Banking on Resolution: Portfolio Effects of Bail-in vs. Bailout*

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Abstract

This paper investigates the impact of supervisory resolution tools– bail-ins and bailouts– on banks' ex-ante portfolio choice and ex-post default probabilities in response to idiosyncratic and systematic shocks. Banks adjust their short-term and long-term risky investments based on anticipated resolution policies. I find that both types of shocks can create financial fragility, which the two resolution tools address distinctly. Creditor bailouts, acting like deposit insurance, eliminate the equilibrium with bank defaults. Bail-ins, on the other hand, lead to ex-ante portfolio composition adjustments: they reduce solvency risk under idiosyncratic risk but increase liquidity risk when both idiosyncratic and systematic risks are present, increasing the likelihood of systemic defaults.

JEL Classification: G21, G28, G33

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1 Introduction

Despite strong political and regulatory support for bail-in resolution policies, scholars such as Avgouleas (2015) caution that bail-ins may pose stability concerns, particularly in the presence of systemic risk. Recent cases demonstrate that supervisors may prefer bailouts in situations of contagion, economic downturns, or when retail investors hold bail-inable debt.[1] This paper argues that bail-ins aim to reduce bank risk-taking by altering expected payoffs, encouraging portfolio reallocations that reduce insolvency risk but increase liquidity risk, potentially triggering fire sales. In contrast, creditor bailouts lower funding costs and prevent defaults, reducing financial fragility without altering shareholder payoffs.

I model a large number of banks operating over two periods, financed through insured short-term debt and fairly-priced long-term debt. Banks allocate funds between a short-term asset with idiosyncratic risk, creating heterogeneity in liquidity and solvency, and a common long-term asset that introduces systematic risk. The common asset is tradable and provides liquidity, but exposes banks to correlated shocks. Bank defaults incur deadweight losses, justifying supervisory intervention through creditor bailouts or bail-ins. Although this paper focuses on banks, by treating the liability side of banks as exogenous and abstracting from banking regulations, the model can also apply to financial intermediaries primarily engaged in asset management. This broader framework allows for analyzing financial stability in sectors outside traditional banking, providing insights into how non-bank financial institutions respond to shocks and resolution policies.

The key aspects of the model are: first, banks balance liquidity risk against insolvency risk when choosing the composition of their portfolios. Second, bank portfolios are opaque. Third, as funding costs rise, banks choose riskier portfolios. As for the portfolio composition trade-off, after short-term returns are realized in the first period, banks may need to sell long-term assets to meet short-term debt. While more short-term holdings raise market

[1] See the Word Bank's case study for a selection of bank resolution cases in the EU after the Global Financial Crisis (Andersen et al., 2017).

liquidity and the cash-in-the-market price, they reduce long-term assets available for sale and second-period returns, increasing insolvency risk. Conversely, higher long-term holdings depress asset prices, raising liquidity risk. Banks balance these two risks when making portfolio decisions.

Second, with opaque portfolios, the cash-in-the-market price of the long-term asset and the gross return, creditors require for the long-term debt, depend on market beliefs about banks' portfolio compositions. When the market assumes banks hold a large amount of short-term assets, it expects higher liquidity and market prices, but greater insolvency risk, leading creditors to demand higher returns. Conversely, if the market believes banks hold fewer short-term assets, it anticipates lower prices, but reduced insolvency risk, which prompts creditors to adjust their required returns, accordingly.

Third, when banks face multiple equilibrium portfolio choices, they choose the option that maximizes expected second-period profits. Optimistic market beliefs lower long-term funding costs, making the safer portfolio more profitable and thus preferred by banks. However under pessimistic market views, long-term funding costs rise, and banks opt for the riskier portfolio. This interaction between market beliefs and bank choices can create multiple equilibria: one where the market anticipates banks to remain solvent and banks choosing a short-term investment that leads to no defaults. In another equilibrium, the market expects bank default, raising the gross return on long-term debt. In this case, banks invest in a portfolio that results in defaults after a negative shock. I interpret the self-fulfilling market beliefs that generate multiple equilibria as a source of financial fragility.

In the presence of financial fragility in laissez-faire, I show that the prospect of creditor bailouts, where the supervisor insures long-term debt, does not change the banks' ex-ante portfolio payoff, since shareholders do not directly benefit from the bailout. However, bailouts lower long-term funding costs as the creditors are fully repaid. These lower funding costs incentivize banks to choose safer portfolios, eliminating the equilibrium with bank defaults. The reduction in financial fragility and bank defaults holds under both idiosyncratic and systematic risk.

In contrast, bail-ins, where long-term debt is converted into equity, impact both ex-ante shareholders' expected payoffs and the return creditors require. By preventing ex-post defaults, bail-ins preserve value by avoiding deadweight losses. Creditors, now equityholders, are better off compared to laissez-faire and demand lower returns. Shareholders, who receive positive payoffs in states where they would have otherwise defaulted, change the ex-ante portfolio composition of their portfolios, internalizing the insolvency risk of their portfolio choice. The combination of lower funding costs and portfolio reallocation has distinct effects under idiosyncratic versus systematic risk.

In the baseline model without aggregate risk, the short-term asset has uncertain idiosyncratic returns, while the long-term asset is safe. Bail-in expectations lead banks to choose a less risky portfolio. However, receiving positive payoffs following a bail-in, they still may prefer a risky portfolio over a safe one. In other words, in anticipation of bail-ins, banks choose a risky portfolio with lower solvency risk. If the ex-ante risk reduction is sufficiently large, bail-in expectations prevent idiosyncratic defaults and financial fragility.

When introducing aggregate risk through uncertain returns on the long-term asset, bail-in expectations still prompt banks to favor riskier portfolios. However, reducing short-term investment under these conditions increases liquidity risk. With greater portfolio correlation, a negative aggregate shock can lead to fire sales and systemic defaults. Therefore, macroprudential supervisors should be particularly concerned with the increased systemic risk linked to bail-in expectations in such environments.

The baseline model with a risky short-term and a safe long-term asset is related to the literature on supervisory interventions under idiosyncratic risk. The prospect of future profits while anticipating bailouts often motivates banks to engage in value-creating projects (Lambrecht and Tse, 2023). However, this pursuit of profit may also lead to increased portfolio risk and leverage among banks (Lambrecht and Tse, 2023; Leanza, Sbuelz, and Tarelli, 2021). More precisely, if the supervisor cannot commit to refrain from bailouts, this may generate a "too-big-too-fail" problem since banks internalize their size effect on the supervisory intervention and increase their leverage (Davila and Walther, 2020). Moreover, combining bailouts with bail-ins cannot resolve this commitment issue (Chari and Kehoe, 2016). However, distributing bailout transfers across banks (Philippon and Wang, 2023) and uncertainty about the timing of the bailout (Nosal and Ordoñez, 2016) can mitigate the moral hazard by incentivizing banks to avoid becoming the worst performer. My paper contributes to the existing literature by showing that strict creditor bailouts, and their associated ex-ante lower funding costs, can effectively prevent idiosyncratic defaults. This is particularly relevant in situations with multiple equilibria driven by market expectations, where both a risky equilibrium with defaults and a safe equilibrium coexist. In such cases, bailouts can eliminate the risky equilibrium, reducing financial fragility.

In the presence of systemic risk, supervisors might resort to bailouts out of fear of contagion, i.e. "too-many-to-fail" problem (Acharya and Yorulmazer, 2007). This preference for bailouts can encourage banks to correlate their portfolios in a way that prompts the supervisor to bail them out during adverse times, contributing to a collective moral hazard (Farhi and Tirole, 2012). Wagner and Zeng (2023) argue that a targeted bailout policy, in which banks are assigned to bailout groups, will solve the "too-many-to-fail" problem. Finally, Keister (2016) demonstrates that a strict no-bailout policy may not be welfare-enhancing because higher investor losses could lead to runs. In my model, the prospect of creditor bailouts results in lower funding costs and banks choosing a safe portfolio, which prevents systemic defaults. In other words, the promise of creditor bailouts, similar to deposit insurance, is enough to contain ex-ante contagion risk.

When considering bail-ins under idiosyncratic risk, Berger, Himmelberg, Roman, and Tsyplakov (2022) show that when shareholders anticipate bail-ins, they are more likely to consider recapitalization and may engage less in risk-shifting. Nevertheless, the higher funding costs associated with bail-ins can introduce moral hazard (Pandolfi, 2022). When examining private bail-ins, where shareholders initiate the bail-in process, the lack of supervisory commitment to refrain from bailouts can distort private incentives to engage in bail-ins (Keister and Mitkov, 2023). This lack of commitment may also prolong the restructuring process (Colliard and Gromb, 2024) and create a moral hazard for lending banks to accept privately negotiated bail-in offers (Benoit and Riabi, 2020). Moreover, when designing bail-ins, supervisors should account for the impact of negative information disclosure to the market, which can trigger runs (Walther and White, 2020). I demonstrate that expectations of bail-ins can lower ex-ante portfolio risk as banks consider the consequences of their risk-taking. If the risk reduction is substantial enough, bail-in expectations can remove the risky equilibrium with defaults, thereby decreasing financial fragility.

Avgouleas and Goodhart (2015) underscore that while facing aggregate risk, relying solely on bail-ins as a resolution policy may exacerbate systemic crises. Dewatripont (2014) suggests that bail-ins and bailouts should complement each other during a crisis. Farmer, Goodhart, and Kleinnijenhuis (2021) further argue that poorly designed bail-ins, especially in bank networks, can result in losses for other interconnected banks, leading to multiple layers of contagion. Bernard, Capponi, and Stiglitz (2022) posit that when interconnected banks participate in a private bail-in, the prospect of a supervisory bailout may undermine the negotiation process. This effect is particularly pronounced when banks are less exposed to contagion risk. Finally, Clayton and Schaab (2022) suggest that the higher the fire-sale risk, the more bail-inable debt banks should hold, and the greater the magnitude of write-downs. This paper demonstrates that while the ex-ante reduction in short-term investment driven by bail-in expectations lowers idiosyncratic risk, it exposes banks to systematic risk, potentially leading to fire sales and systemic defaults.

The paper is organized as follows. Section 2 describes the model. In Section 3, I begin by characterizing the market price of the long-term asset in the first period for the case of no aggregate risk. Following this, I describe the equilibria under no supervisory intervention, bailout anticipations, and bail-in anticipations. Section 4 modifies the baseline model by incorporating aggregate risk stemming from uncertain second-period asset returns. Within this context, I characterize the market price of the long-term asset in the presence of aggregate risk and describe the equilibria under no supervisory intervention, bailout anticipations, and bail-in anticipations. Section 5 concludes. Proofs of the analytical results are in the Appendix.

2 Model setup

Consider an economy with three dates $t = 0, 1, 2$, and a large number of islands. In each island i, there is a single risk-neutral *bank* that issues *short-term insured* debt that matures at $t = 1$ and *long-term uninsured* debt that matures at $t = 2$ to a set of risk-neutral consumers located in the island. There is also a bank *supervisor* who insures the short-term debt and either bails-in or bails out failing banks.

In each island i there is a unit measure of consumers who possess a unit endowment at time $t = 0$. Among these consumers, a fraction θ, referred to as the *early consumers*, only values consumption at $t = 1$, whereas the remaining fraction $1 - \theta$, referred to as *late consumers*, only values consumption at $t = 2$. Consumers know their type, thus the early consumers invest in the bank's short-term debt, while the late consumers invest in the long-term debt. Both types of consumers have access to a safe asset with a zero net return, which determines the expected return of their investments in the bank.

Banks are identical ex-ante and raise funds by issuing short-term and long-term debt to consumers. The gross return on the short-term debt is fixed at one, due to the availability of deposit insurance and the option for consumers to invest in a risk-free asset. The long-term debt is fairly priced and is subject to default costs. Thus, the late consumers' binding participation constraint defines the gross return on the long-term debt D_2.

After collecting one unit of funding, banks have the option to invest in two types of assets: a *short-term island-specific asset*, and a *long-term common (to all islands) asset*. Loans serve as an example of financial assets with idiosyncratic risk (specific to individual banks), while securities are an example of assets exposed to aggregate risk (common across all banks).[2] I assume the short-term asset is a bank output, which follows the "intermediation" approach in modern banking (Sealey Jr. and Lindley, 1977), and exerts diseconomies of scale.[3] Specifically, if bank i chooses to invest a fraction λ_i of its portfolio in the short-term asset, it yields a return of $h(\lambda_i)X_i$, where $h(\lambda_i)$ takes the simple quadratic form

$$h(\lambda_i) = \lambda_i - \lambda_i^2/2\,,$$

which is increasing and concave in λ_i. The short-term asset return is either high X_h with probability $1-\alpha$ or low X_ℓ with probability α, that is

$$X_i = \begin{cases} X_\ell, & \text{with probability } \alpha \\ X_h, & \text{with probability } 1-\alpha \end{cases}$$

where $X_\ell < X_h$, the expected asset return is $\overline{X} = \alpha X_\ell + (1-\alpha)X_h$, and X_i is independent and identically distributed across islands. I call banks with $X_i = X_\ell$ *weak banks* and banks with $X_i = X_h$ *strong banks*. The long-term asset has return Z with cdf $G(Z)$, which I will detail in Sections 3 and 4. I assume bank portfolios are opaque, which means λ_i is unobservable to both the supervisor and the consumers. Hence, the gross return on long-term debt D_2 is a function of the expected market investment λ in the short-term asset. I assume consumers' expectations regarding the equilibrium short-term asset investment are rational.

At $t = 1$, the anticipated return on the long-term asset Z, which will realize at $t = 2$, becomes observable. Then, banks can trade the long-term asset in an economy-wide market at the price p. There is also a demand for this asset by outside investors

$$d(p, Z) = \frac{Z-p}{p}\,, \tag{1}$$

which is decreasing in p and satisfies $d(p, Z) = 0$ for $p \geq Z$. Concurrently, banks can invest

[2] In the US, the average maturity of bank loan portfolios is 3.2 years, compared to 5.7 years for securities held by banks, with residual mortgage-backed securities having an average maturity of 9 years (see Drechsler, Savov, and Schnabl, 2021). Therefore, loans can be considered as the asset class with idiosyncratic risk which is short-term relative to securities which are the asset class with aggregate risk.

[3] See Heffernan (2005) for an in-depth discussion on bank output measurement and economies of scale.

in the safe asset at $t = 1$. Therefore, the price of the common asset cannot exceed the fundamental value Z.

Given price p, if banks can secure enough liquidity to repay early consumers, they will continue to operate until $t = 2$. However, if they fail to do so, they are liquidated. In this situation, because the supervisor is not equipped to manage the assets on her own, she will sell the long-term asset holdings of the defaulting bank in the market and use the proceeds to repay early consumers under the deposit insurance scheme. Defaults at $t = 1$ can happen due to illiquidity if the cash-in-the-market price p of the long-term asset is low, or due to insolvency if the bank fails even when p equals the fundamental value Z. Besides the default at $t = 1$, banks may continue their operations until $t = 2$ and default on their long-term debt. Defaults at $t = 2$ are due to insolvency, but they can occur due to illiquidity at $t = 1$ which forces a bank to sell a large proportion of its long-term asset and thus end up with insolvency at $t = 2$. I assume bank defaults, at $t = 1$ or $t = 2$, generate deadweight losses, with a fraction $1 - c$ of the asset returns being lost.[4]

The supervisor can prevent the default losses at $t = 2$ by either bailing out or bailing-in banks. In a creditor bailout, the supervisor promises to repay the late consumers. In a bail-in the long-term debt is converted to equity with a conversion rate γ. I analyze each resolution policy separately to assess its effect on the banks' ex-ante investment decision and ex-post likelihood of default.

