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

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**Abstract**

This paper investigates the impact of supervisory resolution tools, specifically bail-ins versus bailouts, on the ex-ante banks' portfolio composition and resulting ex-post default probabilities in the presence of both idiosyncratic and systematic shocks. Banks make decisions regarding short-term versus long-term risky investments while considering the expected resolution policy. I find that both types of shocks can generate financial instability, which the two resolution tools address through distinct channels. With only idiosyncratic shocks, creditor bailouts, acting as debt insurance, eliminate the equilibrium with bank defaults, while bail-ins induce banks to invest less in the risky short-term asset, which may also prevent defaults. In the presence of both shocks, creditor bailouts can prevent systemic defaults, while bail-ins are less effective in preventing them and could even contribute to systemic risk.


JEL Codes: G21, G28, G33.

Keywords: Bailouts, bail-ins, bank resolution, systemic risk, bank portfolio allocation, fire sales.

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# 1 Introduction

Despite advocating bail-ins as the primary resolution tool for over a decade, supervisors still often favor bailouts driven by concerns of contagion (e.g., Silicon Valley and Signature Bank in the US in 2023), households and retail investors holding bail-inable debt (e.g., Italy in 2015), or economic contractions (e.g., Banco Espirito Santio in Portugal in 2016).[1] This cautious approach towards employing bail-ins indicates that the trade-offs between bail-ins and bailouts merit further examination. This paper aims to contribute to the discourse by investigating, from a theoretical perspective, the ex-ante impact of supervisory resolution tools on banks' portfolio choices and, consequently, on the equilibrium default outcomes in the presence of idiosyncratic and systematic shocks. Its main contribution is the distinction between the channels through which the expected resolution policy affects bank defaults.

I model a large number of banks that operate over two periods. These banks are financed through insured short-term debt and fairly-priced long-term debt subject to default costs. The banks invest their funds in a short-term asset with idiosyncratic risk and a long-term common asset. The presence of a short-term asset with idiosyncratic risk introduces heterogeneity in banks' short-term liquidity as well as in their long-term solvency. The common risk associated with the long-term asset allows for a systematic shock to the banking system. Apart from that, the common asset is tradable in the first period and thus serves as an endogenous source of liquidity. Bank defaults incur deadweight losses, rationalizing supervisory intervention. The supervisor can prevent second-period defaults by either bailing out the creditors or bailing them in. In this context, the choice of the supervisory resolution policy affects banks' ex-ante portfolio decisions and the gross return of long-term debt, highlighting the pecuniary costs of the resolution policy, especially during fire sales.

In the baseline model with no aggregate risk, the short-term asset has an uncertain idiosyncratic return, while the long-term asset is safe. Banks collect one unit of endowment

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

and decide on their investment portfolio. I assume their portfolio composition is unobservable to the market, such that the market belief about short-term investments defines the price of the long-term asset and the return of the long-term debt. Higher expected short-term investments suggest a larger supply of liquidity in the first period, which in turn increases the cash-in-the-market price of the long-term asset. However, higher investment in the risky asset raises the likelihood of bank defaults and thus increases the return on the long-term debt that consumers require to lend.

In a symmetric equilibrium, market belief about bank risk-taking can influence banks' investment decisions and generate multiple equilibria. In one equilibrium, the market anticipates banks to remain solvent, reducing the cost of long-term funding. In this case, each bank chooses a short-term investment that leads to no defaults. In another equilibrium, the market expects the banks that face a negative short-term shock to default, raising the gross return of long-term debt. In this case, each bank invests more in the risky asset and defaults after a low short-term return. I interpret the self-fulfilling market beliefs that generate multiple equilibria as a source of financial instability.

In the presence of multiple equilibria in laissez-faire, I demonstrate that the prospect of creditor bailouts, in which the supervisor insures the long-term debt, does not alter the trade-off banks face in their investment decisions. However, it leads to a reduction in banks' funding costs. Facing cheaper funding, each bank prefers to remain solvent by choosing a safe portfolio, thereby ruling out the equilibrium with bank defaults. On the other hand, following a bail-in, long-term debt is converted into equity. As a result, each bank takes the downside of its risk-taking into account and invests less in the risky short-term asset. This portfolio reallocation towards less risk can remove the equilibrium with defaults. In other words, if the anticipation of bail-ins reduces the portfolio risk enough, in equilibrium, banks will remain solvent. In summary, when the economy contains no aggregate risk, the anticipation of either supervisory intervention decreases the likelihood of defaults and the need for resolution, but through distinct channels.

Next, I introduce aggregate risk to the baseline model by assuming that the long-term asset, common to all banks, has an uncertain return. The realization of the second-period return is observable in the first-period, depressing the price of the long-term asset when the market anticipates a low return. The reduced price leaves banks with few short-term assets, thus with low first-period liquidity, vulnerable to defaults. I define scenarios in which all banks default simultaneously as systemic events. Macroprudential supervisors are concerned with how the expectation of a resolution tool influences systemic risk, whether it alleviates or exacerbates it.

Regarding creditor bailouts, anticipating supervisory transfers reduces banks' funding costs. This reduction in funding costs may incentivize banks to choose a portfolio that ensures solvency, particularly when the long-term asset has a low return. Thus, the anticipation of bailouts may prevent banks from defaulting simultaneously, while such an event would occur without supervisory intervention. In essence, bailouts have the potential to eliminate systemic risk. Conversely, bail-ins impact the ex-ante portfolio composition, potentially towards a lower short-term investment. Lower holding of the short-term asset decreases the liquidity in the market, depressing the cash-in-the-market price. This effect becomes more pronounced when the expectation of low long-term returns has already depressed the price. The resulting fire sales triggered by the portfolio reallocation effect may lead to systemic defaults, while such an event would not occur without supervisory intervention. In essence, the portfolio reallocation effect of bail-ins is less effective than the reduced funding cost effect of bailouts in addressing systemic risk.

The baseline model is related to the literature on supervisory interventions under idiosyncratic risk. The prospect of future profits while anticipating bailouts often motivates banks to engage in value-creating projects (Lambrecht and Tse, 2023). However, this pursuit of profit may also lead to increased portfolio risk and leverage among banks (Lambrecht and Tse, 2023; Leanza, Sbuelz, and Tarelli, 2021). More precisely, if the supervisor cannot commit to refrain from bailouts, this may generate a "too-big-too-fail" problem since banks internalize their size effect on the supervisory intervention and increase their leverage (Davila and Walther, 2020). Moreover, combining bailouts with bail-ins cannot resolve this commitment issue (Chari and Kehoe, 2016). However, distributing bailout transfers across banks (Philippon and Wang, 2023) and uncertainty about the timing of the bailout (Nosal and Ordoñez, 2016) can mitigate the moral hazard by incentivizing banks to avoid becoming the worst performer. My paper adds to the existing literature by demonstrating that bailouts and their associated ex-ante lower funding costs can effectively prevent defaults when, depending on market expectations, both an equilibrium with default and another with no defaults exist in the absence of supervisory intervention. Moreover, since by the current regulation supervisors cannot bailout bank shareholders, I focus on creditor bailouts which abstract from the moral hazard that is documented in the mentioned bailout literature.

In the presence of systemic risk, supervisors might resort to bailouts out of fear of contagion, i.e. "too-many-to-fail" problem (Acharya and Yorulmazer, 2007). This preference for bailouts can encourage banks to correlate their portfolios in a way that prompts the supervisor to bail them out during adverse times, contributing to a collective moral hazard (Farhi and Tirole, 2012). Wagner and Zeng (2023) argue that a targeted bailout policy, in which banks are assigned to bailout groups, will solve the "too-many-to-fail" problem. Finally, Keister (2016) demonstrates that a strict no-bailout policy may not be welfare-enhancing because higher investor losses could lead to runs. In my model, the prospect of bailouts results in lower funding costs and banks choosing a safe portfolio with a higher common exposure. This portfolio composition reduces risk and thereby prevents systemic defaults. In other words, the promise of bailouts, similar to deposit insurance, is enough to contain contagion risk without eventually being used.

When considering bail-ins under idiosyncratic risk, Berger, Himmelberg, Roman, and Tsyplakov (2022) show that when shareholders anticipate bail-ins, they are more likely to consider recapitalization and may engage less in risk-shifting. Nonetheless, the higher funding costs associated with bail-ins can introduce moral hazard (Pandolfi, 2022). When examining private bail-ins, where shareholders initiate the bail-in process, the lack of supervisory commitment to refrain from bailouts can distort private incentives to engage in bail-ins (Keister and Mitkov, 2023). This lack of commitment may also prolong the restructuring process (Colliard and Gomb, 2020) and create a moral hazard for lending banks to accept privately negotiated bail-in offers (Benoit and Riabi, 2020). Moreover, when designing bail-ins, supervisors should account for the impact of negative information disclosure to the market, which can trigger runs (Walther and White, 2020). I show that as long as a bail-in does not wipe out the bank shareholders, banks tend to invest less in short-term risky assets and may default less often.

Avgouleas and Goodhart (2015) underscore that while facing aggregate risk, relying solely on bail-ins as a resolution tool 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 argues that poorly designed bail-ins, especially in bank networks, can result in losses for other interconnected banks, leading to multiple layers of contagion. Bernard, Capponi, and Stiglitz (2022) posit that when interconnected banks participate in a private bail-in, the prospect of a supervisory bailout may undermine the negotiation process. This effect is particularly pronounced when banks are less exposed to contagion risk. Finally, Clayton and Schaab (2022) suggest that the higher the fire-sale risk, the more bail-inable debt banks should hold, and the greater the magnitude of write-downs. This paper shows that the ex-ante portfolio reallocation towards lower short-term investment, associated with the bail-in expectations, may generate fire sales and systemic risk.

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, in anticipation of bailouts, and in anticipation of bail-ins. 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, in anticipation of bailouts, and in anticipation of bail-ins. Section 5 concludes. Proofs of the analytical results are in Appendix.

## 2 Model setup

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

In each island $i$ there is a unit measure of consumers who possess a unit endowment at time $t = 0$. Among these consumers, a fraction $\theta$, 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 $t = 2$. The early consumers invest in the bank's short-term debt, while the late consumers invest in the long-term debt. Both types of consumers have access to a safe asset with a zero net return, which determines the expected return of their investments in the bank.

