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RUNS VERSUS LEMONS:  
INFORMATION DISCLOSURE AND FISCAL CAPACITY

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**ABSTRACT**

We characterize the optimal use of information disclosure and fiscal backstops during financial crises. In our model, financial crises force governments to choose between runs and lemons. Revealing information about banks' assets reduces adverse selection in credit markets, but it can also create inefficient runs on weak banks. A fiscal backstop mitigates this risk and allows the government to pursue a high disclosure strategy. A government with a strong fiscal position is more likely to run informative stress tests than a government with a weak fiscal position. As a result, such a government is also less likely to rely on outright bailouts.

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Governments intervene in various ways during financial crises ([Gorton, 2012](#)). Some policies, such as liquidity support, credit guarantees, and capital injections are explicitly backed by the balance sheet of the government. Other policies, such as stress tests and asset quality reviews, do not rely directly on the fiscal capacity of the government but rather on its ability to (credibly) disclose information. Governments almost always use both types of interventions, yet the existing literature has only studied one or the other. Our goal is to provide a joint theory of optimal interventions.

One motivation for our analysis is the striking difference between the stress tests implemented in the U.S. and in Europe following the 2008-2009 financial crisis. In May 2009, the Federal Reserve publicly reported the results of the Supervisory Capital Assessment Program (SCAP). The SCAP was an assessment of the capital adequacy, under adverse scenarios, of a large subset of U.S. financial firms. The exercise is broadly perceived as having reduced uncertainty about the health of U.S. banks and helped restore confidence in financial markets.

European policy makers were keenly aware of the U.S. experience, and yet, after much hesitation, ended up designing significantly weaker stress tests. The Committee of European Banking Supervisors (CEBS) conducted E.U.-wide stress tests from May to October 2009 but chose not to disclose the results. The exercise was repeated a year later and the results were published, but the scope of the test was limited, especially with regard to sovereign exposures. Our theory suggests that the lack of a credible backstop made it risky for individual governments to conduct rigorous stress tests. Our theory is also consistent with the fact that the Asset Quality Review (AQR) run by the European Central Bank in 2014, *after* the introduction of financial backstops (ESM, OMT), was significantly more rigorous and probably on a par with the American stress tests.<sup>1</sup>

We also argue, from a theoretical perspective, that fiscal backstops and information disclosure should be jointly studied because this more comprehensive approach leads to new predictions and can overturn existing results. For instance, we find that governments with strong fiscal positions can end up doing fewer bailouts than governments with weak fiscal positions. This prediction is the opposite of what one would expect when considering only one policy at a time. If there is only one policy option, governments with more fiscal slack always provide more bailouts. In our model, however, these governments are also more likely to run aggressive stress tests that can make bailouts unnecessary. This is an important empirical prediction, but also a relevant point when studying time consistency issues and the balance between rules and discretion.

**Disclosure** Disclosure is typically motivated by the need to restore investor confidence in the health of financial firms. We capture this idea using a simple model of adverse selection, following [Akerlof \(1970\)](#) and

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<sup>1</sup>[Ong and Pazarbasioglu \(2014\)](#) provide a thorough overview of the details and perceived success of SCAP and the CEBS stress tests. See [Véron \(2012\)](#) for a discussion of the challenges facing European policy makers.

Myers and Majluf (1984). Our economy is populated by financial intermediaries (“banks”) who privately observe the quality of their existing assets. The main state variable in our economy is the fraction of banks with good legacy assets (strong banks). All banks, weak and strong, have valuable investment opportunities and can raise external funds in credit markets. The riskiness of lending to a particular bank, however, depends on the quality of its old assets, and this creates the potential for adverse selection. When perceived asset quality is high, adverse selection is limited and credit markets operate efficiently. When the fraction of strong banks is believed to be low, credit markets are likely to freeze, and the government can improve welfare by disclosing information about asset quality.<sup>2</sup>

Alleviating adverse selection therefore pushes the government to disclose information about banks’ balance sheets. Why, then, not disclose as much as possible? We argue that an important cost of disclosure is the risk of triggering a run on weak banks. We follow the standard approach of Diamond and Dybvig (1983) in modeling banks as being funded with runnable liabilities.<sup>3</sup> If short term creditors (depositors) learn that a particular bank is weak, they might decide to run. Runs are inefficient because they entail deadweight losses from liquidation and missed investment opportunities.

Disclosure then involves a trade-off between runs and lemons. We first solve for optimal disclosure without any fiscal intervention. We model disclosure as in the Bayesian persuasion model of Kamenica and Gentzkow (2011). The government and the private sector share some prior belief about the health of financial firms. The government chooses the precision of the signals that are generated. Each signal contains information about the quality of an individual bank. Together, the signals reveal the aggregate state. An important point is that the government chooses how much to disclose without knowing the actual fraction of strong banks in the economy. We argue that this captures the essence of stress tests and asset quality reviews. We solve the planner’s disclosure problem, which may or may not be convex, and we show how optimal disclosure depends on the distribution of beliefs about the fraction of strong banks.

**Disclosure vs. Guarantees** Governments can and do extend guarantees to stop runs. Modern runs are less about retail depositors and more about wholesale depositors, money market funds, and more generally about the failure to roll over short term liabilities issued by financial firms.<sup>4</sup> In our model, the benefit from insuring

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<sup>2</sup>In an adverse selection environment, the impact of disclosure on efficiency is not obvious. It is easy to construct examples where disclosure has a negative impact on welfare, for instance by breaking an efficient pooling equilibrium. However, we propose a class of disclosure policies that always improve efficiency. The key feature is that they avoid type I errors, as explained later.

<sup>3</sup>We have in mind all types of short-term runnable liabilities: MMF, repo, ABCP, and, of course, large uninsured deposits. In the model, for simplicity, we always refer to all intermediaries as banks and to all runnable liabilities as deposits.

<sup>4</sup>We take the existence of these runnable claims as given. Our model completely ignores the deep and important issue of why financial firms issue these unstable liabilities in the first place. See Zetlin-Jones (2014) for a model where a bank optimally chooses a fragile capital structure that is subject to bank runs. A critical issue is then whether the private chosen level of runnable claims is

runnable liabilities is to prevent the inefficient liquidation of long-term assets. However, guarantees expose the government to potential losses and, therefore, to deadweight losses from taxation.

The main contribution of our paper is to analyze the interaction between fiscal capacity and optimal disclosure. Our two main insights can be summarized as follows. First, disclosure is a high risk/high return strategy. Imposing meaningful transparency about balance sheets can effectively unfreeze credit markets. This is often a good idea, but there are some states of the world where banks are in worse shape than expected and the government faces a large bank run. The second key insight is that fiscal capacity provides insurance against the risks created by information disclosure. When fiscal capacity is ample, the planner reveals information and, in case of bad outcomes, provides guarantees to banks that are vulnerable to runs. Conversely, when capacity is low, the planner prefers to avoid runs by not disclosing much information.