Figure 1 illustrates the sequence of events. At $t = 0$, the market forms a belief about banks' short-term investment λ, which defines the market price of the long-term asset $p(\lambda)$ and the gross return on long-term debt $D_2(\lambda)$. Then, each bank collects unit endowment and invests in a portfolio that contains λ_i short-term and $1 - \lambda_i$ long-term asset. At $t = 1$, the short-term return realizes, and the long-term return, which will realize at $t = 2$, is observable. Next, banks engage in trading the long-term asset. If a bank cannot collect enough liquidity to repay its short-term debt, it will default, and the supervisor will liquidate the bank. If the

[4]For example Bernard et al. (2022); Chari and Kehoe (2016); Leanza et al. (2021) assume similarly bank default costs proportional to asset values.

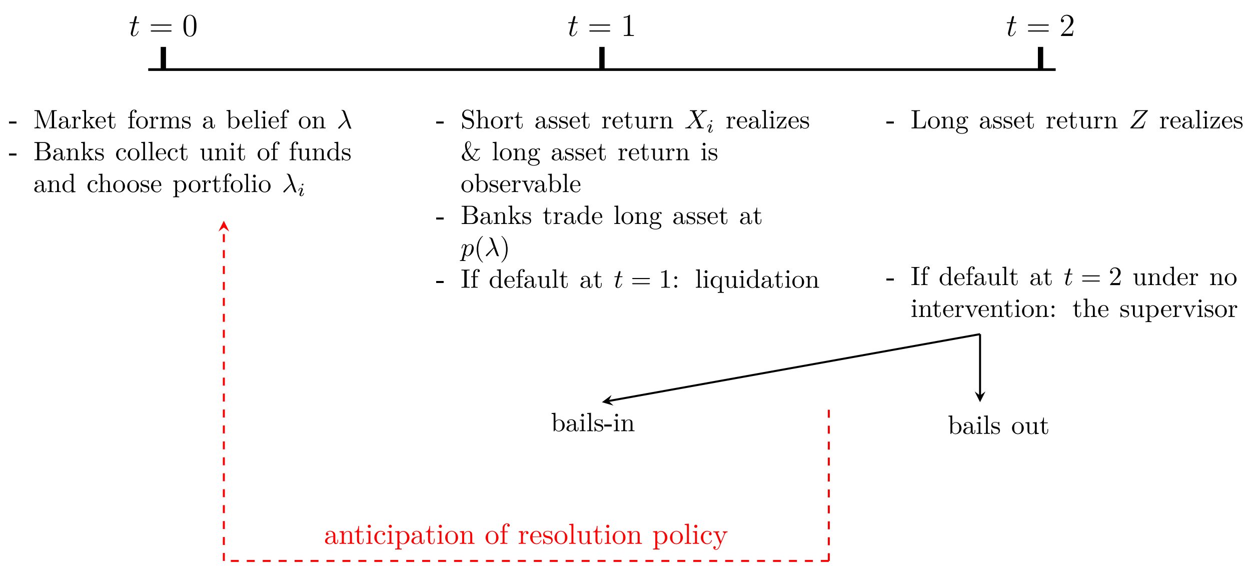

Figure 1 – Timeline of events

bank can repay its short-term debt but is going to default at $t = 2$, the supervisor can either bail-in the long-term creditors or promise to repay them at $t = 2$ in a creditor bail-out. At $t = 2$, the long-term return realizes, and the long-term debt is due. I argue that the market and the bank anticipate the supervisory resolution policy and readjust the gross return on long-term debt and the portfolio composition, respectively.

To compute the portfolio effect of resolution policies, I constructed a simplified bank model with a few essential features. On the asset side, a short-term asset with idiosyncratic risk introduces heterogeneity in banks' liquidity and solvency, while the common risk from the long-term asset adds aggregate risk. Since the common asset is tradable in the first period, it provides liquidity and influences portfolio decisions. The liability side is considered exogenous. Banks may default on short- or long-term debt. Supervisory resolution strategies can prevent second-period defaults, affecting banks' ex-ante portfolio choices and introducing systemic effects.

3 The model without aggregate risk

In this Section, I assume the return on the long-term asset is $Z = \overline{Z}$ with probability 1 implying that the economy is only subject to idiosyncratic risk. At $t = 1$, given price p, the bank in island i has to pay θ to the early consumers. If the combined liquidity from the short-term asset and the sale of the long-term asset is not enough to repay the early consumers, the bank fails at $t = 1$, and the supervisor sells the long-term asset holdings. Alternatively, the bank may accumulate additional liquidity by selling the long-term asset and successfully repaying the early consumers, or may even hold excess liquidity after serving the short-term debt and can buy the long-term asset in the market. In all these scenarios, besides banks with excess liquidity, the outside investors buy the asset provided its price is below its return of $\overline{Z}$.

Given market expectations of banks' short-term investment λ, I first characterize in Proposition 1 the market price $p(\lambda)$ of the long-term asset at $t = 1$ in the absence of aggregate risk. Then, I define the gross return $D_2(\lambda)$ of the long-term debt, that late consumers require. Next step, I characterize each bank's response function as the preferred short-term investment λ_i given $D_2(\lambda)$ and $p(\lambda)$. Finally, I focus on pure strategy symmetric equilibria with rational expectations.

Proposition 1. *The market price of the long-term asset, given the value λ of expected short-term investment, is*

$$p(\lambda) = \max\{p^c(\lambda), p^\ell(\lambda)\} \,,$$

where $p^c(\lambda)$ is the continuation price, when weak banks sell long-term assets but no bank defaults at $t = 1$,

$$p^c(\lambda) = \min\{h(\lambda)\overline{X} + \overline{Z} - \theta, \overline{Z}\} \,,$$

and $p^\ell(\lambda)$ is the liquidation price, when weak banks default at $t = 1$,

$$p^\ell(\lambda) = \min\left\{\frac{(1-\alpha)[h(\lambda)X_h - \theta] + \overline{Z}}{1+\alpha(1-\lambda)}, \overline{Z}\right\}.$$

When banks only hold short-term asset, i.e. $\lambda = 1$, or weak banks have sufficient liquidity at $t = 1$ and do not need to sell long-term assets, i.e. $h(\lambda)X_\ell > \theta$, no trade takes place and the market price of the long-term asset is at its fundamental value $\overline{Z}$.

According to Proposition 1, the market price of the long-term asset increases with the level of short-term investment. As banks hold more short-term asset, the liquidity available in the market at $t = 1$ rises, which drives up the cash-in-the-market price of the long-term asset. However, the market price cannot exceed the long-term asset return due to the presence of a safe asset with zero net return. When $p(\lambda) = \overline{Z}$, banks with liquidity shortage can sell the long-term asset without a discount, banks with excess liquidity are indifferent between buying the asset and investing in the safe asset, and outside investors do not enter the market.

Furthermore, the continuation price, $p^c(\lambda)$, as defined in Proposition 1, represents the market price of the long-term asset when even the banks experiencing a negative idiosyncratic shock survive at $t = 1$. For low values of λ, the market price is low. This may prevent the bank from raising enough liquidity, even with a substantial holding of long-term assets, leading to a default due to illiquidity. However, for high values of λ, on the other hand, the market price is high but the bank's holding of long-term assets is small. This could result in the bank failing to generate sufficient liquidity despite the higher market price, causing it to default due to insolvency. In either case, the market price is determined by the liquidation price, $p^\ell(\lambda)$, which is the price at which banks default at $t = 1$ following a negative idiosyncratic shock.

Assumption 1. *I focus on parameters such that*

$$\frac{\overline{Z}-1}{\theta+\overline{Z}-1} > \frac{\theta}{\overline{\overline{Z}}},$$

By Assumption (1), I focus on cases where the weak banks may face insolvency if their short-term investment is sufficiently large. When banks choose their short-term investment, they trade off the increase in the market price of the long-term asset against a smaller proportion of long-term assets holding. For low λ, the bank has a higher long-term investment but may face illiquidity due to a lower market price. As banks increase their short-term investment, they reach a threshold above which the long-term asset holding is insufficient for the weak banks to generate enough liquidity, leading to insolvency. Assumption (1) ensures that even with no short-term investment, $\lambda = 0$, banks do not experience illiquidity, thereby focusing on insolvency-related defaults at $t = 1$. Consequently, as banks invest more in the short-term risky asset, their solvency risk and the likelihood of liquidation increase.

Figure 2 illustrates the market price definition in Proposition 1 under Assumption (1), showing the market price $p(\lambda)$ alongside the continuation price $p^c(\lambda)$ and the liquidation price $p^\ell(\lambda)$. For low values of λ weak banks must sell assets on the market to repay the early consumers and continue operating until $t = 2$. In this range of values, the continuation price $p^c(\lambda)$ defines the market price. However, when banks allocate significantly more to short-term risky assets, even their entire holding of the long-term asset is not enough to generate the necessary liquidity. In Figure 2, when the banks invest more than $\widetilde{\lambda}_{1,\ell}$, weak banks default at $t = 1$. Above this threshold the liquidation price $p^\ell(\lambda)$ defines the market price.

Given bank i's short-term investment λ_i and the market price $p(\lambda)$, if the bank continues to operate until $t = 2$, its second-period return will consist of the long-term return $\overline{Z}$ multiplied by the volume of long-term assets the bank holds at $t = 2$,

$$1 - \lambda_i + \frac{h(\lambda_i)X_i - \theta}{p(\lambda)},$$

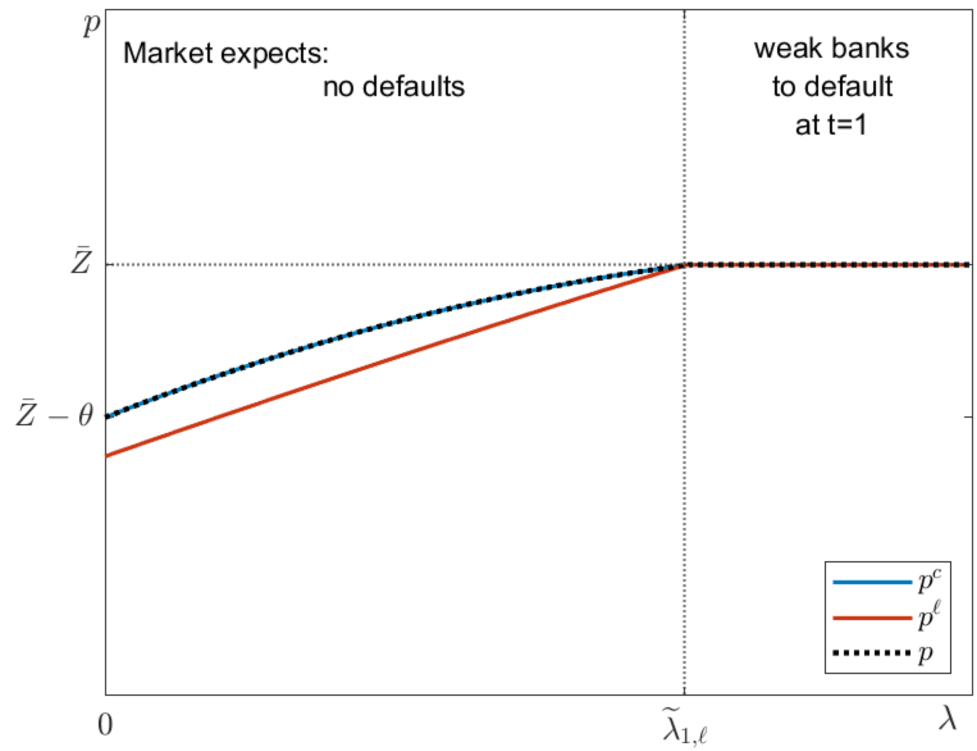

Figure 2 – Market price of the long-term asset

The solid blue line is the continuation price $p^c(\lambda)$ when weak banks can sell assets to repay early consumers. The solid red line is the liquidation price $p^\ell(\lambda)$ when weak banks cannot repay early consumers and are liquidated. The dotted black line is the market price of the long-term asset $p(\lambda)$ at $t = 1$. For short-term investments above $\widetilde{\lambda}_{1,\ell}$ weak banks default at $t = 1$. The parameter values are $\theta = 0.45$, $\alpha = 0.45$, $X_\ell = 0.05$, $X_h = 1.80$, and $\overline{Z} = 1.25$.

which is the bank's initial investment $1 - \lambda_i$ at $t = 0$ and the volume of long-term assets the bank trades at $t = 1$. However, if the bank defaults at $t = 1$, the supervisor liquidates the bank, resulting in no second-period returns.

Therefore, bank i's second-period return is equal to

$$R(\lambda_i, X_i, \lambda) = (1 - \lambda_i + a_i)\overline{Z} \tag{2}$$

where the volume traded is

$$a_i(\lambda_i, X_i, \lambda) = \max\left\{\frac{h(\lambda_i)X_i - \theta}{p(\lambda)}, -(1 - \lambda_i)\right\},$$

which depends on the bank's investment choice λ_i, the bank's short-term asset return X_i, and the market price $p(\lambda)$. The maximum operator ensures that the bank cannot sell more long-term assets than it owns. In other words, if the bank must sell more long-term assets at $t = 1$ than it possesses to continue operating, the bank faces liquidation, i.e. $a_i = -(1 - \lambda_i)$, resulting in a zero second-period return. To simplify the notation, let's denote the second-period return of bank i as $R_h(\lambda_i)$ when its short-term asset return is X_h and as $R_\ell(\lambda_i)$ when the short-term asset return is X_ℓ.

3.1 Equilibrium with no supervisory intervention

Given market expectations of banks' short-term investment λ, the gross return $D_2(\lambda)$ that late consumers require in exchange for their $1-\theta$ long-term lending can be characterized by the consumers' binding participation constraint. According to Assumption 1, for low values of λ, late consumers expect no defaults, meaning they anticipate being fully repaid in every state, and requiring a gross return on long-term debt of $D_2 = 1$. However, when the market expects weak banks to default at $t = 2$ and does not foresee supervisory intervention, i.e. in laissez-faire, the gross return on long-term debt increases as late consumers adjust their expectations to account for a lower payoff after a default. Thus, the participation constraint

$$\alpha c R_\ell(\lambda) + (1 - \alpha)(1 - \theta) D_2(\lambda) = 1 - \theta \,, \tag{3}$$

characterizes the long-term gross return, where the $1-\alpha$ strong banks repay the face value of debt and the α weak banks default at $t = 2$, leaving late consumers with the residual second-period returns after a fraction $1 - c$ of the return is lost due to the default. Finally, when the market anticipates the weak banks to default at $t = 1$, the gross return on long-term debt, based on the binding participation constraint, reaches its maximum

$$D_2 = \frac{1}{1 - \alpha} \,,$$

where late consumers expect to be repaid only by the strong banks.

In sum, the gross return on long-term debt in laissez-faire is equal to

$$D_2(\lambda) = \begin{cases} 1, & \text{if } \lambda \leq \widetilde{\lambda}_{2,\ell} \\ \dfrac{1-\theta-\alpha c R_\ell(\lambda)}{(1-\theta)(1-\alpha)}, & \text{if } \widetilde{\lambda}_{2,\ell} < \lambda < \widetilde{\lambda}_{1,\ell} \\ \dfrac{1}{1-\alpha}, & \text{if } \widetilde{\lambda}_{1,\ell} \leq \lambda \end{cases}$$

where $\widetilde{\lambda}_{2,\ell}$ is the short-term investment threshold below which no bank is expected to default and $\widetilde{\lambda}_{1,\ell}$ is the threshold above which weak banks are expected to default at $t = 1$. Consequently, for intermediate levels of short-term investment, $\widetilde{\lambda}_{2,\ell} < \lambda < \widetilde{\lambda}_{1,\ell}$, weak banks are expected to survive the first period but default at $t = 2$.[5] Finally, $D_2(\lambda)$ is defined for scenarios where strong banks are expected to survive at $t = 2$; otherwise, late consumers would anticipate receiving zero return and would be unwilling to lend their endowment.

