure 2, where we plot the equilibrium threshold for different values of λ.[19]

[18] We assume for the illustration that the measure of attentive agents is at the stationary level whenever there are no runs. This includes assuming that the game starts at the stationary level and that the inflow of depositors maintains this composition.

[19] We take one unit of time to be a day and choose most of the parameters to roughly match those in He and Xiong (2012). Unless otherwise specified we use for the remaining figures $r = (1+7\%)^{\frac{1}{365}} - 1$, $\rho = \mu = (1+15\%)^{\frac{1}{365}} - 1$, $\alpha = 0.55$, $\sigma = 0.0105$, $\lambda = 8$, $\delta = 48$, $\nu = 95\%$, and $\theta = 7^{-1}(5\% + 95\% \cdot N)^{-1}$. The parameters freely chosen here are the entry and exit rates into attention, while we calibrate θ using the specification of the extended model in B.1 that has a 5% share of expert depositors. The values of λ and δ determine an expected length of the inattentive and attentive windows of 3 and 0.5 hours respectively.

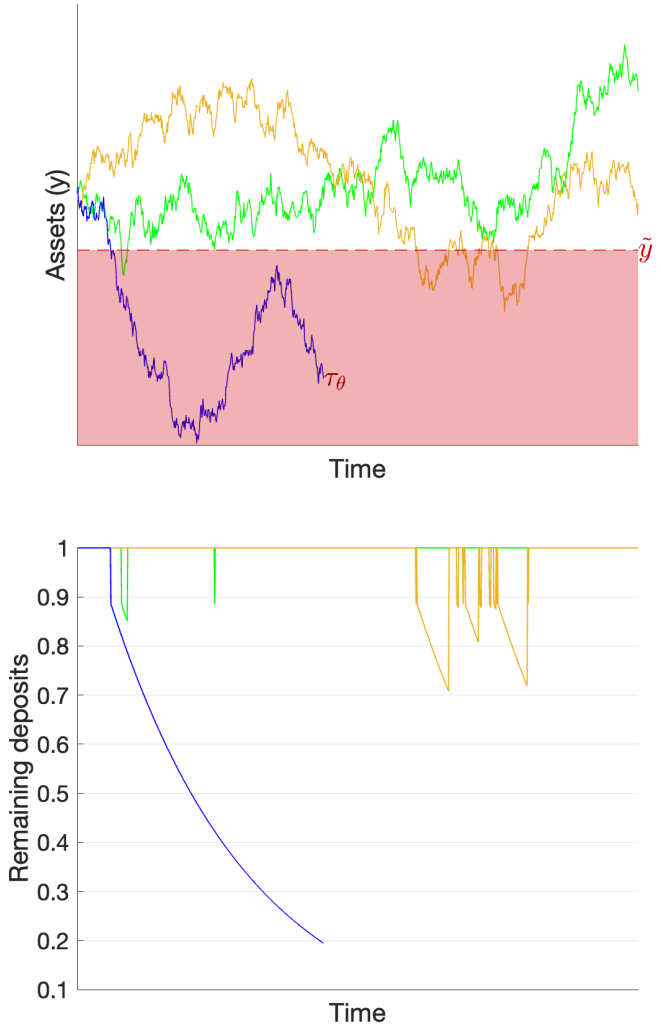


Figure 1: Simulated paths for the bank's assets and the corresponding equilibrium outcomes in an economy where depositors run when y is below $\tilde{y}$. Shaded areas represent the regions where the bank might fail at a random time that we denote τ_θ as it depends on the running intensity and the availability of credit lines θ.

The intuition for this result uncovers the two main mechanisms we want to illustrate in this paper.

First, when λ is small enough, raising it results in a considerable increase in the number of agents monitoring the bank at any time. This means that we have an increase in *running intensity*, which we define as the amount of money the bank needs to obtain in the short run to cover the withdrawals. This results in a higher probability of a bank failure in the event of a run (i.e. $\uparrow \theta \cdot N$), making agents more cautious and, hence, less willing to keep their deposits at the bank. For this reason, the equilibrium threshold rises. This is perhaps the most straightforward effect usually present in the general discussion about the impact of new communication technologies such as social media on running events. As information disseminates faster to the general public, more and more people withdraw their deposits when bad news emerge, making keeping one's deposits in the bank more risky. Likewise, decreasing λ enough eliminates the possibility of a run as the *running intensity* becomes so negligible that the bank is barely vul-

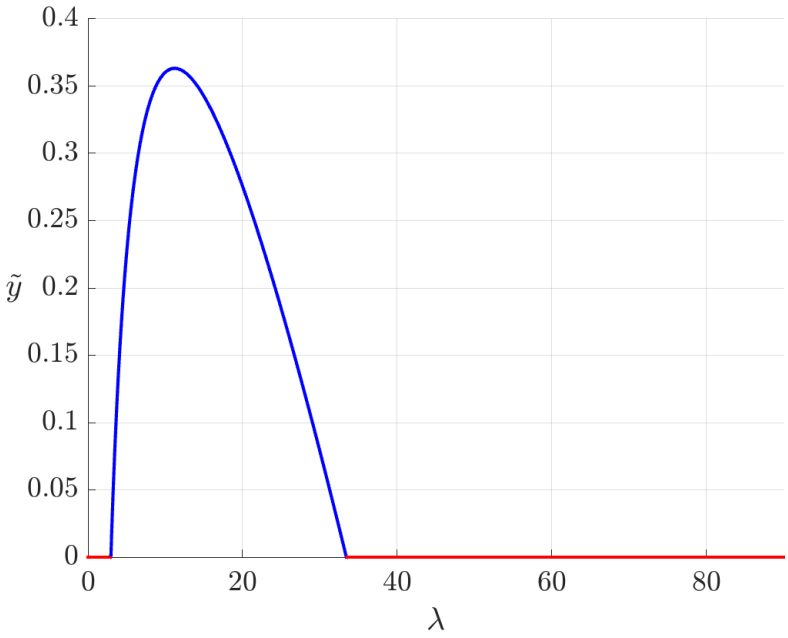


Figure 2: Equilibrium threshold $\tilde{y}$ as a function of λ, using $N(\lambda) = \lambda/(\lambda+\delta)$. Other parameters are according to the standard calibration. The red line corresponds to the threshold being at zero, which means that the only stationary equilibrium possible under said parametrization is that of no runs.

nerable during a run, leading depositors to wait and see even when other attentive agents run. Hence, at first, increases in the frequency of information arrival generate the possibility of a run equilibrium in this model by raising rollover concerns.

However, an increase in λ also affects the frequency with which any particular agent receives information about the bank and, hence, gets to make a withdrawal decision. This decreases running incentives as attentive depositors expect to be able to make a withdrawal decision early in the future in case they become inattentive, exposing them to lower risk if they decide to keep their deposits in the bank for a little longer. To see this, note that if a depositor decides not to withdraw his money, he is exposed to the risk of becoming inattentive and unable to make a withdrawal decision for an expected time of $1/\lambda$. During that window, the bank's assets might deteriorate enough for other depositors to run against it without the agent noticing this on time. Then, an increase in λ decreases the exposure to such risk as the agent expects to be inattentive for a shorter window and, hence, it is less likely that the bank's assets will become bad enough in between and that the bank would fail in the event of a run before he can withdraw his money. In essence, lesser fear of being left behind during a run reduces the urge to withdraw at the first hint of trouble, thus reducing the running threshold.

The interaction of these two effects determines the non-monotonic relationship between the equilibrium threshold and λ. In line with the model in Section 2, our results show that the first effect is stronger for low values of λ, while the second one dominates for high values of λ. The mechanism by which the introduction of new communication technologies decreases the exposure to *inattention risk* and, thus lower running incentives, is missing in the general discussion and turns out to be crucial once enough progress has been made according to this

model.

As illustrated in figure 2, if λ increases enough, the exposure to *inattention risk* decreases until the running equilibrium is eliminated. Even though a significant fraction of agents are monitoring the bank at any time, making it considerably vulnerable in the event of a run, depositors are not so concerned about this as they expect to be attentive once the bank is in distress and, hence, able to make a withdrawal before suffering significant losses. This incentivizes keeping deposits at the bank for a little longer than others, earning more rents and keeping the option value. This mechanism pushes the equilibrium threshold downward to a point where no agent runs in equilibrium.

This result is robust to any specification for the failure rate $\theta \cdot N$ that maps running intensity into failure risk where N is a continuous increasing function of λ satisfying $N(0) = 0$.[20] The force behind the result is the same as in the two-period model. For sufficiently large λ, the marginal benefit of being able to act in real time is large, while the marginal cost of a higher failure intensity is muted because the depositor expects to be able to respond quickly if conditions deteriorate.

In the two-period model this comparison relied on concavity of $N(\cdot)$, which we do not impose here. Even though $N(\cdot)$ may not be concave, the recovery value α^{-1} limits the impact of a higher failure rate on running incentives fixing the exposure to *inattention risk*. Corollary 1 illustrates this idea.

Corollary 1. *The equilibrium threshold increases with N for low values of N. In addition,* $\lim_{N\to\infty} \tilde{y} \propto \alpha^{-1}$.

A high enough failure rate takes the equilibrium threshold close to the recovery value as it would be in any static classic bank run model. Intuitively, agents will not run for asset values above the recovery value as it is expected that the bank will fail almost instantly during a run so that no capital losses are incurred in waiting. This further explains why the equilibrium threshold will converge to a value below α^{-1}. Even when others run if $y \leq \alpha^{-1}$ a depositor has increasing incentives to wait bit longer as N grows large since the expected losses from waiting become negligible relative to the gain of keeping the option value. This implies that there is a limit to how much a higher *running intensity* can affect equilibrium running behavior.

Comparing steady-state outcomes ignores that transitioning from low to high aggregate attention takes time. For instance, a higher λ would imply a higher long-run share $\lambda/(\lambda + \delta)$ of attentive depositors. To discuss how equilibria would change we must take into account how the failure rate would be affected by this in the transition. Intuitively, the speed of withdrawals during a run would be small early in the transition, resulting in lower failure rates and, hence, the decreased exposure to *inattention risk* is more likely to dominate.

3.4 Non-monotonicity and Bank's Liquidity Access

The previous analysis overlooks the fact that banks may adjust their access to liquidity under distress when λ increases, as a result of a higher *running intensity* and perhaps a higher likelihood of a run. In our model, this maps into a decrease in θ, which decreases running incentives

[20] This does not include considering that $\delta(\lambda)$, capturing that an agent would spend more time getting informed (low δ) when it cannot get informed frequently (low λ). The result can be extended provided $\delta(\cdot)$ satisfies mild regularity conditions (e.g., boundedness), including settings where N also depends on δ.

(i.e., *ceteris paribus* the threshold decreases).[21] Intuitively, decreasing θ as a response to increases in λ counteracts the increase in *running intensity*, resulting in a stronger incidence of the reduced exposure to *inattention risk* in the equilibrium threshold.

This is illustrated in Figure 3 where we can see that increases in λ that are accompanied by decreases in θ have a more negative impact on the equilibrium threshold. In particular, even for levels of λ where the increase in *running intensity* is the dominant effect, if that is accompanied by a slight decrease in θ, the threshold will respond negatively. If the bank adapts θ so that the failure rate remains unchanged after the increase in λ, the threshold will change downward. This is illustrated in the figure when moving from point A toward B and then C.

The main intuition here is that better communication technologies allow more tolerance to failure risk from depositors. As a result, banks only need to increase their liquidity access partially counteracting the higher *running intensity* to keep run likelihood unchanged when attention rises.