None of these results could be obtained without the joint modeling of runs and lemons. In the model, as in the real world, it is important that the same aggregate fundamental (the fraction of strong banks) determines both the risk of runs and the risk of a market freeze. It is also important to solve for the joint optimal policy. Our model captures the idea that fiscal capacity acts as an insurance policy that allows regulators to be more aggressive in their disclosure choices. The key prediction, akin to a single crossing property, is that the optimal degree of disclosure increases with the fiscal capacity of the government.

Finally, we extend our model to allow for outright bailouts, by which we mean government subsidies that are not extended in response to runs.<sup>5</sup> Such interventions in markets with adverse selection are technically difficult to analyze because they require solving a mechanism design problem with endogenous outside options. We rely on [Philippon and Skreta \(2012\)](#) and [Tirole \(2012\)](#) to show that the optimal intervention takes a simple form: the government provides a credit-enhancing guarantee to banks that need to borrow. Guarantees of this kind are indeed routinely observed during financial crises. An interesting insight from this analysis is that disclosure and credit bailouts are substitutes. As a result, a government with *more* fiscal capacity might, on average, spend *less* on bailouts.

**Related Literature** Our work builds on the corporate finance literature that studies asymmetric information, in particular [Myers and Majluf \(1984\)](#) and [Nachman and Noe \(1994\)](#), and on the bank runs literature started

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higher than the socially optimal one, which obviously depends on fire sales and other types of externalities. The goal of our paper is not to study these externalities, but it is easy to incorporate them, as in [Philippon and Schnabl \(2013\)](#) for instance. They would only change the optimal level of intervention without changing the design of how to intervene, which is the focus of our paper.

<sup>5</sup>This is of course easier to define in the model than in the real world. For example, capital injections can be used to stop runs and to unfreeze markets at the same time, but such a policy is not optimal in our framework. We use the terms “deposit guarantees” and “credit bailouts” to describe the policies we study because there is a clear distinction in the model in the motivation for government intervention, who benefits the most, and what the optimal instruments are. We impose no restrictions on the instruments that the government can use.

by [Diamond and Dybvig \(1983\)](#). Several recent papers shed light on how runs take place in modern financial systems: theoretical contributions include [Uhlig \(2010\)](#) and [He and Xiong \(2012\)](#); [Gorton and Metrick \(2012\)](#) provide a detailed institutional and empirical characterization of modern runs.

Several recent papers study specifically the trade-offs involved in revealing information about banks. [Goldstein and Sapra \(2014\)](#) review the literature on the disclosure of stress tests results. [Goldstein and Leitner \(2013\)](#) focus on the [Hirshleifer \(1971\)](#) effect: revealing too much information destroys risk-sharing opportunities between risk neutral investors and (effectively) risk averse bankers. These risk-sharing arrangements also play an important role in [Allen and Gale \(2000\)](#). [Shapiro and Skeie \(Forthcoming\)](#) study the reputation concerns of a regulator when there is a trade-off between moral hazard and runs. Other papers, such as [Bouvard et al. \(2015\)](#) and [Parlatore \(2013\)](#), study disclosure in models of bank runs using the global game approach of [Carlsson and van Damme \(1993\)](#) and [Morris and Shin \(2000\)](#). In these models, governments have an incentive to disclose information only if there is a run on all banks and disclosure is used to save stronger banks. At least in the recent crisis, however, disclosure took place without aggregate runs, and the stated goal of the policy was to unfreeze financial markets. This is why our model emphasizes the trade-off between runs and lemons.

In our setting, banks are not able to credibly disclose information about their type. [Alvarez and Barlevy \(2014\)](#) study disclosure and contagion in a banking network. They show that private disclosure choices are not always efficient and that mandatory disclosure can improve welfare. [Gorton and Ordoñez \(2014\)](#) consider a model where crises occur when investors have an incentive to learn about the true value of otherwise opaque assets. [Chari et al. \(2014\)](#) develop a model of secondary loan markets where adverse selection and inefficient pooling equilibria can persist in a dynamic setting due to reputation.

Our paper also relates to the large literature on bank bailouts. [Gorton and Huang \(2004\)](#) argue that the government can provide liquidity more effectively than private investors while [Diamond \(2001\)](#) emphasizes that governments should only bail out the banks that have specialized knowledge about their borrowers. [Philippon and Skreta \(2012\)](#) and [Tirole \(2012\)](#) formally analyze optimal interventions in markets with adverse selection. [Mitchell \(2001\)](#) analyzes interventions when there is both hidden action and hidden information. [Landier and Ueda \(2009\)](#) provide an overview of policy options for bank restructuring. [Diamond and Rajan \(2012\)](#) study the interaction of debt overhang with trading and liquidity. [Philippon and Schnabl \(2013\)](#) study the macroeconomic consequences of debt overhang in the financial sector. Another important strand of the literature studies the ex-ante efficiency of crises and bailouts, following the seminal work of [Kareken and Wallace \(1978\)](#). [Chari and Kehoe \(2013\)](#) show that time consistency issues are worse for a government than for private agents. [Zetlin-Jones \(2014\)](#) shows that occasional systemic crises can in fact be part of an efficient ex-ante equilibrium. We

do not study ex-ante issues since we take as given both the distribution of asset quality and the existence of runnable liabilities. Our results do, however, shed new light on the rules-versus-discretion debate. In our model, the availability of fiscal capacity makes the government more willing to disclose and less likely to bail out. It is therefore important to study time consistency together with disclosure choices, and not only with bailout choices.

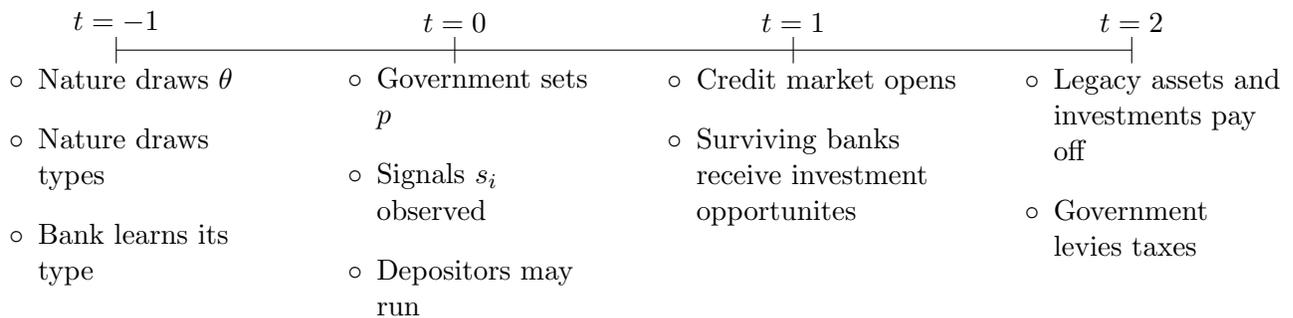
The paper is organized as follows. Section 1 presents the model. Section 2 describes the equilibrium without government interventions. Section 3 studies optimal disclosure. Section 4 analyzes deposit guarantee together with information disclosure. Section 5 extends the baseline model to credit bailouts. Section 6 concludes.

