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 differently. Creditor bailouts, i.e., extending deposit insurance coverage, eliminate the equilibrium with bank defaults. On the other hand, bail-ins lead to ex-ante portfolio reallocation: they reduce idiosyncratic risk but increase liquidity risk when both shocks are present, increasing the likelihood of systemic defaults.

JEL Classification: G21, G28, G33

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1 Introduction

Despite intense political and regulatory support for bail-in as a resolution policy, recent cases reveal supervisory preference for bailouts, particularly when concerned about contagion (e.g., Silicon Valley Bank), economic downturns (e.g., Banco Espírito Santo), or retail investors holding bail-inable debt (e.g., regional Italian banks).[1] Scholars argue that bail-ins may compromise stability, especially when systemic risk is present (e.g., Avgouleas and Goodhart, 2015; Dewatripont, 2014). This paper argues that although bail-ins mitigate banks' idiosyncratic risk by prompting ex-ante portfolio reallocations, they also heighten liquidity risk and financial fragility. By contrast, creditor bailouts reduce funding costs and avert defaults, thus decreasing financial fragility.

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 their unit funding 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.

This model has three key elements. First, banks balance liquidity risk against insolvency risk when choosing the composition of their portfolios. 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 liquidity and the cash-in-the-market price, they reduce long-term assets available for sale and second-period returns, increasing insolvency risk. Banks balance these two risks when choosing the portfolio composition.

Second, bank portfolios are opaque. Therefore, 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 composition. When the market assumes banks hold a large

[1] See the World Bank's case study on post-Global Financial Crisis bank resolution cases in the EU (Andersen et al., 2017).

proportion of short-term assets, it expects higher liquidity and market price but greater insolvency risk, leading creditors to demand higher returns. Conversely, if the market believes banks hold a smaller fraction of short-term assets, it anticipates lower prices but reduced insolvency risk. In this case, the lower expected solvency risk prompts creditors to adjust their required returns accordingly.

Third, as funding costs rise, banks choose riskier portfolios. When banks face multiple portfolio options, they choose the one 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, long-term funding costs rise under pessimistic market views, and banks opt for the riskier portfolio. This interaction between market beliefs and banks' portfolio choice creates multiple equilibria: a good equilibrium, where the market anticipates banks to remain solvent and banks choose a short-term investment that leads to no defaults. In a bad equilibrium, the market expects bank defaults, raising the gross return on long-term debt. In this case, banks invest in a portfolio that leads to 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 under laissez-faire, I show that the prospect of creditor bailouts, in which the supervisor insures long-term debt, does not change the banks' expected profits since shareholders do not directly benefit from the bailout. However, bailouts ex-ante lower long-term funding costs, as the supervisor fully repays the creditors. These lower funding costs incentivize banks to choose safer portfolios, eliminating the equilibrium with bank defaults. The reduction in bank defaults and financial fragility holds under both idiosyncratic and systematic shocks. In contrast, bail-ins, where the supervisor converts long-term debt into equity, impact ex-ante shareholders' expected profits and the return creditors require. Since bail-ins prevent ex-post defaults, they preserve returns by avoiding deadweight losses. Thus, creditors, i.e., the new equity holders following a bail-in, are better off than under laissez-faire and demand lower returns. Moreover, the original shareholders, who receive positive payoffs in states where they would have otherwise defaulted, change their ex-ante portfolio composition. The combination of ex-ante lower funding costs and portfolio reallocation has different effects under idiosyncratic versus systematic shocks.

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 invest less in the short-term asset. 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 idiosyncratic risk. If the ex-ante risk reduction is significant, bail-in expectations prevent idiosyncratic defaults and financial fragility. Similarly, a bail-in policy prompts banks to favor riskier portfolios when introducing aggregate risk through uncertain long-term returns. However, reducing short-term investment under these conditions increases liquidity risk. With higher portfolio correlation, a negative aggregate shock can lead to all banks requiring short-term liquidity, generating fire sales and systemic defaults. Therefore, macroprudential supervisors should be particularly concerned with the increased systemic risk linked to a bail-in policy when aggregate shocks are a concern.

This paper contributes to the literature on bail-ins. 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 problems between banks and investors (Pandolfi, 2022). When examining private bail-ins, in which shareholders voluntarily initiate the 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 problem 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).

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 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. I show that bail-in expectations can reduce banks' ex-ante idiosyncratic risk. If this reduction is significant, bail-in expectations can eliminate the risky equilibrium with defaults, mitigating financial fragility. However, in the presence of aggregate risk, bail-in expectations increase banks' exposure to a common risk, potentially leading to fire sales and systemic defaults following a negative aggregate shock.

The paper relates to the literature on supervisory bailouts. 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.

Under 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 the regulator assigns banks to bailout groups, will solve the "too-many-to-fail" problem. Furthermore, Keister (2016) demonstrates that a strict no-bailout policy may not be welfare-enhancing because higher investor losses could lead to runs. This paper examines creditor bailouts in which shareholders receive no ex-post benefits from the bailout; this is, for example, currently debated under unlimited deposit insurance coverage by the Federal Deposit Insurance Corporation in the United States (FDIC, 2023). This assumption abstracts from the moral hazard problem related to "too-big-to-fail" and "too-many-to-fail" concerns. In this setting, the prospect of creditor bailouts results in lower ex-ante funding costs and banks choosing a safe portfolio, preventing defaults and reducing financial fragility.

The idea that a bail-in policy may generate fire sales connects my paper to the literature on fire sales in the banking environment, in the sense that limited demand for the asset combined with banks suffering from a liquidity shock will lead to significant market price discounts (Allen and Gale, 1994). In expectation of fire sales, banks may hold on to liquidity to gain from buying the asset at a discount (Acharya, Shin, and Yorulmazer, 2011) or may seek illiquidity because the prospect of fire sales depresses current prices (Diamond and Rajan, 2011). In my model, banks prefer to invest in a portfolio with higher common risk as it generates a higher payoff in the states where the bank survives, not internalizing the consequences of fire sales. Particularly, when long-term funding costs are high, the bank expects higher profits from a portfolio with systemic risk.

Finally, although this paper focuses on banks, by treating the liability side as exogenous and abstracting from banking regulation, the model can also apply to financial intermediaries primarily engaged in asset management. Recently, regulators have increasingly focused on the role of non-bank financial intermediaries in financial stability (e.g. Board, 2024; International, 2015). For example, the literature has documented the potential of fire sales in the non-banking sector through commonly held assets, which may propagate to the banking sector. Therefore, this literature emphasizes the need to incorporate the contagion risk from non-banks into banking stress tests (Caccioli, Ferrara, and Ramadiah, 2024; Fricke and Fricke, 2021). In this context, my model offers insights into how non-bank financial institutions might respond to resolution policies affecting financial stability.

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, a bailout policy, and a bail-in policy. 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, a bailout policy, and a bail-in policy. 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.

Each island i has 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 types. 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 ex-ante identical 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.

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*.[2] I assume assets are bank outputs, following the "intermediation" approach in modern banking (Sealey Jr. and Lindley, 1977), and that the short-term asset 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 a low short-term return X_ℓ *weak banks* and banks with a high short-term return 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

[2]Loans serve as an example of financial assets with idiosyncratic risk (specific to individual banks). Securities are an example of assets exposed to aggregate risk (common across all banks). 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.

opaque, which means λ_i is unobservable to both the supervisor and the consumers. Hence, the gross return on long-term debt D is a function of λ, the expected market investment in the short-term asset. I assume consumers' expectations regarding the equilibrium short-term investment are rational.

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

$$d(p, Z) = \begin{cases} \dfrac{Z - p}{p}, & \text{if } p < Z \\ 0, & \text{else} \end{cases}$$

which is weakly decreasing in p. Concurrently, banks can invest 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 its own, it will sell the long-term asset holding 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

[4]For examples of models that assume bank default costs are proportional to asset values, refer to Bernard et al. (2022); Chari and Kehoe (2016); Leanza et al. (2021).

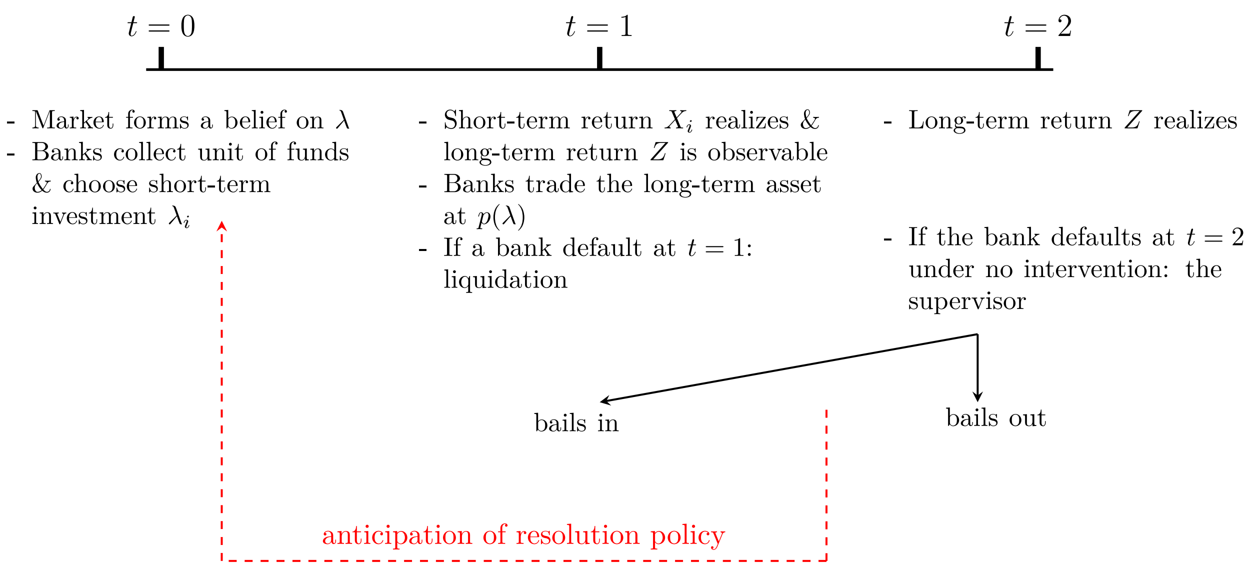

Figure 1 – Timeline of events

bail-in, the supervisor converts the long-term debt into 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 $D(\lambda)$. 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 realized, and the long-term return, which will be realized 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 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 bailout. At $t = 2$, the long-term return is realized, 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.