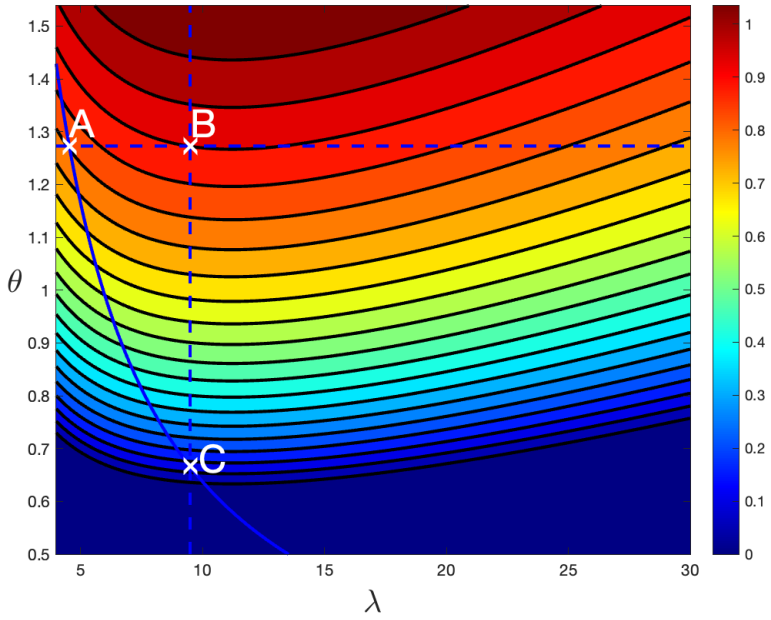


Figure 3: Equilibrium threshold $\tilde{y}$ as a function of λ and θ. The thick blue line represents the pairs of λ and θ that keep the running intensity constant.

This reinforces the decrease in exposure to *innatention risk* as the primary force driving running decisions if θ is endogenous. At least for low values of λ, where we would expect the bank to attempt increasing its liquidity to face runs that are faster and more likely. However, once increases in λ decrease the running threshold, the bank might decide to increase θ as two different forces interplay affecting its fragility. On the one hand, a running event is less likely for higher values of λ. On the other hand, if it does happen, *running intensity* is higher, and the bank is more likely to fail. The bank and regulators face this trade-off when deciding on

[21] To be precise, decreasing θ can increase the equilibrium threshold when θ and σ are high enough as in He and Xiong (2012). This is because of a tricky effect: a higher failure rate makes the bank less likely to fail with a considerably low asset value when the agent is inattentive if the volatility is high enough. We have ignored this in our discussion since it is irrelevant for our main result. At least for banks that suffer an increase in the running threshold when increasing λ, we can ignore this issue, as it is not present.

adjusting θ.[22]

3.5 Non-monotonicity and Portfolio Volatility

We now study how the effects discussed change when the portfolio of the bank is more volatile. We illustrate this in Figure 4. We see that banks with volatile portfolios suffer more from increases in attention at first, but, although the eventual decrease in run frequency is slower, it is achieved for lower levels of attention. The intuition is as follows. At first, a higher σ makes the initial effect of a higher *running intensity* significantly stronger as, once it becomes not negligible and running concerns emerge, the "rat race" among depositors makes the threshold skyrocket given the higher risk entailed in keeping their deposits in case others run. This is because their best response function to $\tilde{y}$ is shifted upwards, as agents want to hedge against the behavior of others more than before for any given failure rate. However, the turning point at which the decreased exposure to *inattention risk* dominates is reached sooner. Intuitively, a higher volatility only affects a depositor's incentives through the risk of becoming inattentive. Hence, at the peak, a higher volatility raises the relative importance of reducing *inattention risk* with respect to an increase in *running intensity*, since its impact on the latter is of second order. At last, the point at which the threshold reaches zero is delayed as rollover concerns remain strong given the higher volatility of assets.

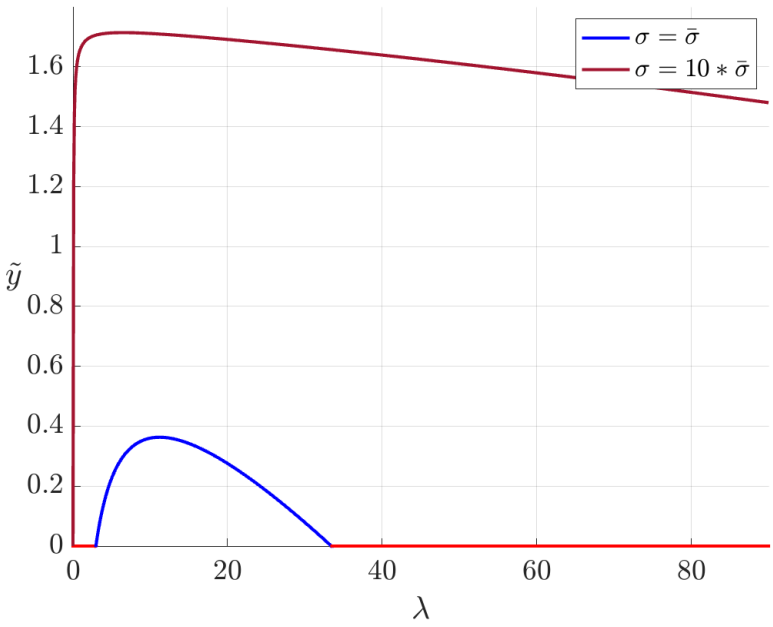


Figure 4: Equilibrium threshold $\tilde{y}$ as a function of λ for different volatility levels. The red line corresponds to the threshold being at zero, which means that the only equilibrium possible under said parametrization is that of no runs. Both curves reach zero for λ close enough to zero.

This shows how the effect of increases in the frequency of information arrival on banks can be asymmetric. While its impact on raising running incentives at the beginning and decreasing

[22]Following previous comments, if volatility is high enough then for large values of λ it might even be more helpful to increase θ, lowering the access to liquidity under distress.

them later on is less beneficial for volatile banks, it can happen that raising λ makes "stable" banks more fragile while reducing the frequency of runs on those with volatile portfolios.

3.6 Discussion and Summary

In this model, increasing the frequency with which individuals receive information (i.e., $\uparrow \lambda$) accelerates the speed of a run-defined as the expected time until failure, conditional on a run-since more agents become aware of the bank's health and hence withdraw their deposits during it. At first, this results in a higher running threshold due to higher rollover concerns and, hence, a higher probability of a run and subsequent banking failure, making banks more fragile. Yet, as communication technologies improve, they may reduce the probability of a bank run since running incentives decrease when people can monitor the bank's assets more frequently. This comes from the fact that observing information about the bank more often reduces the risk of failure under inattention.

Moreover, improved monitoring allows banks to maintain a stable run probability with only partial adjustments to their liquidity buffers, as depositors become more tolerant of risk for any given failure rate.

We have solved the model as if it were optimal for depositors to not act while inattentive. This assumption substantially simplifies the setting, making computations and comparative statics straightforward, since we only have attentive agents making withdrawals.[23] Further, although this makes attentive depositors more willing to run at any time since they cannot act at all when they become inattentive, it does not affect the main mechanisms at interplay here and, hence, the results. This is because the exposure to *inattention risk* would still be a key driver of running decisions as even if depositors are allowed to act while inattentive, their behavior would be deterministic until they receive new information and, thus, they would be severely exposed to others running while they are not paying attention.

4 Testable Implications

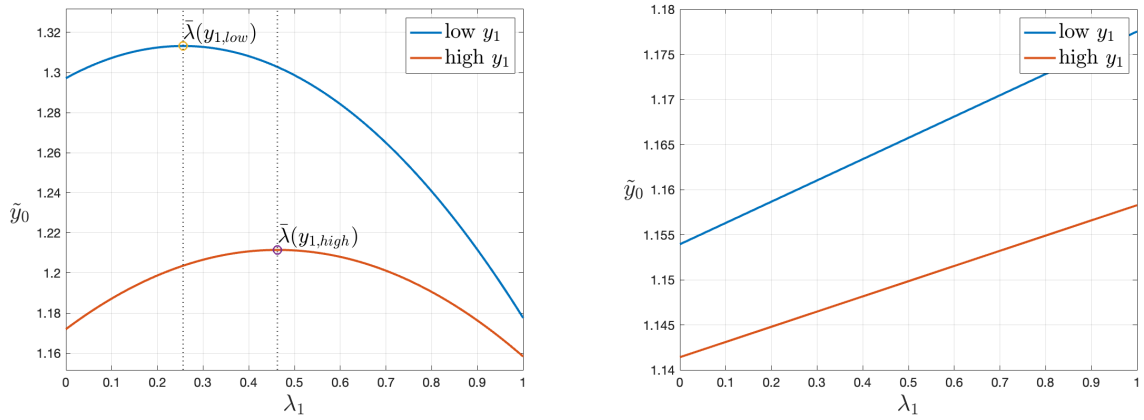
Our theory delivers a set of testable implications that we take to the data. The central prediction is that increasing the frequency with which depositors receive information about their bank can reduce withdrawals, especially for banks with volatile portfolios. As information production becomes more continuous, runs may become less frequent in equilibrium.

Crucially, this prediction does not follow from static considerations in standard bank-run models. It relies on a dynamic mechanism: higher expected future attentiveness raises the continuation value of keeping funds in the bank by lowering the perceived risk of being unable to react in time during a run. The two-period model makes the distinction transparent. Holding fixed future attention, increasing the current mass of attentive depositors, λ_0, raises run incentives in the usual way: more agents monitoring the bank intensifies coordination pressures and increases the willingness to run. By contrast, increasing future attentiveness, λ_1, can reduce run incentives at $t = 0$ precisely because it lowers inattention risk at $t = 1$. Interpreting attentiveness solely as an amplification force at $t = 1$—for instance, by shrinking the set of captive

[23] Without constant failure rates this assumption can hardly be avoided since one would have to track past signals to account for withdrawal decisions made by inattentive agents, which will generally depend on their last observation.

depositors—would give the same qualitative result as an increase in λ_0.

A second implication concerns heterogeneity across banks. For sufficiently high ζ, depositors of weaker banks react less negatively to increases in future attentiveness as reflected in Proposition 1. Figure 5a illustrates this pattern. For any given λ_1, the weaker bank is more exposed to withdrawals, as reflected in a higher threshold $\tilde{y}_0$. Yet, bank fundamentals also determine how $\tilde{y}_0$ changes with λ_1. For weaker banks the threshold is initially less sensitive to increases in λ_1, but as attentiveness rises further, the threshold falls more quickly. This highlights how increased attention can be less detrimental for weak banks.



(a) Benchmark model.

(b) Shutting down attention risk.

Figure 5: Equilibrium running threshold at $t = 0$ in the two-period model as a function of λ_1 for $y_1 < \tilde{y}_1$. Parameters: $\alpha = 0.7$, $\beta = 0.98$, $r = 0.07$, $\theta = 0.3$, $\zeta = 0.9$, and $\lambda_0 = 0.65$.

This implication also departs from the logic of standard bank run models. As Figure 5b and Proposition 5 show, once we shut down the attention risk channel for depositors who are attentive at $t = 0$, a higher mass of attentive depositors at $t = 1$ simply raises rollover risk and it does so more sharply for weaker banks. In our dynamic environment, higher future attentiveness increases failure risk by enlarging runs, but it also raises the option value of waiting by making it more likely that depositors can act when distress emerges. The latter channel is particularly valuable when fundamentals are weak, because the cost of being inattentive during a run is larger. When ζ is sufficiently high, this channel dominates, implying that additional future attentiveness is less de-stabilizing for weaker banks.

Proposition 5. *If all λ_0 attentive depositors at $t = 0$ in our two-period model remain attentive in $t = 1$ with probability one, we have $\frac{\partial V_1^{run}}{\partial \lambda_1} < 0$ with $\frac{\partial^2 V_1^{run}}{\partial \lambda_1 \partial y_1} > 0$ for any $y_1 < \tilde{y}_1$ and, hence, both $\frac{\partial \tilde{y}_0}{\partial \lambda_1} > 0$ and $\frac{\partial^2 \tilde{y}_0}{\partial \lambda_1 \partial y_1} < 0$ hold.*

5 Conclusion

Recent runs in the United States have spurred discussions over the impact of new communication technologies and instant withdrawal technologies on the banking sector's stability. The little academic research on the topic and the general discussion about it in the media suggest that the latter made banks more fragile, exacerbating the intensity of runs and perhaps making them more likely because of the possibility of spreading panic quickly.