## 1 Description of the Model

### 1.1 Technology and Preferences

There are four periods,  $t = -1, 0, 1, 2$ , and one good (consumption) at every period. The economy is populated by a continuum of households, a continuum of mass 1 of financial intermediaries (banks), and a government. Government policies are studied in Sections 3, 4 and 5. Figure 1 summarizes the timing of decisions and events in the model, which are explained in detail below.

Figure 1: Model Timing



*Note:  $\theta$  is the fraction of strong banks,  $s_i$  is a signal about bank  $i$ 's quality, and  $p$  is the precision of the signal.*

Households are risk-neutral, receive an endowment  $\bar{y}_1$  in period 1, and only value consumption in period 2. They have access to a storage technology to transfer resources from period 1 to period 2. This allows us to treat total output at time 2 as the measure of welfare that the government seeks to maximize. Households have deposits in the banks, can lend in the credit market in period 1, and are residual claimants of all banking profits in period 2.

Banks are indexed by  $i \in [0, 1]$  and have pre-existing long-term assets (legacy assets) and redeemable liabilities (deposits). The legacy assets of bank  $i$  generate income  $a_i$  at time 2. Each bank may be of either strong ( $g$ ) or weak ( $b$ ) type. The assets of strong banks yield higher revenues than the assets of weak banks (in a stochastic dominance sense, discussed later). Banks are financed by deposits. Each depositor is entitled to 1 unit of consumption in period 0 and  $D > 1$  in period 2. Banks have access to a liquidation technology to meet potential redemptions. Bank  $i$  receives  $(1 - \delta) a_i$  if it liquidates its assets at any time before time 2. The parameter  $\delta \in (0, 1)$  captures the deadweight loss from early liquidation.

Nature determines the distribution of bank types. Let  $\mathcal{G}$  be the set of strong banks, and  $\mathcal{B}$  be the set of weak banks. Nature draws the fraction of strong banks  $\theta$  from the distribution  $\pi(\theta)$ , and each bank then has the same likelihood of being strong. The random variable  $\theta$  is therefore both the fraction of strong banks in the economy and the ex-ante probability that any given bank is strong:

$$\Pr(i \in \mathcal{G} \mid \theta) = \theta.$$

Each bank *privately* observes its own type.

Households can withdraw their deposits at any time during period 0. Period 0 is also when the government announces its policies. Some of these policies involve the disclosure of information about banks' types. In period 1, each surviving (i.e., non-liquidated) bank receives an investment opportunity that costs a fixed amount  $k$  at time 1 and delivers a random payoff  $v$  at time 2.<sup>6</sup> We maintain the following assumption throughout the paper.

**Assumption 1: Valuable Investments.** *Investment projects have a positive net present value, and investment by all banks is feasible:  $\mathbb{E}[v] > k$  and  $\bar{y}_1 > k$ .*

Finally, at time 2, non-liquidated legacy assets return  $a$ , new investments return  $v$ , and the government levies distortionary taxes. Raising  $\Psi$  units of revenue creates a deadweight loss  $\gamma\Psi^2$  where  $\gamma$  scales the welfare cost of taxation, and is our (inverse) measure of fiscal capacity.

## 1.2 Welfare

Given our assumptions about preferences and technology we can characterize the first best allocation.

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<sup>6</sup>For simplicity, we assume that any amount of liquidation causes the bank to lose its investment opportunity.

**Lemma 1.** *The first best level of welfare in aggregate state  $\theta$  is*

$$\bar{w}(\theta) = \mathbb{E}[a \mid \theta] + \bar{y}_1 + \mathbb{E}[v] - k \quad (1)$$

The first-best allocation has three simple features: (i) no assets are liquidated; (ii) all banks invest; and (iii) taxes are zero. Departures from the first best allocation are driven by information asymmetries, coordination failures, and government interventions. Runs might force some banks to liquidate their assets. We denote by  $\mathcal{L}$  the set of banks that are liquidated. Adverse selection might also push some banks to drop out of the credit market. We denote by  $\mathcal{O}$  the set of banks that are not liquidated but choose not to invest. Finally, the government may choose to intervene to stop bank runs or (in an extension to the model) alleviate adverse selection. These interventions imply a fiscal burden  $\Psi$ . Ex-post welfare in the economy is then

$$w(\theta) = \bar{w}(\theta) - \delta \int_{\mathcal{L}} a_i - \int_{\mathcal{O} \cup \mathcal{L}} (v_i - k) - \gamma \Psi^2 \quad (2)$$

The sets  $\mathcal{L}$  and  $\mathcal{O}$  are complex equilibrium objects that depend (at least) on the realization of  $\theta$  and the menu of policies chosen by the government.

### 1.3 Policies

The government seeks to bring the economy as close as possible to the first best allocation. Let  $\mathcal{P}$  denote the (multidimensional) policy of the government. Given the welfare function in equation (2), this implies

$$\mathcal{P}^* = \arg \min_{\mathcal{P}} \mathbb{E} \left[ \delta \int_{\mathcal{L}_{\theta, \mathcal{P}}} a_i + \int_{\mathcal{O}_{\theta, \mathcal{P}} \cup \mathcal{L}_{\theta, \mathcal{P}}} (v_i - k) + \gamma \Psi_{\theta, \mathcal{P}}^2 \right]$$

The government wants to minimize liquidation costs, missed investment opportunities, and deadweight losses from taxes. Our paper studies the kind of policies that the government should use to achieve these conflicting objectives. We study two broad classes of policies. A first class of policies relies on the revelation of information about the underlying distribution of banks types. We show that this involves a tradeoff between  $\mathcal{L}$  and  $\mathcal{O}$ , i.e., between runs and lemons. Importantly, the government chooses its disclosure policy before knowing  $\theta$  – this makes disclosure risky.

A second class of policies relies on the government’s ability to raise taxes. The government may decide to insure the deposits of a particular bank or to provide credit guarantees to facilitate new investments. These policies involve a tradeoff between  $\mathcal{L}$ ,  $\mathcal{O}$ , and  $\Psi$ . We impose an important restriction on government interven-

tions:

**Assumption 2: Feasible Interventions.** *The government cannot repudiate private contracts and must respect the participation constraints of all private agents.*

Assumption 2 is critical for our analysis as it restricts the set of feasible policies. The government cannot force households to keep their deposits in the banks, nor can it force banks to issue claims they do not want to issue. We maintain the usual definition of a free market economy where the only policy that is allowed to violate participation constraints is taxation, and we add information disclosure to this definition. We later discuss the implications of this assumption in terms of bank regulations, such as forcing banks to raise equity.