For the range of λ where the market anticipates either no default or weak banks defaulting at $t = 1$, the gross return remains constant relative to λ. However, when the market expects weak banks to default at $t = 2$, by Assumption 1, the expected second-period return $R_\ell(\lambda)$ decreases with λ. This implies that as the market becomes more pessimistic about banks' short-term investments, it demands a higher gross return $D_2(\lambda)$. In summary, in laissez-faire, banks' long-term funding costs weakly increase with the market's expectations regarding short-term investment λ. This suggests that as the market expects a rise in short-term investments, the likelihood of default and potential losses for late consumers also increase, prompting them to demand a higher gross return to break even.

Given $p(\lambda)$ and $D_2(\lambda)$, bank i chooses its short-term investment λ_i to maximize expected second-period payoff

$$\max_{\lambda_i \in [0,1)} \mathbb{E}\Big[\max\{R(\lambda_i) - (1-\theta)D_2(\lambda), 0\}\Big].$$

By limited liability, the payoff is either the net second-period return after repaying the late consumers or zero if the bank defaults at $t = 1$ or $t = 2$. The bank chooses a short-term investment that ensures at least a positive second-period payoff following a high short-term

[5] See Appendix for the definition of the thresholds.

return.

If in equilibrium the bank never defaults, that is when

$$R_\ell(\lambda_i^*) > (1-\theta)D_2(\lambda) \tag{4}$$

bank i's expected payoff is

$$(1-\alpha)R_h(\lambda_i) + \alpha R_\ell(\lambda_i) - (1-\theta)D_2(\lambda)\,,$$

which equals

$$\Big[1 - \lambda_i + \frac{h(\lambda_i)\overline{X} - \theta}{p(\lambda)}\Big]\overline{Z} - (1-\theta)D_2(\lambda)\,.$$

According to the first-order condition

$$h'(\lambda_i^*)\overline{X} = p(\lambda)\,,$$

the bank selects a portfolio that equates the expected marginal return on the short-term asset with the marginal value of the long-term asset at $t = 1$, corresponding to its market price. Given $h'(\lambda_i) = (1 - \lambda_i)$, the equilibrium short-term investment

$$\lambda_i^* = \frac{\overline{X} - p(\lambda)}{\overline{X}}$$

defines the bank's portfolio choice, if it satisfies the equilibrium condition (4). I refer to this equilibrium portfolio with $\lambda_i^*(\lambda)$ short-term investment as the *safe* portfolio, indicating that the bank opts to remain safe.

Conversely, if in equilibrium the bank stays solvent at $t = 2$ in the high return X_h occurs, but defaults either at $t = 1$ or $t = 2$ in the low return state X_ℓ, that is when

$$R_h(\lambda_i^{**}) > (1-\theta)D_2(\lambda) > R_\ell(\lambda_i^{**})\,, \tag{5}$$

bank i's expected payoff is

$$(1-\alpha)[R_h(\lambda_i) - (1-\theta)D_2(\lambda)]\,.$$

The first-order condition

$$h'(\lambda_i^{**})X_h = p(\lambda)$$

defines the bank's portfolio choice,

$$\lambda_i^{**} = \frac{X_h - p(\lambda)}{X_h},$$

provided it satisfies the equilibrium condition (5). I refer to the equilibrium portfolio with $\lambda_i^{**}(\lambda)$ short-term investment as the *risky* portfolio, indicating that the bank expects default following a negative short-term shock. When comparing the safe portfolio with the risky one, as $X_h > \overline{X}$, the equilibrium investment in the short-term asset is higher when the bank opts for the risky portfolio $\lambda_i^{**}(\lambda)$, confirming market expectations that higher short-term investment increases the likelihood of default.

Given market expectation λ and the equilibrium conditions (4) and (5), the banks equilibrium choice can be either the safe portfolio $\lambda_i^*(\lambda)$, the risky portfolio $\lambda_i^{**}(\lambda)$, or both. If both the risky and the safe portfolio satisfy the equilibrium conditions, the bank chooses the one that provides the highest payoff. More precisely, the risky portfolio is the local solution to bank i's problem when it generates a higher payoff than the safe portfolio, that is when

$$\alpha[R_\ell(\lambda_i^*) - (1-\theta)D_2(\lambda)] < (1-\alpha)[R_h(\lambda_i^{**}) - R_h(\lambda_i^*)]\,. \tag{6}$$

Condition (6) illustrates the trade-off the bank faces when choosing a risky portfolio. On the one hand, there's the forgone payoff the bank could have received in the low return state if it had stayed solvent by choosing the safe portfolio. On the other hand, there are the higher payoffs it obtains in the high return state when increasing its short-term investment to $\lambda_i^{**}(\lambda)$.

Whether the short-term investments $\lambda_i^*(\lambda)$ or $\lambda_i^{**}(\lambda)$ are an equilibrium depends on the market's short-term investment expectations λ. In a symmetric equilibrium with no defaults, late consumers expect to be fully repaid in each state. In this case, if the safe portfolio is the bank's portfolio choice, based on the assumption of rational expectations, the short-term investment $\lambda_i^*(\lambda)$ characterizes a safe equilibrium with no defaults and by symmetry $\lambda^* = \lambda_i^*$. However, if the bank decides, against market expectations, to invest in the risky portfolio, by symmetry it would result in all banks defaulting in the low state. This outcome contradicts the assumption of rational expectations and the short-term investment $\lambda_i^{**}(\lambda)$ is not an equilibrium.

If in a symmetric equilibrium the market expects weak banks to default either at $t = 1$ or $t = 2$, and banks choose the risky portfolio, based on the assumption of rational expectations, the short-term investment $\lambda_i^{**}(\lambda)$ characterizes a risky equilibrium with bank defaults and by symmetry $\lambda^{**} = \lambda_i^{**}(\lambda)$. However, should the bank, against market expectations, opt for investing in a safe portfolio, by symmetry, all banks would remain solvent. No defaults contradict the assumption of rational expectations and the short-term investment $\lambda_i^*(\lambda)$ is not an equilibrium.

The above analysis reveals that banks' equilibrium portfolio composition depends on market expectations regarding their portfolio choices and default probabilities. When the market anticipates that weak banks are likely to default, the gross return on long-term debt, as well as the market price of the long-term asset, increases. Subsequently, despite individual banks' portfolio choices being unobservable to the market, the bank invests in a risky portfolio, even though it might have chosen a safe portfolio if the market expected no defaults.

Figure 3 illustrates an example for bank i's response function $\lambda_i(\lambda)$ given any market expectation λ. The green line indicates the bank's safe portfolio and the red line indicates the bank's risky portfolio. When both portfolios are equilibrium candidates, the bank chooses the portfolio that generates the highest payoff. The portfolio with the highest payoff is illustrated as a solid line, and its colour indicates whether the portfolio is safe or risky.

For a low λ as in Assumption 1, the market is optimistic and does not expect any bank defaults. Initially, the bank invests in a risky portfolio, with short-term investment $\lambda_i^{**}(\lambda)$, represented by the solid red line. The bank prefers this risky portfolio even when

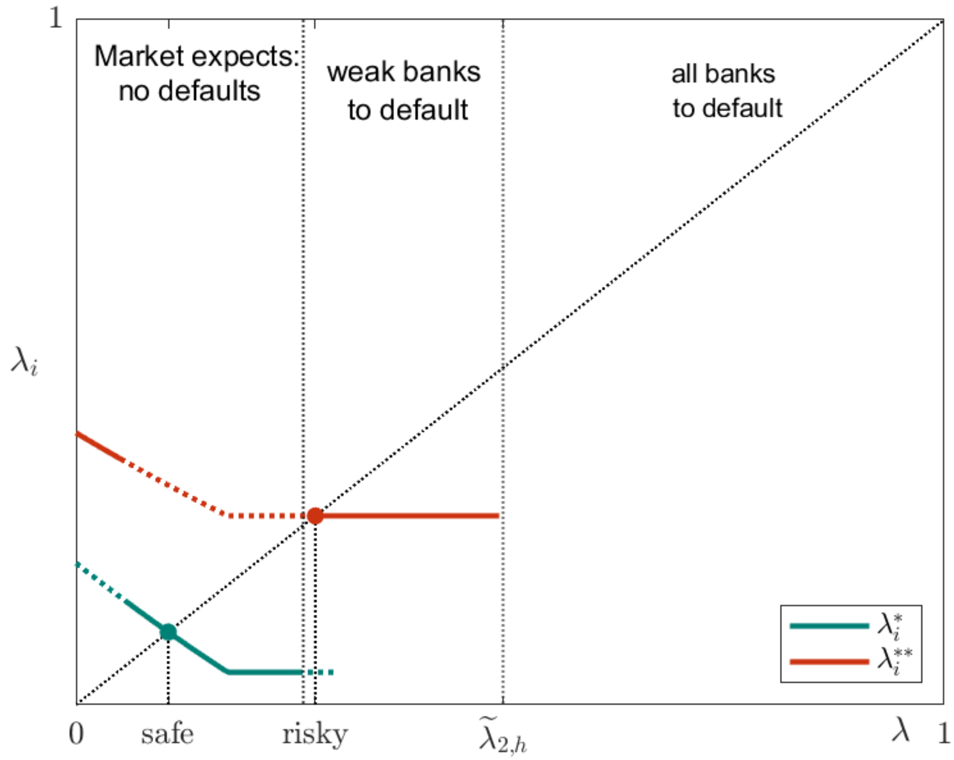

Figure 3 – **Bank's response function given market expectations**

The figure illustrates banks' safe portfolio with short-term investment $\lambda_i^*(\lambda)$ (green line) and risky portfolio with short-term investment $\lambda_i^{**}(\lambda)$ (red line) given any market expectations λ for the laissez-faire case without supervisory intervention. The portfolio with the highest payoff is illustrated as a solid line and its color indicates whether it is a safe portfolio or a risky portfolio. For λs larger than $\widetilde{\lambda}_{2,h}$ both banks are going to default at $t = 2$. For The intersection of the banks' response function with the 45-degree line defines the symmetric equilibrium. Parameter values are $\theta = 0.20$, $\alpha = 0.35$, $X_h = 1.65$, $X_\ell = 0.52$, $\overline{Z} = 1.20$, and $c = 0.65$

it has the option to invest in a safe portfolio, with short-term investment $\lambda_i^*(\lambda)$, shown by the dotted green line parallel to the solid red line. However, this preference contradicts market expectations and cannot form an equilibrium. In the higher range of λ, where the market still expects no defaults, the bank preference shifts and it invests in a safe portfolio, illustrated by the solid green line, while concurrently having the option to invest in a risky portfolio, shown by the dotted red line. This choice aligns with rational expectations. By symmetry, the intersection of the solid green line and the 45-degree line defines a symmetric safe equilibrium.

For larger values of λ, the market becomes pessimistic, expecting weak banks to default, triggering an increase in the required gross return on long-term debt, $D_2(\lambda)$. In response, banks are inclined to choose a risky portfolio, even though they can also invest in a safe portfolio. This scenario is depicted in Figure 3 by the solid red line and the dotted green line. The intersection of the solid red line and the 45-degree line represents a symmetric risky equilibrium where bank defaults occur. At the highest levels of λ, the market anticipates even strong banks defaulting. Consequently, late consumers expect zero returns and are unwilling to lend their endowment, preventing banks from investing in any assets.

Figure 3 demonstrates how banks' equilibrium portfolio choices are shaped by market expectations, leading to multiple equilibria. In one equilibrium, the market is optimistic and anticipates no defaults. Under these conditions, the gross return on long-term debt and the market price of long-term assets are at their lowest, prompting banks to select the safe portfolio over the risky one. In another equilibrium, the market is pessimistic, expecting weak banks to default. This outlook results in higher gross returns on long-term debt and increased market prices, leading banks to choose the risky portfolio, which can trigger defaults following negative short-term shocks.

I interpret the multiple equilibria generated by self-fulfilling market beliefs as the source of financial fragility and discuss how the resolution policy of the supervisor affects the financial fragility. More precisely, when in laissez-faire both the safe and risky equilibrium coexist, I consider a positive analysis of whether the expectations of bailouts versus bail-ins can remove the equilibrium with defaults. As Dybvig (2023) highlighted in his Nobel Price speech: "The purpose of a policy is to remove the bad equilibrium (or more generally restrict the set of possible equilibria), not to move or distort the unique equilibrium."

3.2 Equilibrium with bailout

Under a creditor bailout policy, the supervisor pledges to bail out the creditors of a weak bank facing default at $t = 2$. Hence, the bailout exclusively benefits the creditors, while the bank receives no payoff from the intervention. Consequently, the bank's optimization problem remains the same as under a laissez-faire scenario but faces weakly lower funding costs.

Under a creditor bailout, the supervisor transfers the amount

$$(1-\theta)D_2(\lambda) - c\,R_\ell(\lambda)$$

to the late consumers when weak banks default at $t = 2$. This ensures that late consumers always receive the face value of the debt, whether from the bank or the supervisor. The bailout effectively acts like deposit insurance, making the long-term debt risk-free with a gross return of $D_2^{out} = 1$. Consequently, the gross return on long-term debt in anticipation of bailouts,

$$D_2^{out}(\lambda) = \begin{cases} 1, & \text{if } \lambda \leq \widetilde{\lambda}_{1,\ell} \\ \dfrac{1}{1-\alpha}, & \text{otherwise} \end{cases}$$

is weakly lower than in laissez-faire.

Regarding bank i's optimization problem, given the market expectations λ, the safe and risky portfolios, with short-term investments $\lambda_i^*(\lambda)$ and $\lambda_i^{**}(\lambda)$ respectively, are local solutions to the bank's problem if they satisfy the equilibrium conditions (4) and (5). Finally, if both portfolios are viable solutions to the bank's problem, the bank will opt for the risky portfolio if it offers higher payoffs, as outlined by condition (6).

Rewriting condition (6), the bank prefers the risky portfolio if

$$D_2^{out}(\lambda) > \frac{\mathbb{E}[R(\lambda_i^*)] - (1-\alpha)R_h(\lambda_i^{**})}{\alpha(1-\theta)}\,. \tag{7}$$

Since the reaction functions $\lambda_i^*(\lambda)$ and $\lambda_i^{**}(\lambda)$ are identical under both laissez-faire and bailout scenarios, the right-hand side of inequality (7) remains unchanged. Therefore, when comparing banks' response function under bailout expectations to laissez-faire, its shift from the risky to the safe portfolio depends on the gross return on long-term debt. Since $D_2^{out}(\lambda)$ is lower than $D_2(\lambda)$, the inequality (7) becomes harder to satisfy. When the difference between the two funding costs is large enough, the bank will choose the safe portfolio over the risky one in anticipation of bailouts, even though it would have opted for the risky portfolio in laissez-faire. In other words, the reduced long-term funding costs associated with bailout expectations diminish the bank's preference for riskier investments.

In situations of financial fragility in laissez-faire, optimistic market beliefs lead to a safe equilibrium with no defaults and pessimistic market beliefs prompt banks to choose a risky portfolio, resulting in an equilibrium with defaults. In the latter scenario, expectations of bailouts lower the gross return on long-term debt, triggering banks to favor a safe portfolio instead. Since markets anticipate defaults and subsequent bailouts, the bank's choice of a safe portfolio contradicts rational expectations, thereby, eliminating the equilibrium associated with defaults. Essentially, the expectation of bailouts, akin to debt insurance, mitigates financial fragility, resulting in only the safe equilibrium persisting.

Building on the example shown in Figure 3, for intermediate levels of λ, the market anticipates that weak banks will default and be bailed out at $t = 2$. As a result, the gross return demanded by late consumers remains fixed at 1, leading the bank to prefer a safe portfolio. This is depicted in Figure 4 by the solid green line and the dotted red line. However, this choice of remaining solvent contradicts the market's expectations of a supervisory intervention. Consequently, the anticipation of bailouts eliminates the risky equilibrium associated with defaults.

3.3 Equilibrium with bail-in

Under a bail-in policy, the supervisor intervenes by converting the long-term debt of a weak bank into equity if the bank otherwise was going to default at $t = 2$. At $t = 1$, the supervisor observes the short-term returns and, based on market expectations of λ, applies a conversion rate γ to bail-in the long-term debt.