We argue that there is an additional channel through which the introduction of new communication technologies (e.g., cellphones, news websites, blogs, social media, apps, etc.) can affect the likelihood of runs. If the latter allows people to get informed more frequently, then exposure to the risk of bank failure under inattention decreases, increasing the value of keeping your deposits in the bank. While these technological advancements increase the number of depositors withdrawing their money during a bank run, once this severity reaches a certain point, further increases have little effect on withdrawal behavior, as the recovery value imposes a natural limit. Additionally, larger withdrawals during a run amplifies the importance of minimizing the exposure to *inattention risk*. As a result, when technological progress in communication reaches a sufficient level, further advancements lead to a decreased frequency of bank runs.

Our results suggest that the introduction of improved communication technologies, such as social media, does not necessarily undermine financial stability. Although it increases the severity of runs, it could be a blessing in the limit, reducing the frequency of them to a minimum. According to these results, in the time series, we should observe, all else equal, an increasing frequency of runs with the introduction of new communication technologies, followed by a decline as these technologies mature and further progress is made.

Furthermore, considering the effects on people outside the financial system, the results could be even more promising. Specifically, if agents who do not allocate their money into the banking sector have incentives to do so once they can monitor the value of banks assets more frequently, better technologies could decrease financing costs further. Although Ding and Pennacchi (2024) suggest that better informed uninsured depositors can decrease funding costs, the latter still has not been explored.

Finally, our results highlight that regulation and supervision must take into account private sector's information production not only to inform quantitative decisions properly, but to understand how certain policies can affect information production and, hence, depositor's sensitivity to banks balance-sheets. In particular, higher future attention makes depositors more tolerant to liquidity risk, lowering the need for liquidity buffers. Additionally, while opacity-inducing regulations that restrict the information available to the public can provide times of tranquility, runs can emerge at the first sign of trouble.

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A Appendix: Proofs

A.1 Proof of Lemma 1

For any $y_1 < \tilde{y}_1$ we have

$$\begin{aligned}
\frac{\partial V_1^{cont}}{\partial \lambda_1} &= \frac{\partial}{\partial \lambda_1}\Big[\lambda_1 V_1^{\text{run}} + (1-\lambda_1) V_1^{\text{wait}}\Big] \\
&= V_1^{\text{run}} - V_1^{\text{wait}} + \lambda_1 \frac{\partial V_1^{\text{run}}}{\partial \lambda_1} + (1-\lambda_1)\frac{\partial V_1^{\text{wait}}}{\partial \lambda_1} \\
&= (1-\theta(\lambda_1(1-\lambda_0)+\lambda_0))[1-\beta(1+r)] + \theta(\lambda_1(1-\lambda_0)+\lambda_0)\zeta(1-\alpha y_1) \\
&+ \theta\,(1-\lambda_0)\Big[\alpha y_1 - \beta(1+r) + \lambda_1\Big[\beta(1+r) - 1 + \zeta(1-\alpha y_1)\Big]\Big] \\
&= 2\theta\lambda_1(1-\lambda_0)[\beta(1+r) - 1 + \zeta(1-\alpha y_1)] + 1 - \beta(1+r)(1+\theta(1-2\lambda_0)) \\
&+ \theta\alpha y_1(1-\lambda_0(1+\zeta)) - \lambda_0\theta(1-\zeta)
\end{aligned}$$

which, given $\lambda_0 < 1$, is strictly increasing in λ_1 for $y_1 < \tilde{y}_1$ and equal to zero whenever

$$\lambda_1 = \bar{\lambda} := \frac{\beta(1+r)(1+\theta(1-2\lambda_0)) - 1 + \lambda_0\theta(1-\zeta) - \theta\alpha y_1(1-\lambda_0(1+\zeta))}{2\theta(1-\lambda_0)\,[\beta(1+r) - 1 + \zeta(1-\alpha y_1)]} \in \mathbb{R}$$

Furthermore, $\bar{\lambda}'(y_1) > 0$ if and only if

$$\begin{aligned}
&\zeta\Big(\beta(1+r)(1+\theta(1-2\lambda_0)) - 1 + \lambda_0\theta(1-\zeta) \cancel{-\theta\alpha y_1(1-\lambda_0(1+\zeta))}\Big) > \theta(1-\lambda_0(1+\zeta))\,[\beta(1+r) - 1 + \zeta(1-\cancel{\alpha y_1})] \\
\iff &\zeta\left(\beta(1+r)(\theta^{-1}+1-2\lambda_0) - \theta^{-1} + \lambda_0(1-\zeta)\right) > (1-\lambda_0(1+\zeta))\,[\beta(1+r) - 1 + \zeta] \\
\iff &\zeta(\beta(1+r)-1)(\theta^{-1}+1-\lambda_0) > (\beta(1+r)-1)(1-\lambda_0) \\
\iff &\zeta > \frac{1-\lambda_0}{\theta^{-1}+1-\lambda_0}
\end{aligned}$$

Similarly,

$$\frac{\partial^2 V_1^{cont}}{\partial \lambda_1 \partial y_1} = -2\alpha\theta\lambda_1\zeta(1-\lambda_0) + \theta\alpha(1-\lambda_0(1+\zeta)) < 0 \iff 1 < \zeta\left(2\lambda_1 + \frac{\lambda_0}{1-\lambda_0}\right)$$

and,

$$\frac{\partial^2 V_1^{cont}}{\partial \lambda_1 \partial \lambda_0} = -2\theta\lambda_1\,[\beta(1+r) - 1 + \zeta(1-\alpha y_1)] + 2\theta\beta(1+r) + \theta\zeta(1-\alpha y_1) - \theta(1+\alpha y_1) > 0$$

where the inequality follows from linearity and the fact that it holds at $\lambda_1 = 0$ and $\lambda_1 = 1$. Finally, rewrite $\bar{\lambda}$ as follows and get the desired result:

$$\begin{aligned}
\bar{\lambda} &= \frac{\beta(1+r)(\theta^{-1}+1-2\lambda_0) - \theta^{-1} + \lambda_0(1-\zeta) - \alpha y_1(1-\lambda_0(1+\zeta))}{2(1-\lambda_0)\,[\beta(1+r) - 1 + \zeta(1-\alpha y_1)]} \\
\implies \frac{\partial \bar{\lambda}}{\partial \theta} &< 0 \iff \beta(1+r) > 1
\end{aligned}$$

A.2 Proof of Proposition 1

The first result follows from V_1^{cont} being decreasing in λ_0 and

$$\frac{\partial \tilde{y}_0}{\partial \lambda_0} = (\zeta\alpha)^{-1}\left(\frac{1}{\theta\lambda_0^2}(\beta(V_1^{cont}(y_1;\lambda_1,\lambda_0)+r)-1) - \left(\frac{1}{\theta\lambda_0} - 1\right)\beta\frac{\partial V_1^{cont}(y_1;\lambda_1,\lambda_0)}{\partial \lambda_0}\right)$$

The second result follows from $\tilde{y}_0$ being decreasing in V_1^{cont} and otherwise independent of λ_1.

A.3 Proof of Proposition 2

For any finite Δ and taking as given other's present and future behavior, we have that an attentive depositor at time $t < T$ withdraws whenever

$$V_t^{wait} = (1 - \theta N_t \Delta) e^{-\rho \Delta} \left(r\Delta + \mathbb{E}_t \left[\Delta \delta V_{t+\Delta}^I(y_{t+\Delta}, N_t) + (1 - \Delta\delta) V_{t+\Delta}^A(y_{t+\Delta}, N_t) \right] \right) + \theta N_t \Delta \min\{1, \alpha y_t\} < 1$$

In the limit, this condition transforms into $V_{t^+}^A < 1$. Given any conjecture about future and present strategies, we see that only those directly affecting $V_{t^+}^A$ will be factored in the decision to withdraw. Hence, as long as time t behavior does not affect $V_{t^+}^A$, the decision to withdraw at time t is uniquely pinned down for any given conjectured strategies played in the future. With a finite horizon, backward induction determines a unique outcome under standard uniqueness conditions for differential equations. For example, if the final payoff $V_{T^+}^A = V_T$ equals $\beta(1+r)$ as in the two-period model, depositors do not run ever in equilibrium.

Constant failure rates trivially make $V_{t^+}^A$ independent of time t behavior in a Markov Strategy Equilibrium, since current behavior does not affect the path for the only state variable y. Finally, whenever the failure rate is a continuous function of the total measure of withdrawals and these are processed at arrival rate $\zeta > 0$, we have $\lim_{\Delta \to 0} V_{t+\Delta}^A(y_{t+\Delta}, N + \Delta\zeta \mathcal{A}_t) = V_{t^+}^A(y_t, N)$ for any measure of new withdrawals $\mathcal{A}_t$.

A.4 Proof of Proposition 3

We divide the proof in three steps. First, we characterize equilibrium value functions and symmetric running thresholds through a guess and verify approach. Second, we show under which conditions one such equilibrium exists and derive its uniqueness. Third, we show that a stationary monotone equilibrium must be symmetric.

Step 1. We guess and verify that an equilibrium exists under which all attentive depositors run whenever y is below a strictly positive threshold $\tilde{y}$. To solve the main differential equation, let's express it differently. For $\alpha^{-1} < \tilde{y}$ we have

$$\rho V^A(y_t; \tilde{y}) - \delta \left[V^I(y_t; \tilde{y}) - V^A(y_t; \tilde{y}) \right] = \begin{cases} r + \mu y_t V_1^A(y_t; \tilde{y}) + \frac{\sigma^2}{2} y_t^2 V_{11}^A(y_t; \tilde{y}) & \text{for } \; y_t > \tilde{y} \\ r + \mu y_t V_1^A(y_t; \tilde{y}) + \frac{\sigma^2}{2} y_t^2 V_{11}^A(y_t; \tilde{y}) + \theta N(\lambda) \left[1 - V^A(y_t; \tilde{y}) \right] & \text{for } \; \frac{1}{\alpha} < y_t \leq \tilde{y} \\ r + \mu y_t V_1^A(y_t; \tilde{y}) + \frac{\sigma^2}{2} y_t^2 V_{11}^A(y_t; \tilde{y}) + \theta N(\lambda) \left[\alpha y_t - V^A(y_t; \tilde{y}) \right] & \text{for } \; 0 < y_t \leq \frac{1}{\alpha} \end{cases}$$

For $\alpha^{-1} \geq \tilde{y}$ we have

$$\rho V^A(y_t; \tilde{y}) - \delta \left[V^I(y_t; \tilde{y}) - V^A(y_t; \tilde{y}) \right] = \begin{cases} r + \mu y_t V_1^A(y_t; \tilde{y}) + \frac{\sigma^2}{2} y_t^2 V_{11}^A(y_t; \tilde{y}) & \text{for } \; y_t > \tilde{y} \\ r + \mu y_t V_1^A(y_t; \tilde{y}) + \frac{\sigma^2}{2} y_t^2 V_{11}^A(y_t; \tilde{y}) + \theta N(\lambda) \left[\alpha y_t - V^A(y_t; \tilde{y}) \right] & \text{for } \; 0 < y_t \leq \tilde{y} \end{cases}$$

The remaining conditions to impose are optimality (smooth-pasting) and symmetry. Further, we must characterize V^I. The value function of an agent that became inattentive T periods ago with last observation y_t satisfies the following HJB equation

$$\begin{aligned} \rho V^I(y_t, T) = r + V_2^I(y_t, T) &+ \lambda \left[\mathbb{E}_{y_t, T} \left[V^A(y_{t+T}) \right] - V^I(y_t, T) \right] \\ &+ \theta N(\lambda) \, \mathbb{E}_{y_t, T} \left[I_{\{y_{t+T} \leq \tilde{y}\}} \left[\min\{1, \alpha y_{t+T}\} - V^I(y_t, T) \right] \right] \end{aligned}$$