## 1.4 Technical Assumptions

Our modeling choices for banking assets follow closely those in [Philippon and Skreta \(2012\)](#), and we make the same technical assumptions as them. Formally, we assume that only total income  $a + v$  is observable, that repayment schedules are non-decreasing in total income, and that the distribution of  $a + v$  satisfies the strict monotone hazard rate property with respect to bank types:

$$\frac{f(a + v | b)}{1 - F(a + v | b)} > \frac{f(a + v | g)}{1 - F(a + v | g)}.$$

where  $F$  and  $f$  are the *c.d.f.* and *p.d.f.* of  $a + v$ , respectively. Repayment schedules must be increasing in total income  $a + v$ , and cannot depend on  $a$  and  $v$  separately. These are standard assumptions in corporate finance that can be justified by the possibility of hidden trades.<sup>7</sup> Our results hold under these technical assumptions, but the intuition of the model is more easily explained by using the following special case. Let  $(q, V, A^g, A^b)$  be four strictly positive numbers such that  $q < 1$  and  $A^b < A^g$ :

**Assumption 3: Simplifying Assumptions.** *Legacy assets pay off  $A^g$  for strong banks and  $A^b$  for weak banks. New investments pay off  $v = V$  with probability  $q$  and 0 with probability  $1 - q$ , such that*

$$A^g - \frac{k}{q} > D > A^b > 0.$$

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<sup>7</sup>The important point is that the quality of legacy assets matters for new investment. Technically, there are several (essentially) equivalent ways to derive this dependency. Here we follow the standard corporate finance assumption that only total income at period 2,  $y = a + v$  is contractible. [Tirole \(2012\)](#) instead assumes that new projects are subject to moral hazard, so banks must pledge their existing assets as collateral. One could also assume that bankers can repudiate their debts, engage in risk shifting, etc. All these frictions motivate the role of existing assets as collateral for new loans and are equivalent in our framework. See [Philippon and Skreta \(2012\)](#) for a discussion of all these issues.

Assumption 3 satisfies the technical requirements listed above. The critical elements for adverse selection are that banks know more than outsiders about the quality of their assets and that investment payoffs are random. Here, for simplicity, banks know their assets' payoffs in advance, and investment returns are binary (and do not depend on the type of the bank). The inequalities imply that strong banks are safe at all times while weak banks may be insolvent.

## 2 Equilibrium without Government Intervention

In this section, we characterize the equilibrium with exogenous information and without taxes.

### 2.1 Information

Investors observe public signals  $\{s_i\}_{i \in [0,1]}$  about bank types at the beginning of period 0. Each signal is binary and satisfies  $\Pr(s = 1 \mid \mathcal{G}) = 1$  and

$$\Pr(s = 0 \mid \mathcal{B}) = p$$

for some precision  $p \in (0, 1)$ . The important point about this information structure is that it avoids type I errors. A strong bank is never classified as weak, but a weak bank can pass as strong. We argue that this information structure is both realistic and theoretically appealing. It is realistic in the context of banking stress tests since problems actually uncovered by regulators are almost certainly there, and the main issue is to know which problems have been missed. The theoretical appeal is that this class of signal has the property that disclosure always (weakly) improves welfare in a pure adverse selection model. The general case is treated in [Faria-e Castro et al. \(2015\)](#) but the intuition is clear. The potential downside of disclosure is to break an efficient pooling equilibrium. This can happen if the regulator singles out good banks, as these get to borrow cheaply but the quality of the remaining pool decreases. Singling out some bad banks, however, only forces these banks to borrow at the fair rate, and increases the quality of the remaining pool.<sup>8</sup> We denote by  $n_s$  the mass of banks receiving signal  $s$ . By definition, we have

$$n_0 = p(1 - \theta),$$

and  $n_1 = \theta + (1 - p)(1 - \theta)$ . Agents know  $p$  and observe  $n_0$ , therefore they also learn the aggregate state  $\theta$ .

Let  $z_s$  denote the posterior belief that a bank is strong if it receives signal  $s$ ,  $z_s \equiv \Pr(i \in \mathcal{G} \mid s_i = s)$ . Bayesian

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<sup>8</sup>A previous version of the model used symmetric signals with precision  $p \equiv \Pr(s_i = 1 \mid i \in \mathcal{G}) = \Pr(s_i = 0 \mid i \in \mathcal{B})$ . The current setup is both more realistic and more tractable.

consistency requires  $z_0 = 0$ , and

$$z_1 = \frac{\theta}{\theta + (1-p)(1-\theta)}.$$

Note that the posterior probability depends on the precision  $p$  and on the realization of the aggregate state  $\theta$ .

## 2.2 Bank runs

Depositors can withdraw their deposits from banks at any time.<sup>9</sup> The liquidation technology yields  $1 - \delta$  per unit of asset liquidated and a bank that makes use of this technology loses the opportunity to invest in period 1. If a bank liquidates a fraction  $\lambda$  of its assets, it can satisfy  $(1 - \delta)\lambda a$  early withdrawals and has  $(1 - \lambda)a$  left at time 2. We assume that strong banks are liquid even under a full run while weak banks are not.

**Assumption 4.** *Strong banks are liquid, and weak banks are not*

$$A^b < \frac{1}{1 - \delta} < A^g$$

Suppose first that a bank is known to be strong. Withdrawing early yields 1 while waiting yields the promised payment  $D$ . Since  $D > 1$ , the unique equilibrium is no-run. On the other hand, if the bank is known to be weak, there always exists a run equilibrium. This is a direct consequence of Assumption 4. Since  $(1 - \delta)A^b < 1$  the bank would have no assets left to pay its patient depositors after a full run. Knowing this, no depositor would wait if they anticipate a run.

The decision to run depends on the belief  $z$  about the quality of a bank. We have shown that no-run is the only equilibrium when  $z = 1$ . Let  $z^R$  be the posterior belief above which no run is the unique equilibrium. This threshold is such that depositors are indifferent between running and waiting if all other depositors run. Therefore  $z^R + (1 - z^R)(1 - \delta)A^b = z^R D$ , and

$$z^R = \frac{(1 - \delta)A^b}{D + (1 - \delta)A^b - 1}. \quad (3)$$

For beliefs in the set  $[0, z^R]$  multiple equilibria exist. For simplicity, we select the run equilibrium for any bank whose posterior belief falls in the multiple equilibrium region. What matters for our results is that a run is

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<sup>9</sup>We do not explicitly model households with liquidity shocks that motivate the existence of deposit contracts in the first place, nor do we address the question of whether a planner, assuming that it could, would choose to suspend convertibility. These issues have been studied at length and the trade-offs are well understood (see [Gorton \(1985\)](#), for example). When liquidity demand is random, suspending convertibility is socially costly. We assume that these costs are large enough that the government prefers to guarantee deposits. Note also that our broad interpretation of deposits in the model includes short-term wholesale funding, whose suspension would be difficult to implement in any case.

possible in that range, not that it is certain.<sup>10</sup> We summarize our results in the following lemma.