The choice of the conversion rate is constrained by the No Creditor Worse Off (NCWO) principle. Accordingly, a bail-in must not result in creditors of the weak bank experiencing

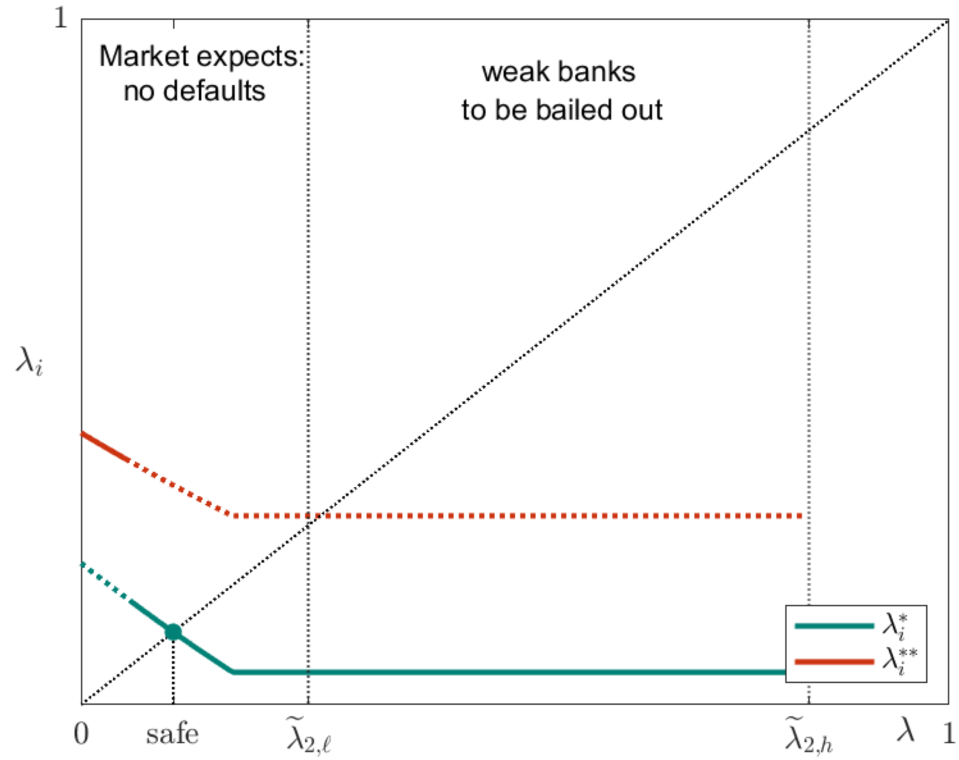

Figure 4 – Bank's response function in anticipation of bailouts

The figure illustrates banks' safe portfolio with short-term investment $\lambda_i^*(\lambda)$ (green line) and risky portfolio with short-term investment $\lambda_i^{**}(\lambda)$ (red line) given any market expectations λ for the case of bailout expectations. The portfolio with the highest payoff is illustrated as a solid line, and its color indicates whether it is a safe or a risky portfolio. For λs larger than $\widetilde{\lambda}_{2,\ell}$ weak banks are going to default at $t = 2$ and for λs larger than $\widetilde{\lambda}_{2,h}$ both banks are going to default at $t = 2$. For The intersection of the banks' response function with the 45-degree line defines the symmetric equilibrium. Parameter values are $\theta = 0.20$, $\alpha = 0.35$, $X_h = 1.65$, $X_\ell = 0.52$, and $\overline{Z} = 1.20$.

losses greater than they would incur in a hypothetical insolvency procedure. More precisely, the late consumers should receive a payoff at least equal to the bank defaulting at $t = 2$. Since in case of default at $t = 2$ the late consumers would have received a fraction c of the second-period returns, the conversion rate should be at least equal to $\gamma \geq c$.

Regarding the gross return on long-term debt, the binding participation constraint of the late consumers when they anticipate bail-in is

$$\alpha\gamma R_\ell(\lambda) + (1-\alpha)(1-\theta)D_2^{in}(\lambda) = 1-\theta\,. \tag{8}$$

Under a bail-in, late consumers receive the face value of their debt from $1-\alpha$ strong banks and a fraction γ of the second-period returns if a bail-in occurs. This avoids the deadweight losses linked to bank defaults, with γ determining how the preserved value is split between shareholders and creditors. Without intervention, late consumers would get a fraction c of returns after default at $t=2$. If $\gamma > c$, bail-ins offer higher payoffs to the late consumers, leading to lower demanded gross returns $D_2^{in}(\lambda)$. As the conversion rate decreases, late consumers' second-period payoff decreases, reducing the difference between the two gross returns. In sum, the gross return on long-term debt under bail-in expectations is equal to

$$D_2^{in}(\lambda) = \begin{cases} 1, & \text{if } \lambda \le \widetilde{\lambda}_{2,\ell} \\ \dfrac{1-\theta-\alpha\gamma R_\ell(\lambda)}{(1-\theta)(1-\alpha)}, & \text{if } \widetilde{\lambda}_{2,\ell} < \lambda < \widetilde{\lambda}_{1,\ell} \\ \dfrac{1}{1-\alpha}, & \text{if } \widetilde{\lambda}_{1,\ell} \le \lambda \end{cases}$$

The second case represents the scenario in which weak banks are expected to survive the first period but default at $t=2$ and are bailed-in. Note that, the higher the conversion rate, the more late consumers receive following bail-in, thereby reducing the gross return they require on long-term debt.

Given the short-term market expectations λ, bank i's maximization problem at $t=0$ while anticipating bail-ins is

$$\begin{aligned} \max_{\lambda_i \in [0,1)} \; & (1-\alpha)[R_h(\lambda_i) - (1-\theta)D_2(\lambda)] \\ & + \alpha\Big[\mathbf{1}\{R_\ell(\lambda_i) \ge (1-\theta)D_2(\lambda)\}\big[R_\ell(\lambda_i) - (1-\theta)D_2(\lambda)\big] \\ & + \mathbf{1}\{0 < R_\ell(\lambda_i) < (1-\theta)D_2(\lambda)\}[1-\gamma]R_\ell(\lambda_i)\Big], \end{aligned}$$

where $\mathbf{1}\{\cdot\}$ is an indicator function with the condition for which it turns one being in the curly brackets. The bank's payoff consists of the expected net second-period returns following a positive short-term shock X_h, the expected net second-period returns following a negative short-term shock X_ℓ when the bank remains solvent, or a share $1-\gamma$ of the second-period return if the bank experiences a negative shock and is bailed-in, or zero if it defaults on the short-term debt.

If in equilibrium the bank never defaults, that is if

$$R_\ell(\lambda_i^*) > (1-\theta)D_2^{in}(\lambda) \tag{9}$$

the portfolio

$$\lambda_i^* = \frac{\overline{X} - p(\lambda)}{\overline{X}}\,,$$

which is identical to the safe portfolio in laissez-faire, characterizes the solution to the bank's problem given it satisfies the equilibrium condition (9).

Conversely, if the bank survives following positive short-term shock X_h, but is going to default at $t = 2$ following a negative short-term shock X_ℓ and hence is bailed-in, that is when

$$R_h(\lambda_i^{in}) > (1-\theta)D_2^{in}(\lambda) > R_\ell(\lambda_i^{in}) > 0\,, \tag{10}$$

bank i's expected payoff is

$$(1-\alpha)[R_h(\lambda_i) - (1-\theta)D_2^{in}(\lambda)] + \alpha(1-\gamma)R_\ell(\lambda_i)$$

and the corresponding first-order condition is

$$(1-\alpha)\frac{\partial R_h(\lambda_i)}{\partial \lambda} + \alpha(1-\gamma)\frac{\partial R_\ell(\lambda_i)}{\partial \lambda} = 0\,,$$

which simplifies to

$$h'(\lambda_i^{in})\left[\frac{\overline{X} - \alpha\gamma X_\ell}{1-\alpha\gamma}\right] = p(\lambda)\,.$$

Then, the solution to the bank's problem is

$$\lambda_i^{in} = 1 - p(\lambda)\left[\frac{\overline{X} - \alpha\gamma X_\ell}{1-\alpha\gamma}\right]^{-1}\,,$$

characterizing the bank's risky portfolio, given it satisfies the equilibrium condition (10). When the original shareholders are completely wiped out following a bail-in, i.e., when $\gamma = 1$, the risky portfolio under bail-in expectations is identical to laissez-faire. However, if the conversion rate is less than one, it can be shown that the term in brackets is smaller than

X_h.[6] This implies that the short-term investment in the risky portfolio, in anticipation of bail-ins, is lower compared to a scenario without supervisory intervention. In other words, since the bank receives a positive payoff following a bail-in, it adjusts for the potential downside of its risk-taking and opts for a less risky portfolio relative to laissez-faire.

Finally, the bank defaults at $t = 1$ following a negative short-term investment, that is when $R_\ell(\lambda_i^{**}) = 0$, bank i's expected payoff is

$$(1-\alpha)[R_h(\lambda_i) - (1-\theta)D_2^{in}(\lambda)]$$

and the first-order condition

$$h'(\lambda_i^{**})X_h = p(\lambda)$$

defines the solution to the bank's problem if

$$\lambda_i^{**} = \frac{X_h - p(\lambda)}{X_h}$$

satisfies the equilibrium condition $R_\ell(\lambda_i^{**}) = 0$. This portfolio is identical to the risky portfolio in laissez-faire.

If multiple portfolios satisfy the equilibrium conditions, the bank chooses the one with the highest payoff. For example, the bank prefers the portfolio in expectation of bail-in over the safe one if

$$D_2^{in}(\lambda) > \frac{\mathbb{E}[R(\lambda_i^*)] - \mathbb{E}[R(\lambda_i^{in})] + \alpha\gamma R_\ell(\lambda_i^{in})}{\alpha(1-\theta)}\,. \tag{11}$$

On the left-hand side, the gross return $D_2^{in}(\lambda)$ is lower than in laissez-faire, as late consumers receive the full second-period return that would have otherwise been lost. These lower long-term funding costs make the inequality (11) harder to satisfy relative to laissez-faire. However, on the right-hand side, the expression equals that in laissez-faire when $\gamma = 1$, and

[6]Note that $\frac{\overline{X}-\alpha\gamma X_\ell}{1-\alpha\gamma} < X_h \Leftrightarrow \alpha\gamma(X_h - X_\ell) < X_h - \overline{X} \Leftrightarrow \alpha\gamma(X_h - X_\ell) < \alpha(X_h - X_\ell) \Leftrightarrow \gamma < 1$.

increases with γ.[7] Thus, the right hand-side of the inequality (11) is weakly lower than in laissez-faire, which makes the inequality (11) easier to satisfy. Thus, as the conversion rate γ decreases, the funding cost effect lessens while the portfolio reallocation effect strengthens, making banks prefer a risky portfolio both in laissez-faire and bail-in scenarios.

In cases of financial fragility in laissez-faire, the anticipation of bail-ins reduces the short-term investments in the risky portfolio but, given the conversion rate, incentivizes banks to prefer the risky portfolio over a safe one. Although the bank still chooses a risky portfolio, a significant reduction in short-term investments can rule out a *symmetric* equilibrium with defaults, resulting in only the safe equilibrium persisting.

To illustrate this with the example presented in Figure 3, when for an intermediate level of market investment λ the market expects weak banks to default at $t = 2$ and be bailed-in at a conversion rate $\gamma = c$, the bank prefers to choose the risky portfolio while also having the option to choose the safe portfolio. This is illustrated by the solid red line and dotted green line. Nevertheless, the risky portfolio contains $\lambda_i^{in}(\lambda)$ short-term asset, which is lower than $\lambda_i^{**}(\lambda)$ in laissez-faire. Since the risk reduction is large enough, a symmetric equilibrium where all banks invest in a risky portfolio is ruled out. In other words, the anticipation of bail-ins has reduced the riskiness of banks' portfolios to the extent that a *symmetric* equilibrium is ruled out, resulting in only the safe equilibrium persisting.

3.4 Summary of results under no aggregate risk

When banks can choose between a risky short-term asset and a safe long-term asset, their portfolio decision involves balancing the trade-off between investing in the long-term asset at $t = 0$ or using the potential excess return from the risky short-term asset at $t = 1$ to purchase the long-term asset, possibly at a discount. As banks allocate more to the

[7] $\frac{dRHS}{d\gamma} = \frac{1}{\alpha(1-\theta)} \left\{ -\underbrace{\frac{\partial \mathbb{E}[R(\lambda_i^{in})]}{\partial \gamma}}_{=0} + \alpha\gamma \underbrace{\frac{\partial R_\ell(\lambda_i^{in})}{\partial \gamma}}_{=0} + \alpha R_\ell(\lambda_i^{in}) \right\}$

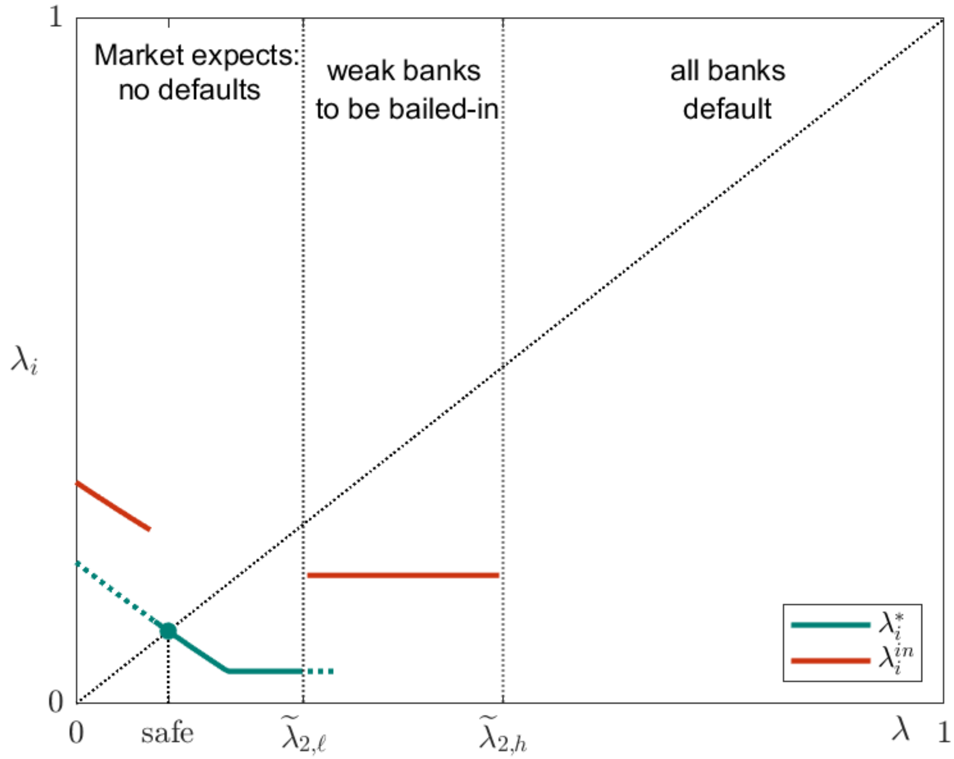

Figure 5 – Bank's response function in anticipation of bail-ins

The figure illustrates banks' safe portfolio with short-term investment $\lambda_i^*(\lambda)$ (green line) and risky portfolio with short-term investment $\lambda_i^{in}(\lambda)$ (red line) given any market expectations λ for the case of bail-in expectations. The portfolio with the highest payoff is illustrated as a solid line and its color indicates whether it is a safe or a risky portfolio. For λs larger than $\widetilde{\lambda}_{2,\ell}$ weak banks are going to default at $t = 2$ and for λs larger than $\widetilde{\lambda}_{2,h}$ both banks are going to default at $t = 2$. For The intersection of the banks' response function with the 45-degree line defines the symmetric equilibrium. Parameter values are $\theta = 0.20$, $\alpha = 0.35$, $X_h = 1.65$, $X_\ell = 0.52$, $\overline{Z} = 1.20$ and $\gamma = c = 0.65$.

short-term asset, their portfolios become riskier, increasing the likelihood of insolvency in the event of a negative short-term shock.