Solving for $V^I(y, T)$ requires computing the posterior of y_{t+T} conditional on y_t and the fact that the bank still has not failed up to $t+T$. Computing this posterior would require numerical methods typically. However, we can avoid doing so noticing that the value of a depositor that just became inattentive at time t (i.e. $V^I(y_t, 0)$) is identical to that of an agent who at time t

becomes inhibited from withdrawing for $\Delta \sim exp(\delta)$ periods but does observe y in the meantime. That is, $V^I(y_t)$, the value after 0 periods of inattention, is identical for a depositor who will not monitor the bank's assets during the inattention period and one that does but is unable to withdraw. The reason is that, at time t, they both have the same information to forecast future outcomes, which do not differ among them.[24] Then, we can compute V^I as the value of an agent that cannot withdraw but does observe y during the inattentive period and use it to evaluate the payoff of exiting the attention window. Said function will satisfy the following HJB equation as it is C^2:

$$\begin{aligned}\rho V^I(y_t;\tilde{y}) = r + \mu y_t V_1^I(y_t;\tilde{y}) + \frac{\sigma^2}{2} y_t^2 V_{11}^I(y_t;\tilde{y}) + \theta N(\lambda) I_{\{y_t \leq \tilde{y}\}} \left[\min\{1, \alpha y_t\} - V^I(y_t;\tilde{y})\right] \\ + \lambda \left[V^A(y_t;\tilde{y}) - V^I(y_t;\tilde{y})\right]\end{aligned}$$

For any $\tilde{y}$, in the continuation region, we can subtract the HJB equations that characterize the value functions of the uninformed both when they can monitor and when they are not to get

$$(\rho + \lambda + \delta)\Gamma = \mu y_t \Gamma_1 + \frac{\sigma^2}{2} y_t^2 \Gamma_{11} - \theta N(\lambda) I_{\{y_t \leq \tilde{y}\}} \Gamma$$

where $\Gamma \equiv V^I(y;\tilde{y}) - V^A(y;\tilde{y})$. With appropriate border conditions,[25] we get that

$$\Gamma(y_t;\tilde{y}) = \begin{cases} A_1 y_t^{\alpha_1} & \text{for } \; y_t > \tilde{y} \\ A_2 y_t^{\alpha_2} + A_3 y_t^{\alpha_3} & \text{for } \; 0 < y_t \leq \tilde{y} \end{cases}$$

where α_1 is the negative root of $\rho + \lambda + \delta = \mu\alpha_1 + \frac{\sigma^2}{2}\alpha_1(\alpha_1 - 1)$. The other roots are given by α_2 and α_3 which are respectively the positive and negative roots of $\rho + \lambda + \delta = \mu\alpha_i + \frac{\sigma^2}{2}\alpha_i(\alpha_i - 1) - \theta N(\lambda)$ for $i = 2, 3$. The constants A_i are the solution to the following system of equations:

$$\begin{aligned} A_1(\tilde{y})^{\alpha_1} &= A_2(\tilde{y})^{\alpha_2} + A_3(\tilde{y})^{\alpha_3} \\ A_1\alpha_1(\tilde{y})^{\alpha_1 - 1} &= A_2\alpha_2(\tilde{y})^{\alpha_2 - 1} + A_3\alpha_3(\tilde{y})^{\alpha_3 - 1} \end{aligned} \tag{2}$$

With an expression for Γ we can now solve for V^A from

$$\begin{aligned}\rho V^A(y_t;\tilde{y}) = r + \mu y_t V_1^A(y_t;\tilde{y}) + \frac{\sigma^2}{2} y_t^2 V_{11}^A(y_t;\tilde{y}) + \delta\Gamma(y_t;\tilde{y}) \\ + \theta \left(N(\lambda) I_{\{y_t \leq \tilde{y}\}}\right) \left[\min\{1, \alpha y_t\} - V^A(y_t;\tilde{y})\right]\end{aligned}$$

Since Γ is a polynomial, we can solve this differential equation with a polynomial of equal exponents as a particular solution. We solve for the equilibrium threshold in the following, considering each case separately.

[24] Of course the value after T periods of inattention will not be the same for an agent that is able to observe y but not withdraw, this is because it can forecast future outcomes using more updated information. The important thing is that, under our assumptions, we do not care about such value but that at the instant of becoming inattentive, in which case they do coincide.

[25] We use that $\lim_{y \to \infty} \Gamma(y) = 0$. We need an extra border condition, which we will obtain from solving for Γ in the withdrawal region. The issue is that this function will depend on the underlying case considered for $\tilde{y}$, so we will leave it for later.

- Case $\tilde{y} \leq \alpha^{-1}$: We begin by characterizing the value function of an uninformed agent in the withdrawal region when she cannot observe y. We do this to obtain an additional border condition for Γ. This solves the following differential equation for any $y \in (0, \bar{y}]$

$$\rho V^I = \begin{cases} r + \mu y V_1^I + \frac{\sigma^2}{2} y^2 V_{11}^I + \lambda[1 - V^I] & \text{for } \ y > \tilde{y} \\ r + \mu y V_1^I + \frac{\sigma^2}{2} y^2 V_{11}^I + \theta N(\lambda) \left[\alpha y - V^I\right] + \lambda[1 - V^I] & \text{for } \ 0 < y \leq \tilde{y} \end{cases}$$

The solution to this differential equation is given by[26]

$$V^I(y) = \begin{cases} D_1 y^{\iota_1} + D_2 y^{\iota_2} + \frac{r+\lambda}{\rho+\lambda} & \text{for } \ y > \tilde{y} \\ D_3 y^{\iota_3} + \frac{\theta N(\lambda)\alpha}{\rho+\lambda+\theta N(\lambda)-\mu} y + \frac{r+\lambda}{\rho+\lambda+\theta N(\lambda)} & \text{for } \ 0 < y \leq \tilde{y} \end{cases}$$

where ι_1 and ι_2 are the positive and negative roots respectively of $\rho+\lambda = \mu\iota_i + \frac{\sigma^2}{2}\iota_i(\iota_i - 1)$, and ι_3 is the positive root of $\rho + \lambda = \mu\iota_i + \frac{\sigma^2}{2}\iota_i(\iota_i - 1) - \theta N(\lambda)$. The constants D_i and A_i are jointly determined by the system (2) and the following equations:

$$\begin{aligned} &D_1(\tilde{y})^{\iota_1} + D_2(\tilde{y})^{\iota_2} + \frac{r+\lambda}{\rho+\lambda} = D_3(\tilde{y})^{\iota_3} + \frac{\theta N(\lambda)\alpha}{\rho+\lambda+\theta N(\lambda)-\mu}\tilde{y} + \frac{r+\lambda}{\rho+\lambda+\theta N(\lambda)} \\ &D_1\iota_1(\tilde{y})^{\iota_1-1} + D_2\iota_2(\tilde{y})^{\iota_2-1} = D_3\iota_3(\tilde{y})^{\iota_3-1} + \frac{\theta N(\lambda)\alpha}{\rho+\lambda+\theta N(\lambda)-\mu} \\ &V^I(\bar{y}) = 1 + \lim_{y\to\bar{y}} \Gamma(y) \\ &V_1^I(\bar{y}) = \lim_{y\to\bar{y}} \Gamma_1(y) + \underbrace{V_1^A(\bar{y})}_{=0} \end{aligned}$$

This gives the final linear system of six equations in six unknowns that we must solve as a function of $\tilde{y}$ and $\bar{y}$. We now turn to the value function of an uninformed agent who is monitoring. In the inaction region it will be given by[27]

$$V^A(y;\tilde{y}) = \begin{cases} B_1 y^{\beta_2} + C_1 y^{\alpha_1} + C_2 & \text{for } \ y_t > \tilde{y} \\ B_2 y^{\beta_3} + B_3 y^{\beta_4} + C_3 y^{\alpha_2} + C_4 y^{\alpha_3} + C_5 y + C_6 & \text{for } \ 0 < y_t \leq \tilde{y} \end{cases}$$

where β_2 is the negative root of $\rho = \mu\beta_2 + \frac{\sigma^2}{2}\beta_2(\beta_2 - 1)$, β_3 and β_4 are respectively the positive and negative roots of $\rho + \theta N(\lambda) = \mu\beta_i + \frac{\sigma^2}{2}\beta_i(\beta_i - 1)$ for $i = 3, 4$. The constants B_i and C_i are the solution to the following system of equations:

$$\begin{aligned} &C_1 = -\delta A_1(\lambda + \delta)^{-1} \\ &C_2 = \frac{r}{\rho} \\ &C_3 = -\delta A_2(\lambda + \delta)^{-1} \\ &C_4 = -\delta A_3(\lambda + \delta)^{-1} \\ &C_5 = \frac{\theta N(\lambda)\alpha}{\rho + \theta N(\lambda) - \mu} \\ &C_6 = \frac{r}{\rho + \theta N(\lambda)} \\ &B_1(\tilde{y})^{\beta_2} + C_1(\tilde{y})^{\alpha_1} + C_2 = B_2(\tilde{y})^{\beta_3} + B_3(\tilde{y})^{\beta_4} + C_3(\tilde{y})^{\alpha_2} + C_4(\tilde{y})^{\alpha_3} + C_5\tilde{y} + C_6 \\ &B_1\beta_2(\tilde{y})^{\beta_2-1} + C_1\alpha_1(\tilde{y})^{\alpha_1-1} = B_2\beta_3(\tilde{y})^{\beta_3-1} + B_3\beta_4(\tilde{y})^{\beta_4-1} + C_3\alpha_2(\tilde{y})^{\alpha_2-1} + C_4\alpha_3(\tilde{y})^{\alpha_3-1} + C_5 \end{aligned}$$

together with $\lim_{y\to\bar{y}^+} V^A(y;\tilde{y}) = 1$ and the *smooth-pasting* condition $V_1^A(\bar{y}) = 0$. Note that these two introduce another constant to obtain: the individual threshold or best

[26] We already imposed that $\lim_{y\to 0} V^I(y)$ has to be finite, eliminating the term with a negative root (i.e., $D_4 = 0$).

[27] I use the fact that $\lim_{y\to\infty} V^A(y;\tilde{y}) = r/\rho$ as a border condition already.

response of the agent to $\tilde{y}$. Finally, imposing symmetry so that $\bar{y} = \tilde{y}$ we get that the last two conditions are equivalent to

$$1 = B_1(\tilde{y})^{\beta_2} + C_1(\tilde{y})^{\alpha_1} + \frac{r}{\rho}$$
$$0 = B_1\beta_2(\tilde{y})^{\beta_2 - 1} + C_1\alpha_1(\tilde{y})^{\alpha_1 - 1}$$

After solving for A_1, we use these last two equations to obtain the following equilibrium threshold

$$\tilde{y} = \frac{(\alpha_1 - \iota_3)\left(\frac{r}{\rho} - 1\right)\frac{\lambda+\delta}{\delta}\frac{\beta_2}{\beta_2 - \alpha_1} - \iota_3\left(1 - \frac{r+\lambda}{\rho+\lambda+\theta N(\lambda)}\right)}{(1-\iota_3)\frac{\theta N(\lambda)\alpha}{\rho+\lambda+\theta N(\lambda)-\mu}} \tag{3}$$

which exists as long as the numerator is strictly negative.[28] Having solved for the equilibrium threshold, we can recover the value of A_1 and with it, all the remaining integration constants.