I constructed a simplified bank model with a few essential features to compute the portfolio effect of resolution policies. 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 risk.

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 $\overline{Z}$.

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 in the absence of aggregate risk. Then, I define the gross return $D(\lambda)$ of the long-term debt that late consumers require. Next step, I characterize each bank's response function $\lambda_i(\lambda)$ as the preferred short-term investment, given $D(\lambda)$ 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 do not default 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 assets, 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 a larger proportion of short-term assets, 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 all banks, even those experiencing a negative idiosyncratic shock, survive at $t = 1$. The market price is low for low values of λ, which prevents 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 small long-term holding 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 liquidation price, $p^{\ell}(\lambda)$, characterizes the market price.

Assumption 1. *I focus on parameter values such that*

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

which ensures no illiquidity defaults at $t=1$.

By Assumption 1, I focus on cases where the weak banks may face insolvency if their short-term investment is sufficiently large but do not default due to illiquidity for low values of λ. 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 default risk and the likelihood of liquidation increase.

Figure 2 illustrates the market price definition in Proposition 1 under Assumption 1, showing the market price $p(\lambda)$ (dotted black line) alongside the continuation price $p^{c}(\lambda)$ (blue line) and the liquidation price $p^{\ell}(\lambda)$ (red line). 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 the short-term risky asset, 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.

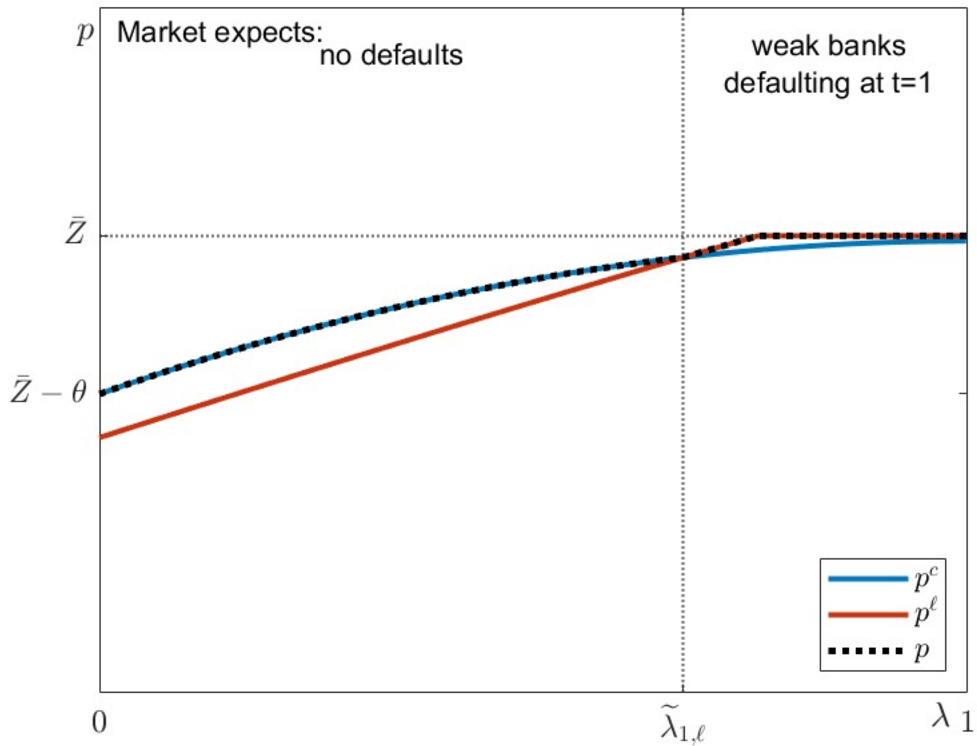

Figure 2 – **Market price under idiosyncratic risk**

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 $p(\lambda)$ of the long-term asset. For short-term investments above $\widetilde{\lambda}_{1,\ell}$ weak banks default at $t = 1$. The parameter values are $\theta = 0.45$, $\alpha = 0.45$, $X_\ell = 0.10$, $X_h = 1.50$, and $\overline{Z} = 1.30$.

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 $t = 2$,

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

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 $t = 1$, its second-period return is zero. Therefore, bank i's second-period return is equal to

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

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 and faces liquidation, i.e., $a_i = -(1 - \lambda_i)$, resulting in a zero second-period return. To simplify the notation, I 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 its the short-term asset return is X_ℓ.

3.1 Equilibrium under no supervisory intervention

Given market expectations of banks' short-term investment λ, the consumers' binding participation constraint can characterize the gross return $D(\lambda)$ that late consumers require in exchange for their $1-\theta$ long-term lending. 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 of 1. However, when the market expects weak banks to default at $t = 2$ and does not foresee supervisory intervention, i.e., under 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 late consumers' participation constraint

$$\alpha c R_\ell(\lambda) + (1 - \alpha)(1 - \theta)D(\lambda) = 1 - \theta,$$

characterizes the gross return on long-term debt, 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 $1/(1 - \alpha)$, where late consumers expect to be repaid only by the $1 - \alpha$ strong banks.

In sum, for λs such that strong banks survive $t = 2$, the gross return on long-term debt under laissez-faire is equal to

$$D(\lambda) = \begin{cases} 1, & \text{if } R_\ell(\lambda) \geq 1 - \theta \\ \dfrac{1 - \theta - \alpha c R_\ell(\lambda)}{(1-\theta)(1-\alpha)}, & \text{else} \end{cases}$$

where in the first case, no bank is expected to default, and in the second case, weak banks are expected to default.[5] Finally, $D(\lambda)$ can only be characterized for scenarios where strong banks are expected to survive at $t = 2$; otherwise, late consumers would anticipate zero return and would be unwilling to lend to the banks. According to Assumption (1), for low values of λ, the market anticipates no default, and the gross return remains constant relative to λ. As λ increases, the expected second-period return $R_\ell(\lambda)$ decreases with λ, and so does the late consumers' expected return. Thus, as the market expects a rise in short-term investments, the likelihood of default and potential losses for late consumers also increase, prompting the late consumers to demand a higher gross return to break even.

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

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

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 return.

[5] See the proof of Assumption 1 in Appendix characterizing the thresholds of λ for each case.

If in equilibrium, the bank never defaults, that is when

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

bank i's expected payoff is

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

which equals

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

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

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

defines the bank's portfolio composition if it satisfies the equilibrium condition (1). I refer to this portfolio with $\lambda_i^*(\lambda)$ short-term investment as the *safe portfolio*, indicating that the bank opts to remain solvent.

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

$$R_h(\lambda_i^{**}) > (1-\theta)D(\lambda) > R_\ell(\lambda_i^{**})\,, \tag{2}$$

bank i's expected payoff is

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

The first-order condition

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

defines the bank's portfolio composition with a short-term investment

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

provided it satisfies the equilibrium condition (2). I refer to the 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, confirming market expectations that higher short-term investment increases the likelihood of default.

Given market expectation λ and the equilibrium conditions (1) and (2), either the safe, risky, or both portfolios can be local bank choices. 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

$$\alpha R_\ell(\lambda_i^*) + (1-\alpha)R_h(\lambda_i^*) - (1-\theta)D(\lambda) < (1-\alpha)[R_h(\lambda_i^{**}) - (1-\theta)D(\lambda)],$$

which, after rearranging the terms, equals

$$\alpha[R_\ell(\lambda_i^*) - (1-\theta)D(\lambda)] < (1-\alpha)[R_h(\lambda_i^{**}) - R_h(\lambda_i^*)]. \tag{3}$$

Condition (3) illustrates the trade-off the bank faces when choosing a risky portfolio. On the one hand, there is 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 local portfolios with short-term investments $\lambda_i^*(\lambda)$ or $\lambda_i^{**}(\lambda)$ are a pure-strategy symmetric equilibrium under rational expectations depends on the market's short-term investment λ. Late consumers expect to be fully repaid in an equilibrium with no defaults. In this case, if the safe portfolio is the bank's local portfolio choice, based on rational expectations and by symmetry, the portfolio with short-term investment $\lambda^* = \lambda_i^*(\lambda)$ characterizes a safe equilibrium with no defaults. 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 portfolio with short-term investment $\lambda_i^{**}(\lambda)$ cannot be an equilibrium.