Banks are identical ex-ante. They raise funds by offering short-term and long-term debt to the consumers. The gross return on the short-term debt is set at one, considering that consumers can invest in the safe asset, and there is deposit insurance. The long-term debt is fairly priced and is subject to default costs. Thus, the late consumers' binding participation constraint defines the gross return on the long-term debt $D_2$. Once the bank collects one unit of funds, it can invest in two assets, a *short-term island-specific asset*, and a *long-term common (to all islands) asset*. Specifically, if bank $i$ chooses to invest a fraction $\lambda_i$ 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 $\lambda_i$. The short-term asset return is either high $X_h$ with probability $1-\alpha$ or low $X_\ell$ with probability $\alpha$, that is

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

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

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

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

which is decreasing in $p$ and satisfies $d(p, Z) = 0$ for $p \geq Z$. Concurrently, banks can invest 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 such a case, the supervisor will sell off the long-term asset holdings of the defaulting bank and repay the early consumers as the deposit insurer. In addition to the possibility of default at $t = 1$, banks may continue their operations until $t = 2$ and default on their long-term debt. I assume bank defaults, at $t = 1$ or $t = 2$, generate deadweight losses, with a fraction $1 - c$ of the asset returns being lost.[2]

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. On the other hand, in bail-ins the long-term debt is converted to equity with a conversion rate $\gamma$. I analyze each resolution policy separately to assess its ex-ante effect on banks' investment decision and their likelihood of default.

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

Comparing the portfolio effect of bank resolutions, I have established a simplified bank model with essential characteristics. On the asset side of banks' balance sheets, the short-term asset with idiosyncratic risk introduces heterogeneity in both banks' short-term liquidity and long-term solvency. The common risk associated with the long-term asset introduces aggregate risk to the banking system. Furthermore, since the common asset is tradable in the first period, it serves as an endogenous source of liquidity that influences banks' portfolio choices. Regarding the liability side of banks' balance sheets, banks may default on their short-term or long-term debt. The supervisor can avert the deadweight losses associated

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

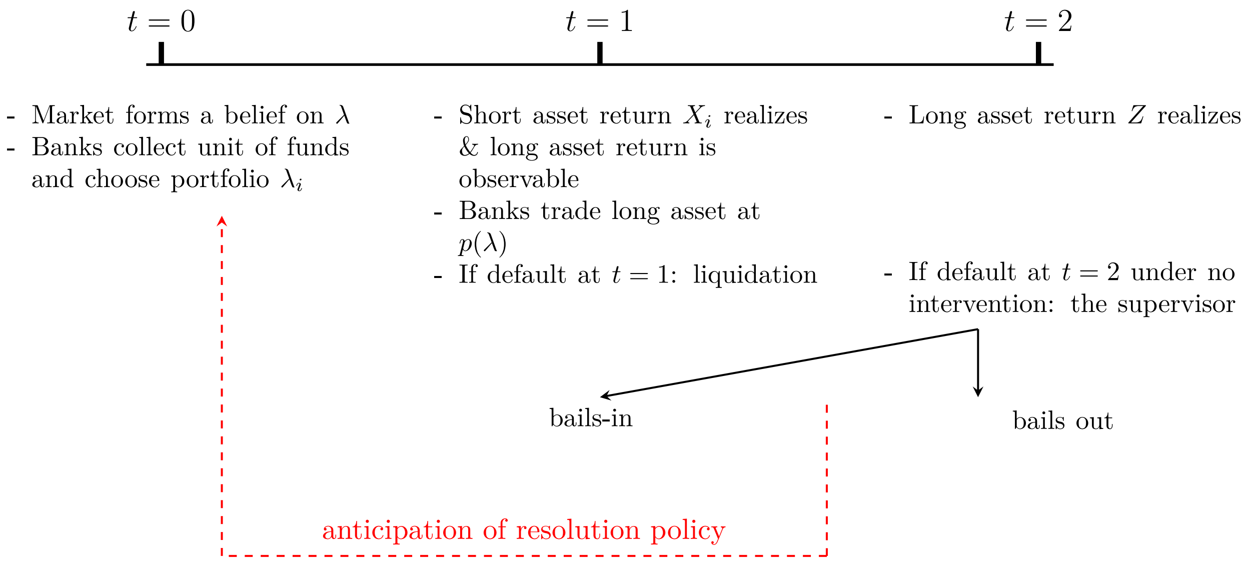



**Figure 1 – Timeline of events**

with the second-period defaults by bank resolution. However, the choice of the supervisory resolution strategy affects banks' ex-ante portfolio decisions, impacting the market price of the long-term asset and highlighting the pecuniary costs of the resolution policy, particularly during fire sales.

# 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. At $t = 1$, given price $p$, the bank in island $i$ has to pay $\theta$ 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 proceeds to liquidate 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 covering the short-term debt and can buy the long-term asset in the market. In all these scenarios, besides banks with excess liquidity, the outside investors buy the asset provided its price is below its return of $\overline{Z}$.

In a symmetric equilibrium, banks in all islands choose the same short-term investment equal to $\lambda$. Then, the liquidity in the market generated by the short-term asset defines the cash-in-the-market price of the long-term asset $p(\lambda)$. Proposition 1 characterizes the market price for the case of no aggregate risk.

**Proposition 1.** *The market price of the long-term asset, for any value $\lambda$ of the banks' expected investment in the short-term asset, is*

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

*where $p^c(\lambda)$ is the continuation price, when no bank defaults at $t = 1$,*

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

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

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

*For parameters such that*

$$\frac{X_\ell}{2} < \theta < \max\left\{\frac{\overline{Z}}{2}, \frac{X_h}{2}\right\} \,,$$

*strong banks survive the first period, but weak banks may default at $t = 1$ if the ex-ante investment in the short-term asset is too large.*

Figure 2 illustrates the result in Proposition 1, showing the market price $p(\lambda)$, alongside the continuation price $p^c(\lambda)$, and the liquidation price $p^\ell(\lambda)$. For low values of $\lambda$ weak banks cannot repay the early consumers at $t = 1$ with the return of the short-term asset. Therefore, they have to sell a portion of their long-term asset to survive. Then, the continuation price $p^c(\lambda)$ defines the market price. This price, as depicted in Figure 2, is increasing in $\lambda$. Specifically, larger investments in the short-term asset lead to higher average first-period returns. The increase in returns translates to larger liquidity in the market, thereby raising the cash-in-the-market price of the long-term asset.

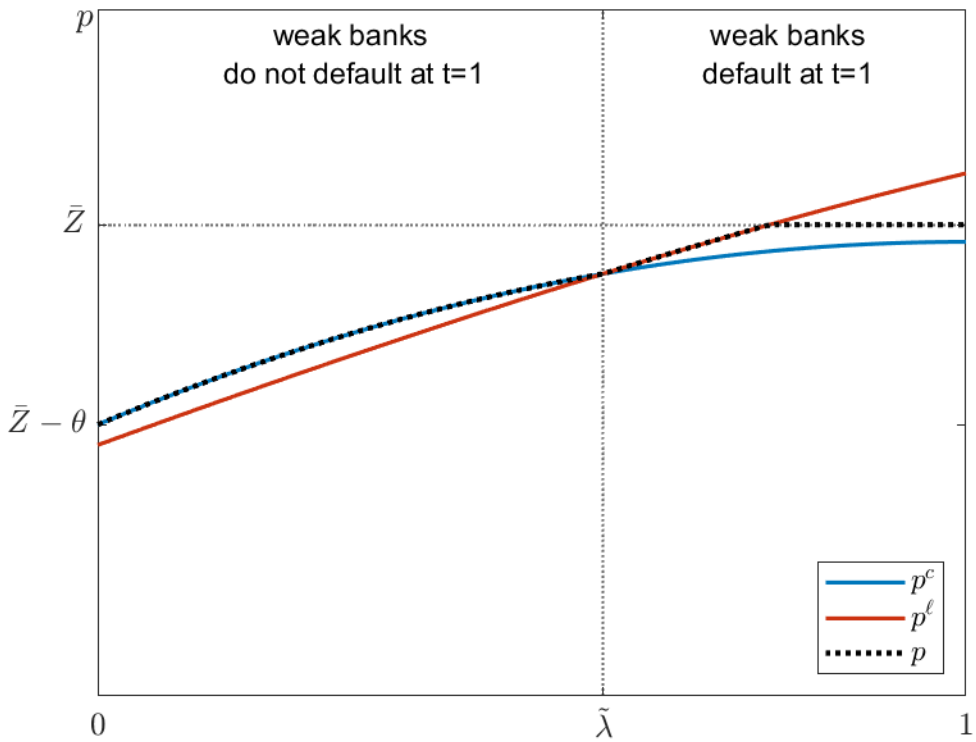



**Figure 2 – Market price of the long-term asset**

The solid blue line is the continuation price $p^c(\lambda)$ when weak banks can sell assets to repay early consumers. The solid red line is the liquidation price $p^\ell(\lambda)$ when weak banks cannot repay early consumers and are liquidated. The dotted black line is the market price of the long-term asset $p(\lambda)$ at $t = 1$. The threshold $\widetilde{\lambda}$ is the intersection of the continuation and liquidation price, above which weak banks default at $t = 1$. The parameter values are $\theta = 0.70$, $\alpha = 0.40$, $X_\ell = 0.20$, $X_h = 2.0$, and $\overline{Z} = 1.65$.

When banks invest a lot in the short-term risky asset, even when the weak banks sell their entire holding of the long-term asset, they cannot repay early consumers, leading to their failure at $t = 1$. In Figure 2, when the banks invest more than $\widetilde{\lambda}$, which is the intersection of the liquidation price and the continuation price, weak banks default at $t = 1$. Then, the liquidation price $p^\ell(\lambda)$ defines the market price. This price, as depicted in Figure 2, is increasing in $\lambda$. Specifically, as banks hold a large amount of short-term assets, the strong banks will have more net liquidity to buy the asset, and the volume of assets for sale will be smaller. In other words, there are fewer assets for sale and more cash in the market, raising the liquidation price.

Finally, the market price, as defined in Preposition 1, cannot exceed the long-term asset return due to the availability of a safe asset with zero net return. If $p(\lambda) = \overline{Z}$ weak banks sell the long-term asset without a discount, strong banks are indifferent between buying the asset and investing in the safe asset, and the outside investors do not enter the market.

If, given bank $i$'s short-term investment $\lambda_i$ and the market price $p(\lambda)$, the bank defaults at $t = 1$ the supervisor sells the bank's long-term assets $1-\lambda_i$, and there are no second-period returns for the bank. If, on the other hand, the bank survives at $t = 1$, it will yield a return

$$\left(1 - \lambda_i + \frac{h(\lambda_i)X_i - \theta}{p(\lambda)}\right)\overline{Z}$$

at $t = 2$. The value inside the large parentheses represents the volume of long-term assets the bank holds at $t = 2$, which consists of the bank's initial investment of $1 - \lambda_i$ at $t = 0$ and the volume of long-term assets the bank trades at $t = 1$.