Since bank portfolios are opaque, the market forms expectations about banks' short-term investments and adjusts the market price and the gross return on long-term debt accordingly. Specifically, larger investments in short-term asset increase market liquidity, thereby raising the cash-in-the-market price of the long-term asset. However, as the market anticipates a higher likelihood of default, the long-term funding costs rise. These self-fulfilling market beliefs influence the bank's portfolio decisions and might create financial fragility in laissez-faire.

Under financial fragility in laissez-faire, a supervisory promise of bailouts acts like insurance for late consumers, reducing long-term funding costs without affecting shareholders' portfolio trade-offs. This incentivizes banks to choose safer portfolios, eliminating the risky equilibrium. In contrast, bail-ins alter both creditor payoffs and shareholders' ex-ante portfolio trade-offs. Bail-in expectations lower long-term funding costs and reduce short-term investments in risky portfolios, encouraging banks to prefer a risky portfolio with lower insolvency risk, which may also rule out the symmetric risky equilibrium with defaults.

Figure 6 illustrates a summary of the model's findings in the absence of aggregate risk, showing the symmetric equilibrium for different values of $\alpha \in (0, 1)$, which represents the likelihood of a low short-term asset return. Higher values of α correspond to lower expected short-term returns. The figure compares the scenarios under no supervisory intervention, bailout anticipations, and bail-in anticipations. The green line depicts the equilibrium where banks opt for a safe portfolio, while the red line represents the equilibrium where banks select a risky portfolio. The overlap between the green and red lines indicates the presence of multiple equilibria and financial fragility. The range of α values for which none of the two lines exist indicates the non-existence of a pure strategy symmetric equilibrium.

In laissez-faire, as α increases, the expected return on the short-term asset decreases. With the short-term asset becoming less profitable given the long-term asset, banks reduce

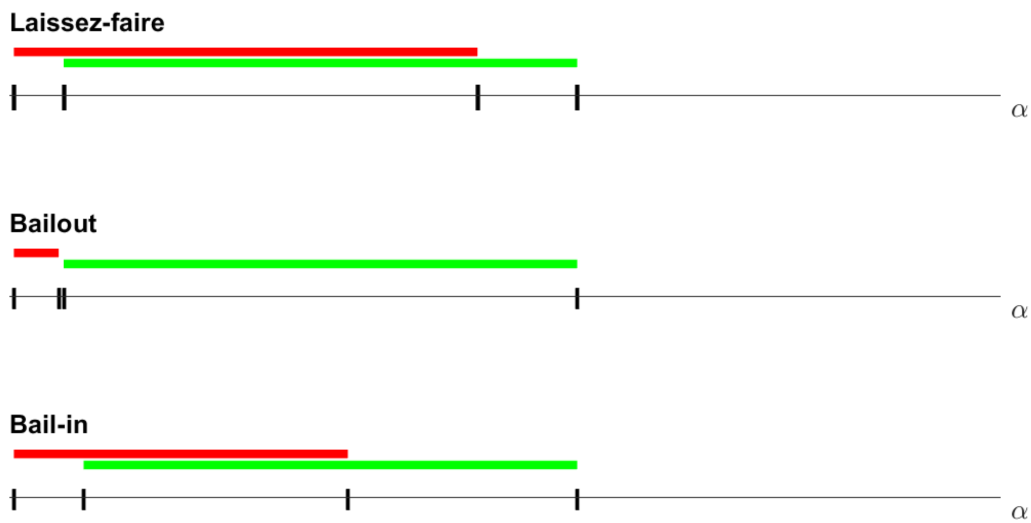

Figure 6 – Multiple equilibrium in anticipation of resolution

The figure depicts the symmetric equilibrium across the range of possible values for the probability of a low short-term asset return α under no supervisory intervention, bailout anticipations, and bail-in anticipations. The green line signifies the equilibrium with no defaults and the red line signifies the equilibrium in which weak banks default at $t = 2$. The overlapping region between the red and green lines depicts cases of multiple equilibria. Parameter values are $\theta = 0.20$, $X_h = 1.65$, $X_\ell = 0.52$, $\overline{Z} = 1.20$ and $\gamma = c = 0.65$.

their investment in the risky short-term asset and gradually shift from a risky equilibrium to a safe equilibrium. This shift is represented by a red line for lower values of α (where banks choose a risky portfolio) and a green line for higher values of α (where banks choose a safe portfolio). For intermediate values of α, market expectations create the possibility of both equilibria coexisting. In this range, banks may opt for a risky portfolio when the market is pessimistic or a safe portfolio when the market is optimistic, illustrating financial fragility.

When the market anticipates bailouts, long-term funding costs decrease, and in response, banks are more inclined to choose the safe portfolio over the risky one. As a result, banks remain solvent across a wider range of α, which is illustrated by a shorter red line compared to the laissez-faire scenario. More importantly, the anticipation of bailouts eliminates the presence of multiple equilibria. In Figure 6, under bailouts, the green and red lines no longer overlap, indicating that the financial fragility has been resolved and the coexistence of safe and risky equilibria is removed.

When the market anticipates bail-ins banks reduce their short-term investments in the risky portfolio. If this ex-ante effect is strong enough, the risky equilibrium is ruled out. This is illustrated in Figure 6 by the shorter red line. However, since the conditions for bail-in expectations to eliminate the risky equilibrium are more difficult to meet, bail-ins are less effective in resolving financial fragility. This is represented by the larger overlap between the red and green lines, indicating a wider range of values where both equilibria coexist compared to the bailout scenario.

4 The model with aggregate risk

In this Section, I assume the long-term asset return is either high Z_g with probability $1-\beta$ or low Z_b with probability β, that is

$$Z_j = \begin{cases} Z_b, & \text{with probability } \beta \\ Z_g, & \text{with probability } 1-\beta \end{cases}$$

where $Z_b < Z_g$ and $\overline{Z} = (1-\beta)Z_g + \beta Z_b$. I use the subscript $j = \{b, g\}$ to refer to the systematic return realization. A high long-term asset return Z_g will be called *good times* and a low realization Z_b will be called *bad times*.

I assume at $t = 1$ before banks trade the long-term asset, the asset return, which will realize at $t = 2$, is observable, eliminating all uncertainty about the asset's fundamental value.[8] As a result of this transparency, the market price of the long-term asset does not exceed its fundamental value due to the presence of a safe asset, ensuring that banks do not incur losses from trading the asset, as would occur under uncertainty. Next, I characterize the market price of the long-term asset at $t = 1$, given any market expectation λ regarding short-term investment.

Proposition 2. *The market price of the long-term asset, given the value λ of expected*

[8] This assumption aligns with models of financial intermediaries with a market to trade banks' assets, as demonstrated in Allen and Gale (2004).

short-term investment and the long-term asset return Z_j, is

$$p(\lambda, Z_j) = \max\{p^c(\lambda, Z_j), p^\ell(\lambda, Z_j), p^b(\lambda, Z_j)\}\,,$$

where $p^c(\lambda, Z_j)$ is the continuation price when weak banks sell the long-term asset but no bank defaults at $t = 1$,

$$p^c(\lambda, Z_j) = \min\{h(\lambda)\overline{X} + Z_j - \theta, Z_j\}\,,$$

$p^\ell(\lambda, Z_j)$ is liquidation price, when weak banks default at $t = 1$,

$$p^\ell(\lambda, Z_j) = \min\left\{\frac{(1-\alpha)[h(\lambda)X_h - \theta] + Z_j}{1 + \alpha(1-\lambda)}, Z_j\right\}\,,$$

and $p^b(\lambda, Z_j)$ is the crisis price, when both banks default at $t = 1$,

$$p^b(\lambda, Z_j) = \frac{Z_j}{2-\lambda}\,.$$

When banks only hold short-term asset, i.e. $\lambda = 1$, or weak banks have sufficient liquidity at $t = 1$ and do not need to sell long-term assets, i.e. $h(\lambda)X_\ell > \theta$, no trade takes place and the market price of the long-term asset is at its fundamental value Z_j.

When a bank cannot repay its short-term debt from its short-term returns, it must sell part of its long-term assets in the market. If the bank can generate sufficient liquidity at $t = 1$, it continues to operate until $t = 2$. As defined in Proposition 2, The continuation price $p^c(\lambda, Z_j)$ characterizes the market price of the long-term asset when all banks survive at $t = 1$. On the contrary, when weak banks are expected to default at $t = 1$, the liquidation price $p^\ell(\lambda, Z_j)$ characterizes the market price. Finally, when in anticipation of a negative aggregate shock all banks, even strong banks, default at $t = 1$, the crisis price $p^b(\lambda, Z_b)$ characterizes the market price. In these systemic default cases, all banks are liquidated and the outside investors are the buyers of the asset.

Moreover, the market price of the long-term asset, defined in Proposition 2, increases with the level of short-term investment the market expects banks to hold. As banks hold more short-term asset, the liquidity available in the market at $t = 1$ rises, which drives up the cash-in-the-market price of the long-term asset. Furthermore, the market price is increasing in the fundamental value of the long-term asset Z_j. As the the long-term return increases, the outside investors' demand for the asset increases, driving up the price of the asset. Thus, the market price is at its lowest when the market expects a negative aggregate shock and low short-term investments, and it is at its highest when the market expects a positive aggregate shock and high levels of short-term investment. Finally, the market price cannot exceed the long-term asset return due to the presence of a safe asset with zero net return. When $p(\lambda) = Z_j$, banks with liquidity shortage can sell the long-term asset without a discount, banks with excess liquidity are indifferent between buying the asset and investing in the safe asset, and outside investors do not enter the market.

Given Z_j, for low values of λ, the market price is low. This may prevent the bank from raising enough liquidity, even with a substantial holding of long-term assets, leading to a default due to illiquidity. For high values of λ, on the other hand, the market price is high but the bank's holding of long-term assets is small. This could result in the bank failing to generate sufficient liquidity despite the higher market price, causing it to default due to insolvency. By Assumption 1 and $Z_g > \overline{Z}$, when good times are expected, no bank is defaulting at $t = 1$ due to illiquidity, but banks may default due to insolvency.

In contrast, when bad times are expected, if banks hold low short-term investments, they face a depressed market price. In these cases, even with a high short-term return and large holding of the short-term asset, they cannot collect enough liquidity to serve their short-term debt and default collectively at $t = 1$. I interpret these scenarios in which all banks default as systemic events. Thus, when a negative aggregate shock is expected, fire sales may lead to systemic defaults. If the supervisor has a macroprudential mandate, being primarily concerned with systemic events rather than individual bank defaults, she is invested in whether a resolution policy prevents systemic events or rather contributes to them.

Figure 7 illustrates the result in Proposition 2, showing the market price $p(\lambda, Z_j)$ (dotted black line), alongside the continuation price $p^c(\lambda, Z_j)$ (solid green line), the liquidation price $p^\ell(\lambda, Z_j)$ (solid red line), and the crisis price $p^b(\lambda, Z_j)$ (solid blue line) for high long-term asset return Z_g in Panel (A) and low long-term asset return Z_b in Panel (B).

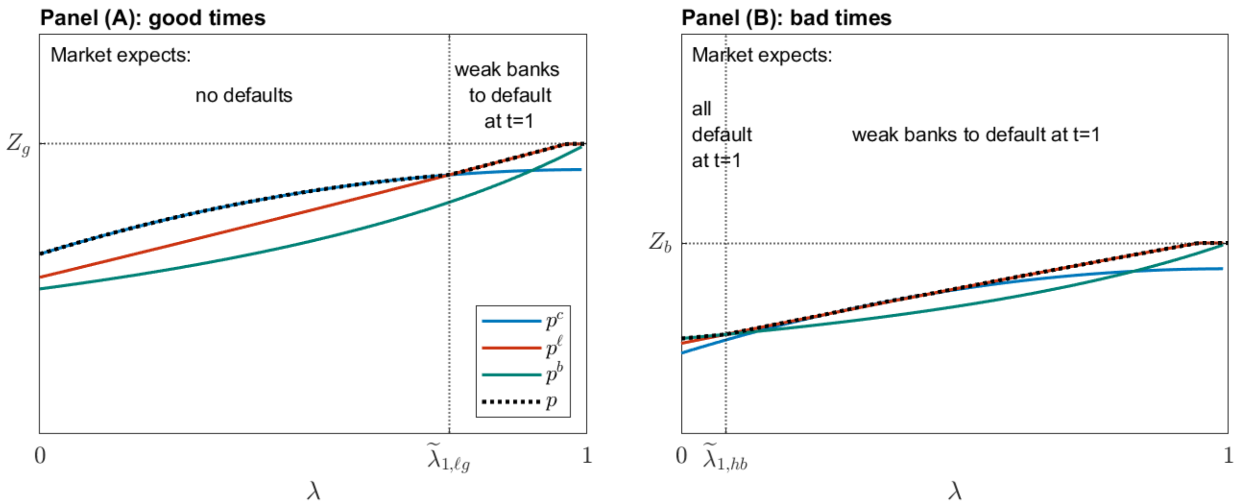

Figure 7 – Market price of the long-term asset

Panel (A) illustrates the long-term asset price in good times Z_g and Panel (B) illustrates the price in bad times Z_b. The solid blue lines are the continuation prices $p^c(\lambda, Z_j)$ when weak banks can sell assets to repay early consumers. The solid red lines are the liquidation prices $p^\ell(\lambda, Z_j)$ when weak banks cannot repay early consumers and are liquidated. The green solid lines are the crisis prices $p^b(\lambda, Z_j)$ when both banks default at $t = 1$ and are liquidated. The dotted black line is the market price of the long-term asset $p(\lambda, Z_j)$ at $t = 1$. For λs above the threshold $\widetilde{\lambda}_{1,\ell g}$ weak banks default at $t = 1$ in good times. For λs below the threshold $\widehat{\lambda}_{1,hb}$ both banks default at $t = 1$ in bad times. Parameter values are $\theta = 0.75$, $\alpha = 0.50$, $\beta = 0.75$, $X_h = 1.65$, $X_\ell = 0.65$, $Z_g = 2$, $Z_b = 1.3$.

In good times, for low values of λ, according to Assumption 1, the market expects weak banks to collect enough liquidity and to survive the first period, despite the relatively lower market prices. Then, the continuation price $p^c(\lambda, Z_g)$ characterizes the market price. However, when banks allocate a substantial portion of investments into the risky short-term asset, even selling the entire holding of the long-term asset at a relatively high market price may not provide enough liquidity for weak banks to repay early consumers. Then weak banks are expected to default at $t = 1$ and the liquidation price $p^\ell(\lambda, Z_g)$ characterizes the market price. In Figure 7 Panel (A), when the banks invest more than $\widetilde{\lambda}_{1,\ell g}$ into the short-term asset, weak banks are expected to default at $t = 1$.

In bad times, the market price decreases uniformly relative to the good times. As illustrated in Figure 7, when the long-term asset return is low, the market price shown in Panel (B) is lower relative to the price in Panel (A). The depressed prices in bad times increase the likelihood of bank defaults. When only weak banks default, the liquidation price $p^{\ell}(\lambda, Z_b)$ characterizes the market price, and when both banks default and are liquidated, the crisis price $p^{b}(\lambda, Z_b)$ characterizes the market price. In Figure 4 Panel (B), when the banks invest less than $\widehat{\lambda}_{1,hb}$ in the short-term asset, all banks are going to default at $t = 1$. Finally, if despite the depressed prices, all banks survive the first period the continuation price $p^{c}(\lambda, Z_b)$ defines the market price.