If in equilibrium, the market expects weak banks to default either at $t = 1$ or $t = 2$, and banks choose the risky portfolio, based on rational expectations and by symmetry, the portfolio with short-term investment $\lambda^{**} = \lambda_i^{**}(\lambda)$ characterizes a risky equilibrium with bank defaults. 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 portfolio with short-term investment $\lambda_i^*(\lambda)$ cannot be an equilibrium.

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 local candidates, the bank chooses the portfolio that generates the highest payoff. A solid line illustrates the portfolio with the highest payoff, and its color 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 and requires $D = 1$. In this region, initially, the bank prefers a risky portfolio, with short-term investment $\lambda_i^{**}(\lambda)$, represented by the solid red line. The bank prefers this risky portfolio even when 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 towards

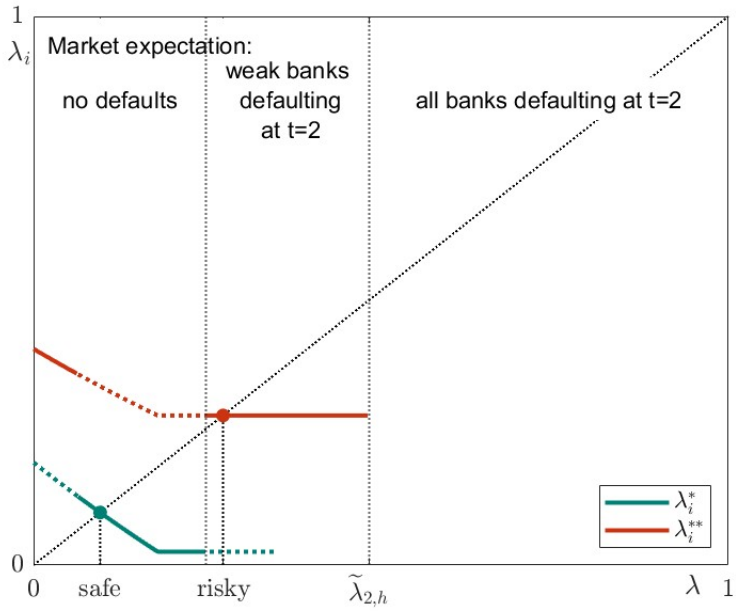

Figure 3 – **Banks' local portfolio choice under laissez-faire**

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 under laissez-faire without supervisory intervention. The portfolio with the highest payoff is illustrated as a solid line. For λs larger than $\widetilde{\lambda}_{2,h}$ both banks are expected to default at $t = 2$. The intersection of banks' response with the 45-degree line (dotted black line) defines the safe (green dot) and risky (red dot) symmetric equilibrium. Parameter values are $\theta = 0.20$, $\alpha = 0.35$, $X_h = 1.65$, $X_\ell = 0.45$, $\overline{Z} = 1.20$, and $c = 0.65$.

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 safe equilibrium with no defaults.

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, $D(\lambda)$. 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 risky equilibrium with bank defaults. At the highest levels of λ, the market anticipates even strong banks defaulting. Consequently, late consumers expect zero returns and are unwilling to lend to the banks.

Figure 3 demonstrates how banks' equilibrium portfolio choices are shaped by market expectations, generating multiple equilibria. In one equilibrium, the market is optimistic and anticipates no defaults. Under these conditions, the gross return on long-term debt is at its 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 both the safe and risky equilibrium coexists under laissez-faire, 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 Prize 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 under a bailout policy

Under a creditor bailout policy, the supervisor pledges to repay 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

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

to the late consumers when weak banks default at $t = 2$. This transfer ensures that late consumers always receive the face value of the debt, either from the bank or the supervisor. The bailout effectively acts like a deposit insurance, making the long-term debt risk-free with a gross return of 1. Consequently, for λs such that the strong banks survive $t = 1$, the gross return on long-term debt under a bailout policy is

$$D^{out}(\lambda) = \begin{cases} 1, & \text{if } R_\ell(\lambda) > 0 \\ \dfrac{1}{1-\alpha}, & \text{else} \end{cases}$$

Note that late consumers receive a higher payoff when weak banks are bailed out than under laissez-faire. Thus, the gross return on long-term debt is weakly lower than under laissez-faire.

Regarding bank i's portfolio choice, 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 (1) and (2). Finally, if both portfolios are local solutions, the bank will opt for the risky portfolio if it offers higher payoffs than the safe portfolio. This choice implies, after rearranging condition (3), that the bank prefers the risky portfolio if

$$D^{out}(\lambda) > \frac{\mathbb{E}[R(\lambda_i^*)] - (1-\alpha)R_h(\lambda_i^{**})}{\alpha(1-\theta)}. \tag{4}$$

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 (4) 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 $D^{out}(\lambda)$ is lower than $D(\lambda)$, the inequality (4) 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 under laissez-faire. In other words, the reduced long-term funding costs associated with bailout expectations diminish the bank's preference for riskier investments and resolve financial fragility.

In situations of financial fragility under 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 the market anticipates bailouts, the bank's choice of a safe portfolio contradicts rational expectations, eliminating the equilibrium associated with defaults. Essentially, the expectation of bailouts, akin to debt insurance, results in only the safe equilibrium persisting, resolving financial fragility.

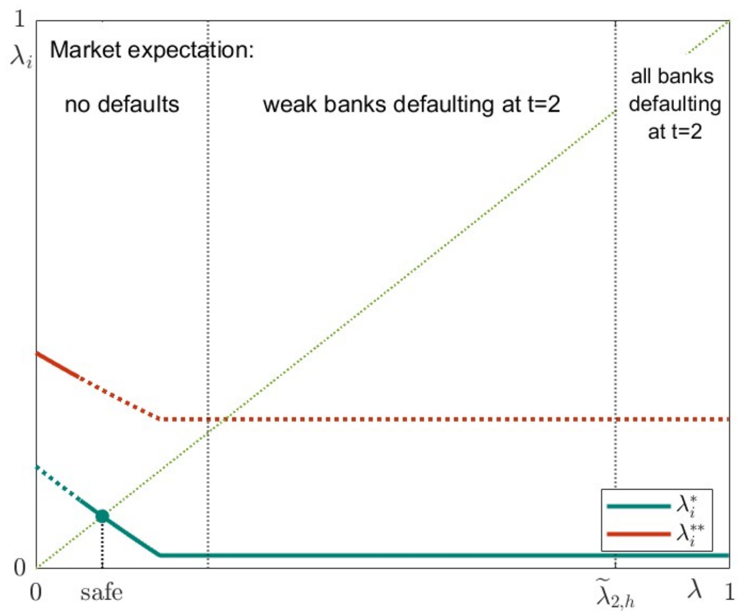

Figure 4 – Banks' local portfolio choice under a bailout policy

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 under a bailout policy. The portfolio with the highest payoff is illustrated as a solid line. For λs larger than $\widetilde{\lambda}_{2,h}$ both banks are expected to default at $t = 2$. The intersection of banks' response with the 45-degree line (dotted black line) defines the safe symmetric equilibrium (green dot). Parameter values are $\theta = 0.20$, $\alpha = 0.35$, $X_h = 1.65$, $X_\ell = 0.45$, and $\overline{Z} = 1.20$.

In Figure 4, which modifies the example in Figure 3 to account for a bailout policy, the market anticipates that weak banks are likely to fail and will be bailed out at intermediate levels of λ. As a result, the gross return on long-term debt remains fixed at 1, leading banks to choose a safe portfolio. The solid green line represents the safe portfolio choice and the dotted red line banks' alternative option of a risky portfolio. However, this decision to remain solvent contradicts the rational market's expectations of bailouts. Consequently, the anticipation of bailouts eliminates the risky equilibrium with defaults.

3.3 Equilibrium under a bail-in policy

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 losses larger than they would incur in an 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

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

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. The bail-in avoids the deadweight losses linked to bank defaults, with γ defining how the preserved value is split between shareholders and creditors. Late consumers would get a fraction c of returns following a default at $t = 2$ under laissez-faire. If $\gamma > c$, bail-ins offer higher payoffs to the late consumers, leading to lower gross return $D^{in}(\lambda)$. As the conversion rate decreases, late consumers' second-period payoff decreases, reducing the difference between the two gross returns. In sum, for values of λs such that the strong banks survive $t = 1$, the gross return on long-term debt under a bail-in policy is

$$D^{in}(\lambda) = \begin{cases} 1, & \text{if } R_\ell(\lambda) \geq 1-\theta \\ \dfrac{1-\theta-\alpha\gamma R_\ell(\lambda)}{(1-\theta)(1-\alpha)}, & \text{else} \end{cases}$$

The second case represents the scenarios in which either weak banks are expected to be bailed in or default at $t = 1$. The higher the conversion rate, the more late consumers receive following bail-in, reducing the gross return they require on long-term debt.

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

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

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 is bailed-in, or zero if it defaults on the short-term debt.

If in equilibrium, the bank never defaults, that is, if

$$R_\ell(\lambda_i^*) > (1-\theta)D^{in}(\lambda) \tag{5}$$

the portfolio

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

which is identical to the safe portfolio under laissez-faire, characterizes the solution to the bank's problem given it satisfies the equilibrium condition (5).