In sum, bank $i$'s second-period return is equal to

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

where the volume traded is

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

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

### 3.1 Equilibrium with no supervisory intervention

The late consumers' expectation $\lambda$ of the banks' short-term investment determines the gross return of long-term debt $D_2(\lambda)$ to which they are willing to lend their endowments. Moreover, in a symmetric equilibrium with rational expectations, the market price of the long-term asset $p(\lambda)$ is a function of $\lambda$. Given $p(\lambda)$ and $D_2(\lambda)$, bank $i$ chooses its short-term investment $\lambda_i$ to maximize its expected payoff

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

By limited liability, the payoff is either the net second-period return after repaying the late consumers or zero if the bank defaults at $t = 1$ or $t = 2$. The bank chooses a short investment that leads to being solvent at $t = 2$ when the return of the short-term asset is high. Otherwise, the bank's payoff in all states would be zero. Consequently, bank $i$'s problem can be written as

$$\max_{\lambda_i \in [0,1)} (1-\alpha)[R_h(\lambda_i) - (1-\theta)D_2(\lambda)] + \alpha\Big[\max\{R_\ell(\lambda_i) - (1-\theta)D_2(\lambda), 0\}\Big] .$$

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

$$R_h(\lambda_i^*) > R_\ell(\lambda_i^*) > (1-\theta)D_2(\lambda) \tag{2}$$

then, bank $i$'s expected payoff is

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

which is equal to

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

According to the first-order condition

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

the bank selects a portfolio that equates the expected marginal return of the short-term asset with the marginal value of the long-term asset at $t = 1$, which corresponds to its market price. The fact that $h'(\lambda_i) = (1 - \lambda_i)$ implies that

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

defines the solution to the bank's problem if it satisfies the equilibrium condition (2). I call the equilibrium portfolio with $\lambda_i^*(\lambda)$ short-term investment the *safe* portfolio.

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

$$R_h(\lambda_i^{**}) > (1 - \theta)D_2(\lambda) > R_\ell(\lambda_i^{**}) \,, \tag{3}$$

then, bank $i$'s expected payoff is

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

The first-order condition

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

defines the solution to the bank's problem if

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

satisfies the equilibrium condition (3). I call the equilibrium portfolio with $\lambda_i^{**}(\lambda)$ short-term investment the *risky* portfolio. For a risky portfolio, bank receives a positive payoff when the short-term asset return is $X_h$. Therefore, the bank solely considers the marginal value of the short-term asset in the high-return state while choosing its short-term investment. When comparing the safe portfolio with the risky one, as $X_h > \overline{X}$, the equilibrium investment in the risky short-term asset is higher when the bank chooses $\lambda_i^{**}(\lambda)$. This risk-taking underscores the moral hazard stemming from opaque portfolios and limited liability.

Finally, if both the safe and risky portfolios are solutions to bank $i$'s problem, the bank chooses the portfolio that generates the highest payoff. More precisely, given market belief about $\lambda$, the risky portfolio is the local solution to bank $i$'s problem when it generates higher payoff than the safe portfolio, that is when

$$\alpha[R_\ell(\lambda_i^*) - (1-\theta)D_2(\lambda)] < (1-\alpha)[R_h(\lambda_i^{**}) - R_h(\lambda_i^*)]\,. \tag{4}$$

Condition (4) illustrates the trade-off confronting the bank when choosing a risky portfolio that results in default. On one hand, there's the forgone payoff the bank could have received in the low return state if it had stayed solvent by choosing the safe portfolio. On the other hand, there are the higher payoffs it obtains in the high return state when increasing its short-term investment to $\lambda_i^{**}(\lambda)$.

Whether the equilibrium conditions (2) or (3) are satisfied and the short-term investments $\lambda_i^*(\lambda)$ or $\lambda_i^{**}(\lambda)$ are an equilibrium depends on the market short investment $\lambda$. In a symmetric equilibrium with no defaults, late consumers are fully repaid in each state. Therefore, given an expectation of zero default probability, the gross return on the long-term debt is $D_2(\lambda) = 1$. In this case, if the safe portfolio is the solution to the bank's problem, based on the assumption of rational expectations, the short-term investment $\lambda_i^*(\lambda)$ represents an equilibrium with no defaults and by symmetry $\lambda^* = \lambda_i^*$. However, if the bank decides, contrary to market expectations of no defaults, to invest in the risky portfolio, which leads to the bank's default in the low state $X_\ell$, by symmetry, it would result in all banks defaulting in the low state. These defaults contradict the assumption of rational expectations and the short-term investment $\lambda_i^{**}$ is not an equilibrium portfolio.

On the other hand, when the market expects weak banks to default at $t = 2$, the gross return on long-term debt increases as late consumers anticipate weak banks to default. This gross return is determined by the binding late consumers' participation constraint

$$\alpha c R_\ell(\lambda) + (1-\alpha)(1-\theta)D_2(\lambda) = 1-\theta\,, \tag{5}$$

where the strong banks repay the face value of debt and the weak banks default, in which case the late consumers receive the second-period returns after a fraction $1 - c$ of return is destroyed by the default. Finally, when the market anticipates the weak banks to default at $t = 1$, the gross return of long-term debt, based on the binding late consumers' participation constraint, reaches its maximum

$$D_2(\lambda) = \frac{1}{1-\alpha}\,,$$

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

If in a symmetric equilibrium the market expects weak banks to default either at $t = 1$ or $t = 2$, and banks choose the risky portfolio, based on the assumption of rational expectations, the short-term investment $\lambda_i^{**}(\lambda)$ stands as an equilibrium with bank defaults and by symmetry $\lambda^{**} = \lambda_i^{**}(\lambda)$. However, should the bank, contrary to market expectations, opt for investing $\lambda_i^{*}(\lambda)$ in the short-term asset, which leads to the bank staying solvent, by symmetry, all banks would remain solvent. No defaults is inconsistent with market expectations and cannot be considered an equilibrium.

The above analysis reveals that banks' equilibrium portfolio composition depends on market expectations regarding their portfolio choices and default probabilities. When the market anticipates that weak banks are likely to default, the gross return of the long-term debt, as well as the market price of the long-term asset, increase. Subsequently, even though individual banks' portfolio choices are not observable to the market and hence not priced in, the bank invests in a risky portfolio whereas the bank would have chosen a safe portfolio, if the market expected no defaults. The risky portfolio, in turn, leads to bank defaults when short-term return is low, confirming the market expectations.

Figure 3 illustrates an example for bank $i$'s response function $\lambda_i(\lambda)$ given any market expectation $\lambda$. The green line indicates the bank's safe portfolio and the red line indicates the bank's risky portfolio. Given any $\lambda$, when both portfolios are equilibrium candidates, the bank chooses the portfolio that generates the highest payoff. The portfolio with the highest payoff is illustrated as a solid line, and its color indicates whether the portfolio is safe or risky. For a low $\lambda$, markets expect no bank defaults. However, each bank prefers to deviate and invest $\lambda_i^{**}(\lambda)$ in the short-term asset, leading to the bank defaulting at $t = 1$, which contradicts market expectations. For intermediate levels of $\lambda$, the bank chooses a short-term investment $\lambda_i^{*}(\lambda)$, resulting in all banks staying solvent. By symmetry, the intersection of the green solid line and the 45-degree line defines a safe equilibrium. For larger values of $\lambda$, the market expects weak banks to default at $t = 2$, and individual banks choose to invest $\lambda_i^{**}(\lambda)$ in the short-term asset, which leads to weak banks defaulting. Hence, the intersection of the red solid line and the 45-degree line defines another symmetric equilibrium with bank defaults.

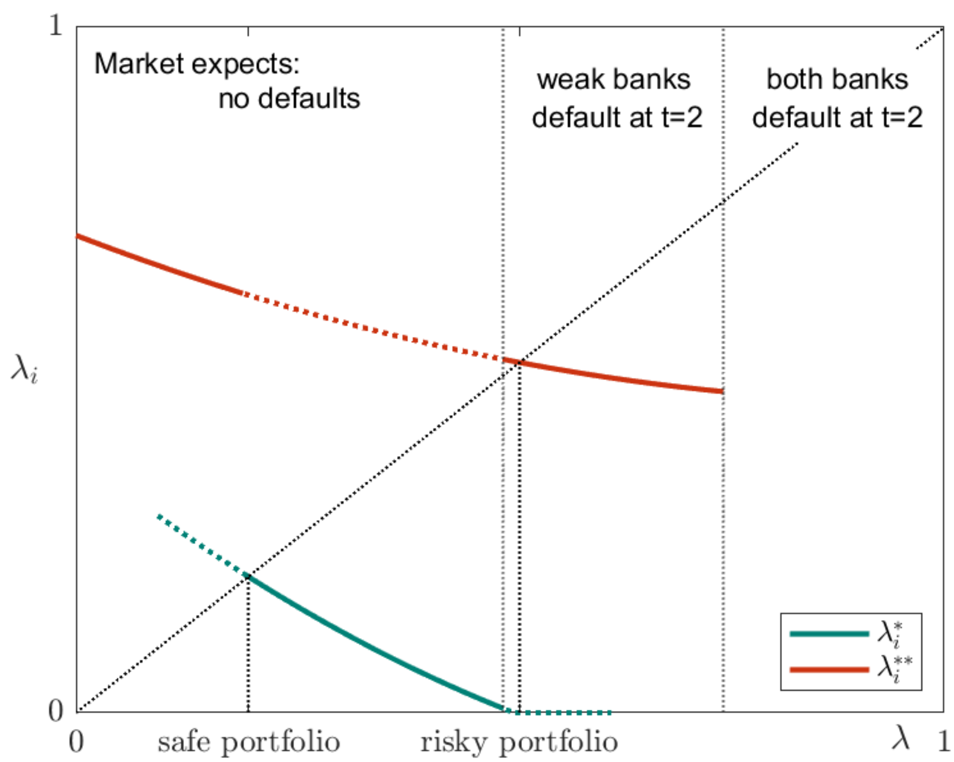



**Figure 3 – Bank's response function given market expectations**

The figure illustrates banks' safe portfolio with short-term investment $\lambda_i^*(\lambda)$ (green line) and risky portfolio with short-term investment $\lambda_i^{**}(\lambda)$ (red line) given any market expectations $\lambda$ for the laissez-faire case without supervisory intervention. The portfolio with the highest payoff is illustrated as a solid line, where its color indicates whether it is a safe or a risky portfolio. The intersection of the banks' response function with the 45-degree line defines the symmetric equilibrium of the depicted example. Parameter values are $\theta = 0.65$, $\alpha = 0.70$, $X_h = 2.80$, $X_\ell = 0.75$, $Z_g = 1.75$, $Z_b = 1.5$, and $c = 0.65$.