Next, bank i's second-period return is equal to

$$R(\lambda_i, p, X_i, Z_j) = (1 - \lambda_i + a_i)Z_j$$

where the volume traded is

$$a_i(\lambda_i, p, X_i, Z_j) = \max\left\{\frac{h(\lambda_i)X_i - \theta}{p(\lambda, Z_j)}, -(1 - \lambda_i)\right\},$$

which depends on the bank's investment choice λ_i, the bank's short-term asset return X_i, the long-term asset return Z_j, and the market price $p(\lambda)$. The maximum operator ensures that the bank cannot sell more long-term assets than it owns.

To simplify the notation, let's denote the second-period return of bank i as $R_{ij}(\lambda_i)$ when its short-term asset return is X_i and the long-term asset return is Z_j. Finally, let's define the probability of idiosyncratic shocks as $\Pr(i = \ell) = \alpha$ and $\Pr(i = h) = 1 - \alpha$, and the probability of systematic shocks as $\Pr(j = b) = \beta$ and $\Pr(j = g) = 1 - \beta$.

When banks fully invest in the short-term asset, their portfolios are unaffected by the aggregate risk, and banks may default due to a negative idiosyncratic shock. Conversely, when they invest entirely in the long-term asset, idiosyncratic risk is absent, and all banks may default during bad times. When investing in the long-term asset, banks increase the correlation of their portfolios and thus their common risk exposure. In other words, the likelihood of systemic events increases as the short-term asset holding decreases. Hence, resolution tools that ex-ante lower short-term investment raise the likelihood of systemic defaults.

4.1 Equilibrium with no supervisory intervention

In laissez-faire with no supervisory intervention, given the market expectation λ, late consumers expect to receive either the face value of debt when the bank stays solvent, a fraction c of the second-period return when the bank defaults at $t = 2$, or zero when the bank defaults at $t = 1$. Thus, the late consumers' anticipated payoff, conditional on the realization of X_i and Z_j, can be summarized as

$$\nu_{ij}(\lambda) = \begin{cases} (1-\theta)D_2(\lambda), & \text{if } R_{ij}(\lambda) \geq (1-\theta)D_2(\lambda) \\ c\,R_{ij}(\lambda), & \text{else} \end{cases}$$

Then, the late consumers' binding participation constraint given λ,

$$\sum_{i\in\{\ell,h\}} \sum_{j\in\{b,g\}} \Pr(i)\Pr(j)\nu_{ij}(\lambda) = (1-\theta)\,,$$

characterizes the gross return the late consumers require to break even. According to Assumption 1 and Proposition 2, for low levels of expected short-term investment, the probability of systemic risk is high, so late consumers do not anticipate full repayment in bad times. As λ rises, they start expecting strong banks to fulfill their obligations. However, the likelihood of weak banks defaulting decreases as liquidity improves but later increases due to insolvency risk. As a result, $D_2(\lambda)$ follows a U-shape, first falling as liquidity risk drops, then rising as insolvency risk grows.

Given the market price $p(\lambda, Z_j)$ and the gross return of long-term debt $D_2(\lambda)$, bank i's second-period profit depends on its short-term investment λ_i. The bank will either receive the net second-period return after repaying its late consumers or zero in case of default at $t = 1$ or $t = 2$. More precisely, the bank i's profit, conditional on the realization of X_i and

Z_j, is equal to

$$\pi_{ij}(\lambda_i) = \begin{cases} R_{ij}(\lambda_i) - (1-\theta)D_2(\lambda), & \text{if } R_{ij}(\lambda_i) \geq (1-\theta)D_2(\lambda) \\ 0, & \text{else} \end{cases} \tag{12}$$

Thus, bank i chooses its short-term investment λ_i to maximize its expected second-period payoff

$$\sum_{i \in \{\ell,h\}} \sum_{j \in \{b,g\}} \Pr(i)\Pr(j)\pi_{ij}(\lambda_i)\,,$$

and the first-order condition of the bank's problem is

$$\sum_{i \in \{\ell,h\}} \sum_{j \in \{b,g\}} \Pr(i)\Pr(j)\frac{\partial \pi_{ij}(\lambda_i)}{\partial \lambda_i} = 0\,.$$

The portfolio satisfying the first-order condition is a local solution to the bank's problem if the corresponding equilibrium condition as in (12) is satisfied. Lastly, if more than one portfolio satisfies the first-order condition, the bank chooses the portfolio that generates the highest payoff.

As an example to illustrate a bank's portfolio preference, take the case in which the bank has the option of investing in a safe portfolio with no bank defaults. For the equilibrium condition

$$R_{\ell b}(\lambda_i^*) \geq (1-\theta)D_2(\lambda)\,, \tag{13}$$

bank i's expected second-period profit is

$$(1-\beta)\mathbb{E}[(R_{ig}(\lambda_i)] + \beta\mathbb{E}[(R_{ib}(\lambda_i)] - (1-\theta)D_2(\lambda)\,,$$

where $\mathbb{E}[(R_{iz}(\lambda_i)]$ is the conditional expected second-period return when $Z = Z_z$. The first-order condition

$$(1-\beta)\left[-1 + \frac{(1-\lambda_i^*)\overline{X}}{p(\lambda, Z_g)}\right] Z_g + \beta\left[-1 + \frac{(1-\lambda_i^*)\overline{X}}{p(\lambda, Z_b)}\right] Z_b = 0\,,$$

characterizes the equilibrium *safe* portfolio with short-term investment $\lambda_i^*(\lambda)$, given it satisfies the equilibrium condition (13). In addition to the safe portfolio, consider the case in which the bank has the option to invest in a portfolio that results in all banks defaulting at $t = 2$ in bad times. In this case, for the equilibrium condition

$$R_{\ell g}(\lambda_i^{**}) \geq (1-\theta)D_2(\lambda) > R_{hb}(\lambda_i^{**}) > 0\,, \tag{14}$$

bank i's expected second-period profit in laissez-faire is

$$(1-\beta)\Big[\mathbb{E}[(R_{ig}(\lambda_i)] - (1-\theta)D_2(\lambda)\Big]\,.$$

The first-order condition

$$(1-\lambda_i^{**})\overline{X} = p(\lambda, Z_g)\,,$$

characterizes the equilibrium *systemic* portfolio with short-term investment $\lambda_i^{**}(\lambda)$, given it satisfies the equilibrium condition (14).

Finally, when the bank has the two options of investing in a safe portfolio $\lambda_i^{*}(\lambda)$ and a systemic portfolio $\lambda_i^{**}(\lambda)$, it will prefer the systemic portfolio if the expected profits from this option exceed those generated by the safe portfolio,

$$(1-\beta)\Big[\mathbb{E}[(R_{ig}(\lambda_i^{**})] - (1-\theta)D_2(\lambda)\Big] > (1-\beta)\mathbb{E}[(R_{ig}(\lambda_i^{*})] + \beta\mathbb{E}[(R_{ib}(\lambda_i^{*})] - (1-\theta)D_2(\lambda)\,.$$

Rearranging the inequality,

$$D_2(\lambda) > \frac{(1-\beta)\Big[\mathbb{E}[(R_{ig}(\lambda_i^{*}) - (R_{ig}(\lambda_i^{**})] + \beta\mathbb{E}[(R_{ib}(\lambda_i^{*})]}{\beta(1-\theta)} \tag{15}$$

the bank opts for the systemic portfolio whenever the gross return of long-term debt is sufficiently large.

4.2 Equilibrium with bailout

If the supervisor announces to bailout creditors, late consumers expect to receive the face value of their debt whenever the bank survives at $t = 1$. Thus, the late consumers' anticipated payoff conditional on the realization of X_i and Z_j, can be summarized as

$$\nu_{ij}(\lambda) = \begin{cases} (1-\theta)D_2^{out}(\lambda), & \text{if } R_{ij}(\lambda) > 0 \\ 0, & \text{else} \end{cases}$$

and their binding participation constraint is

$$\sum_{i\in\{\ell,h\}}\sum_{j\in\{b,g\}} \Pr(i)\Pr(j)\nu_{ij}(\lambda) = (1-\theta)\,.$$

Under a bailout policy, late consumers are fully repaid in the event of an imminent default at $t = 2$, and they receive the same payoff as in laissez-faire under any other circumstance. Consequently, since bailouts ensure a weakly higher payoff for late consumers, the gross return they demand to break even is weakly lower. In other words, the expectation of creditor bailouts results in banks facing a weakly lower long-term funding cost.

Regarding bank profits under a creditor bailout policy, since creditors are the only beneficiaries of the bailout, banks themselves receive zero profit in the event of a bailout. This outcome mirrors the laissez-faire scenario where the bank would have defaulted. However, for the same short-term investment λ_i, bank i's profit, conditional on the realization of X_i and Z_j,

$$\pi_{ij}(\lambda_i) = \begin{cases} R_{ij}(\lambda_i) - (1-\theta)D_2^{out}(\lambda), & \text{if } R_{ij}(\lambda_i) \geq (1-\theta)D_2^{out}(\lambda) \\ 0, & \text{else} \end{cases} \tag{16}$$

is weakly higher than in laissez-faire because conditional on survival, the bank repays a lower face value of debt. Additionally, the equilibrium condition for survival at $t = 2$ is more easily met. These two factors of higher likelihood of survival and higher payoffs given survival, motivate banks to choose a safer portfolio relative to laissez-faire. More precisely, given bank i's expected second-period returns,

$$\sum_{i\in\{\ell,h\}}\sum_{j\in\{b,g\}} \Pr(i)\Pr(j)\pi_{ij}(\lambda_i)\,,$$

the first-order condition characterizing a bank's portfolio choice is

$$\sum_{i\in\{\ell,h\}}\sum_{j\in\{b,g\}}\Pr(i)\Pr(j)\frac{\partial \pi_{ij}(\lambda_i)}{\partial \lambda_i}=0\,.$$

The first-order condition remains identical to the laissez-faire scenario. The key difference in bank i's problem lies in the equilibrium condition (16), which is more easily satisfied since $D_2^{out}(\lambda)$ is lower than in laissez-faire. This means equilibrium portfolios where late consumers are fully repaid are more likely under the expectation of a creditor bailout. Additionally, if multiple portfolios meet the first-order condition, the bank tends to select the safer one, as reduced long-term funding costs make this option more profitable.

Continuing with the example in which banks can choose between a safe and a systemic portfolio in laissez-faire when banks expect bailouts, they anticipate zero second-period profits. Thus, the equilibrium safe portfolio with short-term investment $\lambda_i^*(\lambda)$ and systemic portfolio with short-term investment $\lambda_i^{**}(\lambda)$ are identical to laissez-faire. As a result, the right-hand side of the inequality (15) remains unchanged. However, when the markets expect bailouts, the gross return on long-term decreases and the left-hand side of inequality (15) is lower. Hence, the inequality is less often satisfies. In other words, under bailout expectations it is more likely that the bank prefers a safe portfolio over a systemic one.

Figure 8 illustrates the shift in bank portfolio risk based on market expectations. It shows bank i's response function $\lambda_i(\lambda)$ relative to market's expected short-term investment λ. The green line represents a safe portfolio with no defaults, while the red line represents a systemic portfolio, with systemic defaults during bad times. The left panel depicts laissez-faire, and the right shows bailout expectations. When both portfolios are an equilibrium option, the bank selects the one offering the highest payoff, marked by solid lines reflecting whether the portfolio is safe or systemic.

In laissez-faire (left panel), for low levels of λ the market expects all banks to default in bad times. Adjusting the gross return late consumers expect for the long-term debt, the bank opts for the systemic portfolio (solid red line). For intermediate levels of λ, the market

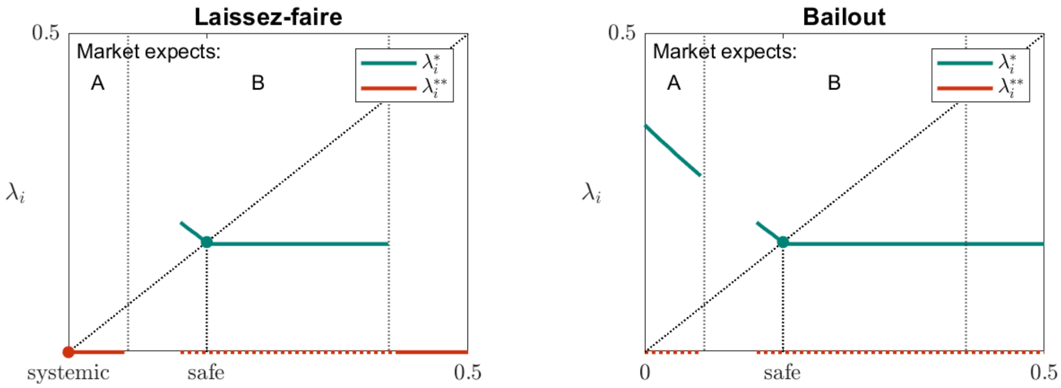

Figure 8 – **Bank's response function in laissez-faire and bailout under aggregate risk** The figure illustrates banks' safe portfolio with short-term investment $\lambda_i^*(\lambda)$ (green line) and portfolio with systemic risk and short-term investment $\lambda_i^{**}(\lambda)$ (red line) given any market expectations λ for the cases of laissez-faire (left panel) and bailout expectations (right panel). The portfolio with the highest payoff is illustrated as a solid line and its color indicates whether it is a non-systemic or a systemic portfolio. The intersection of banks' response function with the 45-degree line defines the symmetric equilibrium of the depicted example. For the range of short-term investment expectations $\lambda \in [0, 1]$, the market expects (A) all banks defaulting in bad times, and (B) no bank defaulting. Parameter values are $\theta = 0.25$, $\alpha = 0.25$, $\beta = 0.75$, $X_h = 1.65$, $X_\ell = 1.30$, $Z_g = 2.30$, $Z_b = 1.00$, and $c = 0.65$.

anticipates no defaults, reducing the gross return of the long-term debt, and the bank chooses the safe portfolio (solid green line) while having the option of the systemic portfolio (dotted red line). The example demonstrates financial fragility stemming from self-fulfilling market beliefs.

Under a bailout policy, although for low levels of λ, the market expects banks to default in bad times, as the late consumers are fully repaid under the bailout, the gross return on long-term debt remains unchanged. Facing low long-term funding costs, the bank opts for the safe portfolio (green solid line), while having the option of the systemic portfolio (dotted red line). Thus, the anticipation of bailouts eliminates the systemic equilibrium and financial fragility.

4.3 Equilibrium with bail-in

If the supervisor bails-in banks that are going to default at $t = 2$, she first observes the short-term asset return X_i realized at $t = 1$ and the long-term asset return Z_j which is going to realize at $t = 2$. Then, she converts the long-term debt of the failing banks into equity. The NCWO principle restricts the conversion rate γ such that creditors do not experience losses higher than those they would face in a default scenario. As described in Section 3, this principle sets the lower bound of the conversion rate at c, the fraction of returns lost due to a bank default.

The late consumers receive either the face value of their debt in cases the bank remains solvent at $t = 2$, a fraction γ of second-period returns in case the bank is imminent to default at $t = 2$ and, thus, is bailed-in, and zero in cases of default at $t = 1$. Thus, the late consumer's second-period payoffs, conditional on the realization of X_i and Z_j, are equal to

$$\nu_{ij}(\lambda) = \begin{cases} (1-\theta)D_2^{in}(\lambda), & \text{if } R_{ij}(\lambda) \geq (1-\theta)D_2^{in}(\lambda) \\ \gamma R_{ij}(\lambda), & \text{if } (1-\theta)D_2^{in}(\lambda) > R_{ij}(\lambda) > 0 \\ 0, & \text{else} \end{cases}$$

and their binding participation constraint is

$$\sum_{i\in\{\ell,h\}} \sum_{j\in\{b,g\}} \Pr(i)\Pr(j)\nu_{ij}(\lambda) = (1-\theta)\,.$$

Compared to laissez-faire, under a bail-in, late consumers receive a fraction γ of the second-period returns in cases of imminent default at $t = 2$, which is greater than or equal to c. In all other cases, their payoff remains the same. As a result for short-term investment λ, the expected gross return on long-term debt is weakly lower when a bail-in is anticipated compared to laissez-faire.