Conversely, if the bank survives following a 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

$$R_h(\lambda_i^{in}) > (1-\theta)D^{in}(\lambda) > R_\ell(\lambda_i^{in}) > 0\,, \tag{6}$$

bank i's expected payoff is

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

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 bank's portfolio composition contains a short-term investment

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

characterizing the bank's risky portfolio, given that it satisfies the equilibrium condition (6). When the original shareholders are entirely 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, if the bank defaults at $t = 1$ following a negative short-term shock, that is when $R_\ell(\lambda_i^{**}) = 0$, bank i's expected payoff is

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

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

and the first-order condition

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

defines the solution to the bank's problem if

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

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

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

$$D^{in}(\lambda) > \frac{\mathbb{E}[R(\lambda_i^*)] - \mathbb{E}[R(\lambda_i^{in})] + \alpha\gamma R_\ell(\lambda_i^{in})}{\alpha(1-\theta)}\,. \tag{7}$$

On the left-hand side, the gross return $D^{in}(\lambda)$ is lower than under laissez-faire, as late consumers receive a proportion of the second-period return that would have otherwise been lost. This lower long-term funding cost makes the inequality (7) harder to satisfy relative to laissez-faire. However, on the right-hand side, the expression equals that under laissez-faire when $\gamma = 1$ and increases with γ.[7] Thus, the right-hand side of inequality (7) is weakly lower than under laissez-faire, which makes inequality (7) easier to satisfy. Thus, the funding cost effect weakens as the conversion rate γ decreases. In contrast, the portfolio reallocation effect strengthens, making banks prefer a risky portfolio under laissez-faire and bail-in scenarios.

In summary, the anticipation of bail-ins exerts two ex-ante effects: (a) lowering funding costs *(funding cost channel)*, and (b) reducing short-term investments in the risky portfolio *(portfolio reallocation channel)*. When banks face multiple local options under laissez-faire, these effects influence banks' portfolio choices in opposite directions. Lower funding costs encourage banks to favor the safe portfolio, while shareholders not being entirely wiped out creates incentives to opt for the riskier portfolio. As the conversion rate γ decreases, the

[7] $\frac{dRHS}{d\gamma} = \frac{\partial RHS}{\partial \gamma} = \frac{R_\ell(\lambda_i^{in})}{1-\theta}$.

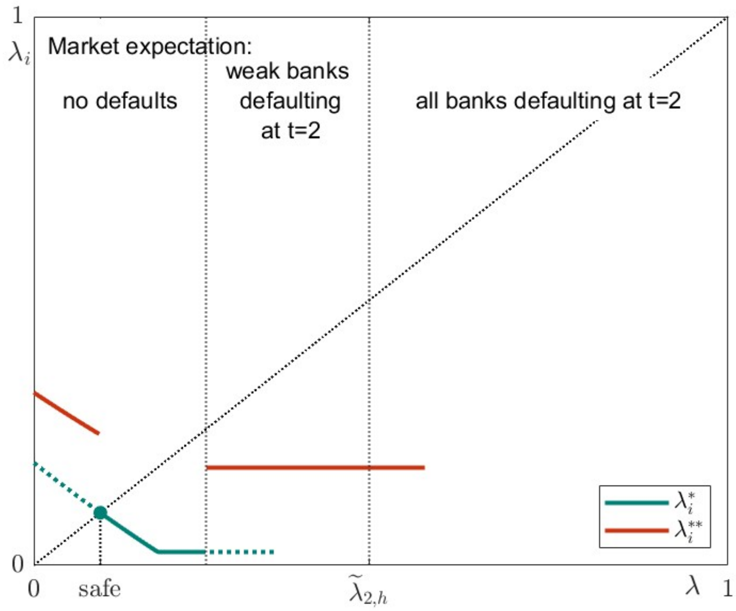

Figure 5 – Banks' local portfolio choice under a bail-in policy

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 under a bail-in policy. The portfolio with the highest payoff is illustrated as a solid line. For λs larger than $\widetilde{\lambda}_{2,h}$ both banks are going to default at $t = 2$. For The intersection of banks' response with the 45-degree line (dotted black line) defines the safe symmetric equilibrium (green dot). Parameter values are $\theta = 0.20$, $\alpha = 0.35$, $X_h = 1.65$, $X_\ell = 0.45$, $\overline{Z} = 1.20$ and $\gamma = c = 0.65$.

funding cost channel weakens while the portfolio reallocation channel strengthens. Thus, for a sufficiently low γ, if a bank would have chosen a risky portfolio under laissez-faire, it still prefers a risky portfolio under a bail-in policy, though with a lower idiosyncratic risk.

In cases of financial fragility under laissez-faire, market beliefs can create two equilibria: a good equilibrium where banks choose a safe portfolio and a risky equilibrium where banks opt for a riskier portfolio. Under a bail-in policy with a sufficiently low conversion rate γ, banks favor a safe portfolio under optimistic market conditions and a risky portfolio under pessimistic ones. However, the risky portfolio now carries reduced idiosyncratic risk. Thus, a sufficient reduction in short-term investments can eliminate the *symmetric* equilibrium with defaults, leaving only the safe equilibrium as the prevailing outcome. Alternatively, for a sufficiently high γ, the bank may prefer a safe portfolio that contradicts the market's rational expectations of a bail-in, removing the bank equilibrium with defaults.

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. The solid red line illustrates the risky portfolio choice, and the dotted green line is the safe alternative option. Nevertheless, the risky portfolio contains $\lambda_i^{in}(\lambda)$ short-term asset, which is lower than $\lambda_i^{**}(\lambda)$ under 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, so 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 short-term asset, their portfolios become riskier, increasing the likelihood of insolvency in the event of a negative short-term shock. Consequently, although bank portfolios are opaque, the market expects a higher likelihood of default, increasing the gross return on long-term debt. The self-fulfilling market beliefs influence the bank's portfolio decisions and might create financial fragility under laissez-faire.

Under financial fragility under laissez-faire, a supervisory promise of bailouts acts like insurance for late consumers, reducing long-term funding costs without affecting shareholders' portfolio trade-offs and incentivizing banks to choose safer portfolios, eliminating the risky equilibrium. In contrast, bail-in expectations lower long-term funding costs and reduce short-term investments in risky portfolios, encouraging banks to prefer a risky portfolio

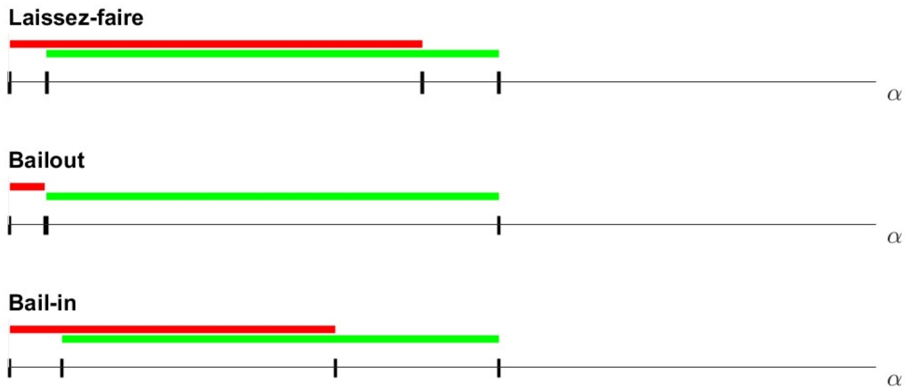

Figure 6 – Financial fragility under idiosyncratic risk

The figure illustrates the symmetric equilibrium across possible values of α probability of a negative short-term shock under no supervisory intervention, a bailout policy, and a bail-in policy. The green line signifies the equilibrium with no defaults and the red line the equilibrium in which weak banks default at $t = 2$. The overlapping region between the red and green lines depicts multiple equilibria. Parameter values are $\theta = 0.20$, $X_h = 1.65$, $X_\ell = 0.50$, $\overline{Z} = 1.20$ and $\gamma = c = 0.65$.

with lower idiosyncratic risk and possibly ruling out the symmetric risky equilibrium with defaults.

Figure 6 summarizes the model's findings in the absence of aggregate risk, showing the symmetric equilibrium for different values of $\alpha \in (0, 1)$. 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 choose a safe portfolio, while the red line represents the equilibrium where banks choose 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, banks reduce 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 multiple equilibria. Banks may opt for a risky portfolio when the market is pessimistic or a safe portfolio when the market is optimistic, illustrating financial fragility.

Under a bailout policy, 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 broader 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, the green and red lines no longer overlap under a bailout policy, indicating that the financial fragility has been resolved and the coexistence of safe and risky equilibria is removed. Under a bail-in policy, banks reduce their short-term investments in the risky portfolio. The risky equilibrium is ruled out if this ex-ante effect is strong enough, illustrated in Figure 6 by the shorter red line. However, since the conditions for bail-in expectations to eliminate the risky equilibrium are more challenging to meet, bail-ins are less effective in resolving financial fragility, represented by the larger overlap between the red and green lines, indicating a broader range of values where both equilibria coexist compared to the bailout scenario.