As illustrated in Figure 3, the fact that banks' equilibrium portfolio depends on market expectations can lead to the existence of multiple equilibria, which I define as the source of financial instability. One equilibrium corresponds to a scenario in which the market expects no defaults. In this case, the gross return of the long-term debt is at its lowest because it is safe. The price of the long-term asset is also low due to less cash in the market. Combining these two factors, banks choose the safe portfolio over the risky one. In the second equilibrium, the market expects weak banks to default. Then, the gross return of the long-term debt increases, and the market price of the long-term asset is also higher. In this scenario, banks choose the risky portfolio, which leads to defaults when the bank's short-term return is low.

## 3.2 Equilibrium with bailout

At $t = 1$, the supervisor observes the short-term asset return and bails out the creditors of the weak bank when the bank is going to default at $t = 2$. Similar to the default case, the bank receives zero payoffs after a creditor bailout. As a result, the bank's optimization problem is identical to the laissez-faire case. Given market portfolio $\lambda$, which defines the market price $p(\lambda)$ and $D_2(\lambda)$, the safe and risky portfolios with the short-term investments $\lambda_i^*(\lambda)$ and $\lambda_i^{**}(\lambda)$ are the local solutions to the banks problem if they satisfy the equilibrium conditions (2) and (3). Finally, as defined by condition (4), if both portfolios are solutions to the bank's problem, the bank chooses the risky portfolio if it generates higher payoffs.

Rewriting condition (4), the bank prefers the risky portfolio if

$$D_2(\lambda) > \frac{\mathbb{E}[R(\lambda_i^*)] - \mathbb{E}[R(\lambda_i^{**})]}{\alpha(1-\theta)} . \tag{6}$$

Note that because the reaction functions $\lambda_i^*(\lambda)$ and $\lambda_i^{**}(\lambda)$ are identical to laissez-faire, the right-hand side of the inequality (6) is identical for both the case of laissez-faire and bailout. Thus, when comparing bailouts with laissez-faire, a bank's preference for the risky portfolio depends on the gross return of the long-term debt. In a creditor bailout, the supervisor commits to repaying the debt to the late consumers. More precisely, the supervisor transfers the amount

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

when weak banks default at $t = 2$. As a result, late consumers always receive the face value of the debt, either from the bank or the supervisor. The bailout promise resembles deposit insurance and renders the long-term debt risk-free, with a gross return $D_2^{out}(\lambda) = 1$. Thus, the gross return of the long-term debt is lower in anticipation of bailouts than in laissez-faire, as in (5). The fact that banks now benefit from cheaper long-term funding costs impacts bank's preference for the risky portfolio. Since the left-hand side of the inequality (6) is weakly lower than in laissez-faire (and the right-hand side is identical), anticipating bailouts, the bank prefers the safe portfolio more often.

In the case of multiple equilibria in laissez-faire, this shift in the bank's local portfolio preference, due to lower gross return of the long-term debt, may eliminate the equilibrium with defaults. More precisely, without supervisory intervention, banks may have chosen a safe portfolio $\lambda_i^*(\lambda)$ when the market expects no defaults and a risky portfolio $\lambda_i^{**}(\lambda)$ when the market expects the weak banks to default at $t = 2$. In terms of the condition 6, when the inequality

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

holds one equilibrium with a risky portfolio and the gross return of long-term debt $D_2(\lambda)$, and another equilibrium with a safe portfolio and the gross return of long-term debt being 1 exists. When the market expects bailouts, the gross return of the long-term debt reduces to 1, violating the above condition. More precisely, even if the market expects weak banks to default at $t = 2$, banks still prefer to stay solvent, and hence the equilibrium with defaults is ruled out.

Expanding on the example depicted in Figure 3, when for an intermediate level of market investment $\lambda$ the market expects weak banks to default at $t = 2$, the gross return of debt remains unchanged at 1 due to the insurance late consumers anticipate from the supervisor. Then, the bank prefers the safe portfolio, as the expected payoff from staying solvent increases relative to the payoff the bank would have received from a risky portfolio. However, the choice of remaining solvent contradicts market expectations and cannot be an equilibrium. As a result, as depicted in Figure 4 in a scenario with multiple equilibria, the anticipation of bailouts excludes the second equilibrium with defaults. Therefore, creditor bailouts mitigate the financial instability that arises from market expectations via their effect on funding costs.

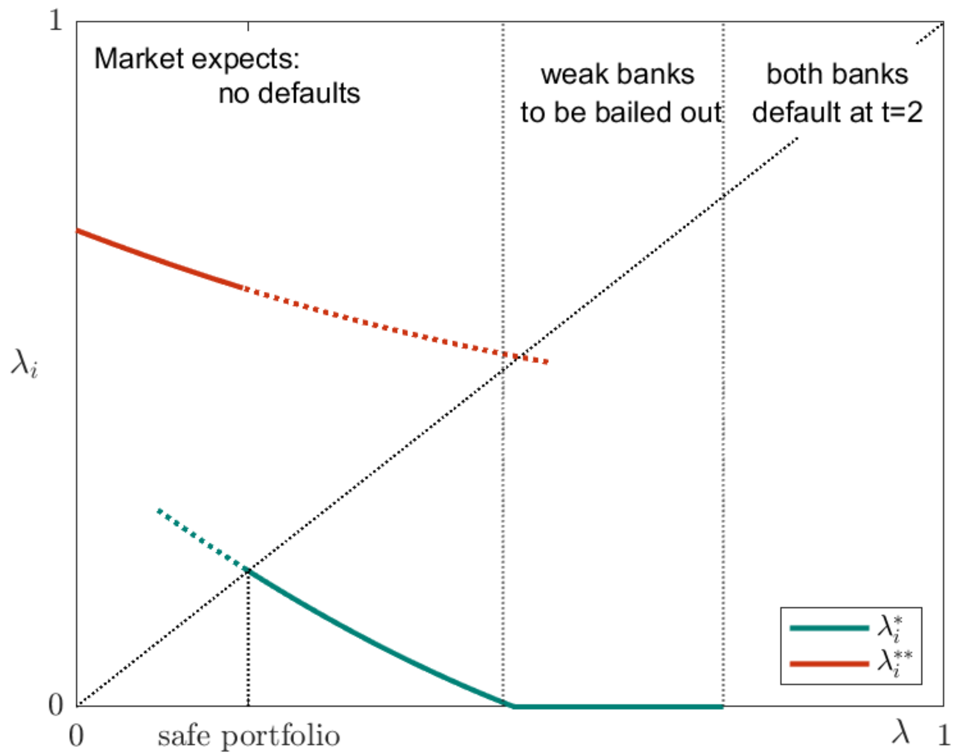



**Figure 4** – **Bank's response function in anticipation of bailouts**

The figure illustrates banks' safe portfolio with short-term investment $\lambda_i^*(\lambda)$ (green line) and risky portfolio with short-term investment $\lambda_i^{**}(\lambda)$ (red line) given any market expectations $\lambda$ for the case of bailout expectations. The portfolio with the highest payoff is illustrated as a solid line, where its color indicates whether it is a safe or a risky portfolio. The intersection of the banks' response function with the 45-degree line defines the symmetric equilibrium of the depicted example. Parameter values are $\theta = 0.65$, $\alpha = 0.70$, $X_h = 2.80$, $X_\ell = 0.75$, $Z_g = 1.75$, $Z_b = 1.5$, and $c = 0.65$.

### 3.3 Equilibrium with bail-in

Alternative to a creditor bailout, the supervisor can bail-in the weak banks that would otherwise default at $t = 2$. At $t = 1$, the supervisor observes the short-term returns and, given market expectations of $\lambda$, converts the long-term debt of the weak banks into equity using a conversion rate $\gamma(\lambda)$.

The choice of the conversion rate is constrained by the No Creditor Worse Off (NCWO) rule. Accordingly, a bail-in should not result in weak bank creditors experiencing losses greater than the losses they would face in a liquidation scenario at $t = 1$. In other words, the late consumers should receive a payoff at least equal to the proceeds from closing the bank, selling the long-term asset in the market, and repaying the early consumers first, that is

$$\gamma \left( 1 - \lambda + \frac{h(\lambda)X_\ell - \theta}{p^c(\lambda)} \right) \overline{Z} \geq (1-\lambda)p^\ell(\lambda) + h(\lambda)X_\ell - \theta \,.$$

The left-hand side of the inequality is a fraction $\gamma$ of the second-period return that late consumers receive after the bail-in, where due to no defaults at $t = 1$ the market price of the long-term asset is $p^c(\lambda)$. The right-hand side is the payoff late consumers receive when weak banks are liquidated, and the market price is $p^\ell(\lambda)$.

To demonstrate the largest ex-ante effect of bail-ins on bank portfolios, I assume that the supervisor selects the conversion rate that exactly satisfies the NCWO rule, which gives

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

The conversion rate $\gamma(\lambda)$ is smaller than one. To see this, note that the term in brackets is the pecuniary cost of selling the long-term asset in the market after liquidating the weak banks at $t = 1$, which reduces the market price from the continuation price $p^c(\lambda)$ to the liquidation price $p^\ell(\lambda)$, and is born by the late consumers. The fact that the liquidation price is lower than the continuation price is because according to Proposition 1, the continuation price $p^c(\lambda)$ is higher than the liquidation price $p^\ell(\lambda)$ whenever the weak banks survive at $t = 1$.

Moreover, the fraction $p^c(\lambda)/\overline{Z}$ is smaller than or equal to one and strictly smaller than one in case of fire sales, i.e., whenever the cash-in-the-market price of the long-term asset is smaller than the asset return.

Given the market price $p(\lambda)$ and the gross return on the long-term asset $D_2(\lambda)$, bank $i$'s maximization problem at $t = 0$ while anticipating bail-in is

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

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 net second-period returns in the case of $X_h$, the net second-period returns when $X_\ell$ while the bank remains solvent, or a share $1 - \gamma(\lambda)$ of the second-period return if it is bailed-in, or zero if it defaults on the short-term debt.

If in equilibrium the bank never defaults, that is if

$$R_h(\lambda_i^*) > R_\ell(\lambda_i^*) > (1-\theta)D_2(\lambda) \tag{8}$$

the portfolio

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

which is identical to the laissez-faire case, defines the solution to the bank's problem if it satisfies the equilibrium condition (8).

If, on the other hand, in equilibrium, the bank remains solvent at $t = 2$ in the high return state $X_h$, but is going to default at $t = 2$ in the low return state $X_\ell$ and hence is bailed-in, that is when

$$R_h(\lambda_i^{in}) > (1-\theta)D_2(\lambda) > R_\ell(\lambda_i^{in}) > 0 \tag{9}$$

then, bank $i$'s expected payoff is

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

and the first-order condition is

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

which simplifies to

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

Then, the solution to the bank's problem is

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

if it satisfies the equilibrium condition (9). In this case, one can show that the term in the brackets is smaller than $X_h$.[3] This implies that the short-term investment in anticipation of bail-ins is lower than it would be without supervisory intervention. Given that the bank receives a positive payoff after a bail-in, it accounts for the downside of its risk-taking and selects a less risky short-term investment relative to laissez-faire. Essentially, bail-ins mitigate the moral hazard stemming from limited liability and opaque portfolios.