**Lemma 2.** *Depositors run on any bank whose perceived quality falls below  $z^R$ .*

*Proof.* See above. □

The set of banks that are liquidated is therefore:

$$\mathcal{L}(\theta; p, \emptyset) = \{i \in [0, 1] \mid z_i \leq z^R\},$$

where  $\emptyset$  denotes the absence of fiscal government support.

### 2.3 Credit markets and investment in period 1

Banks receive valuable investment opportunities in period 1 but they must raise  $k$  externally. Under the assumptions of Section 1, we have the following standard result in optimal contracting:

**Lemma 3.** *Debt is an optimal contract to finance investment in period 1.*

*Proof.* See [Nachman and Noe \(1994\)](#) and [Philippon and Skreta \(2012\)](#). □

If a bank borrows at rate  $r$  and invests, the payoffs of depositors, new lenders, and equity holders are

$$\begin{aligned} y^D &= \min(a + v, D) \\ y^l &= \min(a + v - D, rk) \\ y^e &= a + v - y^l - y^D \end{aligned}$$

These payoffs reflect the fact that deposits are senior, and equity holders are residual claimants. Adverse selection arises from the fact that banks know the payoffs of their legacy assets while lenders do not. Strong banks know that they always pay back their debts (Assumption 3), so they find it profitable to borrow at rate  $r$  only when  $A^g - D + qV - rk \geq A^g - D$ . Strong banks therefore invest if and only if the market rate is below  $r^g$ , where

$$r^g \equiv \frac{qV}{k}. \tag{4}$$

We are interested in situations where the information asymmetry can induce adverse selection in the credit market. This happens when the interest rate for weak banks,  $q^{-1}$ , exceeds the maximum interest rate at which strong types are willing to invest:  $q^{-1} > r^g$ , which is equivalent to imposing  $q \leq \sqrt{\frac{k}{V}}$ .

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<sup>10</sup>We have solved our model under two alternative and often used equilibrium selection devices: dispersed information and sunspots. Our results are robust to using these alternative refinements.

Equity holders of weak banks earn nothing if they do not invest since their existing assets are insufficient to repay their depositors. As a result, weak banks always prefer to invest. Even in the absence of asymmetric information, however, underinvestment by weak banks could occur due to debt overhang, as in [Philippon and Schnabl \(2013\)](#). Debt overhang is not the focus of our analysis, so we assume that  $q \geq \frac{k}{V+A^b-D}$ , which guarantees that  $A^b - D + V - \frac{k}{q} \geq 0$  and weak banks always prefer to invest. To summarize, we consider the following parametric restrictions:

**Assumption 5.** *There is potential for adverse selection in the credit market*

$$\frac{k}{V - (D - A^b)} < q < \sqrt{\frac{k}{V}}$$

Adverse selection models can have multiple equilibria. For instance, if lenders expect only weak banks to invest, they set  $r = q^{-1}$  and indeed, at that rate, strong banks do not participate. This multiplicity disappears when governments can intervene, however, because (as we show below) the government can costlessly implement the best pooling equilibrium by setting the interest rate appropriately. Without loss of generality, we therefore select the best pooling equilibrium.

The equilibrium rate must satisfy the break-even condition of lenders. Consider a pooling equilibrium where lenders have a belief  $z$  about the type of a bank in the pool. Given that the risk free rate at which lenders can store is one, the break-even condition is

$$k = zrk + (1 - z)qrk$$

Lenders know that there is a probability  $1 - z$  of lending to a weak bank that only repays with probability  $q$ . The pooling rate is therefore

$$r(z) = \frac{1}{z + (1 - z)q}.$$

Figure 2 illustrates the equilibrium conditions.

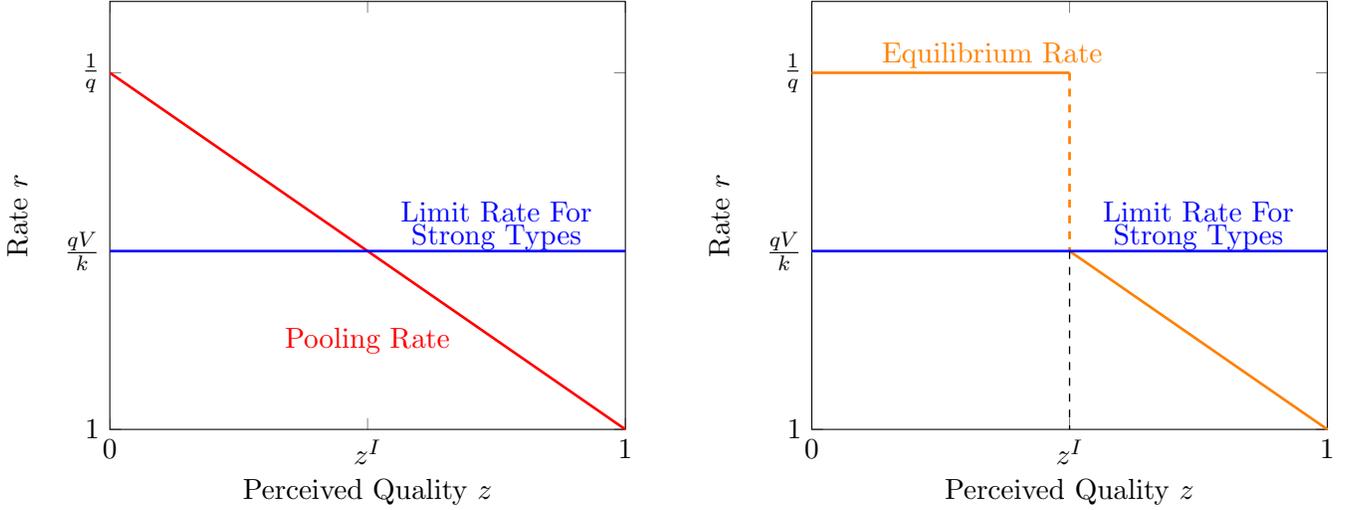
Finally, we need to check the consistency of the pooling equilibrium by requiring that  $r(z) < r^g$ . This defines a threshold  $z^I$  such that the pooling equilibrium is sustainable if and only if  $z > z^I$ :

$$z^I \equiv \frac{\frac{k}{qV} - q}{1 - q}. \tag{5}$$

When  $z < z^I$ , only the weak types invest, and the interest rate is  $r = \frac{1}{q}$ .<sup>11</sup> We summarize the credit market

<sup>11</sup>We assume here that depositors do not observe new borrowing decisions by banks. As a result, weak types can invest without creating a run. Our findings are robust to the alternative assumption.