Finally, let us examine the equilibrium results for the specific case of $\gamma = 1$, where shareholders are entirely wiped out in a bail-in. Under this condition, since shareholders derive no benefit from the bail-in, the portfolio reallocation channel does not exist, and the risky portfolio is identical to laissez-faire. Additionally, since late consumers gain the most from the bail-in, the funding cost channel is maximized. When banks have both safe and risky portfolio options, these effects lead banks to favor a safe portfolio more often, allowing a bail-in policy to eliminate the risky equilibrium with defaults more effectively. However, it is essential to note that funding costs under bail-ins remain higher than under a bailout policy. Therefore, even though bail-ins and bailouts lead to identical ex-ante portfolio composition, bailout promises may be more effective in reducing financial fragility.

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 the expected return is $\overline{Z} = (1-\beta)Z_g + \beta Z_b$. 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 that at $t = 1$ before banks trade the long-term asset, the asset return, which will be realized 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 short-term investment λ.

Proposition 2. *Given the value λ of expected short-term investment and the long-term asset return Z_j, the market price of the long-term asset 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 do not default 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 $t = 1$,

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

[8] For an example of a model with a market to trade bank assets under certainty, refer to Allen and Gale (2004).

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 assets, 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 asset in the market. If the bank can generate sufficient liquidity at $t = 1$, it continues to operate until $t = 2$. In this case, as defined in Proposition 2, The continuation price $p^c(\lambda, Z_j)$ characterizes the market price of the long-term asset. 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, the supervisor liquidates all banks, and the outside investors are the sole buyers of the asset.

Moreover, the market price of the long-term asset, defined in Proposition 2, increases with λ the level of short-term investment the market expects banks to hold. As banks hold a larger proportion of short-term assets, 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 long-term return increases, the outside investors' demand for the asset increases, driving up the asset's price. 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, which 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. However, the bank's holding of long-term assets is small, resulting 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 the market expects good times, no bank is defaulting at $t = 1$ due to illiquidity, but banks may default due to insolvency.

In contrast, when the market expects bad times, 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, banks may not collect enough liquidity to serve their short-term debt and all default collectively at $t = 1$. I interpret these scenarios in which all banks default as systemic events. Thus, fire sales may lead to systemic defaults when the market expects a negative aggregate shock. Thus, a supervisor with a macroprudential mandate, i.e., primarily concerned with systemic events rather than individual bank defaults, should be invested in whether a resolution policy prevents systemic events or contributes to them.

Figure 7 illustrates the result in Proposition 2 under Assumption 1, 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).

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

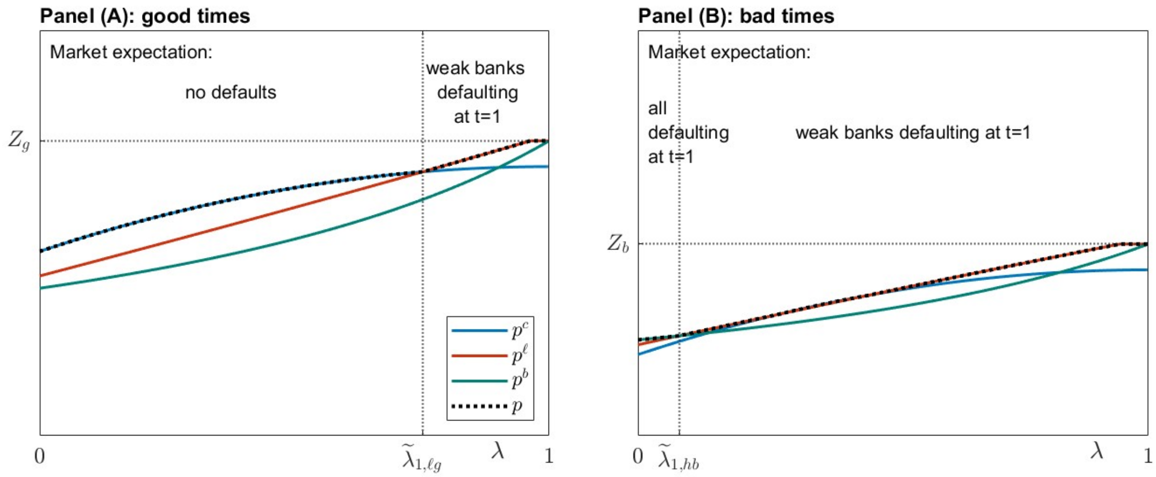

Figure 7 – **Market price under idiosyncratic and aggregate risk**

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 $p(\lambda, Z_j)$. 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 $\theta = 0.75$, $\alpha = 0.50$, $\beta = 0.75$, $X_h = 1.65$, $X_\ell = 0.65$, $Z_g = 2.00$, $Z_b = 1.30$.

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. The 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 compared to 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

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

where the volume traded is

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

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, I 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, I 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 under 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

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

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 expect 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, $D(\lambda)$ 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 $D(\lambda)$, 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

$$\pi_{ij}(\lambda_i) = \begin{cases} R_{ij}(\lambda_i) - (1-\theta)D(\lambda), & \text{if } R_{ij}(\lambda_i) \geq (1-\theta)D(\lambda) \\ 0, & \text{else} \end{cases} \tag{8}$$

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 (8) is satisfied. Lastly, if more than one portfolio satisfies the first-order condition, the bank chooses the portfolio that generates the highest payoff.

To illustrate a bank's local portfolio choice, take the case in which the bank can invest in a safe portfolio with no bank defaults. For the equilibrium condition

$$R_{\ell b}(\lambda_i^*)\geq(1-\theta)D(\lambda)\,, \tag{9}$$

bank i's expected second-period profit is

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

where $\mathbb{E}[R_{ij}(\lambda_i)|Z_j]$ is the expected second-period return conditional on Z_j. 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 local *safe portfolio* with short-term investment $\lambda_i^*(\lambda)$, given it satisfies the equilibrium condition (9). In addition to the safe portfolio, consider the case in which the bank can invest in a portfolio that results in all banks defaulting at $t=2$ in bad times. In this case, for the equilibrium condition

$$R_{\ell g}(\lambda_i^{**})\geq(1-\theta)D(\lambda)>R_{hb}(\lambda_i^{**})>0\,, \tag{10}$$

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

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

The first-order condition

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

characterizes the local *systemic portfolio* with short-term investment $\lambda_i^{**}(\lambda)$, given it satisfies the equilibrium condition (10).

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,

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

Rearranging the inequality,

$$D(\lambda) > \frac{(1-\beta)\mathbb{E}[R_{ig}(\lambda_i^*) - R_{ig}(\lambda_i^{**})|Z_g] + \beta\mathbb{E}[R_{ib}(\lambda_i^*)|Z_b]}{\beta(1-\theta)} \tag{11}$$

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

4.2 Equilibrium under a bailout policy

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

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

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, the supervisor repays the late consumers in the event of a default at $t=2$, and they receive the same payoff as under 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 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 receive zero profit in case 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,

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

is weakly higher than under 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 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 critical difference in bank i's portfolio composition lies in the equilibrium condition (12), which is more easily satisfied since $D^{out}(\lambda)$ is lower than under laissez-faire. Thus, equilibrium portfolios where late consumers are fully repaid are more likely under a creditor bailout policy. 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 where banks can choose between a safe and a systemic portfolio under laissez-faire, they anticipate zero second-period profits under a bailout policy.

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 (11) remains unchanged. However, when the markets expect bailouts, the gross return on long-term decreases, and the left-hand side of inequality (11) is lower. Hence, the inequality is less often satisfied. In other words, under a bailout policy, the bank is more likely to choose a safe portfolio over a systemic one.

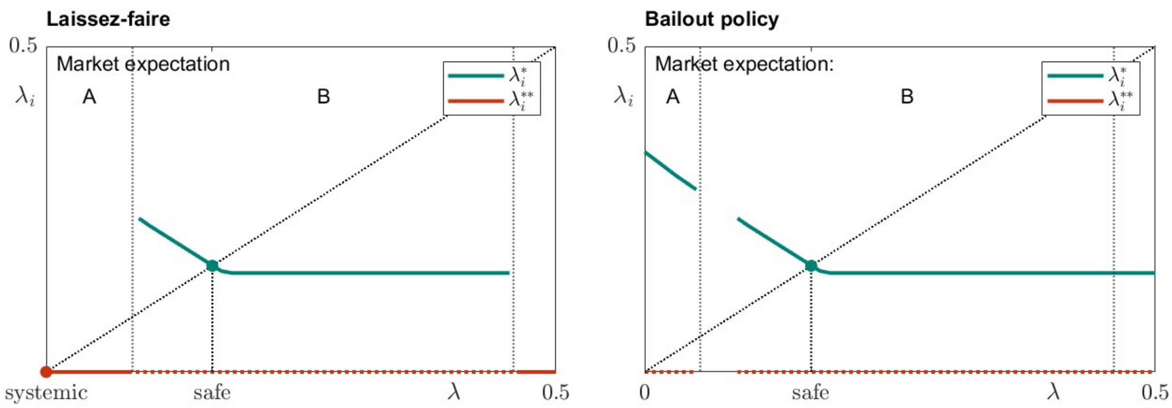

Figure 8 – Banks' local portfolio with aggregate risk under laissez-faire and bailouts The figure illustrates banks' safe portfolio with short-term investment $\lambda_i^*(\lambda)$ (green line) and portfolio with systemic risk and short-term investment $\lambda_i^{**}(\lambda)$ (red line) given any market expectations λ under laissez-faire (left panel) and under a bailout policy (right panel). The portfolio with the highest payoff is illustrated as a solid line. The intersection of banks' response function with the 45-degree line (doted black line) defines the symmetric safe (green dots) and systemic (red dot) equilibrium. 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 $c = 0.65$.