If the bank defaults at $t=1$ when it receives a low short-term investment $X_\ell$, that is when $R_\ell(\lambda_i^{**})=0$, then, bank $i$'s expected payoff is

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

and the first-order condition

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

defines the solution to the bank's problem if

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

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

satisfies the equilibrium condition $R_\ell(\lambda_i^{**}) = 0$, which is identical to the risky portfolio in laissez-faire. Finally, if more than one of these three portfolios are a solution to banks problem, the bank chooses the portfolio with the largest payoff.

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

$$\alpha\gamma(\lambda)R_\ell(\lambda) + (1-\alpha)(1-\theta)D_2(\lambda) = 1-\theta\,. \tag{10}$$

That is late consumers receive the face value of their debt from strong banks and a fraction $\gamma(\lambda)$ of the second-period returns from weak banks. In the absence of supervisory intervention, late consumers would have received a fraction $c$ of the second-period return if weak banks had defaulted at $t = 2$. However, when late consumers are bailed-in, they receive a fraction $\gamma(\lambda)$ of the returns, which can be either larger or smaller than $c$. As a result, the impact of bail-ins on ex-ante funding costs is ambiguous.

In cases where multiple equilibria exist in laissez-faire, the anticipation of bail-ins can eliminate the equilibrium with defaults if the reduction in short-term investment is large enough in magnitude. To illustrate this with the example presented in Figure 3, when the market expects weak banks to default at $t = 2$ for an intermediate level of market investment $\lambda$, the bank prefers to invest $\lambda_i^{in}(\lambda)$ in the short-term asset while anticipating bail-ins. Consequently, the short-term investment is lower than what it would have been in laissez-faire $\lambda_i^{**}(\lambda)$. For the example illustrated, $\lambda_i^{in}(p)$ is low enough to rule out a symmetric equilibrium where all banks invest in a risky portfolio. In other words, the anticipation of bail-ins can reduce the riskiness of banks' portfolios to the extent that in a symmetric equilibrium, all banks remain solvent.

Figure 6 summarizes the finding in the model without aggregate risk. The figure illustrates the symmetric equilibrium across the range of possible values for the probability of a low short-term asset return $\alpha \in (0, 1)$ in case of no supervisory intervention, in anticipation of bailouts, and in anticipation of bail-ins. Higher values of $\alpha$ translates into lower

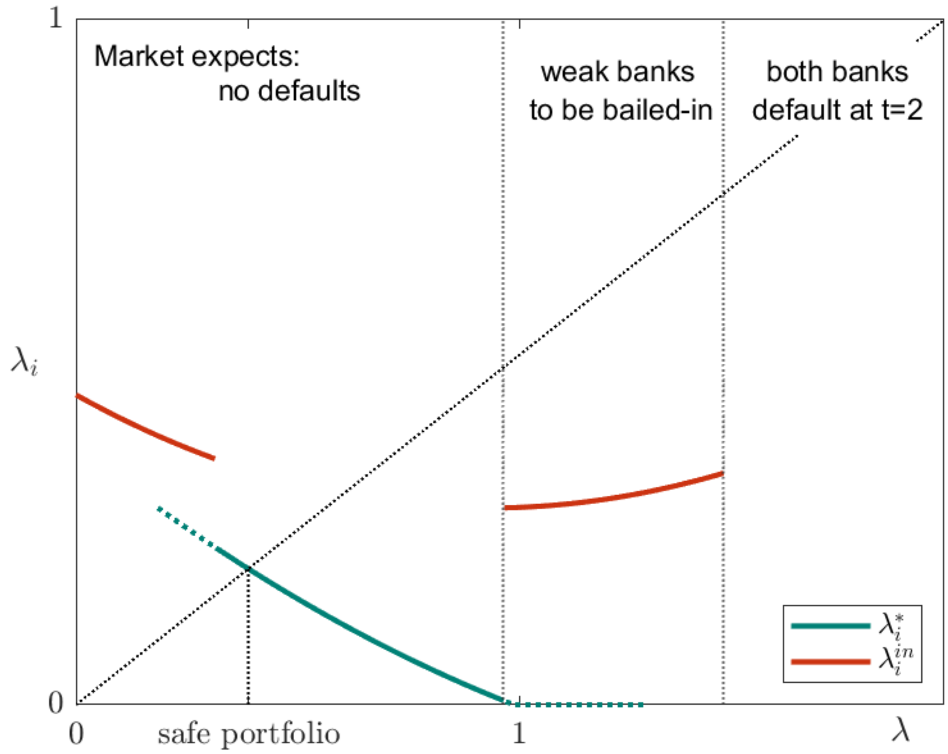



**Figure 5 – Bank's response function in anticipation of bail-ins**

The figure illustrates banks' safe portfolio with short-term investment $\lambda_i^*(\lambda)$ (green line) and risky portfolio with short-term investment $\lambda_i^{in}(\lambda)$ (red line) given any market expectations $\lambda$ for the case of bail-in expectations. The portfolio with the highest payoff is illustrated as a solid line, where its color indicates whether it is a safe or a risky portfolio. The intersection of the banks' response function with the 45-degree line defines the symmetric equilibrium of the depicted example. Parameter values are $\theta = 0.65$, $\alpha = 0.70$, $X_h = 2.80$, $X_\ell = 0.75$, $Z_g = 1.75$, $Z_b = 1.5$, and $c = 0.65$.

expected short-term return. The green line represents the equilibrium in which banks choose a safe portfolio, while the red line illustrates the equilibrium in which banks choose a risky portfolio. The overlap of the green and red line indicates multiple equilibria.

In laissez-faire, an decrease in short-term expected return, i.e. rising $\alpha$, leads to banks investing less in the risky short-term asset and hence transitioning from an equilibrium in which they default to another in which they stay solvent. That is for low values of $\alpha$ the short them asset is profitable and banks choose the risky portfolio. For intermediate levels of $\alpha \in (0, 1)$, the presence of market expectations allows for the coexistence of both equilibria, reflecting instability. Finally, for a low expected short-term return the banks invest less in the

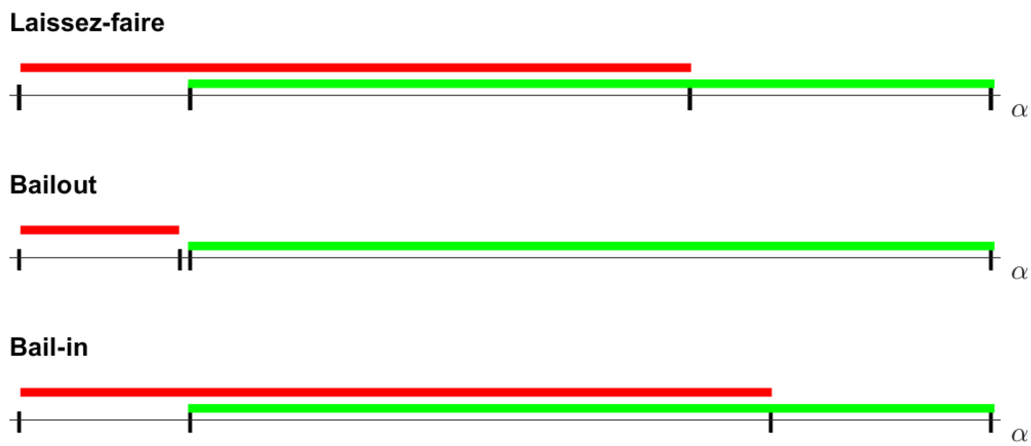



**Figure 6 – Multiple equilibrium in anticipation of resolution**

The figure depicts the symmetric equilibrium across the range of possible values for the probability of a low short-term asset return $\alpha$ in case of no supervisory intervention, in anticipation of bailouts, and in anticipation of bail-ins. The green line signifies the equilibrium with no defaults and the red line signifies the equilibrium in which weak banks default at $t = 2$. The overlapping region between the red and green lines depicts cases of multiple equilibria. Parameter values are $\theta = 0.30$, $X_h = 3.00$, $X_\ell = 0.60$, $\overline{Z} = 1.40$, and $c = 0.65$.

short-term asset and stay solvent. When banks and the market expect bailouts, the banks prefer to stay solvent over a larger range of $\alpha$ s, thus eliminating the default equilibrium in cases of multiple equilibria. However, if the portfolio reallocation effect of bail-ins is not significant enough, as in this example, bail-in expectations does not rule out the equilibrium with defaults. It may even broaden the region where multiple equilibria exist, amplifying instability.

# 4 The model with aggregate risk

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

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

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

I assume at $t = 1$ before banks trade the long-term asset, the asset return, which will realize at $t = 2$, is observable, eliminating all uncertainty about the assets fundamental value.[4] Thus, due to the available safe asset, the market price of the long-term asset does not exceed its fundamental value, and banks will not incur losses from trading the asset, as is the case under uncertainty. In the following, I begin by defining the market price of the long-term asset at $t = 1$, given any short-term market investment $\lambda$. Then, I describe banks' investment decisions at $t = 0$.