- Case $\tilde{y} > \alpha^{-1}$: We proceed the same way as before, characterizing V^I in the withdrawal region. This solves the following differential equation for any $y \in (0, \bar{y}]$

$$\rho V^I = \begin{cases} r + \mu y V_1^I + \frac{\sigma^2}{2} y^2 V_{11}^I + \lambda[1 - V^I] & \text{for } \ y > \tilde{y} \\ r + \mu y V_1^I + \frac{\sigma^2}{2} y^2 V_{11}^I + \theta N(\lambda)\left[1 - V^I\right] + \lambda[1 - V^I] & \text{for } \ \alpha^{-1} < y \leq \tilde{y} \\ r + \mu y V_1^I + \frac{\sigma^2}{2} y^2 V_{11}^I + \theta N(\lambda)\left[\alpha y - V^I\right] + \lambda[1 - V^I] & \text{for } \ 0 < y \leq \alpha^{-1} \end{cases}$$

The solution to this differential equation is given by[29]

$$V^I(y) = \begin{cases} D_1 y^{\iota_1} + D_2 y^{\iota_2} + \frac{r+\lambda}{\rho+\lambda} & \text{for } \ y > \tilde{y} \\ D_3 y^{\iota_3} + D_3 y^{\iota_4} + \frac{r+\lambda+\theta N(\lambda)}{\rho+\lambda+\theta N(\lambda)} & \text{for } \ \alpha^{-1} < y \leq \tilde{y} \\ D_5 y^{\iota_3} + \frac{\theta N(\lambda)\alpha}{\rho+\lambda+\theta N(\lambda)-\mu} y + \frac{r+\lambda}{\rho+\lambda+\theta N(\lambda)} & \text{for } \ y \leq \alpha^{-1} \end{cases}$$

where ι_1, ι_2, and ι_3 are defined already, and ι_4 is the negative root of $\rho + \lambda = \mu\iota_i + \frac{\sigma^2}{2}\iota_i(\iota_i - 1) - \theta N(\lambda)$. In this case the constants D_i and A_i are jointly determined by the system (2) and the following equations:

$$D_1(\tilde{y})^{\iota_1} + D_2(\tilde{y})^{\iota_2} + \frac{r+\lambda}{\rho+\lambda} = D_3(\tilde{y})^{\iota_3} + D_4(\tilde{y})^{\iota_4} + \frac{r+\lambda+\theta N(\lambda)}{\rho+\lambda+\theta N(\lambda)}$$
$$D_1\iota_1(\tilde{y})^{\iota_1 - 1} + D_2\iota_2(\tilde{y})^{\iota_2 - 1} = D_3\iota_3(\tilde{y})^{\iota_3 - 1} + D_4\iota_4(\tilde{y})^{\iota_4 - 1}$$
$$D_3(\alpha)^{-\iota_3} + D_4(\alpha)^{-\iota_4} + \frac{r+\lambda+\theta N(\lambda)}{\rho+\lambda+\theta N(\lambda)} = D_5(\alpha)^{-\iota_3} + \frac{\theta N(\lambda)\alpha}{\rho+\lambda+\theta N(\lambda)-\mu}\alpha^{-1} + \frac{r+\lambda}{\rho+\lambda+\theta N(\lambda)}$$
$$D_3\iota_3(\alpha)^{-\iota_3+1} + D_4\iota_4(\alpha)^{-\iota_4+1} = D_5\iota_3(\alpha)^{-\iota_3+1} + \frac{\theta N(\lambda)\alpha}{\rho+\lambda+\theta N(\lambda)-\mu}$$
$$V^I(\bar{y}) = 1 + \lim_{y\to\bar{y}} \Gamma(y)$$
$$V_1^I(\bar{y}) = \lim_{y\to\bar{y}} \Gamma_1(y) + \underbrace{V_1^A(\bar{y})}_{=0}$$

This gives the final linear system of eight equations in eight unknowns that we need to solve as a function of $\tilde{y}$ and $\bar{y}$. We now turn to the value function of an uninformed agent

[28] The denominator is always strictly negative as long as it is well-defined.

[29] We already imposed that $\lim_{y\to 0} V^I(y)$ has to be finite, eliminating the term with a negative root (i.e., $D_6 = 0$).

who is monitoring. In the inaction region it will be given by[30]

$$V^A(y;\tilde{y}) = \begin{cases} B_1 y^{\beta_2} + C_1 y^{\alpha_1} + C_2 & \text{for } y_t > \tilde{y} \\ B_2 y^{\beta_3} + B_3 y^{\beta_4} + C_3 y^{\alpha_2} + C_4 y^{\alpha_3} + C_5 & \text{for } \alpha^{-1} < y_t \leq \tilde{y} \\ B_5 y^{\beta_3} + B_6 y^{\beta_4} + C_3 y^{\alpha_2} + C_4 y^{\alpha_3} + C_6 y + C_7 & \text{for } 0 < y_t \leq \alpha^{-1} \end{cases}$$

where β_2, β_3, and β_4 were previously defined. The constants B_i and C_i are the solution to the following system of equations:

$$\begin{aligned}
C_1 &= -\delta A_1(\lambda+\delta)^{-1} \\
C_2 &= \frac{r}{\rho} \\
C_3 &= -\delta A_2(\lambda+\delta)^{-1} \\
C_4 &= -\delta A_3(\lambda+\delta)^{-1} \\
C_5 &= \frac{r+\theta N(\lambda)}{\rho+\theta N(\lambda)} \\
C_6 &= \frac{\theta N(\lambda)\alpha}{\rho+\theta N(\lambda)-\mu} \\
C_7 &= \frac{r}{\rho+\theta N(\lambda)} \\
B_1(\tilde{y})^{\beta_2} + C_1(\tilde{y})^{\alpha_1} + C_2 &= B_2(\tilde{y})^{\beta_3} + B_3(\tilde{y})^{\beta_4} + C_3(\tilde{y})^{\alpha_2} + C_4(\tilde{y})^{\alpha_3} + C_5 \\
B_1\beta_2(\tilde{y})^{\beta_2-1} + C_1\alpha_1(\tilde{y})^{\alpha_1-1} &= B_2\beta_3(\tilde{y})^{\beta_3-1} + B_3\beta_4(\tilde{y})^{\beta_4-1} + C_3\alpha_2(\tilde{y})^{\alpha_2-1} + C_4\alpha_3(\tilde{y})^{\alpha_3-1} \\
B_2(\alpha)^{-\beta_3} + B_3(\alpha)^{-\beta_4} + C_5 &= B_5(\alpha)^{-\beta_3} + B_6(\alpha)^{-\beta_4} + C_6\alpha^{-1} + C_7 \\
B_2\beta_3(\alpha)^{-\beta_3+1} + B_3\beta_4(\alpha)^{-\beta_4+1} &= B_5\beta_3(\alpha)^{-\beta_3+1} + B_6\beta_4(\alpha)^{-\beta_4+1} + C_6
\end{aligned}$$

together with $\lim_{y\to\bar{y}^+} V^A(y;\tilde{y}) = 1$ and the *smooth-pasting* condition $V_1^U(\bar{y}) = 0$. Finally, imposing symmetry so that $\bar{y} = \tilde{y}$ we get that the last two conditions are equivalent to

$$\begin{aligned}
1 &= B_1(\tilde{y})^{\beta_2} + C_1(\tilde{y})^{\alpha_1} + \frac{r}{\rho} \\
0 &= B_1\beta_2(\tilde{y})^{\beta_2-1} + C_1\alpha_1(\tilde{y})^{\alpha_1-1}
\end{aligned}$$

After solving for A_1, we use these last two equations to obtain the following equilibrium threshold

$$\alpha\cdot\tilde{y} = \left[\frac{(\alpha_1-\iota_3)\left(\frac{r}{\rho}-1\right)\frac{\lambda+\delta}{\delta}\frac{\beta_2}{\beta_2-\alpha_1} - \iota_3\left(1-\frac{r+\lambda+\theta N(\lambda)}{\rho+\lambda+\theta N(\lambda)}\right)}{\iota_3\frac{\theta N(\lambda)}{\rho+\lambda+\theta N(\lambda)} + (1-\iota_3)\frac{\theta N(\lambda)}{\rho+\lambda+\theta N(\lambda)-\mu}}\right]^{\frac{1}{\iota_4}} \tag{4}$$

which exists since both the numerator and denominator are strictly positive. Having solved for the equilibrium threshold, we can recover the value of A_1 and with it, all the remaining integration constants.

Step 2. Having characterized the value function through obtaining the two candidate thresholds, we can show that the function

$$V(\bar{y}) \equiv V^A(\bar{y};\bar{y}) = \begin{cases} \frac{r}{\rho} - \frac{\delta}{\lambda+\delta}\frac{\beta_2-\alpha_1}{\beta_2}\frac{1}{\alpha_1-\iota_3}\left(\iota_3\left(1-\frac{r+\lambda}{\rho+\lambda+\theta N(\lambda)}\right) + (1-\iota_3)\frac{\theta N(\lambda)\alpha}{\rho+\lambda+\theta N(\lambda)-\mu}\bar{y}\right) & \text{for } \bar{y} \leq \alpha^{-1} \\ \frac{r}{\rho} - \frac{\delta}{\lambda+\delta}\frac{\beta_2-\alpha_1}{\beta_2}\frac{1}{\alpha_1-\iota_3}\left(\iota_3\left(1-\frac{r+\lambda+\theta N(\lambda)}{\rho+\lambda+\theta N(\lambda)}\right) + (\alpha\bar{y})^{\iota_4}\left(\iota_3\frac{\theta N(\lambda)}{\rho+\lambda+\theta N(\lambda)} + (1-\iota_3)\frac{\theta N(\lambda)}{\rho+\lambda+\theta N(\lambda)-\mu}\right)\right) & \text{for } \alpha^{-1} < \bar{y} \end{cases}$$

[30] I use the fact that $\lim_{y\to\infty} V^A(y;\tilde{y}) = r/\rho$ as a border condition already.

is continuous and strictly increasing over $(0,\infty)$. Then, as long as $V(0)<1$ and $V(\infty)>1$, there exists a unique $\tilde{y}$ such that $V(\tilde{y})=1$. Then, we need

$$V(0)=\frac{r}{\rho}-\frac{\delta}{\lambda+\delta}\frac{\beta_2-\alpha_1}{\beta_2}\frac{1}{\alpha_1-\iota_3}\iota_3\left(1-\frac{r+\lambda}{\rho+\lambda+\theta N(\lambda)}\right)<1$$
$$V(\infty)=\frac{r}{\rho}-\frac{\delta}{\lambda+\delta}\frac{\beta_2-\alpha_1}{\beta_2}\frac{1}{\alpha_1-\iota_3}\iota_3\left(1-\frac{r+\lambda+\theta N(\lambda)}{\rho+\lambda+\theta N(\lambda)}\right)>1$$

The second condition holds since we have $r>\rho$. As for the first inequality, note that it is equivalent to

$$\frac{(\alpha_1-\iota_3)\left(\frac{r}{\rho}-1\right)\frac{\lambda+\delta}{\delta}\frac{\beta_2}{\beta_2-\alpha_1}-\iota_3\left(1-\frac{r+\lambda}{\rho+\lambda+\theta N(\lambda)}\right)}{(1-\iota_3)\frac{\theta N(\lambda)\alpha}{\rho+\lambda+\theta N(\lambda)-\mu}}>0$$

since the denominator is always negative and $\min\{(\alpha_1-\iota_3)\beta_2,\beta_2-\alpha_1\}>0$. This means that as long as the expression obtained for the threshold in the lower region is strictly positive an equilibrium exists. Moreover, we can reduce it to

$$\frac{\rho+\theta N(\lambda)+\frac{\delta+\lambda}{\delta}\frac{\iota_3-\alpha_1}{\beta_2-\alpha_1}\frac{-\beta_2}{\iota_3}(\rho+\lambda+\theta N(\lambda))}{\left(1+\frac{\delta+\lambda}{\rho\delta}\frac{\iota_3-\alpha_1}{\beta_2-\alpha_1}\frac{-\beta_2}{\iota_3}(\rho+\lambda+\theta N(\lambda))\right)}>r$$

which determines a strictly positive upper bound for the interest rate r.