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

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 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 a 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 a 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 under a bail-in policy

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 when the bank remains solvent at $t = 2$, a fraction γ of second-period returns when the bank is bailed in, and zero when it defaults at $t = 1$. Thus, the late consumer's second-period payoffs, conditional on the realization of X_i and Z_j, are equal to

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

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

$$\pi_{ij}(\lambda_i)=\begin{cases}R_{ij}(\lambda_i)-(1-\theta)D^{in}(\lambda), & \text{if } R_{ij}(\lambda_i)\geq(1-\theta)D^{in}(\lambda)\\ (1-\gamma)R_{ij}(\lambda_i), & \text{if } (1-\theta)D^{in}(\lambda)>R_{ij}(\lambda_i)>0\\ 0, & \text{else}\end{cases}\tag{13}$$

Since γ is at most one, banks receive weakly higher payoffs following a bail-in relative to zero under laissez-faire. Moreover, the bank's profit is higher as the second-period funding costs are weakly lower, conditional on survival at $t=2$. 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 (13) is satisfied. Unlike the model with only idiosyncratic risk, in the presence of aggregate risk and given the relative expected profitability of the two assets, it is ambiguous whether a bank would prefer a portfolio with higher or lower short-term investments under a bail-in policy 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. It 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 under 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 (10) bank i's expected second-period profit following bail-ins is

$$(1-\beta)\Big[\mathbb{E}[R_{ig}(\lambda_i)|Z_g] - (1-\theta)D^{in}(\lambda)\Big] + \beta(1-\gamma)\mathbb{E}[R_{ib}(\lambda_i)|Z_b]\,.$$

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 (10). 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

$$D^{in}(\lambda) > \frac{(1-\beta)\mathbb{E}[R_{ig}(\lambda_i^*) - R_{ig}(\lambda_i^{in})|Z_g] + \beta\mathbb{E}[R_{ib}(\lambda_i^*) - (1-\gamma)R_{ib}(\lambda_i^{in})|Z_b]}{\beta(1-\theta)}\,. \qquad (14)$$

Since $\gamma \geq c$, the long-term funding cost under bail-in expectations is weakly lower than under laissez-faire, making it harder to satisfy inequality (14). However, the ex-ante portfolio reallocation changes the right-hand side of the inequality in (14). If the right-hand side of the inequality (14) is lower than that of the inequality (11), the bank may prefer the systemic portfolio, even though it would have chosen the safer one under laissez-faire.

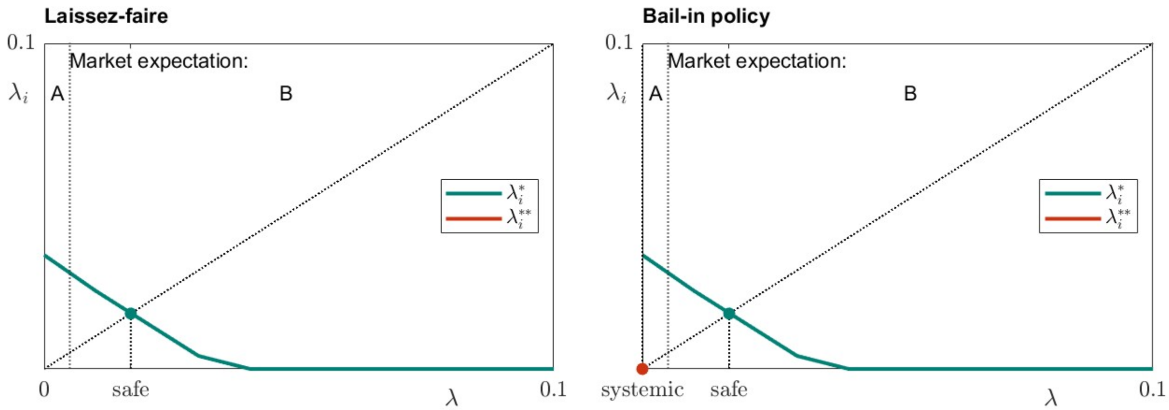

Figure 9 – **Banks' local portfolio with aggregate risk under laissez-faire and bail-ins**

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 under laissez-faire (left panel) and under a bail-in policy (right panel). The portfolio with the highest payoff is illustrated as a solid line. The intersection of banks' response function with the 45-degree line (black dotted line) defines the symmetric safe (green dots) and systemic (red dot) equilibrium. The market expects (A) all banks defaulting in bad times, and (B) no bank defaulting. Parameter values are $\theta = 0.25$, $\alpha = 0.50$, $\beta = 0.75$, $X_h = 2.00$, $X_\ell = 0.35$, $Z_g = 1.65$, $Z_b = 1.30$, 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 $\lambda_i(\lambda)$ as a function of market 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 banks response under a bail-in policy. When both portfolios are an equilibrium option, the bank selects the one offering the highest payoff, marked by solid lines.

under 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 of banks 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 portfolio, 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, cannot collect sufficient liquidity when selling their long-term assets at low prices. A resolution policy that reduces ex-ante short-term holdings in this setting increases systemic risk. Creditor bailout policy keeps portfolio compositions unchanged relative to laissez-faire but reduces long-term funding costs, encouraging banks to choose safer portfolios when multiple options exist. In contrast, a bail-in policy affects ex-ante portfolio composition and long-term funding costs. While reducing funding costs discourages risk-taking like a bailout policy, the ex-ante portfolio reallocation may lead banks to choose a portfolio with systemic defaults in bad times.

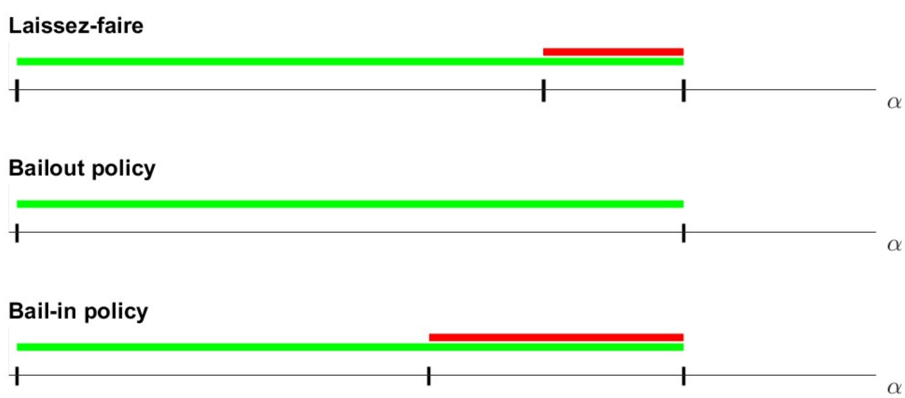

Figure 10 – Financial fragility under idiosyncratic and aggregate risk

The figure illustrates the systemic risk across the possible values of α probability of a negative short-term shock under no supervisory intervention, a bailout policy, and a bail-in policy. 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 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 probability range 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.

A bailout policy insures the long-term debt and, hence, reduces 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 safer portfolios, avoiding systemic defaults. Moreover, a bailout policy removes the region where the red and green lines overlap and resolves the financial fragility.

A bail-in policy alters expected bank payoffs and hence triggers ex-ante portfolio reallocation. Figure 10 illustrates that for intermediate levels of α, this portfolio reallocation incentivizes choosing 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, a bail-in policy is less effective in averting systemic risk and might even contribute to it.

5 Conclusion

This paper contributes to the ongoing debate on supervisory resolution policy, particularly the choice between bail-ins and bailouts. I show that a creditor bailout policy reduces ex-ante long-term funding costs, incentivizing banks to choose a safe portfolio and decreasing the likelihood of bank defaults. Similar to the deposit insurance in the bank run model á la Diamond and Dybvig (1983) or the “whatever-it-takes” promise by the former President of the European Central Bank Mario Draghi (ECB, 2012), a promise to bailout creditors rules out the equilibrium with defaults and reduces ex-post supervisory interventions.

A Bail-in policy, on the other hand, reduces banks' ex-ante long-term funding costs and changes the banks' ex-ante portfolio composition. In cases of idiosyncratic risk, bail-in expectations incentivize banks to choose a portfolio with lower idiosyncratic risk, potentially pre-empting defaults. However, when aggregate risk is present, reducing 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 bailouts, as 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,” as 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 without commitment, and the corresponding results are defined as described in this paper.

A wide range of literature models and demonstrates the moral hazard problem associated with bailout policies, where shareholders anticipate benefits from bailouts and 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 debates in the United States on unlimited deposit insurance coverage and negative public views toward shareholder bailouts, this assumption seems reasonable. Nevertheless, extending the model to include a broader definition of bailouts is possible. 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 a bail-in policy are driven by fire sales and liquidity risk, liquidity facilities can ex-post mitigate fire sales and prevent systemic defaults. However, literature has argued that in expectation of fire sales and government interventions in the form of the lender of last resort or the buyer of last resort, banks will readjust their investments, leading to ex-ante portfolio reallocations (e.g., Diamond and Rajan, 2011; Acharya et al., 2011). Combining these portfolio effects with the ex-ante effects of a bail-in policy 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

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

they need to sell a fraction of their long-term asset 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,

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

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 continuation 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' long-term assets. 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 liquidation price cannot exceed $\overline{Z}$.