Regarding bank profits under a creditor bailout policy, bank i either receives the net second-period return after repaying its late consumers, a fraction $1-\gamma$ of the second-period returns in cases of a bail-in, or zero in cases of default at $t = 1$. More precisely, the bank i's profit, conditional on the realization of X_i and Z_j, is equal to

$$\pi_{ij}(\lambda_i) = \begin{cases} R_{ij}(\lambda_i) - (1-\theta)D_2^{in}(\lambda), & \text{if } R_{ij}(\lambda_i) \geq (1-\theta)D_2^{in}(\lambda) \\ (1-\gamma)R_{ij}(\lambda_i), & \text{if } (1-\theta)D_2^{in}(\lambda) > R_{ij}(\lambda_i) > 0 \\ 0, & \text{else} \end{cases} \tag{17}$$

Note that, since γ is at most one, banks receive weakly higher payoffs following a bail-in relative to zero in laissez-faire. Moreover, as the second-period funding costs are weakly lower, conditional on survival at $t = 2$, the bank's profit is higher and the equilibrium condition for survival is easier to satisfy. Thus, the anticipation of bail-ins has a direct ex-ante portfolio effect.

Finally, the bank i chooses its short-term investment λ_i to maximize its expected second-period payoff

$$\sum_{i\in\{\ell,h\}} \sum_{j\in\{b,g\}} \Pr(i)\Pr(j)\pi_{ij}(\lambda_i)\,,$$

and the first-order condition of the bank's problem is

$$\sum_{i\in\{\ell,h\}} \sum_{j\in\{b,g\}} \Pr(i)\Pr(j)\frac{\partial \pi_{ij}(\lambda_i)}{\partial \lambda_i} = 0\,.$$

given the equilibrium condition as in (17) is satisfied. Unlike the model with only idiosyncratic risk, in the presence of aggregate risk, it is ambiguous whether a bank would prefer a portfolio with higher or lower short-term investments under expectations of a bail-in compared to the laissez-faire scenario. However, the ex-ante portfolio reallocation effect of bail-in expectations changes the expected profits generated by each portfolio and can lead to banks preferring a systemic portfolio over a non-systemic one.

Continuing with the example in which banks can choose between a safe and a systemic portfolio in laissez-faire, when banks expect bail-ins, the equilibrium safe portfolio with short-term investment $\lambda_i^*(\lambda)$ remains unchanged. However, in case of systemic defaults in bad times, for the equilibrium condition, (14) bank i's expected second-period profit following bail-ins is

$$(1-\beta)\Big[\mathbb{E}[(R_{ig}(\lambda_i)] - (1-\theta)D_2(\lambda)\Big] + \beta(1-\gamma)\mathbb{E}[(R_{ib}(\lambda_i)]\,.$$

The first-order condition

$$(1-\beta)\left[-1 + \frac{(1-\lambda_i^{in})\overline{X}}{p(\lambda, Z_g)}\right] Z_g + \beta(1-\gamma)\left[-1 + \frac{(1-\lambda_i^{in})\overline{X}}{p(\lambda, Z_b)}\right] Z_b = 0\,,$$

characterizes the equilibrium systemic portfolio with short-term investment $\lambda_i^{in}(\lambda)$, given it satisfies the equilibrium condition (14). Note that because the market price is uniformly decreasing in the fundamental value of the long-term asset, the short-term investment of the systemic portfolio under bail-in expectations is lower than in the laissez-faire case, and for $\gamma < 1$ higher than the safe portfolio, i.e. $\lambda_i^{**}(\lambda) < \lambda_i^{in}(\lambda) < \lambda_i^{*}(\lambda)$.

The bank chooses the systemic portfolio when it generates higher expected profits

$$D_2^{in}(\lambda) > \frac{(1-\beta)\Big[\mathbb{E}[(R_{ig}(\lambda_i^*)] - \mathbb{E}[(R_{ig}(\lambda_i^{in})]\Big] + \beta\Big[\mathbb{E}[(R_{ib}(\lambda_i^*)] - (1-\gamma)\mathbb{E}[(R_{ib}(\lambda_i^{in})]\Big]}{\beta(1-\theta)}. \quad (18)$$

Since $\gamma \geq c$, the long-term funding cost under bail-in expectations is weakly lower than in laissez-faire, making it harder to satisfy inequality (18). However, the ex-ante portfolio reallocation changes the right-hand side of the inequality in (18). Since the right-hand side of the inequality (18) is lower than that of the inequality (15), the bank may prefer the systemic portfolio, even though it would have chosen the safer one in laissez-faire conditions.

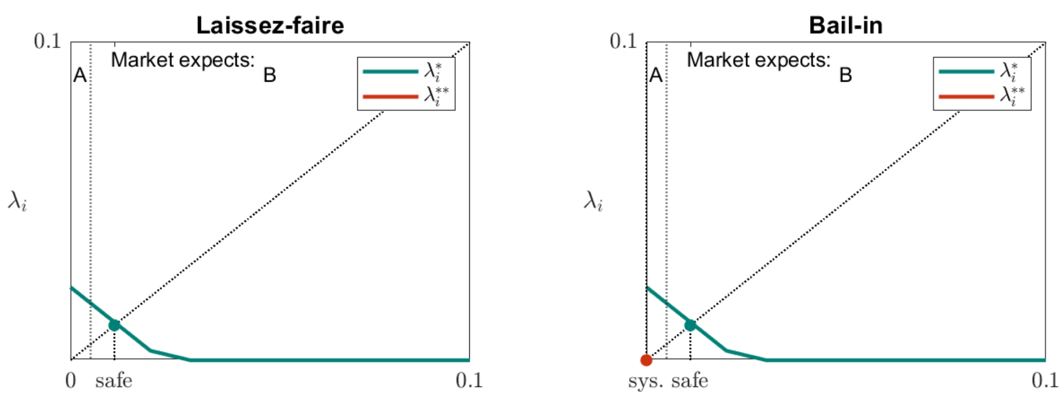

Figure 9 – Bank's response function in laissez-faire and bail-ins under aggregate risk

The figure illustrates banks' safe portfolio with short-term investment $\lambda_i^*(\lambda)$ (green line) and portfolio with systemic risk and short-term investment $\lambda_i^{**}(\lambda)$ (red line) given any market expectations λ for the cases of laissez-faire (left panel) and bail-in expectations (right panel). The portfolio with the highest payoff is illustrated as a solid line, and its color indicates whether it is a non-systemic or a systemic portfolio. The intersection of banks' response function with the 45-degree line defines the symmetric equilibrium of the depicted example. For the range of short-term investment expectations $\lambda \in [0, 1]$, the market expects (A) all banks defaulting in bad times, and (B) no bank defaulting. Parameter values are $\theta = 0.25$, $X_h = 1.98$, $X_\ell = 0.35$, $Z_g = 1.65$, $Z_b = 1.30$, $\alpha = 0.50$, $\beta = 0.75$, and $\gamma = c = 0.65$.

Figure 9 illustrates the shift in bank portfolio risk based on market expectations. It shows bank i's response function $\lambda_i(\lambda)$ relative to the market's expected short-term investment λ. The green line represents a safe portfolio with no defaults, while the red line represents a systemic portfolio, with defaults during bad times. The left panel depicts laissez-faire and the right shows bail-in expectations. When both portfolios are an equilibrium option, the bank selects the one offering the highest payoff, marked by solid lines reflecting whether the portfolio is safe or systemic.

In laissez-faire (left panel), for low levels of λ, the market expects defaults in bad times, but the bank opts for the safe portfolio (solid green line) while having the systemic portfolio as an option. For intermediate λ, no defaults are expected, lowering long-term debt returns, and the bank continues to choose the safe portfolio. Under bail-in policies, however, for low λ, the market anticipates bail-ins to reduce long-term funding costs and the ex-ante proportion of short-term investment the banks choose relative to laissez-faire, leading to systemic default. These two effects shift the expected profits of each portfolio option, leading the bank to favor the systemic portfolios, increasing systemic risk and financial fragility.

4.4 Summary of results with aggregate risk

When aggregate risk is present in the model, market prices decline while anticipating bad times. These depressed prices give rise to systemic default if banks hold too little short-term asset because all banks, even those with a positive idiosyncratic shock, are unable to collect sufficient liquidity when selling their long-term assets at low prices. In other words, when banks have small short-term investments they correlate their portfolios and increase the systemic exposure.

In this setting, a resolution policy that reduces ex-ante short-term holdings increases systemic risk in the economy. Creditor bailouts keep expected portfolio payoffs unchanged relative to laissez-faire but reduce long-term funding costs, encouraging banks to choose safer portfolios when multiple options exist. In contrast, bail-ins affect both ex-ante portfolio composition and long-term funding costs. While the reduction in funding costs discourages risk-taking like in bailouts, the ex-ante portfolio reallocation leads banks to prefer a portfolio with systemic defaults in bad times.

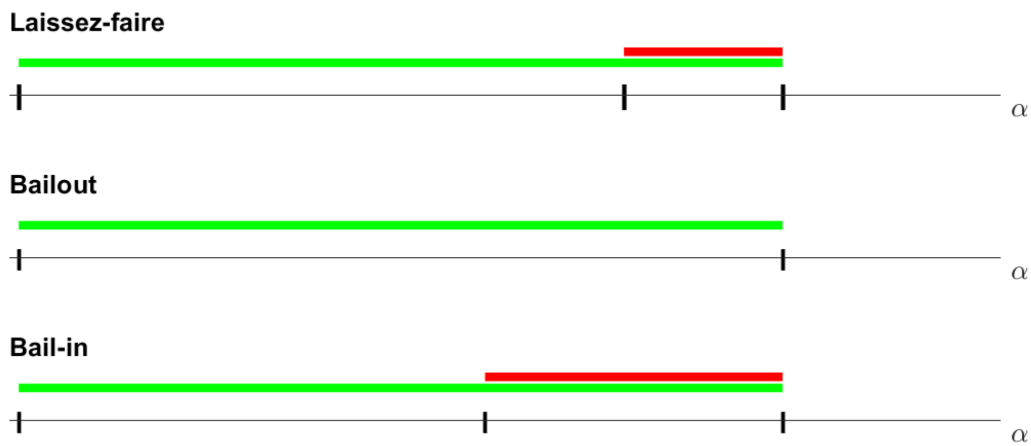

Figure 10 – Systemic risk under aggregate risk

The figure depicts the systemic risk across the range of possible values for the probability of a low long-term asset return $\beta \in (0,1)$ in case of no supervisory intervention, in anticipation of bailouts, and in anticipation of bail-ins. The green line signifies the equilibrium with no systemic defaults and the red line signifies the equilibrium with systemic defaults. The overlapping region between the red and green lines demonstrates cases of multiple equilibria. Parameter values are $\theta = 0.25$, $\beta = 0.75$, $X_h = 2.30$, $X_\ell = 0.65$, $Z_g = 2.30$, $Z_b = 1.30$, and $\gamma = c = 0.65$.

Figure 10 depicts the systemic risk across the range of the probability of low long-term asset return $\alpha \in (0,1)$. The green line illustrates an equilibrium in which the strong bank remains solvent independent of the long-term asset return. The red line illustrates an equilibrium in which both banks default when the long-term asset will have a low return. When these two lines overlap, it indicates the presence of multiple equilibria. As α increases the expected return of the short-term asset decreases. In laissez-faire, as the expected return of the short-term asset decreases relative to the long-term asset, banks prefer to invest more in the long-term asset. Thus, for low values of α, the bank invests more in the short-term asset, increasing the short-term liquidity and preventing fire sales (the green line). As α increases, banks reduce their short-term investment, getting into the region where all banks default due to illiquidity in bad times, generating systemic risk (red line). Finally, when the two lines overlap, banks can either invest in a portfolio that generates systemic defaults or in a portfolio with no systemic risk. Their choice depends on the market's beliefs about bank risk-taking and the resulting gross return on long-term debt the market requires.

The bailouts insure the long-term debt and, hence, reducing the ex-ante long-term funding costs. The reduction in the gross return on long-term debt reduces the region in which the equilibrium with systemic bank defaults exists, i.e., reducing the length of the red line or as in Figure 10 removing the red line. In other words, when banks can collect cheaper funds, they prefer to hold saver portfolios, avoiding systemic defaults. Moreover, the bailout expectations removes the region where the red and green lines overlap. Thus, the expectation of bailouts has resolved the fragility of the system.

Bail-ins alter expected bank payoffs and hence trigger ex-ante portfolio reallocation. Figure 10 illustrates that for intermediate levels of α, this portfolio reallocation incentivizes to choose a systemic portfolio with lower short-term investments. In essence, the anticipation of bail-ins can introduce multiple equilibria (larger region of green and red line overlapping) and generate systemic risk (larger region of red line). As a result, bail-ins are less effective in averting systemic risk and might even contribute to it.

5 Conclusion

This paper contributes to the ongoing debate about supervisory resolution policy, particularly the choice between bail-ins and bailouts. I show that creditor bailout expectations reduce long-term funding costs, incentivizing each bank to choose a safe portfolio and decreasing the likelihood of bank defaults. Similar to the deposit insurance in the bank run model by Diamond and Dybvig (1983) or the "whatever-it-takes" promise by the former President of the European Central Bank Mario Draghi, a promise to bailout creditors rules out the equilibrium with defaults and reduce ex-post supervisory interventions.

Bail-in expectations, on the other hand, influence banks' long-term funding costs and their ex-ante portfolio composition. In cases of idiosyncratic risk, bail-in expectations incentivize banks to choose a risky portfolio with lower solvency risk, potentially pre-empting defaults. However, when aggregate risk is present, this reduction in idiosyncratic risk can lead to higher correlation across bank portfolios, thereby increasing systemic risk. The results in this paper suggest that a resolution policy that pre-conditions bail-ins for any bail-outs, which for example is the case in Europe, may contribute to the fragility of the banking environment. In contrast, a resolution policy that leaves the possibility of creditor bailouts open to “systemic risk exceptions”, which for example is the case in the United States, may reduce the likelihood of systemic events.

The supervisory resolution policy in this paper is treated as exogenous to assess the positive effects of each policy on ex-ante bank portfolios and ex-post default outcomes. A natural next step involves explicitly defining the supervisory mandate, i.e. objective function, to analyze the (social) costs associated with bailouts versus bail-ins and to formalize the supervisor’s preferred resolution policy. Existing literature emphasizes the commitment challenge faced by supervisors in refraining from bailouts. It is worth investigating the supervisory preferences and whether a commitment problem exists. If this is the case, regardless of the supervisory resolution announcement, the market will anticipate the ex-post resolution policy and the corresponding results are defined as described in this paper.

A wide range of literature models and evidences the moral hazard associated with bailout policies, where shareholders anticipate benefits from bailouts and, ex-ante, select portfolios that increase the likelihood of bailouts in both idiosyncratic and systemic risk scenarios. This paper avoids this issue by focusing on a creditor bailout, in which shareholders ex-post do not benefit. Given the current regulatory framework in Europe and the U.S., along with negative public views toward shareholder bailouts, this assumption seems reasonable. Nevertheless, it is possible to extend the model to include a broader definition of bailouts. Under a shareholder bailout, moral hazard would incentivize banks to select riskier portfolios. This shift towards higher risk diminishes the effectiveness of bailouts in mitigating bank defaults and overall financial fragility.

Finally, since systemic events under bail-in expectations are driven by fire sales and liquidity risk, liquidity facilities—well-studied in the literature and empirically tested—can ex-post mitigate fire sales and prevent systemic defaults. However, these facilities alter banks' expected payoffs across the different states, leading to their own ex-ante portfolio effects. Combining these portfolio effects with the ex-ante effects of bail-ins, makes characterizing the equilibrium challenging. Nevertheless, exploring a bail-in resolution policy jointly with liquidity facilities offers a promising avenue for further research.