Step 3. Finally, we show that any stationary monotone equilibrium must have a unique symmetric threshold. We prove it by contradiction following Lemma 4 in He and Xiong (2012). Suppose that there exists an asymmetric monotone equilibrium. Then, there exist at least two groups of depositors who use two different monotone strategies with thresholds $\tilde{y}_1<\tilde{y}_2$. Let γ be the set containing all equilibrium thresholds. Let i denote the type of depositor that uses threshold $\tilde{y}_i$, with corresponding value when being attentive $V^{A,i}(y;\gamma)$. At the corresponding thresholds, we must have

$$V^{A,1}(\tilde{y}_1;\gamma)=V^{A,2}(\tilde{y}_2;\gamma)=1$$

and then

$$V^{A,1}(\tilde{y}_2)=V^{A,2}(\tilde{y}_1)=1$$

since both creditors are free to switch between these two strategies. Then, for all $y\in[\tilde{y}_1,\tilde{y}_2]$, we must have $V^{A,1}(y)=V^{A,2}(y)=1$. Otherwise the threshold strategies cannot be optimal. This implies that each creditor is indifferent between choosing any threshold in the set $[\tilde{y}_1,\tilde{y}_1]$. Denote by $m(y)$ the measure of creditors who use a threshold lower than $y\in[\tilde{y}_1,\tilde{y}_2]$. Then, $V^{A,i}$ has to satisfy the following HJB equation for all y in this region:

$$\rho V^{A,i}(y)=r+\mu y V_1^{A,i}+\frac{\sigma^2}{2}y^2V_{11}^{A,i}+\delta\left[V^{I,i}(y;\gamma)-V^{A,i}(y;\gamma)\right]$$
$$+\theta N(\lambda)m(y)\left[\min\{1,\alpha y\}-V^{A,i}(y;\gamma)\right]$$

Since $V^{A,i}(y)=1$ for any $y\in[\tilde{y}_1,\tilde{y}_2]$, we have

$$\rho=r+\delta\left[V^{I,i}(y;\gamma)-1\right]+\theta N(\lambda)\zeta(y)\left[\min\{1,\alpha y\}-1\right]$$

Since $m(y)$ and $\min\{1,\alpha y\}$ are non-decreasing in y and $V^{I,i}(y;\gamma)$ is monotonically increasing in y this equation cannot hold for all $y\in[\tilde{y}_1,\tilde{y}_2]$ since $r>\rho$ by assumption.

A.5 Proof of Proposition 4

An equilibrium with $\tilde{y} > 0$ exists as long as the expression in (3) is strictly positive. Take that as a starting point. A necessary condition is that $r < \rho + \theta N(\lambda)$, which does not hold for small values of λ since $r > \rho$. Then, since the expression in (3) is continuous in λ and becomes negative as λ approaches zero, it must be that the unique equilibrium threshold is strictly increasing and below α^{-1} for small values of λ.

As for the second part, it is also true that the expression in (3) becomes negative for large enough values of λ, implying that the unique equilibrium threshold must be decreasing and below α^{-1} eventually. This follows from rewriting equation (3) as follows

$$\tilde{y} = \frac{\left(\frac{\alpha_1}{\iota_3} - 1\right)\left(\frac{r}{\rho} - 1\right)\frac{\lambda+\delta}{\delta}\frac{\beta_2}{\beta_2-\alpha_1} - \left(1 - \frac{r+\lambda}{\rho+\lambda+\theta N(\lambda)}\right)}{\left(\frac{1}{\iota_3} - 1\right)\frac{\theta N(\lambda)\alpha}{\rho+\lambda+\theta N(\lambda)-\mu}}$$

and noting that the denominator will be always strictly negative, while the numerator becomes arbitrarily large as λ grows. Since the equilibrium threshold is unique and continuous in λ, this concludes the proof showing that when λ is small enough the equilibrium threshold lies on $(0, \alpha^{-1})$ and is increasing in λ, whereas for large values of λ it is decreasing and eventually becomes below α^{-1}.

A.6 Proof of Corollary 1

We know the expression for the equilibrium threshold becomes negative if $\theta N + \rho < r$, implying that it must be increasing in N for low enough values of it. To see the behavior in the limit we have to consider both possible expressions for the threshold. If we consider that for $\tilde{y} < \alpha^{-1}$, we obtain the following

$$\begin{aligned}\lim_{N\to\infty} \tilde{y} &= \lim_{N\to\infty} \alpha^{-1} \cdot \frac{\left(\frac{\alpha_1}{\iota_3} - 1\right)\left(\frac{r}{\rho} - 1\right)\frac{\lambda+\delta}{\delta}\frac{\beta_2}{\beta_2-\alpha_1} - \left(1 - \frac{r+\lambda}{\rho+\lambda+\theta N(\lambda)}\right)}{\left(\frac{1}{\iota_3} - 1\right)\frac{\theta N(\lambda)}{\rho+\lambda+\theta N(\lambda)-\mu}} \\ &= \alpha^{-1} \cdot \left[\left(\frac{r}{\rho} - 1\right)\frac{\lambda+\delta}{\delta}\frac{\beta_2}{\beta_2-\alpha_1} + 1\right] < \alpha^{-1}\end{aligned}$$

which, given our existence proof, implies that the limiting equilibrium threshold exists and is below the recovery value α^{-1}.

A.7 Proof of Proposition 5

This is a small variation of the two-period model. Consider the threshold that determines whether all attentive depositors run at $t = 0$ or not. This is determined by equating the following two expressions:

$$\begin{aligned}V_0^{\text{wait}}(y_0) &= \theta\lambda_0 \min\{1, \alpha y_0\} + (1 - \theta\lambda_0)\beta\left[r + \mathbb{I}_{y_1 \le \tilde{y}_1} V_1^{\text{run}}(y_1; \lambda_1, \lambda_0) + \mathbb{I}_{y_1 > \tilde{y}_1}\beta(1+r)\right] \\ V_0^{\text{run}}(y_0) &= (1 - \theta\lambda_0) + \theta\lambda_0\left(\zeta + (1-\zeta)\min\{1, \alpha y_0\}\right)\end{aligned}$$

where $\tilde{y}_1$ and v_1^{run} are as defined in the main text with $N_0 = \lambda_0$. This gives the following threshold for any $y_1 < \tilde{y}_1$:

$$\tilde{y}_0 := \begin{cases} \frac{1}{\alpha}\left(1 - \frac{(1-\theta\lambda_0)\left(\beta(V_1^{\text{run}}(y_1;\lambda_1,\lambda_0)+r)-1\right)}{\theta\lambda_0\zeta}\right) & \text{if } \beta(V_1^{\text{run}}(y_1;\lambda_1,\lambda_0)+r) - 1 > 0 \\ \infty \quad \text{ow.} \end{cases}$$

where the unbounded case is the equilibrium where even without failure it is not profitable to stay in the bank. Note that

$$\frac{\partial V_1^{\text{run}}}{\partial \lambda_1} = (1-\lambda_0)\theta(1-\zeta)(\alpha y_1 - 1) < 0$$

is increasing in y_1. Finally, we conclude by noting that $\tilde{y}_0$ is decreasing in V_1^{run} and otherwise independent of λ_1 and y_1.

B Appendix: Model with Heterogeneity

B.1 Information Reach and Deposit Base Composition

Developments from The Digital Era such as cellphones and the internet may have allowed certain "captive" depositors to start monitoring their bank. We study this possibility in this section.

Consider that the share of depositors that get informed, as described in the previous model, is $1-\nu$ with $\nu \in (0,1)$. This means that we have a measure ν of depositors who do not monitor the bank at all. This means that, during a run, there would be a lower measure of depositors making withdrawals, decreasing the *running intensity*. We introduce that in the model with a failure rate $\theta \cdot (1-\nu) \cdot N(\lambda)$ proportional to the measure of attentive agents. In the HJB equation of an attentive depositor, it looks as follows

$$\begin{aligned}\rho V^A(y_t;\tilde{y}) = r + \mu y_t V_1^U(y_t;\tilde{y}) + \frac{\sigma^2}{2} y_t^2 V_{11}^A(y_t;\tilde{y}) + \delta\left[V^I(y_t;\tilde{y}) - V^U(y_t;\tilde{y})\right] \\ + \theta(1-\nu)N(\lambda)I_{\{y_t \leq \tilde{y}^A\}}\left[\min\{1,\alpha y_t\} - V^A(y_t;\tilde{y})\right]\end{aligned}$$

What happens then when new information technologies allow some "captive" depositors to inform themselves? For simplicity consider that they do with the same technology as the other $1-\nu$ creditors of the bank. This maps into decreasing ν in the previous equation, increasing the *running intensity* and, hence, the failure rate while not affecting the asset side of the bank at all.[31] Then, we know that the equilibrium threshold will surely increase, making the bank more fragile as runs are more likely and intense.

Consider now that these "captive" depositors do get informed about the bank, but they do so at a much lower frequency. How does equilibrium behavior change when new technologies allow them to get informed as well as "experts"? This is different because now "captive" depositors are not inactive before the technological change and, hence, improving their monitoring technology might make them less reluctant to run.

For simplicity, we focus on an extreme case. Say $1-\nu$ depositors can monitor the bank continuously with a technology of $\lambda' = \infty$, while the remaining ν depositors do so intermittently with $\lambda \in \mathbb{R}_{++}$. We call them "expert" and "captive" depositors, respectively. For illustration purposes, consider $\lim_{x\to\infty} N(\infty) = 1$ and define the failure rate as a weighted average of $N(\lambda^i)$. Following the same steps as with the previous model, we guess and verify that each type of agent will run if and only if the most recent observed signal is below some threshold $\tilde{y}^i$, where $i \in \{\lambda, \infty\}$ indexes the type. Trivially, $\tilde{y}^\lambda > \tilde{y}^\infty$ since the agents with $\lambda = \infty$ do not face any *inattention risk*. This additional source of risk makes uninformed agents less likely to keep

[31] Note that we again focus on comparing steady-state outcomes here. The intuition for the short-run is identical.

their deposits in the bank. Let $\gamma = \{\tilde{y}^{\lambda}, \tilde{y}^{\infty}\}$. Then, at any point in time, the value function of a captive depositor who is monitoring and chooses a threshold $\bar{y} > 0$ in the continuation region is given by

$$\begin{aligned}\rho V^A(y_t;\gamma) = r + \mu y_t V_1^A(y_t;\gamma) + \frac{\sigma^2}{2} y_t^2 V_{11}^A(y_t;\gamma) + \delta\left[V^I(y_t;\gamma) - V^A(y_t;\gamma)\right] \\ + \theta\left((1-\nu) I_{\{y_t \leq \tilde{y}^{\infty}\}} + \nu N(\lambda) I_{\{y_t \leq \tilde{y}^{\lambda}\}}\right)\left[\min\{1, \alpha y_t\} - V^A(y_t;\gamma)\right]\end{aligned}$$

which is C^2 and satisfies $\lim_{y \to \bar{y}+} V^A(y;\gamma) = 1$. Note that there is only one key difference in this differential equation concerning the one for the model with homogeneous depositors. The term $\left[\min\{1, \alpha y_t\} - V^A(y_t;\gamma)\right]$ that reflects the potential loss under the bank's failure is now multiplied by a different failure rate, which increases for lower values of the bank's assets. This is because of two reasons. First, not all depositors run simultaneously because they have different running incentives. Second, and in contrast with captive depositors, all those depositors who continuously monitor the bank will run simultaneously and only when the bank is facing severe difficulties. In this lower region, the failure rate is proportional to the weighted average of the fraction of expert and captive agents that monitor the bank at any time, as those are the ones that will put the bank in the greatest distress. This reflects the fact that, once $\nu > 0$, decreasing it leads to a lower *running intensity* when the bank starts facing distress and but increases it more so when the bank is in the most danger of failure.

Analogously, the value function of an agent with $\lambda = \infty$ who chooses a threshold $\bar{y} > 0$ is, in the continuation region, given by

$$\begin{aligned}\rho V^{\infty}(y_t;\gamma) = r + \mu y_t V_1^{\infty}(y_t;\gamma) + \frac{\sigma^2}{2} y_t^2 V_{11}^{\infty}(y_t;\gamma) \\ + \theta\left((1-\nu) I_{\{y_t \leq \tilde{y}^{\infty}\}} + \nu N(\lambda) I_{\{y_t \leq \tilde{y}^{\lambda}\}}\right)\left[\min\{1, \alpha y_t\} - V^{\infty}(y_t;\gamma)\right]\end{aligned}$$

which is C^2 and satisfies $\lim_{y \to \bar{y}^+} V^{\infty}(y;\gamma) = 1$. The main difference with the previous expression is that the term reflecting the risk of becoming inattentive is not present in this differential equation.