**Proposition 2.** *The market price of the long-term asset, for any value $\lambda$ of the banks' investment in the short-term asset and given the long-term asset return $Z_j$, is*

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

*where $p^c(\lambda, Z_j)$ is the continuation price, when no bank defaults at $t = 1$,*

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

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

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

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

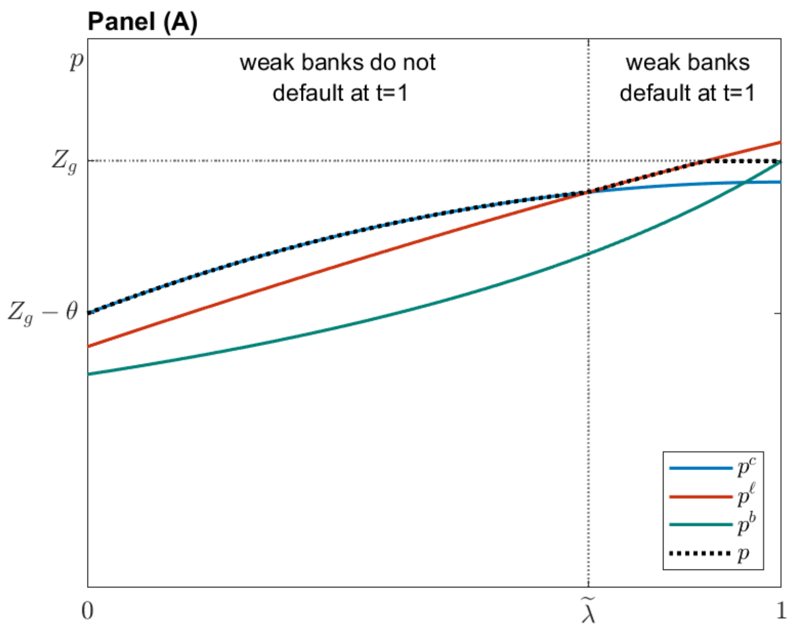
$$p^b(\lambda, Z_j) = \frac{Z_j}{2-\lambda}\,.$$

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

*For parameters such that*

$$\frac{X_\ell}{2} < \theta < \max\left\{\frac{\overline{Z}}{2}, \frac{X_h}{2}\right\},$$

*strong banks survive at* $t = 1$ *in good times, but weak banks may default at* $t = 1$ *if the ex-ante investment in the short-term asset is too large. However, in bad times, both may default at* $t = 1$ *if their ex-ante investment in the short-term asset is too low.*



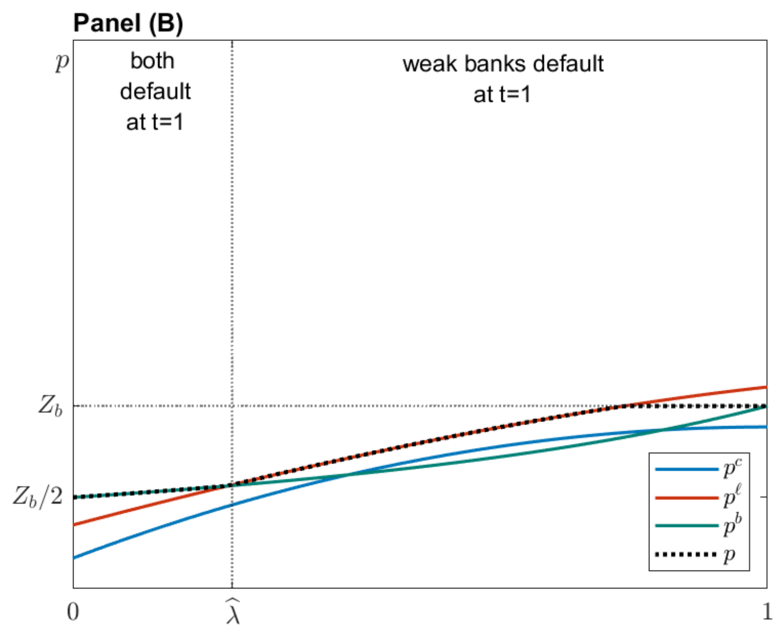



**Figure 7 – Market price of the long-term asset**

Panel (A) illustrates the long-term asset price in good times $Z_g$ and Panel (B) illustrates the price in bad times $Z_b$. The solid blue lines are the continuation prices $p^c(\lambda, Z_j)$ when weak banks can sell assets to repay early consumers. The solid red lines are the liquidation prices $p^\ell(\lambda, Z_j)$ when weak banks cannot repay early consumers and are liquidated. The green solid lines are the crisis prices $p^b(\lambda, Z_j)$ when both banks default at $t = 1$ and are liquidated. The dotted black line is the market price of the long-term asset $p(\lambda, Z_j)$ at $t = 1$. The threshold $\widetilde{\lambda}$ is the intersection of $p^c(\lambda, Z_g)$ and $p^\ell(\lambda, Z_g)$ above which weak banks default at $t = 1$. The threshold $\widehat{\lambda}$ is the intersection of $p^c(\lambda, Z_b)$ and $p^b(\lambda, Z_b)$ below which both banks default at $t = 1$. Parameter values are $\theta = 0.625$, $\alpha = 0.375$, $\beta = 0.250$, $X_h = 1.50$, $X_\ell = 0.375$, $Z_g = 1.75$, $Z_b = 0.75$.

Figure 7 illustrates the result in Proposition 2, showing the market price $p(\lambda, Z_j)$, alongside the continuation price $p^c(\lambda, Z_j)$, the liquidation price $p^\ell(\lambda, Z_j)$, and the crisis price $p^b(\lambda, Z_j)$ 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 $\lambda$, weak banks cannot repay the early consumers at $t = 1$, and need to sell a portion of their long-term assets to survive. Then, the continuation price $p^c(\lambda, Z_g)$ defines the market price. However, when banks allocate large investments into the risky short-term asset, even selling the entire holding of the long-term asset is not enough for the weak banks to repay early consumers, leading to their failure at $t = 1$ and the liquidation price $p^\ell(\lambda, Z_g)$ defining the market price. In Figure 7 Panel (A), when the banks invest more than $\widetilde{\lambda}$, which is the intersection of the liquidation price and the continuation price, weak banks are going to default at $t = 1$. Finally in good times, strong banks are solvent at $t = 1$, regardless of the short-term investment. This can be seen in Figure 4 Panel (A) as the crisis price $p^b(\lambda, Z_g)$ not intersecting with the liquidation price $p^\ell(\lambda, Z_g)$.

In bad times, the market price decreases relative to the good times. As illustrated in Figure 7, when the long-term asset return is low, the market price shown in Panel (B) is lower relative to the price in Panel (A). According to Proposition 2, the market price is increasing in the long-term asset return $Z_j$ because, for any market price lower than the long-term asset return $Z_j$, the outside investors' demand for the long-term asset (1) increases with the long-term asset return. In other words, the higher the return generated by the long-term asset, the more the outside investors are willing to buy, which increases the market price. The depressed price in bad times increases the likelihood of weak banks defaulting at $t = 1$. In Figure 7 Panel (B), the liquidation price $p^\ell(\lambda, Z_b)$ stays above the continuation price $p^c(\lambda, Z_b)$, which means weak banks default in bad times for any value of short-term investment.

Moreover, just like the market price outlined in Proposition 1 and for the same reason, the continuation prices $p^c(\lambda, Z_j)$ and the liquidation prices $p^\ell(\lambda, Z_j)$ are increasing in the short-term asset investment. Furthermore, the crisis prices $p^b(\lambda, Z_j)$ increase with $\lambda$. When all banks default and are liquidated, an increase in short-term asset holdings results in fewer long-term assets being sold in the market, consequently leading to an increase in price. The combination of the two factors of lower prices in bad times and prices increasing with $\lambda$, may result in strong banks defaulting at $t = 1$. That is because for low values of $\lambda$ the fire sales are so deep that even strong banks may have insufficient amounts of long-term asset to sell and repay early consumers. Then, both banks default and are liquidated, the crisis price $p^b(\lambda, Z_b)$ defines the market price, and the outside investors are the only buyers of the asset in the market. In Figure 4 Panel (B), when the banks invest less than $\widehat{\lambda}$, which is the intersection of the liquidation price and the crisis price, both banks are going to default at

$t = 1$.

If, given bank $i$'s short-term investment $\lambda_i$, long-term asset return $Z_j$, and the market price $p(\lambda)$, the bank defaults at $t = 1$ the supervisor sells the bank's long-term assets $1 - \lambda_i$ and there are no second-period returns for the bank. If, on the other hand, the bank survives at $t = 1$, it will yield a return

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

at $t = 2$ if the bank has a short-term return $X_\ell$, and

$$\left(1 - \lambda_i + \frac{h(\lambda_i)X_h - \theta}{\max\{p^c(\lambda, Z_j), p^\ell(\lambda, Z_j)\}}\right) Z_j$$

if the bank has a short-term return $X_h$. The values inside the parentheses represent the volume of long-term assets the bank holds at $t = 2$, which comprises the bank's initial investment of $1 - \lambda_i$ at $t = 0$ and the volume of long-term assets the bank trades at $t = 1$.

In sum, bank $i$'s second-period return can be generalized as

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

where the volume traded is

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

for the weak bank and

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

for the strong bank. Thus, the volume traded depends on the bank's investment choice, the bank's short-term asset return, the long-term asset return, and the market price. The maximum operator ensures that the bank cannot sell more long-term assets than it owns. In other words, if the bank must sell more long-term assets at $t = 1$ to continue operating than it possesses, the bank faces liquidation.

To simplify the notation, given long-term asset return $Z_j$, let's denote the second-period return of bank $i$ as $R_{hj}(\lambda_i)$ when its short-term asset return is $X_h$ and as $R_{\ell j}(\lambda_i)$ when the short-term asset return is $X_\ell$.

**Systemic events**: In the model with aggregate risk, banks may choose an investment in the short-term asset $\lambda_i$, which leads to a symmetric equilibrium where both strong and weak banks face defaults either at $t = 1$ or $t = 2$, particularly in bad times. That means all banks may default in bad times regardless of their short-term return. I refer to these cases as *systemic* events. If the supervisor has a macroprudential mandate, her primary concern is systemic events rather than individual bank defaults. Therefore, the key questions revolve around whether a supervisory resolution can prevent systemic events or whether it might inadvertently contribute to such events.

When in laissez-faire, with no supervisory intervention, the banks choose a portfolio that results in all banks simultaneously defaulting in bad times, the anticipation of either bail-in or bailout can influence banks' short-term asset investment and their resulting payoffs. This adjustment can prevent a systemic event from occurring. On the other hand, if banks under laissez-faire already choose a portfolio that leads to strong banks remaining solvent, the anticipation of bail-in or bailout may push the equilibrium towards a systemic event. In this case, the supervisory resolution tool itself becomes a factor contributing to systemic risk.

## 4.1 Equilibrium with no supervisory intervention

In the laissez-faire with no supervisory intervention, given the market expectation $\lambda$, which defines the market price $p(\lambda, Z_i)$ and the gross return of the long-term debt $D_2(\lambda)$, the bank either receives the net second-period return after repaying the late consumers or zero in case of default either at $t = 1$ or $t = 2$. Then, the maximization problem of the bank at $t = 0$ is

$$\max_{\lambda_i \in [0,1)} \Pr\Big(R_{ij}(\lambda_i) \geq (1-\theta)D_2(\lambda)\Big)\mathbb{E}\Big[R_{ij}(\lambda_i) - (1-\theta)D_2(\lambda) | R_{ij}(\lambda_i) \geq (1-\theta)D_2(\lambda)\Big].$$

Since the bank chooses $\lambda_i$ such that it stays at least solvent in good times, the first-order condition to the bank's problem is

$$(1-\alpha)(1-\beta)\frac{\partial R_{h\,g}(\lambda_i^*)}{\partial \lambda_i}+ \\ \Pr\Big(R_{i\,j}(\lambda_i) \geq (1-\theta)D_2(\lambda)\Big)\mathbb{E}\Big[\frac{\partial R_{i\,j}(\lambda_i^*)}{\partial \lambda_i}\Big| R_{i\,j}(\lambda_i) \geq (1-\theta)D_2(\lambda)\Big] = 0\,,$$

where

$$\frac{\partial R_{i\,j}(\lambda_i)}{\partial \lambda_i} = \left[-1 + \frac{(1-\lambda_i)X_i}{p(\lambda, Z_j)}\right] Z_j\,. \tag{11}$$

The portfolio satisfying the first-order condition is a solution to the bank's problem if the corresponding equilibrium condition

$$R_{i\,j}(\lambda_i^*) \geq (1-\theta)D_2(\lambda)$$

for no default in the state $\{i, j\}$ is satisfied. Lastly, if more than one portfolio satisfies the first-order condition, the bank chooses the portfolio that generates the highest payoff.