Figure 2: Credit Market Equilibrium



This figure illustrates the equilibrium in credit markets by plotting the break-even rate for lenders  $r$  on the vertical axis, against the perceived quality of the pool of banks  $z$  in the horizontal axis. Due to strong banks opting out of participation in credit markets, the pooling rate on the left panel is not an equilibrium for  $z < z^I$ . The right panel illustrates the equilibrium with adverse selection: below  $z^I$ , the equilibrium interest rate is  $q^{-1}$  and only weak banks participate in credit markets.

equilibrium in the following lemma.

**Lemma 4.** *The credit market in period 1 is characterized by a cutoff  $z^I$  on the perceived quality of any pool of banks. When  $z > z^I$ , both strong and weak types invest, and the interest rate is  $r(z) = \frac{1}{z+(1-z)q}$ . When  $z < z^I$ , only weak types invest, and the interest rate is  $r^b = q^{-1}$ .*

*Proof.* See above. □

The set of banks that opt out of credit markets is therefore

$$\mathcal{O}(\theta; p, \emptyset) = \{i \in \mathcal{G} \mid z^R \leq z_i < z^I\}.$$

Before characterizing the equilibrium of our economy with runs and adverse selection, we introduce an assumption on the ordering of  $z^R$  and  $z^I$ . The case  $z^R \geq z^I$  is not interesting since liquidated banks cannot invest. We therefore make the following natural assumption:

**Assumption 6.** *The threshold for bank runs is strictly smaller than the threshold for full investment:  $z^R < z^I$ , which requires*

$$\frac{(1 - \delta) A^b}{D + (1 - \delta) A^b - 1} < \frac{\frac{k}{qV} - q}{1 - q}.$$

## 2.4 Equilibrium

The following proposition summarizes the equilibrium of our economy with runs and adverse selection, absent any government intervention.

**Proposition 5.** *Equilibrium in the economy with runs and adverse selection is characterized by the set  $\mathcal{L}$  of banks that are liquidated and the set  $\mathcal{O}$  of banks that opt out of credit markets*

$$\begin{aligned}\mathcal{L}(\theta; p, \emptyset) &= \{i \in [0, 1] \mid z_i \leq z^R\}, \\ \mathcal{O}(\theta; p, \emptyset) &= \{i \in \mathcal{G} \mid z^R \leq z_i < z^I\},\end{aligned}$$

where  $z^R$  and  $z^I$  are given by (3) and (5). Equilibrium welfare is:

$$w(\theta; p, \emptyset) = \bar{w}(\theta) - \delta \int_{\mathcal{L}} A^b - \int_{\mathcal{O} \cup \mathcal{L}} (qV - k) \quad (6)$$

*Proof.* Follows from Lemmas 2 and 4. □

Welfare depends on  $\theta$  not only through average asset quality, as in the first best, but also, and more importantly, via liquidation and lost investment opportunities.

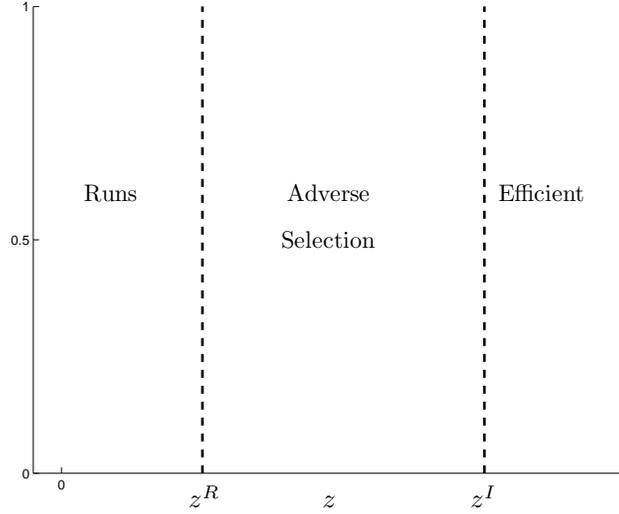
The equilibrium regions in the space of beliefs  $z$  are depicted in Figure 3: banks with posterior belief lower than  $z^R$  suffer a run and are liquidated (these banks make up the set  $\mathcal{L}$ ); banks with posterior belief in the  $[z^R, z^I]$  interval are not run on, but credit markets for these banks are affected by adverse selection (the strong banks in this interval make up the set  $\mathcal{O}$ ); finally, all banks with belief greater than  $z^I$  invest, since credit markets for these banks are free from adverse selection.

For a given  $p$ , the outcome depends on the realization of  $\theta$ . Figures 4 and 5 illustrate two possible outcomes depending on the realization of  $\theta$ : if the realization is low, not only the mass of banks with the bad signal is high, but the posterior belief for banks that received the good signal is low. If the realization is high, the posterior is both higher and receives more mass.

Notice that issuing equity is not an equilibrium outcome at any stage of the model. Issuing equity to finance investment is suboptimal by Lemma 3. Equity issuance is also suboptimal at time 0 since in addition to the usual negative signaling costs of equity, there is the possibility that a bad signal might trigger a run. The same argument rules out voluntary mergers of strong and weak banks. In our model, the value of weak banks' assets is less than their deposits and there is no way for them to raise equity.

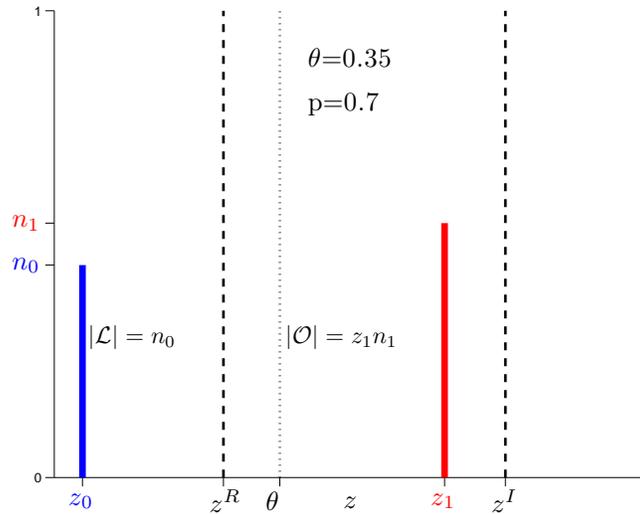
Raising equity under symmetric information (at time  $-1$ ) can improve welfare but, as discussed, is no longer

Figure 3: Equilibrium Regions



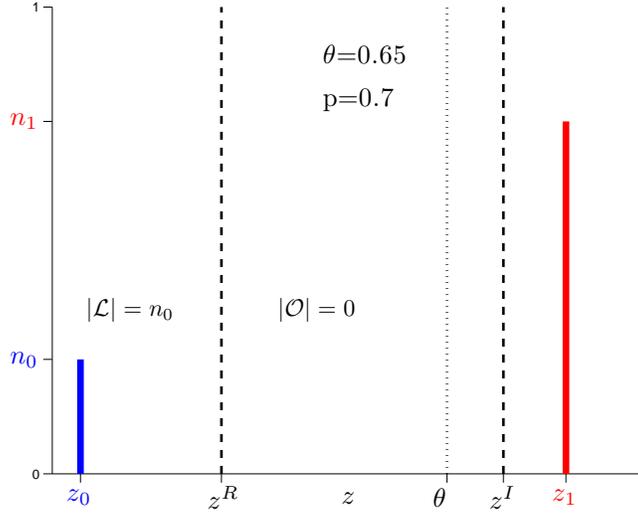
This figure illustrates the equilibrium thresholds: for posteriors below  $z^R$ , banks suffer runs. For posteriors between  $z^R$  and  $z^I$ , the economy faces suboptimal investment, as only weak banks invest. For posteriors above  $z^I$ , all banks invest without facing adverse selection in credit markets.