To characterize the market price, first note that the inequality

$$\widetilde{p}(\lambda) \gtrless h(\lambda)\overline{X} + \overline{Z} - \theta$$

is, after some rearranging, equal to

$$\widetilde{p}(\lambda) \gtrless \frac{(1-\alpha)[h(\lambda)X_h - \theta] + \overline{Z}}{1 + \alpha(1-\lambda)}. \tag{A1}$$

Second, for both the liquidation and continuation prices being below $\overline{Z}$, the liquidation price can be rewritten as

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

or as

$$p^{\ell}(\lambda) = \widetilde{p}(\lambda) + \frac{[p^{c}(\lambda) - \widetilde{p}(\lambda)]}{1+\alpha(1-\lambda)}. \tag{A3}$$

Characterizing the market price: If for some λ we have $\widetilde{p}(\lambda) < p^{c}(\lambda)$ and

- $p^{\ell}(\lambda) = p^{c}(\lambda) = \overline{Z}$, then

$$\widetilde{p}(\lambda) < p^{c}(\lambda) = p^{\ell}(\lambda)$$

- if $p^{\ell}(\lambda) < \overline{Z} = p^{c}(\lambda)$, then $\widetilde{p}(\lambda) < \overline{Z} < h(\lambda)\overline{X} + \overline{Z} - \theta$ and (A1) implies $\widetilde{p}(\lambda) < p^{\ell}(\lambda)$, that is

$$\widetilde{p}(\lambda) < p^{\ell}(\lambda) < p^{c}(\lambda)$$

- $p^{\ell}(\lambda) < \overline{Z}$ and $p^{c}(\lambda) < \overline{Z}$, then (A2) implies $p^{\ell}(\lambda) < p^{c}(\lambda)$ and (A3) implies $\widetilde{p}(\lambda) < p^{\ell}(\lambda)$, that is

$$\widetilde{p}(\lambda) < p^{\ell}(\lambda) < p^{c}(\lambda).$$

Thus, if for some λ we have $\widetilde{p}(\lambda) < p^c(\lambda)$, then

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

and the continuation price $p^c(\lambda)$, which is above the threshold $\widetilde{p}(\lambda)$, becomes the market price. Moreover, one cannot have weak banks defaulting, because the liquidation price $p^\ell(\lambda)$ is above the threshold $\widetilde{p}(\lambda)$. Finally, notice that if for some λ we have $\widetilde{p}(\lambda) < p^c(\lambda)$ and $p^c(\lambda) < p^\ell(\lambda) = \overline{Z}$, this implies $\widetilde{p}(\lambda) < p^c(\lambda) < p^\ell(\lambda)$. However, $p^c(\lambda) < \overline{Z}$ requires $h(\lambda)\overline{X} < \theta$, which implies

$$(1-\alpha)h(\lambda)X_h - \theta < -\alpha h(\lambda)X_\ell\,.$$

Moreover, $p^\ell(\lambda) = \overline{Z}$ requires

$$(1-\alpha)h(\lambda)X_h - \theta + \alpha\theta > \alpha(1-\lambda)\overline{Z}\,.$$

Then, the condition $p^c(\lambda) < p^\ell(\lambda) = \overline{Z}$ requires

$$-\alpha h(\lambda)X_\ell + \alpha\theta > \alpha(1-\lambda)\overline{Z}\,,$$

which after rearranging equals $\widetilde{p}(\lambda) > \overline{Z}$. This contradicts the assumption of $\widetilde{p}(\lambda) < p^\ell(\lambda) = \overline{Z}$. Thus, when for some λs we have $\widetilde{p}(\lambda) < p^c(\lambda)$, the prices cannot be $p^c(\lambda) < p^\ell(\lambda) = \overline{Z}$.

If for some λ we have $\widetilde{p}(\lambda) \geq p^c(\lambda)$ and

- $p^\ell(\lambda) = p^c(\lambda) = \overline{Z}$, then

$$\widetilde{p}(\lambda) \geq p^c(\lambda) = p^\ell(\lambda)$$

- $p^c(\lambda) < p^\ell(\lambda) = \overline{Z}$, then $\widetilde{p}(\lambda) \geq h(\lambda)\overline{X} + \overline{Z} - \theta$ and (A1) implies $\widetilde{p}(\lambda) \geq p^\ell(\lambda)$, that is

$$\widetilde{p}(\lambda) > p^\ell(\lambda) > p^c(\lambda)$$

- $p^\ell(\lambda) < \overline{Z}$ and $p^c(\lambda) < \overline{Z}$, then (A2) implies $p^\ell(\lambda) \geq p^c(\lambda)$ and (A3) implies $\widetilde{p}(\lambda) \geq p^\ell(\lambda)$, that is

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

Thus, if for some λ we have $\widetilde{p}(\lambda) \geq p^c(\lambda)$, then

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

and the liquidation price $p^\ell(\lambda)$, which is below the threshold $\widetilde{p}(\lambda)$, becomes the market price $p(\lambda)$. Moreover, one cannot have weak banks surviving, because the continuation price $p^c(\lambda)$ is below the threshold $\widetilde{p}(\lambda)$. Finally, note that if we have $\widetilde{p}(\lambda) \geq p^c(\lambda)$ and $p^\ell(\lambda) < \overline{Z} = p^c(\lambda)$, then $\widetilde{p}(\lambda) \geq p^c(\lambda) > p^\ell(\lambda)$, which is equal to

$$\frac{\theta - h(\lambda)X_\ell}{1-\lambda} \geq \overline{Z} > \frac{(1-\alpha)[h(\lambda)X_h - \theta] + \overline{Z}}{1+\alpha(1-\lambda)}$$

After rearranging, the above condition is equal to

$$\theta - h(\lambda)X_\ell > (1-\lambda)\overline{Z} > \frac{(1-\alpha)[h(\lambda)X_h - \theta]}{\alpha}$$

which requires that

$$\alpha[\theta - h(\lambda)X_\ell] > (1-\alpha)[h(\lambda)X_h - \theta]$$

or $\theta > h(\lambda)\overline{X}$, which contradicts the assumption of $p^c(\lambda) = \overline{Z}$. Thus, when for some λs we have $\widetilde{p}(\lambda) \geq p^c(\lambda)$, the prices cannot be $p^\ell(\lambda) < \overline{Z} = p^c(\lambda)$. $\square$

Proof of Assumption 1. *Defining default thresholds:* If weak banks survive until $t = 2$, their second-period return is concave in λ (proof provided below). Otherwise, the return is equal to zero. Given this concavity and the parameter values, there are at most two thresholds,

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

that characterize the range of λ for which weak banks default at $t = 1$. Given that the market price is increasing in λ. the first threshold, $\widehat{\lambda}_{1,\ell}$, marks the point below which weak banks default due to illiquidity. The second threshold, $\widetilde{\lambda}_{1,\ell}$, marks the point above which weak banks default due to insolvency. The subscript 1 indicates that these thresholds are marking defaults at $t = 1$.

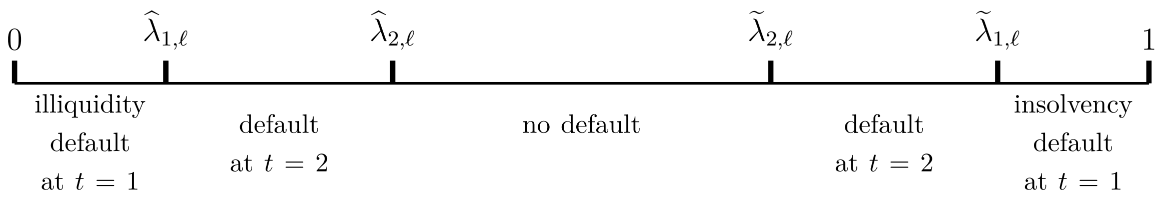

Figure A1 – Market expected defaults

The figure illustrates the weak banks' default regions expected by the market as a function of market short-term investment λ.

When the market expects no defaults at $t = 2$ the face value of long-term debt is equal to $1 - \theta$. Then, given the concavity of $R_\ell(\lambda)$ and parameter values, there exist at most two thresholds,

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

that characterize the range of λ for which weak banks default at $t = 2$. The first threshold, $\widehat{\lambda}_{2,\ell}$, which is larger than $\widehat{\lambda}_{1,\ell}$, marks the point below which weak banks and the second threshold, $\widetilde{\lambda}_{2,\ell}$, which is smaller than $\widetilde{\lambda}_{1,\ell}$, marks the point above which weak banks. The subscript 2 indicates that these thresholds are marking defaults at $t = 2$.

As summarized in Figure A1, in the short-term investment range $0 \leq \lambda \leq \widehat{\lambda}_{1,\ell}$ the market expects weak banks to default at $t = 1$ due to illiquidity, in the range $\widetilde{\lambda}_{1,\ell} < \lambda \leq \widetilde{\lambda}_{2,\ell}$ it expects them to default at $t = 2$, and in $\widetilde{\lambda}_{2,\ell} < \lambda \leq \widetilde{\lambda}_{2,\ell}$ 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, in $\widetilde{\lambda}_{1,\ell} < \lambda < 1$ the market expects weak banks to default at $t = 1$ due to insolvency. Given specific parameter values, these ranges may differ in length, and some may not occur at all. Finally, if, for a given λ, the market could interpret conditions as supporting both scenarios, i.e. no default and weak banks defaulting, each interpretation would imply different gross returns on long-term debt. I assume the market takes an optimistic stance, favoring the scenario with the fewer (later) defaults.