Regarding the gross return of the long-term debt, late consumers 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 $t = 1$. Hence, their binding participation constraint for the market short-term investment $\lambda$ is

$$\Pr\Big(R_{i\,j}(\lambda) \geq (1-\theta)D_2(\lambda)\Big)(1-\theta)D_2(\lambda)+ \\ c\Pr\Big(0 < R_{i\,j}(\lambda) < (1-\theta)D_2(\lambda)\Big)\mathbb{E}\Big[R_{i\,j}(\lambda)|0 < R_{i\,j}(\lambda) < (1-\theta)D_2(\lambda)\Big] = 1-\theta\,.$$

## 4.2 Equilibrium with bailout

If the supervisor announces to bailout creditors, the bank payoff is zero, which is identical to the case of the bank defaulting. Hence, the bank's maximization problem at $t = 0$ is identical to laissez-faire, and the solutions to the problem are the same. However, since the supervisor transfers the late consumers,

$$(1-\theta)D_2(\lambda) - R_{i\,j}(\lambda)\,,$$

they receive the face value of their debt whenever the bank survives at $t = 1$. Thus, the late consumers' binding participation constraint is

$$(1 - \theta)D_2(\lambda)\Pr\Big(R_{ij}(\lambda) > 0\Big) = 1 - \theta\,.$$

Since late consumers receive weakly more compared to the laissez-faire case, the gross return of long-term debt is lower in anticipation of bailouts than in laissez-faire, $D_2^{out}(\lambda) \leq D_2(\lambda)$. Thus, similar to the model without aggregate risk, cheaper long-term funding in anticipation of bailouts may change the bank's portfolio choice.

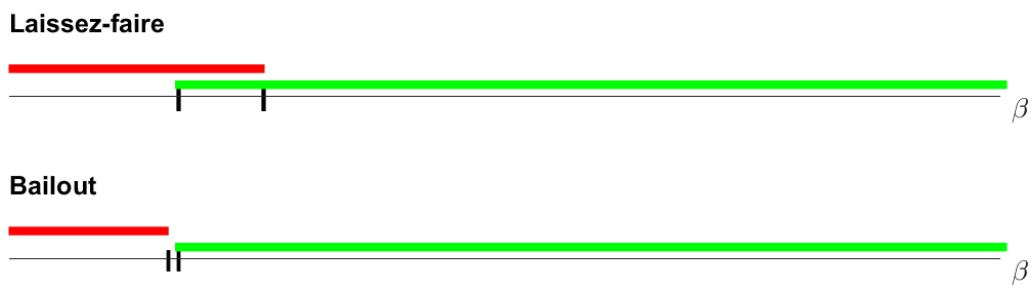



**Figure 8 – Systemic risk in anticipation of bailouts**

The figure depicts the systemic risk across the range of possible values for the probability of a low long-term asset return $\beta \in (0, 1)$ in case of no supervisory intervention, and in anticipation of bailouts. The green line signifies the equilibrium with no systemic defaults and the red line signifies the equilibrium with systemic defaults. The overlapping region between the red and green lines demonstrates cases of multiple equilibria. Parameter values are $\theta = 0.40$, $X_h = 3.00$, $X_\ell = 0.60$, $Z_g = 2.60$, $Z_b = 1.20$, and $\alpha = 0.45$.

Figure 8 depicts the systemic risk across the range of the probability of low long-term asset return $\beta \in (0, 1)$. 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 $\beta$ increases the expected return of the long-term asset decreases. In laissez-faire, as the expected return of the long-term asset decreases, banks prefer to invest more in the short-term asset. Thus, for low values of $\beta$, the bank invests more in the long-term asset, reducing the short-term liquidity and generating systemic defaults (the red line). As $\beta$ increases, banks reduce their long-term investment, getting into the region where at least strong banks survive in bad times (green 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 of the long-term debt the market requires.

The bailouts insure the long-term debt and, hence, bailout expectations reduce the long-term funding costs. As illustrated in Figure 8, the reduction in the gross return of long-term debt reduces the region in which the equilibrium with systemic bank defaults exists, i.e., reducing the red line. In other words, when banks can collect cheaper funds, they prefer to hold a portfolio with higher short-term investment, omitting systemic defaults. Moreover, in this numerical example, the ex-ante effect of bailout expectations removes the region where the red and green lines overlap. Thus, the expectation of bailouts has removed the fragility of the system.

## 4.3 Equilibrium with bail-in

If the supervisor bails-in banks that are going to default at $t = 2$, she first observes the short-term asset return $X_i$ realized at $t = 1$ and the long-term asset return $Z_j$ which is going to realize at $t = 2$. Then, she converts the long-term debt of the failing banks into equity with a conversion rate equal to $\gamma_{i\,j}$. The NCWO rule restricts the conversion rate such that creditors do not experience losses higher than those they would face in a liquidation scenario at $t = 1$. In the presence of aggregate risk, this means in good times, if the weak banks are going to default at $t = 2$, a bail-in should generate payoffs for the late consumers equal to those they would receive when weak banks are liquidated at $t = 1$. In bad times, after a bail-in, late consumers should receive payoffs at least equal to proceeds from either liquidating weak banks or, in case of a systemic default, the proceeds from liquidating both banks. Hence, the NCWO rule can be generalized as

$$\gamma_{i\,j}\left(1-\lambda+\frac{h(\lambda)X_i-\theta}{p(\lambda,Z_j)}\right)Z_j \geq (1-\lambda)\max\left\{p^{\ell}(\lambda,Z_j),p^{b}(\lambda,Z_j)\right\}+h(\lambda)X_i-\theta\,.$$

The left-hand side of the inequality is a fraction $\gamma_{i\,j}$ of the second-period return that late consumers receive after the bail-in as shareholders. In this case, the market price is either $p^c(\lambda, Z_i)$ when both banks survive at $t = 1$ and either (or both) of them are bailed-in, or $p^\ell(\lambda, Z_i)$ when only strong banks survive at $t = 1$ and are bailed-in. The right-hand side is the payoff late consumers receive when the defaulting bank is liquidated. The market price is either $p^\ell(\lambda, Z_j)$ if only weak banks are liquidated or $p^b(\lambda, Z_j)$ if both banks are liquidated.

I assume the supervisor chooses a conversion rate equal to

$$\gamma_{i\,j}(\lambda) = \left[\frac{(1-\lambda)\max\{p^\ell(\lambda, Z_j), p^b(\lambda, Z_j)\} + h(\lambda)X_i - \theta}{(1-\lambda)p(\lambda, Z_j) + h(\lambda)X_i - \theta}\right]\frac{p(\lambda, Z_j)}{Z_j}\,,$$

which just satisfies the NCWO rule. Then, the banks' maximization problem at $t = 0$ is

$$\begin{aligned}\max_{\lambda_i \in [0,1)} \Pr\Big(0 < R_{i\,j}(\lambda_i) \le (1-\theta)D_2(\lambda)\Big)\mathbb{E}\Big[\Big(1-\gamma_{i\,j}(\lambda)\Big)R_{i\,j}(\lambda_i) | 0 < R_{i\,j}(\lambda_i) \le (1-\theta)D_2(\lambda)\Big] \\ + \Pr\Big(R_{i\,j}(\lambda_i) \ge (1-\theta)D_2(\lambda)\Big)\mathbb{E}\Big[R_{i\,j}(\lambda_i) - (1-\theta)D_2(\lambda) | R_{i\,j}(\lambda_i) \ge (1-\theta)D_2(\lambda)\Big]\,,\end{aligned}$$

where the first term means banks receive a fraction $1 - \gamma_{i\,j}(\lambda)$ of the second-period asset return if the bank is bailed-in. The second term means when the bank is solvent at $t = 2$, banks receive the excess second-period return after repaying the late consumers. The short-term investment $\lambda_i^*$ that satisfies the first-order condition

$$\begin{aligned}\Pr\Big(0 < R_{i\,j}(\lambda_i) \le (1-\theta)D_2(\lambda)\Big)\mathbb{E}\Big[\Big(1-\gamma_{i\,j}(\lambda)\Big)\frac{\partial R_{i\,j}(\lambda_i^*)}{\partial \lambda_i}\Big| 0 < R_{i\,j}(\lambda_i) \le (1-\theta)D_2(\lambda)\Big] \\ + \Pr\Big(R_{i\,j}(\lambda_i) \ge (1-\theta)D_2(\lambda)\Big)\mathbb{E}\Big[\frac{\partial R_{i\,j}(\lambda_i^*)}{\partial \lambda_i}\Big| R_{i\,j}(\lambda_i) \ge (1-\theta)D_2(\lambda)\Big] = 0\,,\end{aligned} \tag{12}$$

characterizes the equilibrium portfolio if the equilibrium conditions

$$R_{i\,j}(\lambda_i^*) \ge (1-\theta)D_2(\lambda)$$

for no default in the state $\{i, j\}$ and

$$0 < R_{i\,j}(\lambda_i) \le (1-\theta)D_2(\lambda)$$

for a bail-in are satisfied. When comparing the first-order condition in anticipation of bail-ins with the one in laissez-faire (11), the additional first term in (12) underscores that banks' now endogenous the effect of their portfolio choice on the second-period asset return following a bail-in, which could be positive or negative. As a result, resembling the situation without aggregate risk, bail-ins introduce ex-ante portfolio reallocation. If the bail-in expectations incentivize banks to reduce their short-term investments, strong banks' liquidity might be insufficient to repay either early or late consumers during bad times. Then, all banks default simultaneously when the long-term asset return is low $Z_b$. In other words, the portfolio impact of bail-ins may not prevent systemic events or even contribute to systemic events.