Figure 4: Equilibrium for low  $\theta$



This figure illustrates the posterior beliefs  $z_s(\theta, p)$  and mass of banks  $n_s(\theta, p)$  for  $s = \{0, 1\}$  at each posterior. The realization of  $\theta$  is low and  $p = 0.7$ . Credit markets for banks that received the good signal feature adverse selection (leading to suboptimal investment).  $|\mathcal{L}| = n_0$  and  $|\mathcal{O}| = z_1 n_1$  since the strong banks in the adverse selection region (of which there are  $z_1 n_1$ ) opt out of investment.

Figure 5: Equilibrium for high  $\theta$



This figure illustrates the posterior beliefs  $z_s(\theta, p)$  and mass of banks  $n_s(\theta, p)$  for  $s = \{0, 1\}$  at each posterior. The realization of  $\theta$  is high and  $p = 0.7$ . All banks that receive the good signal invest, since  $z_1 > z^I$ .  $|\mathcal{L}| = n_0$  and  $|\mathcal{O}| = 0$ , since strong banks invest.

an equilibrium outcome once banks know their types. An exception to this is when a full run (an unconditional run on the entire population of banks) is possible, which happens if  $\theta < z^R$ . In this case strong banks may have an incentive to alter their capital structure so as to avoid liquidation. We briefly discuss what strong banks can do in Appendix B. In the following section we introduce a refinement to the model that allows us to abstract from the possibility of a full run in the remainder of the paper.

Finally, a regulator might have the power to force all banks to raise equity at time 0. This would clearly violate the participation constraint of strong banks but might improve welfare. But it could also force strong banks to guarantee the deposits of weak banks, and this would in fact be cheaper in our model. If we allow the government to force agents to take actions against their interests, the menu of policies becomes endless. By Assumption 2, the government cannot implement any of these policies: redistribution must happen via distortionary taxation or disclosure of information.

### 3 Endogenous Disclosure

We now endogenize information disclosure by letting the government choose the precision of the signals received by each bank. The government announces its choice of  $p$  at the beginning of period 0 without knowing the fraction of strong banks  $\theta$ . All agents share a common prior belief about the distribution of  $\theta$ , with probability density  $\pi(\theta)$ .

We assume throughout that banks themselves are not able to credibly disclose any information about the quality of their assets, or that they have already disclosed all they can, and our model is about residual uncertainty. Our model simply assumes that bank insiders know more than outsiders about the quality of their legacy assets, which is almost tautological. What is less obvious, however, is why and how the government can do better. There are two deep reasons for this. First, the government does not have the same conflict of interest as individual banks: imagine that there are two banks and that investors know that one is weak, but do not know which one. Both banks would always claim to be the strong one, whereas the government is indifferent about the identity of the weak bank. Absent the risk of a run, the government would therefore reveal the identity of the weak bank. Second, the government can mandate costly stress tests and asset quality reviews, and can impose the same standards and procedures on all banks. As a result, it can compare the results across banks with greater ease than private investors.<sup>12</sup> For these two reasons, we assume that the government is able to disclose information that the private sector cannot credibly reveal.

After the realization of the aggregate state and of the signal for each bank, agents form posterior probabilities of each bank being strong, as explained earlier. Since  $z^R > 0$ , banks that receive the bad signal always suffer runs. Banks that receive the good signal may or may not suffer runs depending on how  $z_1$  compares to  $z^R$ . The case  $z_1 < z^R$  is not very interesting since it implies a full, unconditional run. To sharpen our analysis, we employ the following refinement.

**Refinement:** *A (small but measurable) set of agents observe the aggregate state  $\theta$  at the beginning of period 0.*

With this refinement, if the aggregate state is such that  $\theta < z^R$  then an aggregate run occurs immediately. The informed agents run, and all other depositors observe the run and run as well. A run on the entire system obviously renders stress tests and AQRs useless. In such a scenario, the government would simply try to save banks by issuing guarantees, as discussed later. This is not a very interesting scenario<sup>13</sup> and the refinement allows us to separate this extreme case from more interesting, intermediate ones.

Conditional on no immediate run all agents know that  $\theta \geq z^R$ , and since  $z_1 > \theta$  there is no run on banks that receive good signals. We can then think of  $\pi(\theta)$  as the distribution of  $\theta$  conditional on no aggregate run being observed.<sup>14</sup> At the other extreme, the case  $\theta > z^I$  does not change our findings but requires additional

<sup>12</sup>Indeed, the costs of complying with the post-crisis reporting environment are significant. For example, *Success in Fed stress tests comes with a cost* (<http://www.risk.net/risk-magazine/feature/2357474/success-in-fed-stress-tests-comes-with-a-cost>).

<sup>13</sup>To wit, in the aftermath of the financial crisis, even countries with deeply troubled banking systems such as Cyprus did not experience such unconditional runs.

<sup>14</sup>Formally, let the primitive distribution of  $\theta$  be denoted by  $\pi_0(\theta)$ . Our analysis focuses on the distribution that arises conditional

notation, so we remove this possibility as well.<sup>15</sup>

**Assumption 7.** *The support of the probability density function  $\pi(\theta)$  is  $[\underline{\theta}, \bar{\theta}] = [z^R, z^I]$ .*

With this additional assumption, the equilibrium with stress testing is characterized by the number of banks in each category,  $n_0$  and  $n_1$ , and by the comparison between  $z_1(\theta, p)$  and  $z^I$ .<sup>16</sup> For banks with good signals, there are two possible outcomes, depending on the values of  $\theta$  and  $p$ .

1. Banks with the good signal face adverse selection,  $z^R \leq z_1(\theta, p) < z^I$ ;
2. All banks with the good signal invest,  $z^I \leq z_1(\theta, p)$ .