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Appendix

Proof of Proposition 1. When weak banks cannot repay early consumers out of the first-period return, that is when

$$\theta > h(\lambda_i)X_\ell \,,$$

they need to sell a fraction of their long-term asset holding to prevent a default at $t = 1$. In this case, if the short-term asset return plus the proceeds from selling the long-term asset is enough to repay the early consumers,

$$h(\lambda)X_\ell + p(1-\lambda) < \theta \,,$$

that is when

$$p \geq \widetilde{p}(\lambda) = \frac{\theta - h(\lambda)X_\ell}{1-\lambda} \,,$$

the market clearing condition,

$$\alpha[h(\lambda)X_\ell - \theta] + (1-\alpha)[h(\lambda)X_h - \theta] + (\overline{Z} - p) = 0 \,,$$

defines the cash-in-the-market price. Thus, the continuation price is characterized as

$$p^c(\lambda) = \min\{h(\lambda)\overline{X} + \overline{Z} - \theta, \overline{Z}\} \,,$$

where superscript c indicates that all banks continue to operate until $t = 2$ and due to the storage technology the price cannot exceed the return of the long-term asset $\overline{Z}$.

When weak banks fail to repay early consumers, that is when $p < \widetilde{p}(\lambda)$, the supervisor liquidates weak banks' assets, $1 - \lambda_i$. In this case, the market-clearing condition

$$-\alpha(1-\lambda) + (1-\alpha)\frac{h(\lambda)X_h - \theta}{p} + \frac{\overline{Z} - p}{p} = 0 \,,$$

defines the cash-in-the-market price. Thus, the liquidation price is characterized as

$$p^\ell(\lambda) = \min\left\{\frac{(1-\alpha)[h(\lambda)X_h - \theta] + \overline{Z}}{1 + \alpha(1-\lambda)}, \overline{Z}\right\} \,,$$

where superscript ℓ indicates that the weak banks are liquidated at $t = 1$ and due to the storage technology the price cannot exceed the return of the long-term asset $\overline{Z}$. Note that the liquidation price, if not equal to $\overline{Z}$, can be rewritten as

$$p^{\ell}(\lambda) = p^{c}(\lambda) + \frac{\alpha(1-\lambda)}{1+\alpha(1-\lambda)}[\widetilde{p}(\lambda) - p^{c}(\lambda)] \tag{A1}$$

or as

$$p^{\ell}(\lambda) = \widetilde{p}(\lambda) + \frac{[p^{c}(\lambda) - \widetilde{p}(\lambda)]}{1+\alpha(1-\lambda)}\,. \tag{A2}$$

If for some λ we have $\widetilde{p}(\lambda) \leq p^{c}(\lambda)$, then (A1) implies $p^{\ell}(\lambda) \leq p^{c}(\lambda)$ and (A2) implies $\widetilde{p}(\lambda) \leq p^{\ell}(\lambda)$, that is

$$\widetilde{p}(\lambda) \leq p^{\ell}(\lambda) \leq p^{c}(\lambda). \tag{A3}$$

And if for some λ we have $\widetilde{p}(\lambda) > p^{c}(\lambda)$, then (A1) implies $p^{\ell}(\lambda) \geq p^{c}(\lambda)$ and (A2) implies $\widetilde{p}(\lambda) > p^{\ell}(\lambda)$, that is

$$\widetilde{p}(\lambda) > p^{\ell}(\lambda) \geq p^{c}(\lambda). \tag{A4}$$

In the first case, one cannot have weak banks defaulting, because the liquidation price $p^{\ell}(\lambda)$ is above the threshold $\widetilde{p}(\lambda)$, so the continuation price $p^{c}(\lambda)$ (which is above the threshold $\widetilde{p}(\lambda)$) becomes the market price $p(\lambda)$. In the second case, one cannot have weak banks surviving, because the continuation price $p^{c}(\lambda)$ is below the threshold $\widetilde{p}(\lambda)$, so the liquidation price $p^{\ell}(\lambda)$ (which is below the threshold $\widetilde{p}(\lambda)$) becomes the market price $p(\lambda)$. Hence, it follows that $p(\lambda) = \max\{p^{c}(\lambda), p^{\ell}(\lambda)\}$. □

Proof of Assumption 1. A bank experiencing a negative idiosyncratic shock is expected to default at $t = 1$ if it cannot repay its short-term debt and to be liquidated. Given that the second-period return is concave in λ and given exogenous parameter values, there exist two thresholds

$$\left\{\widehat{\lambda}_{1,\ell}, \widetilde{\lambda}_{1,\ell}\right\} : R_{\ell}(\lambda) = 0$$

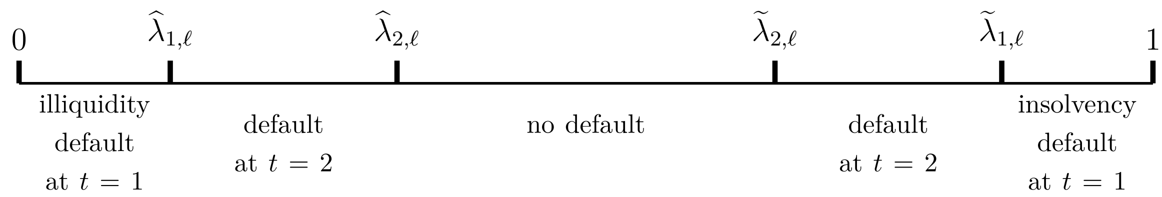

Figure A1 – Market expected defaults

An illustration of weak banks' default regions expected by the market as a function of market short-term investment λ.

characterizing the range of λ values that lead to defaults at $t = 1$. The first threshold, $\widehat{\lambda}_{1,\ell}$, marks the point below which the weak bank defaults due to illiquidity. The second threshold, $\widetilde{\lambda}_{1,\ell}$, marks the point above which the bank defaults due to insolvency. The subscript 1 indicates these thresholds are relevant for defaults at $t = 1$.

If the weak bank survives the first-period, but cannot repay the face value of the long-term debt, it defaults at $t = 2$. Given that the second-period return is concave in λ and given exogenous parameter values, there exist two thresholds,

$$\left\{\widehat{\lambda}_{2,\ell}, \widetilde{\lambda}_{2,\ell}\right\} : R_\ell(\lambda) = (1 - \theta)$$

characterizing the range of λ values that lead to defaults at $t = 2$. The first threshold, $\widehat{\lambda}_{2,\ell} > \widehat{\lambda}_{1,\ell}$, below which the weak bank defaults at $t = 2$ and the second threshold, $\widetilde{\lambda}_{2,\ell} < \widetilde{\lambda}_{1,\ell}$, above which the bank defaults at $t = 2$. The subscript 2 indicates these thresholds are relevant for defaults at $t = 2$.

As summarized in Figure A1, the expected short-term investment range $0 \leq \lambda \leq \widehat{\lambda}_{1,\ell}$, corresponds to the market expecting weak banks to default at $t = 1$ due to illiquidity. For the range $\widetilde{\lambda}_{1,\ell} < \lambda \leq \widetilde{\lambda}_{2,\ell}$ the market expects them to default at $t = 2$. When $\widetilde{\lambda}_{2,\ell} < \lambda \leq \widetilde{\lambda}_{2,\ell}$ the market expects no bank defaults. In the range $\widetilde{\lambda}_{2,\ell} < \lambda \leq \widetilde{\lambda}_{1,\ell}$ the market expects weak banks to default at $t = 2$, and finally, for $\widetilde{\lambda}_{1,\ell} < \lambda \leq 1$ the market expects weak banks to default at $t = 1$ due to insolvency.

By assuming parameter values such that weak banks will not default at $t = 2$ for low values of λ, the thresholds $\widehat{\lambda}_{2,\ell}$ and $\widehat{\lambda}_{1,\ell}$ are eliminated. More specifically, I assume that weak banks are expected to survive until $t = 2$ even when $\lambda = 0$, i.e., $R_\ell(0) > (1-\theta)$. This can be rewritten as

$$\left[1 - \frac{\theta}{\overline{Z} - \theta}\right]\overline{Z} > 1 - \theta \;\Leftrightarrow\; \frac{\overline{Z} - 1}{\theta + \overline{Z} - 1} > \frac{\theta}{\overline{Z}}\,.$$

When this inequality holds, weak banks are not at risk of defaulting due to illiquidity at $t = 1$ or from a default at $t = 2$ following an illiquidity shock at $t = 1$. □

Proof of Proposition 2. Strong banks fail at $t = 1$ when the short-term asset return plus the proceeds from selling the entire holding of the long-term asset are not enough to repay the early consumers,

$$h(\lambda)X_h + p(1-\lambda) < \theta\,.$$

That is when

$$p \leq \widehat{p}(\lambda) = \frac{\theta - h(\lambda)X_h}{1-\lambda}\,.$$

When strong banks fail, weak banks are also going to fail because

$$\widehat{p}(\lambda) = \frac{\theta - h(\lambda)X_h}{1-\lambda} < \frac{\theta - h(\lambda)X_\ell}{1-\lambda} = \widetilde{p}(\lambda)\,.$$

Then, both banks are liquidated, and the market clearing condition

$$-\alpha(1-\lambda) - (1-\alpha)(1-\lambda) + \frac{Z_j - p}{p} = 0\,.$$

defines the crisis liquidation price

$$p^b(\lambda, Z_j) = \frac{Z_j}{2-\lambda}\,,$$

with the superscript h indicating that both the weak and strong banks are liquidated at $t = 1$.

If strong banks can successfully repay the early consumers and continue to operate until $t = 2$, but weak banks are going to fail at $t = 1$,

$$\widehat{p}(\lambda) < p < \widetilde{p}(\lambda)\,,$$

then weak banks' liquidation price

$$p^\ell(\lambda, Z_j) = \min\left\{\frac{(1-\alpha)[h(\lambda)X_h - \theta] + Z_j}{1+\alpha(1-\lambda)}, Z_j\right\}$$

is the market price, where superscript ℓ indicates that only the weak banks are liquidated at $t = 1$. Note that due to the storage technology the price cannot exceed the return of the long-term asset $\overline{Z}$. The liquidation price, if not equal to $\overline{Z}$, can be rewritten as

$$p^\ell(\lambda, Z_i) = p^b(\lambda, Z_i) + \frac{(1-\alpha)(1-\lambda)}{1+\alpha(1-\lambda)}[p^b(\lambda, Z_i) - \widehat{p}(\lambda)] \tag{A5}$$

or as

$$p^\ell(\lambda, Z_i) = \widehat{p}(\lambda) + \frac{2-\lambda}{1+\alpha(1-\lambda)}[p^b(\lambda, Z_i) - \widehat{p}(\lambda)]\,. \tag{A6}$$

Finally, if both banks are solvent at $t = 2$,

$$\widehat{p}(\lambda) < \widetilde{p}(\lambda) < p\,,$$

the continuation price

$$p^c(\lambda, Z_j) = \min\{h(\lambda)\overline{X} + Z_j - \theta, Z_j\},$$

is the market price, where superscript c indicates that all banks continue to operate until $t = 2$ and due to the storage technology the price cannot exceed the return of the long-term asset $\overline{Z}$. Note that the liquidation price, if not equal to $\overline{Z}$, can be rewritten as

$$p^\ell(\lambda, Z_j) = p^c(\lambda, Z_j) + \frac{\alpha(1-\lambda)}{1+\alpha(1-\lambda)}[\widetilde{p}(\lambda) - p^c(\lambda, Z_j)] \tag{A7}$$

or as

$$p^\ell(\lambda, Z_j) = \widetilde{p}(\lambda) + \frac{[p^c(\lambda, Z_j) - \widetilde{p}(\lambda)]}{1+\alpha(1-\lambda)}\,. \tag{A8}$$

If for some λ we have $\widehat{p}(\lambda) \geq p^b(\lambda, Z_j)$, then (A5) implies $p^b(\lambda, Z_j) \geq p^\ell(\lambda, Z_j)$ and (A6) implies $\widehat{p}(\lambda) \geq p^\ell(\lambda, Z_j)$, that is

$$\widehat{p}(\lambda) \geq p^b(\lambda, Z_j) \geq p^\ell(\lambda, Z_j).$$

Since $\widetilde{p}(\lambda) > \widehat{p}(\lambda)$, the above inequalities imply $\widetilde{p}(\lambda) \geq p^{\ell}(\lambda, Z_j)$. Then (A8) implies $\widetilde{p}(\lambda) > p^c(\lambda, Z_j)$ and then (A7) implies $p^{\ell}(\lambda, Z_j) > p^c(\lambda, Z_j)$. That is,

$$\widetilde{p}(\lambda) > \widehat{p}(\lambda) \geq p^b(\lambda, Z_j) \geq p^{\ell}(\lambda, Z_j) > p^c(\lambda, Z_j).$$

In this case, weak banks cannot survive at $t = 2$, because the continuation price $p^c(\lambda, Z_j)$ is below the default threshold $\widetilde{p}(\lambda)$ and the strong banks cannot survive at $t = 2$ because the weak banks' liquidation price $p^{\ell}(\lambda, Z_j)$ is below the default threshold $\widehat{p}(\lambda)$. Then crisis price $p^b(\lambda, Z_j)$ (which is below the threshold $\widehat{p}(\lambda)$) becomes the market price $p(\lambda, Z_j)$.

If for some λ we have $\widehat{p}(\lambda) < p^b(\lambda, Z_j)$, then (A5) implies $p^b(\lambda, Z_j) < p^{\ell}(\lambda, Z_j)$ and (A6) implies $\widehat{p}(\lambda) < p^{\ell}(\lambda, Z_j)$, that is

$$\widehat{p}(\lambda) < p^b(\lambda, Z_j) < p^{\ell}(\lambda, Z_j). \tag{A9}$$

Additionally, if we have $p^{\ell}(\lambda, Z_j) < \widetilde{p}(\lambda)$, then (A8) implies $p^c(\lambda, Z_j) < \widetilde{p}(\lambda, Z_j)$, and then (A7) implies $p^c(\lambda, Z_j) < p^{\ell}(\lambda, Z_j)$, that is

$$p^c(\lambda, Z_j) < p^{\ell}(\lambda, Z_j) < \widetilde{p}(\lambda). \tag{A10}$$

From the combination of the two inequalities (A9) and (A10) it follows that weak banks cannot survive at $t = 2$, because the continuation price $p^c(\lambda, Z_j)$ is below the default threshold $\widetilde{p}(\lambda)$ and strong banks cannot default because the crisis price $p^b(\lambda, Z_j)$ is above the threshold $\widehat{p}(\lambda)$. Consequently, the weak banks' liquidation price $p^{\ell}(\lambda, Z_j)$ (with is above the threshold $\widehat{p}(\lambda)$ and below the threshold $\widetilde{p}(\lambda)$) becomes the market price $p(\lambda)$.

However, if $p^{\ell}(\lambda, Z_j) \geq \widetilde{p}(\lambda)$, then (A7) implies $p^c(\lambda, Z_j) \geq \widetilde{p}(\lambda, Z_j)$ and then (A8) implies $p^c(\lambda, Z_j) \geq p^{\ell}(\lambda, Z_j)$, that is

$$p^c(\lambda, Z_j) \geq p^{\ell}(\lambda, Z_j) \geq \widetilde{p}(\lambda). \tag{A11}$$

From the combination of the two inequalities (A9) and (A11) it follows that weak banks cannot default, because the weak banks' liquidation price $p^{\ell}(\lambda, Z_j)$ is above the threshold

$\widetilde{p}(\lambda)$ and strong banks cannot default because the crisis price $p^b(\lambda, Z_j)$ is above the threshold $\widehat{p}(\lambda)$, so the continuation price $p^c(\lambda, Z_j)$ (which is above the threshold $\widetilde{p}(\lambda)$ becomes the market price $p(\lambda, Z_j)$). In sum, the market price for the long-term asset is

$$p(\lambda, Z_j) = \max\left\{p^c(\lambda, Z_j), p^b(\lambda, Z_j), p^\ell(\lambda, Z_j)\right\}.$$

$\square$