Regarding the gross return of long-term debt given the market expectation $\lambda$, the late consumers' binding participation constraint is

$$\Pr\Big(0 < R_{i\,j}(\lambda_i) \leq (1-\theta)D_2(\lambda)\Big)\mathbb{E}\Big[\gamma_{i\,j}(\lambda)R_{i\,j}(\lambda_i)|0 < R_{i\,j}(\lambda_i) \leq (1-\theta)D_2(\lambda)\Big] + (1-\theta)D_2(\lambda)\Pr\Big[R_{i\,j}(\lambda_i) \geq (1-\theta)D_2(\lambda)\Big] = 1-\theta\,,$$

where the first term means late consumers receive equity payoffs when the bank is bailed-in. The second term means when the bank is solvent at $t = 2$, the late consumers receive the face value of long-term debt. When compared to laissez-faire, the impact of the expectation of bail-ins on the gross return of long-term debt is uncertain, and it depends on the conversion rate $\gamma_{i,j}(\lambda)$ relative to the recovery rate after default $c$. Given market short-term investment $\lambda$, if late consumers receive lower payoffs after a bail-in than after a default at $t = 2$, i.e., $\gamma_{i,j}(\lambda) < c$, the gross return of long-term debt while anticipating bail-ins is higher than with no supervisory intervention.

Figure 9 depicts the systemic risk across the range of possible values for the probability of low long-term asset return $\beta \in (0, 1)$. Bail-ins alter banks' payoffs and hence trigger ex-ante portfolio reallocation. Figure 9 illustrates that for intermediate levels of $\beta$, this portfolio reallocation effect creates the possibility of banks investing less in the short-term asset relative to the laissez-faire scenario. This adjustment can push them into the region where they default during bad times. In essence, the anticipation of bail-ins can introduce multiple equilibria (larger region of green and red line overlapping) and generate systemic risk (larger region of red line). As a result, bail-ins are less effective in averting systemic risk

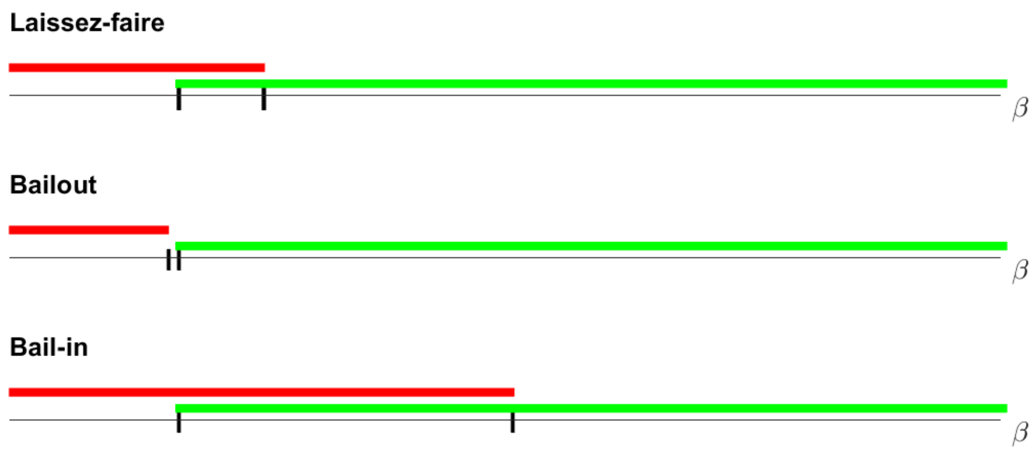



**Figure 9** – **Systemic risk in anticipation of bail-ins**

The figure depicts the systemic risk across the range of possible values for the probability of a low long-term asset return $\beta \in (0, 1)$ in case of no supervisory intervention, in anticipation of bailouts,and in anticipation of bail-ins. The green line signifies the equilibrium with no systemic defaults and the red line signifies the equilibrium with systemic defaults. The overlapping region between the red and green lines demonstrates cases of multiple equilibria. Parameter values are $\theta = 0.40$, $X_h = 3.00$, $X_\ell = 0.60$, $Z_g = 2.60$, $Z_b = 1.20$, and $\alpha = 0.45$.

and might even contribute to it.

# 5 Conclusion

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

Bail-in expectations, on the other hand, reduce the ex-ante short-term risky investment. If this portfolio reallocation effect is large enough, it can prevent idiosyncratic bank default. However, it also increases the likelihood of fire sales and systemic defaults in the presence of aggregate risk. Thus, the fact that bail-in expectations have an ex-ante portfolio effect makes bail-in policies effective against idiosyncratic risk but vulnerable to systemic risk. The results in this paper suggest that a resolution policy that pre-conditions bail-ins for any bail-outs, which, for example, is the case in Europe, may contribute to the fragility of the banking environment. In contrast, a resolution policy that leaves the possibility of bailouts open to “systemic risk exceptions”, which, for example, is the case in the United States, may reduce the likelihood of systemic events.

The supervisory resolution policy in this paper is treated as an exogenous variable to assess the positive effects of each policy on bank portfolios and 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 tool. Existing literature emphasizes the commitment challenge faced by supervisors in refraining from bailouts. Since prices are ex-post not affected by a resolution policy change, the supervisor has no incentive to ex-post deviate from a bail-in to a bailout policy to prevent fire sales. However, 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, where the results are defined as described in this paper.

# Appendix

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

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

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

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

that is when

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

the market clearing condition,

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

defines the continuation price,

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

where superscript $c$ indicates that all banks continue to operate until $t = 2$.

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

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

defines the liquidation price,

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

where superscript $\ell$ indicates that the weak banks are liquidated at $t = 1$. Note that the liquidation price can be rewritten as

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

or as

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

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

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

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

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

In the first case, one cannot have weak banks defaulting, because the liquidation price $p^{\ell}(\lambda)$ is above the threshold $\widetilde{p}(\lambda)$, so the continuation price $p^c(\lambda)$ (which is above the threshold $\widetilde{p}(\lambda)$) becomes the market price $p(\lambda)$. In the second case, one cannot have weak banks surviving, because the continuation price $p^c(\lambda)$ is below the threshold $\widetilde{p}(\lambda)$, so the liquidation price $p^{\ell}(\lambda)$ (which is below the threshold $\widetilde{p}(\lambda)$) becomes the market price $p(\lambda)$. Hence, it follows that $p(\lambda) = \max\{p^c(\lambda), p^{\ell}(\lambda)\}$. Finally, the market price $p(\lambda)$ cannot exceed the return of the long-term asset $\overline{Z}$, which defines the market price as

$$p(\lambda) = \min\{\max\{p^c(\lambda), p^{\ell}(\lambda)\}, \overline{Z}\}\,.$$

The model focuses on cases in which strong banks are always solvent, whereas weak banks need to sell long-term asset to repay early consumers and may be solvent at $t = 2$ or default either at $t = 1$ or $t = 2$. To restrict attention to these cases, I make the following parameter assumptions:

First, note that the continuation price

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

is increasing and concave in short-term asset investment $\lambda$. The default threshold $\widetilde{p}(\lambda)$ is convex in $\lambda$,

$$\frac{\partial^2 \widetilde{p}}{\partial \lambda^2} = \frac{2\theta - X_\ell}{(1-\lambda)^3}\,,$$

for $\theta > X_\ell/2$. Moreover, for a portfolio with no short-term assets $\lambda = 0$ the continuation price is higher than the default threshold,

$$p^c(0) = \overline{Z} - \theta > \theta = \widetilde{p}(0)\,.$$

when $\theta < \overline{Z}/2$. Consequently, in the parameter range

$$\frac{X_\ell}{2} < \theta < \frac{\overline{Z}}{2}\,,$$

the continuation price $p^c(\lambda)$ and the default threshold $\widetilde{p}(\lambda)$ intersect once at $\tilde{\lambda}$. For $\lambda < \tilde{\lambda}$ the continuation price is above the threshold and defines the market price, case (A3). For $\lambda \geq \tilde{\lambda}$, the continuation price falls below the threshold and the liquidation price defines the market price, case (A4).

Finally note that for $\theta > X_\ell/2$, the weak banks' first-period net liquidity

$$h(\lambda)X_\ell - \theta = -\frac{\lambda_i^2}{2}X_\ell + \lambda_i X_\ell - \theta$$

is negative for any short-term asset investment $\lambda$. This means weak banks need to sell their long-term asset at $t = 1$ independent of their portfolio.

Strong banks default at $t = 1$ if selling the entire asset holding is not enough to repay early consumers,

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

that is when

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

Note that for $\theta < X_h/2$ the default threshold for the strong banks is concave and decreasing in $\lambda$. Moreover, for a portfolio with no short-term assets $\lambda = 0$ and $\theta < \overline{Z}/2$ weak banks will not default at $t = 1$, therefore strong banks, which have a higher first-period return, will also not default. Hence, for

$$\theta < \max\left\{\frac{\overline{Z}}{2}, \frac{X_h}{2}\right\}\,,$$

the strong banks do not default at $t = 1$ regardless of $\lambda$, because the threshold $\widehat{p}(\lambda)$ does not intersect with the continuation price $p^c(\lambda)$. To summarize, for the parameters

$$\frac{X_\ell}{2} < \theta < \max\left\{\frac{\overline{Z}}{2}, \frac{X_h}{2}\right\}\,,$$

strong banks do not default at $t = 1$, but weak banks may default if banks' ex-ante investment in the short-term asset is too large, $\lambda > \tilde{\lambda}$. □

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

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

That is when

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

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

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

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

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

defines the crisis liquidation price

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

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

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

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

then weak banks' liquidation price

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

is the market price, where superscript $\ell$ indicates that only the weak banks are liquidated at $t = 1$. Note that the liquidation price can be rewritten as

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

or as

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

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

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

the continuation price

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

is the market price, where superscript $c$ indicates that all banks continue to operate until $t = 2$. Note that the liquidation price can be rewritten as

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

or as

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

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

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

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

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

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

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

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

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

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

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

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

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

From the combination of the two inequalities (A9) and (A11) it follows that weak banks cannot default, because the weak banks' liquidation price $p^\ell(\lambda, Z_j)$ is above the threshold $\widetilde{p}(\lambda)$ and strong banks cannot default because the crisis price $p^b(\lambda, Z_j)$ is above the threshold $\widehat{p}(\lambda)$, so the continuation price $p^c(\lambda, Z_j)$ (which is above the threshold $\widetilde{p}(\lambda)$ becomes the market price $p(\lambda, Z_j)$.

Then, in sum, the market price for the long-term asset is

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

where the market price $p(\lambda, Z_j)$ cannot exceed the return of the long-term asset $Z_j$. Finally, note that for the parameter range defined in Proposition 1, both banks survive at $t = 1$ when $Z_j = Z_g$ because $Z_g > \overline{Z}$. However, for $Z_j = Z_b$ either bank may default at $t = 1$. □

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