We solve for the equilibrium numerically. It can be shown that any stationary monotone equilibrium with runs must have unique thresholds for each type and exhibit $(\tilde{y}^{\lambda}, \tilde{y}^{\infty}) >> 0$.[32] An illustration of such an equilibrium can be found in Figure **??**. The main difference with that in Figure 1 is that here two different shaded areas mark the different *running intensities* that a bank faces during a run. The light red region represents that only those with the worse technology run. A measure $\nu \cdot \lambda/(\lambda + \delta)$ of them suddenly withdraws their money from the bank as soon as the bank's assets touch $\tilde{y}^{\lambda}$, and a fraction λdt per unit of time of the remaining captive depositors become aware of the bank's situation and withdraws their deposits during the run. Moreover, as soon as the bank's assets touch $\tilde{y}^{\infty}$, all those who continuously monitor the bank cash out their deposits, putting the bank in quite a fragile situation reflected in a higher failure rate in the dark red region.[33]

Concerning the simulations, one key difference emerges. The bank that fails does recover deposits at some point during the run. This is because its portfolio improves enough so that

[32] Proofs and derivations for this model are available upon request.

[33] These features are consistent with depositors that are better informed only withdrawing when the bank faces severe difficulties while others run even for smaller shocks Iyer et al. (2016).

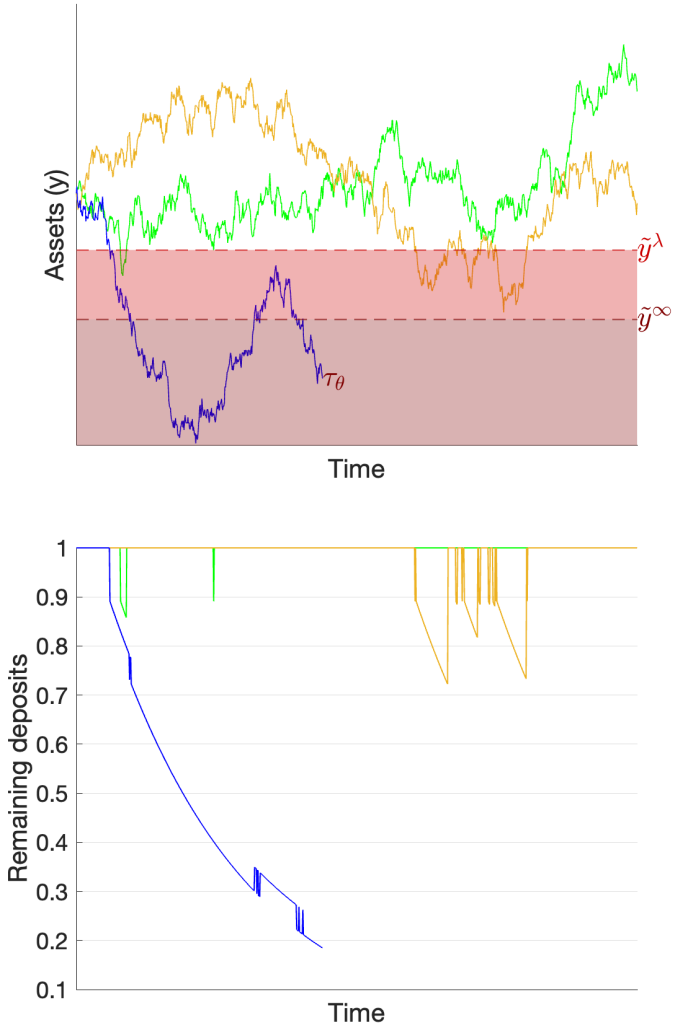


Figure 6: Simulated paths for the bank's assets and the corresponding equilibrium outcomes in an economy with two types of depositors, varying in their degree of exposure to *inattention risk*. Agent's thresholds are denoted according to the frequency with which they exit inattention $i \in \{\infty, \lambda\}$. Shaded areas represent the regions where the bank might fail at a random time that we denote τ_θ as it depends on the running intensity and the availability of credit lines θ.

depositors continuously monitoring the bank have incentives to deposit back their money. However, the bank's assets deteriorate again and eventually it fails.

We are now ready to answer the question that motivated studying the extended model. We want to know how equilibrium outcomes change when the fraction ν of captive depositors decreases, reflecting that some of them become able to monitor the bank more frequently. We show the resulting equilibrium thresholds in figure 7 for various values of ν. We observe that the impact on $\tilde{y}^{\lambda}$ is again non-monotonic.[34] At the beginning, increasing the fraction of experts increases the frequency of runs as it raises the fraction of agents that will be aware of a run and

[34]Note that looking at this threshold tells us for which values of its portfolio we will have a run on the bank as these agents (at least those of them who are attentive) are the first to run. We omit presenting a plot for the other one as their qualitative behavior concerning ν, except for that shown in the second plot of figure 7, is identical.

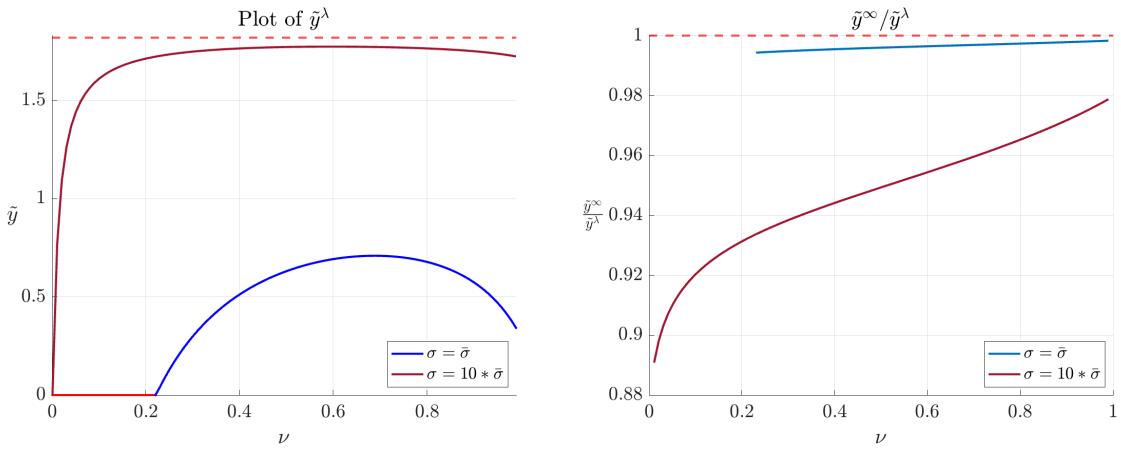


Figure 7: Equilibrium outcomes for $\nu \in (0, 1)$ at two volatility levels when depositors have different technologies to get informed. The red line marks that the only equilibrium is that of no runs for the corresponding case. We use $N(x) = x/(x + \delta)$.

withdraw at the very beginning of it. However, once the measure of experts is large enough, we see that increasing it results in a decreased frequency of runs up to the point that they are eliminated. Up to this point, the previous effect becomes less strong since experts will wait considerably longer to run when the *running intensity* of captive agents is small. Precisely for that reason, now the fact that increasing the share of experts decreases the *running intensity* of those that run first becomes the dominant effect, resulting in a decreased running threshold. The idea is that increasing the share of experts makes depositors in general less concerned about the running behavior of those more prone to run. This is key because these agents are the ones that generate the run in the first place, since an expert always has an incentive to wait a little longer than others when captives do not run. This is exactly what Theorem 3 illustrates.

In general, however, we do not expect that increasing the share of experts in a bank's portfolio will eliminate runs, as these may not have such a superior technology. Yet, the same intuition follows. In a way, that of the main model applies here: at first, increasing the access to information for the average depositor raises rollover concerns and, hence, the likelihood of a run, but eventually, the decreased exposure to *inattention risk* for the average depositor dominates, decreasing the equilibrium threshold.[35]

Increasing the fraction of informed agents almost mechanically increases the *running intensity* in the region where the bank is the most vulnerable. At the same time, it decreases it in the one where only captive depositors run since there will be less of them monitoring the bank. The distance between both thresholds also increases as the experts face less risk from waiting during a run since captive depositors put less pressure on the bank. Further, the running thresholds do not respond monotonically to increases in the share of experts in the bank's portfolio. It is then unclear how a bank's stability will be impacted by this.

[35]Though based on a different mechanism, this result aligns with Schotter and Yorulmazer (2009), which suggests that depositors with inside information affect the dynamics of bank runs and can help mitigate their severity.

B.2 Non-monotonic Running Frequency and Heterogeneity

We now take a closer look at how heterogeneity in the depositor base can affect our main result. The model is as described in the previous section with a fraction $1-\nu$ of depositors that have a higher, but finite, entry rate into attention λ_H. Both type of agents share the same attention span given by δ. Let $\tilde{y}^H$ be the optimal running threshold of the type H depositors and $\tilde{y}^L$ that of the type L. We consider two simple types of heterogeneity and compare the result to those of the main model with average entry rate λ and threshold $\tilde{y}$. First, if the heterogeneity is of the form $\lambda_H = \lambda + h$ and $\lambda_L = \lambda - h$, both thresholds typically follow the behavior $\tilde{y}$ as λ increases, reaching the decreasing part later on. Although the region for which an equilibrium with runs exists is larger, both $\tilde{y}^H$ and $\tilde{y}^L$ converge fast to $\tilde{y}$ as $\lambda \to \infty$. This is because the heterogeneity vanishes as λ becomes large.

A more interesting case is that with $\lambda_H = \lambda*(1+h)$ and $\lambda_L = \lambda*(1-h)$ with $h \in (0,1)$. We can see in figure 8 how the thresholds behave compared to the case with $h = 0$. As heterogeneity does not vanish with $\lambda \to \infty$, we see that it takes much longer for bank runs to decrease in frequency. Note that λ_H increases more rapidly than λ_L, making informed depositors of type L increasingly concerned about the inattention span of experts of type H. This effect maintains a high willingness to hedge from the behavior of experts, resulting not only on a higher running threshold relative to $\tilde{y}$ but a running frequency that takes considerably longer to reach low levels.

Although the main result follows through, it is clear that this type of heterogeneity that makes technological progress to not close the gap between experts and informed depositors considerably delays the rate at which running thresholds decrease. Taking this into account is crucial when making predictions about current and future running behavior as technological progress advances. In addition, it highlights how banks can be differentially affected by technological progress at a specific point in time if the composition of their deposit base is more dispersed.

C Appendix: Digital Banking

In practice, digitalization has also transformed the way banks deliver services to their creditors-particularly by improving accessibility for initiating transactions and by reducing processing times. We interpret these developments as factors that shorten the time between a depositor's decision to withdraw and the actual receipt of funds. This reduction may stem from technological advancements such as Real-Time Payments (RTP), which accelerate processing, or from improved accessibility, which enables depositors to quickly issue withdrawal orders once they decide to act.

We solve the model using $\zeta < \infty$: it takes a random delay $Z \sim \exp(\zeta)$ to receive the funds when deciding to withdraw. The idea is that since the moment the depositor decides to withdraw based on the information it has about the bank's assets, it may take some time until it is able to communicate to the bank this desire as well as for the bank to process the transaction and deliver the funds as required. Then, technologies that facilitate placing withdrawal orders as well as speeding up processing times increase ζ. Our main model is the version where $\zeta = \infty$.