Proof of Assumption 1: I assume parameter values are such that weak banks do not default at $t = 2$ for low values of λ. This implies the thresholds $\widehat{\lambda}_{2,\ell}$ and $\widehat{\lambda}_{1,\ell}$ do not exist.

Specifically, I assume that weak banks are expected to survive at $t = 2$ even with $\lambda = 0$, meaning $R_\ell(0) > (1 - \theta)$. This can be rewritten as

$$\left[1 - \frac{\theta}{\overline{Z} - \theta}\right]\overline{Z} > 1 - \theta$$

or as

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

When this inequality holds, for $\lambda = 0$ weak banks face no risk of defaulting either from illiquidity at $t = 1$ or from a subsequent default at $t = 2$ due to an illiquidity shock at $t = 1$.

To complete the proof, the second-period return of weak banks, if not liquidated at $t = 1$,

$$R_\ell(\lambda) = \left\{1 - \lambda + \frac{h(\lambda)X_\ell - \theta}{p^c(\lambda)}\right\}\,,$$

is concave in λ as its second derivative is negative for both the cases in which $p^c(\lambda) < \overline{Z}$

$$\frac{\partial^2 R_\ell(\lambda)}{\partial\lambda^2} = \frac{-[\overline{X}\theta + X_\ell(\overline{Z} - \theta)]}{[p^c(\lambda)]^3}\left\{2(1-\lambda)\frac{\partial p^c(\lambda)}{\partial\lambda} + p^c(\lambda)\right\}\,,$$

where the price is increasing in λ, and for the cases in which $p^c(\lambda) = \overline{Z}$

$$\frac{\partial^2 R_\ell(\lambda)}{\partial\lambda^2} = \frac{-X_\ell}{\overline{Z}}\,.$$

□

Proof of Proposition 2. Strong banks fail at $t = 1$ when their 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

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

Then, given Z_j, 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 continue to operate until $t = 2$, but weak banks default at $t = 1$,

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

then the 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, which that due to the storage technology cannot exceed the return of the long-term asset Z_j. The liquidation price, if not equal to Z_j, can be rewritten as

$$p^\ell(\lambda, Z_j) = p^b(\lambda, Z_j) + \frac{(1-\alpha)(1-\lambda)}{1+\alpha(1-\lambda)}[p^b(\lambda, Z_j) - \widehat{p}(\lambda)] \tag{A4}$$

or as

$$p^\ell(\lambda, Z_j) = \widehat{p}(\lambda) + \frac{2-\lambda}{1+\alpha(1-\lambda)}[p^b(\lambda, Z_i) - \widehat{p}(\lambda)]\,. \tag{A5}$$

If both banks are solvent at $t = 1$,

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

the continuation price

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

is the market price which due to the storage technology cannot exceed Z_j. Note that the liquidation price, if both $p^c(\lambda)$ and $p^\ell(\lambda)$ are below Z_j, can be rewritten as

$$p^\ell(\lambda, Z_j) = p^c(\lambda, Z_j) + \frac{\alpha(1-\lambda)}{1+\alpha(1-\lambda)}[\widetilde{p}(\lambda) - p^c(\lambda, Z_j)] \tag{A6}$$

or as

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

Finally, one can show that, first, when the strong bank needs to sell long-term asset to survive $t = 1$, i.e. $h(\lambda)X_h < \theta$, the liquidation price is $p^\ell(\lambda, Z_j) < Z_j$ as

$$-(1-\alpha)[\theta - h(\lambda)X_h] < \alpha(1-\lambda)Z_j \tag{A8}$$

and the continuation price is $p^c(\lambda, Z_j) < Z_j$ as

$$h(\lambda)\overline{X} < \theta \tag{A9}$$

Second, if for some λ we have $p^c(\lambda, Z_j) < p^\ell(\lambda, Z_j) = \overline{Z}$. Then, $\widetilde{p}(\lambda) > p^\ell(\lambda, Z_j) > p^c(\lambda, Z_j)$. Moreover, if for some λ we have $p^\ell(\lambda, Z_j) < p^c(\lambda, Z_j) = \overline{Z}$ this implies $\widetilde{p}(\lambda) < p^\ell(\lambda, Z_j) < p^c(\lambda, Z_j)$ (proof identical to Proposition 1).

Characterizing the market price: If for some λ we have $\widehat{p}(\lambda) \geq p^b(\lambda, Z_j)$, this implies that $\widehat{p}(\lambda) > 0$ which translates to strong banks requiring liquidity, i.e. $h(\lambda)X_h < \theta$. Then, (A8) implies $p^\ell(\lambda, Z_j) < Z_j$ and (A9) implies $p^c(\lambda, Z_j) < Z_j$. Moreover, (A4) implies $p^\ell(\lambda, Z_j) \leq p^b(\lambda, Z_j)$ and (A5) implies $p^\ell(\lambda, Z_j) \leq \widehat{p}(\lambda)$, that is

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

Since $\widetilde{p}(\lambda) \geq \widehat{p}(\lambda)$, the above inequalities imply $\widetilde{p}(\lambda) \geq p^\ell(\lambda, Z_j)$. Then, (A7) implies $\widetilde{p}(\lambda) \geq$

$p^c(\lambda, Z_j)$ and (A6) implies $p^\ell(\lambda, Z_j) \geq p^c(\lambda, Z_j)$. That is,

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

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 liquidation price $p^\ell(\lambda, Z_j)$ is below the default threshold $\widehat{p}(\lambda)$. Then, the crisis price $p^b(\lambda, Z_j)$, which is below the threshold $\widehat{p}(\lambda)$, becomes the market price,

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

If for some λ we have $\widehat{p}(\lambda) < p^b(\lambda, Z_j)$, then either $p^b(\lambda, Z_j) < p^\ell(\lambda, Z_j) = Z_j$, or if $p^\ell < Z_j$, (A4) implies $p^\ell(\lambda, Z_j) > p^b(\lambda, Z_j)$ and (A5) implies $p^\ell(\lambda, Z_j) > \widehat{p}(\lambda)$. In both cases this results in

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

Additionally, if we have $p^\ell(\lambda, Z_j) < \widetilde{p}(\lambda)$ and

- $p^c(\lambda, Z_j) = p^\ell(\lambda, Z_j) = Z_j$ then $\widetilde{p}(\lambda) > p^c(\lambda, Z_j) = p^\ell(\lambda, Z_j)$.
- $p^c(\lambda, Z_j) < p^\ell(\lambda, Z_j) = \overline{Z}$, then $\widetilde{p}(\lambda) > p^\ell(\lambda, Z_j) > p^c(\lambda, Z_j)$
- $p^c(\lambda, Z_j) < Z_j$ and $p^\ell(\lambda, Z_j) < Z_j$, then (A7) implies $p^c(\lambda, Z_j) < \widetilde{p}(\lambda, Z_j)$, and then (A6) implies $p^\ell(\lambda, Z_j) > p^c(\lambda, Z_j)$.

In either of the cases it follows that

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

From the combination of the two inequalities (A10) and (A11) it follows that weak banks cannot survive at $t = 1$, 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

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

Finally, note that if $p^\ell(\lambda, Z_j) < p^c(\lambda, Z_j) = \overline{Z}$ then, $\widetilde{p}(\lambda) < p^\ell(\lambda, Z_j) < p^c(\lambda, Z_j)$, which contradict the assumption of $p^\ell(\lambda, Z_j) < \widetilde{p}(\lambda)$.

On the other hand, if $p^\ell(\lambda, Z_j) \geq \widetilde{p}(\lambda)$ and

- $p^c(\lambda, Z_j) = p^\ell(\lambda, Z_j) = Z_j$ then $\widetilde{p}(\lambda) \leq p^c(\lambda, Z_j) = p^\ell(\lambda, Z_j)$.
- $p^c(\lambda, Z_j) = Z_j > p^\ell(\lambda, Z_j)$, then $\widetilde{p}(\lambda) \leq p^\ell(\lambda, Z_j) < p^c(\lambda, Z_j)$
- $p^c(\lambda, Z_j) < Z_j$ and $p^\ell(\lambda, Z_j) < Z_j$, then (A7) implies $p^c(\lambda, Z_j) \geq \widetilde{p}(\lambda, Z_j)$ and then (A6) implies $p^\ell(\lambda, Z_j) \leq p^c(\lambda, Z_j)$

In either of the cases it follows that

$$p^c(\lambda, Z_j) \geq p^\ell(\lambda, Z_j) \geq \widetilde{p}(\lambda). \tag{A12}$$

From the combination of the two inequalities (A10) and (A12) it follows that weak banks cannot default, because the 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

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

Finally, note that if for some λ we have $p^c(\lambda, Z_j) < p^\ell(\lambda, Z_j) = \overline{Z}$ then, $\widetilde{p}(\lambda) > p^\ell(\lambda, Z_j) > p^c(\lambda, Z_j)$, which contradicts the assumption of $p^\ell(\lambda, Z_j) \geq \widetilde{p}(\lambda)$. $\square$