We assume that the decision to withdraw is irreversible-once a depositor takes action to place a withdrawal order, it cannot cancel this decision. We impose this assumption since generally

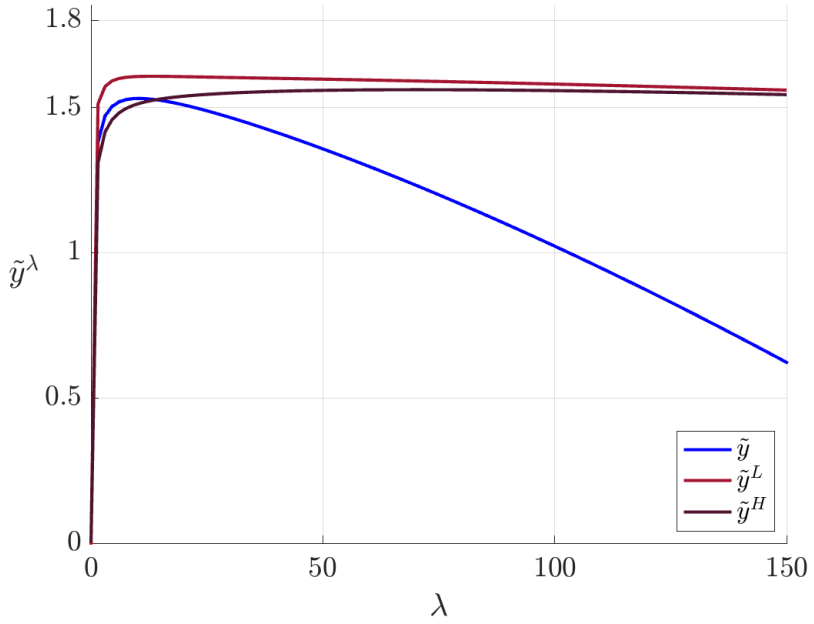


Figure 8: Equilibrium thresholds as a function of λ: homogeneous vs heterogeneous deposit base. We use $\lambda_H = \lambda(1+h)$ and $\lambda_L = \lambda(1-h)$ with $h = 0.9$. Other parameters are as in the standard calibration except for $\nu = 0.5$ and $\sigma = 5\bar{\sigma}$. We use $N(x) = x/(x+\delta)$.

withdrawal orders are not easy to cancel and agents rarely change their minds with respect to this type of decision. This will bring an extra force to be discussed later: a lock-in effect. In addition, we assume that the depositor receives rents until it actually receives the funds.

In this case, we allow the failure rate in a run to be a generic function $\theta N(\lambda, \zeta)$. We look for a monotone stationary equilibrium again. Let $\mathcal{T}$ be the set of admissible stopping times based on the depositor's information. Given the process for the random time at which the bank fails τ_θ, governed by the others' optimal stopping decisions, the problem of each agent that is attentive at t is given by

$$V^A = \max_{\tau \in \mathcal{T}} \mathbb{E}\left\{ \int_t^{\min\{\tau,\tau_\theta,\tau_\delta\}} e^{-\rho(s-t)} r ds + e^{-\rho(\min\{\tau,\tau_\theta,\tau_\delta\}-t)} \left[\min\left(1, \alpha y_{\tau_\theta}\right) I_{\{\min\{\tau,\tau_\delta\}>\tau_\theta\}} \right.\right.$$
$$\left.\left. + I_{\{\tau<\min\{\tau_\theta,\tau_\delta\}\}} V^W(y_\tau) + V^I\left(y_{\tau_\delta}\right) I_{\{\tau_\delta<\min\{\tau_\theta,\tau\}\}} \right] \mid \mathcal{F}_t \right\}$$

where $V^I(\cdot)$ reflects the value function of a depositor the moment it becomes inattentive and $V^W(\cdot)$ is the value of placing a withdrawal order. Now V^A solves

$$\rho V^A(y_t;\tilde{y}) = r + \mu y_t V_1^A(y_t;\tilde{y}) + \frac{\sigma^2}{2} y_t^2 V_{11}^A(y_t;\tilde{y}) + \delta\left[V^I(y_t;\tilde{y}) - V^A(y_t;\tilde{y})\right]$$
$$+ \theta N(\lambda,\zeta) I_{\{y_t \le \tilde{y}\}}\left[\min\{1, \alpha y_t\} - V^A(y_t;\tilde{y})\right]$$

with $\lim_{y\to\bar{y}+} V^A(y;\tilde{y}) = V^W(\bar{y};\tilde{y})$ and $\tilde{y}$ being the running threshold of all other depositors. The payoff when placing a withdrawal order is given by

$$V^W(y_t) = \mathbb{E}\left[\int_t^{\min\{\tau_\theta,\tau_\zeta\}} r e^{\rho(s-t)} ds + e^{-\rho(\min\{\tau_\theta,\tau_\zeta\}-t)} \left[\min\left(1, \alpha y_{\tau_\theta}\right) I_{\left\{\tau_\zeta>\tau_\theta\right\}} + I_{\left\{\tau_\zeta<\tau_\theta\right\}} \right] \mid y_t \right]$$

and solves

$$\rho V^W(y_t;\tilde{y}) = r + \mu y_t V_1^W(y_t;\tilde{y}) + \frac{\sigma^2}{2} y_t^2 V_{11}^W(y_t;\tilde{y}) + \zeta\left[1 - V^W(y_t;\tilde{y})\right]$$
$$+ \theta N(\lambda,\zeta) I_{\{y_t \le \tilde{y}\}}\left[\min\{1, \alpha y_t\} - V^W(y_t;\tilde{y})\right]$$

with border conditions $\lim_{y\to\infty} V^W(y) = \zeta(\rho+\zeta)^{-1}$ and $\lim_{y\to 0} V^W(y) \in \mathbb{R}_{++}$. Note that these equations reflect the crucial differences between this setting and the main model of the paper. First, the outside option of an attentive depositor is now endogenous, incorporating the risk of failure a depositor faces while waiting to receive its funds.[36] Second, the failure rate in a run now incorporates, through its dependence on ζ, that the amount of effective withdrawals does not depend only on the fraction of attentive depositors but on the speed the bank must provide them with the funds.

In figure 9 we illustrate the effects of increasing ζ while keeping the failure rate $\theta \cdot N$ constant. In case ζ is close to zero withdrawing a little sooner than others still leaves the depositor heavily exposed to failure risk and makes it loose the option value. Then, increasing processing times give more value to placing a withdrawal order when the bank is in distress since it makes withdrawing before bank failure actually possible. This makes agents more willing to run, thus raising the running threshold and making bank runs more likely. Once ζ is large enough, increasing it results in a reduced frequency of runs by decreasing the chance of receiving a low liquidation payoff in case the bank fails while the transaction is being processed. Reducing this *delay risk* makes agents more tolerant and, hence, willing to wait a little longer while the banks assets deteriorate since they will receive their funds fast once they decide to withdraw. However, this channel is not as powerful as that of decreasing the exposure to *inattention risk* since the limit case with $\zeta = \infty$ does not necessarily exhibit no runs.[37] This is because, even under instantaneous withdrawals, sufficient exposure to *inattention risk* makes depositors to preemptively withdraw funds before others do in case $\tilde{y}$ is close enough to zero. Whether this channel will dominate depends on the functional form of $N(\zeta)$.

We expect as well that decreases in processing times will increase failure risk by giving banks less time to obtain the necessary funds to service withdrawals. This means that N should be an increasing function of ζ. A higher failure rate as a result of reduced processing times will typically increase running incentives in equilibrium. This makes the impact of digital banking on running frequency not obvious, even for large values of ζ.

We display in figure 10 the results of a specification in which N is increasing in ζ and converges to the fraction of attentive agents as it approaches infinity. In the long-run increases in ζ reduce the frequency of runs since the impact it has on the failure rate is small. However, we do not expect this qualitative behavior to be true in general, even in a setting where N is an increasing function of ζ that satisfies $\lim_{\zeta\to\infty} N \in \mathbb{R}_{++}$. Although we can show that the threshold will be increasing in ζ for low enough values of it, its behavior in the short- and long-run will heavily depend on the functional form used for N and the parameters chosen.[38] In contrast with reducing the exposure to *inattention risk*, the effect of reducing *delay risk* is naturally limited, making it less strong of a channel.

[36] Strictly speaking the value of a dollar outside of the bank is still normalized to one, what is endogenous is the payoff when placing a withdrawal order.

[37] Recall that the main model exhibits no runs in equilibrium under perfect information (i.e. $\lambda = \infty$) as long as the failure rate remains finite.

[38] We can show that for high enough values of σ the threshold will decrease with ζ eventually since a higher failure rate would decrease running incentives. Otherwise, since both effects (i.e. reduced *delay risk* and increased *running risk*) have limited impact on $\tilde{y}$ in the long-run the speed of convergence becomes crucial.

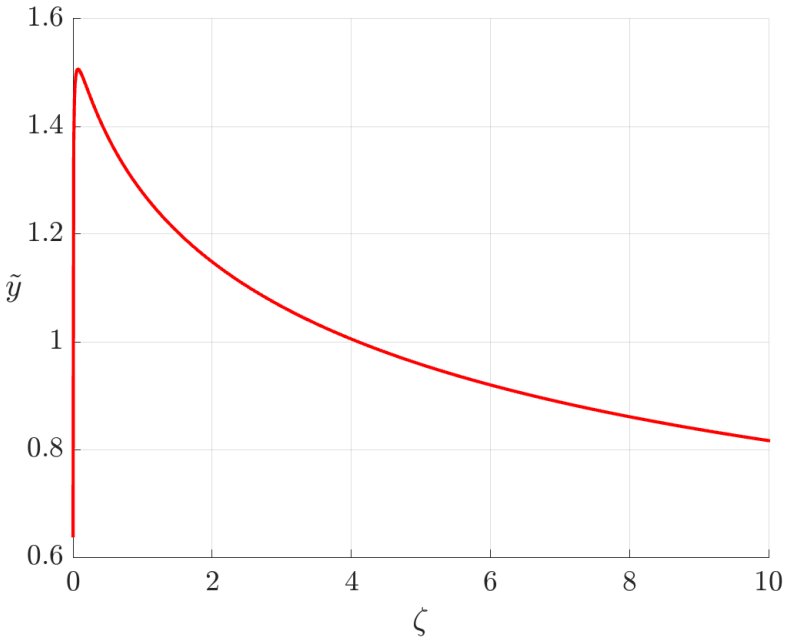


Figure 9: Equilibrium threshold $\tilde{y}$ as a function of ζ with a fixed failure rate $\theta N = \theta\lambda/(\lambda + \delta)$. Other parameters are according to the standard calibration. The curve converges to the threshold under immediate withdrawals.

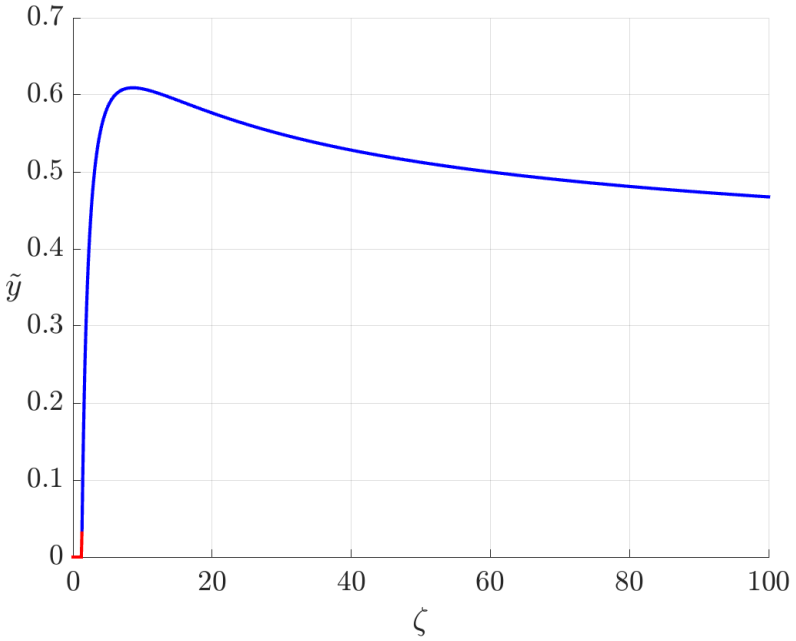


Figure 10: Equilibrium threshold $\tilde{y}$ as a function of ζ with a failure rate $N = \lambda(\lambda+\delta)^{-1} \cdot (\zeta(1+\zeta)^{-1})^2$. Other parameters are according to the standard calibration. The curve converges to the threshold under immediate withdrawals. The red line is the zone where the only equilibrium is that without runs.