We can characterize the equilibrium outcome for banks that receive the good signal for any pair  $(\theta, p)$  using a threshold on  $\theta$ : the minimum realization of the aggregate state for which all banks that receive the good signal invest

$$\theta^I(p) = \min \{ \theta \mid z(\theta, p) \geq z^I \} \quad (7)$$

The power of the stress test  $p$  determines this threshold, against which the realization of  $\theta$  is compared to determine the equilibrium outcome. This threshold, and the possible equilibrium regions, are depicted in Figure 6 for  $\theta \in [z^R, z^I]$  and  $p \in [0, 1]$ .

For the economy with stress testing, welfare is as given by (6), with the masses in each set being given by

$$\begin{aligned} \mathcal{L}(\theta, p) &= p(1 - \theta) \\ \mathcal{O}(\theta, p) &= \mathbb{1}[z(\theta, p) < z^I] \theta \end{aligned}$$

where  $\mathbb{1}$  is the indicator function. This results in the following expression for welfare in the decentralized equilibrium, given  $(\theta, p)$

$$w(\theta, p) = \bar{w}(\theta) - p(1 - \theta) \left( \delta A^b + qV - k \right) - \mathbb{1}[z(\theta, p) < z^I] \theta (qV - k) \quad (8)$$

The first term is first-best welfare as defined in (1); the second term corresponds to losses due to liquidation and foregone investment by banks that suffer runs; the final term is foregone investment due to adverse selection.

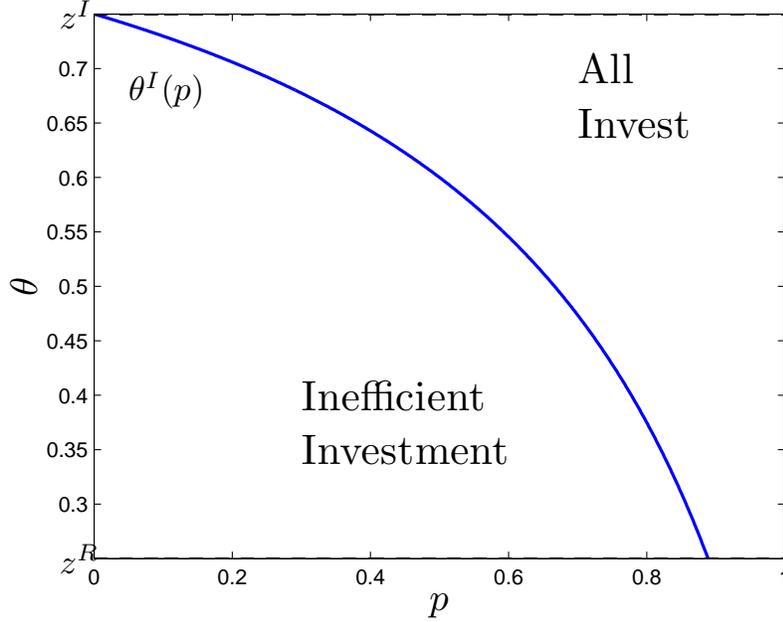
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on  $\theta \geq z^R$ , which we call  $\pi(\theta) \equiv \frac{\pi_0(\theta | \theta \geq z^R)}{1 - \Pi_0(z^R)}$  for simplicity.

<sup>15</sup>We present the set-up for the general model in Online Appendix E.

<sup>16</sup>Most results we derive from this point onwards are also valid for the case where  $[\underline{\theta}, \bar{\theta}] \subset [z^R, z^I]$ , at the expense of minor adjustments and extra notation.

Figure 6: Equilibrium Regions



This figure illustrates the equilibrium regions in  $(p, \theta)$  space. The line is the investment threshold,  $\theta^I(p)$ .

Note that the last term is only positive when  $z(\theta, p) < z^I$ , or  $\theta < \theta^I(p)$ . Taking expectations over  $\theta$ , expected welfare can be written as

$$\mathbb{E}_\theta [w(\theta, p)] = \mathbb{E}_\theta [\bar{w}(\theta)] - p\mathbb{E}_\theta [1 - \theta] (\delta A^b + qV - k) - (qV - k) \int_{z^R}^{\theta^I(p)} \theta d\Pi(\theta) \quad (9)$$

where  $\Pi(\theta) = \int_{\underline{\theta}}^{\theta} \pi(x) dx$  is the cumulative distribution function of  $\theta$ .

The government's disclosure problem, before the aggregate state  $\theta$  is realized, can then be formulated as

$$\max_{p \in [0,1]} \mathbb{E}_\theta [w(\theta, p)] \quad (10)$$

By increasing the informativeness of its disclosure policy, the government raises (in expectation) the perceived quality  $z_1$  of banks that receive the good signal, thereby increasing expected investment by strong banks. This comes at the cost of revealing some banks to be weak and therefore causing runs (recall that banks that receive the bad signal are run with certainty). The government effectively trades off the (expected) sizes of the sets  $\mathcal{L}(\theta, p)$  and  $\mathcal{O}(\theta, p)$ .

To further develop intuition about the costs and benefits of disclosure, Lemmas 6 and 7 provide results on optimal disclosure in the absence of runs and lemons, respectively.

**Lemma 6.** *If there are no runs, welfare is weakly increasing in  $p$  (strictly increasing if  $\theta^I(p) > z^R$ ), and full*

disclosure is optimal.

*Proof.* See Appendix D. □

In the absence of runs, welfare is strictly increasing in  $p$  starting from zero disclosure: disclosing information increases the average quality of banks with the good signal, decreasing the probability that credit markets will be affected by adverse selection.<sup>17</sup> Beyond a certain level of  $p$ , which we denote by  $p^m$ , the average quality of banks with the good signal is high enough that they all invest with certainty in every state of the world, even for very low realizations of  $\theta$ . Increasing  $p$  yields no further benefits, so in the absence of runs the planner is indifferent between disclosure choices in  $[p^m, 1]$ .

$$p^m : \theta^I(p^m) = z^R \Rightarrow p^m = \frac{z^I - z^R}{z^I(1 - z^R)} \in (0, 1)$$

**Lemma 7.** *If there is no adverse selection, welfare is strictly decreasing in  $p$  and zero disclosure is optimal.*

*Proof.* See Appendix D. □

Absent adverse selection, the only effect of disclosure is that banks that are revealed to be weak suffer runs. Figure 7 represents the trade-off graphically: it plots the expected mass of banks that are affected by adverse selection, and the expected mass of banks that suffer runs, as a function of  $p$ . The mass of banks that are expected to suffer a run is strictly increasing in  $p$ , as  $p = 1$  corresponds to the extreme case in which the signal is perfect and no weak bank receives the good signal. The mass of banks that are expected to suffer from adverse selection is decreasing until  $p^m$ , after which disclosure is high enough that the pool of banks with the good signal invests efficiently even for low realizations of  $\theta$ .

We proceed to characterize the problem with runs and lemons. We first establish that there exists an interior upper bound on the amount of disclosure that the planner chooses.

**Corollary 8.** *In the economy with runs and lemons, the planner never sets  $p > p^m$ .*

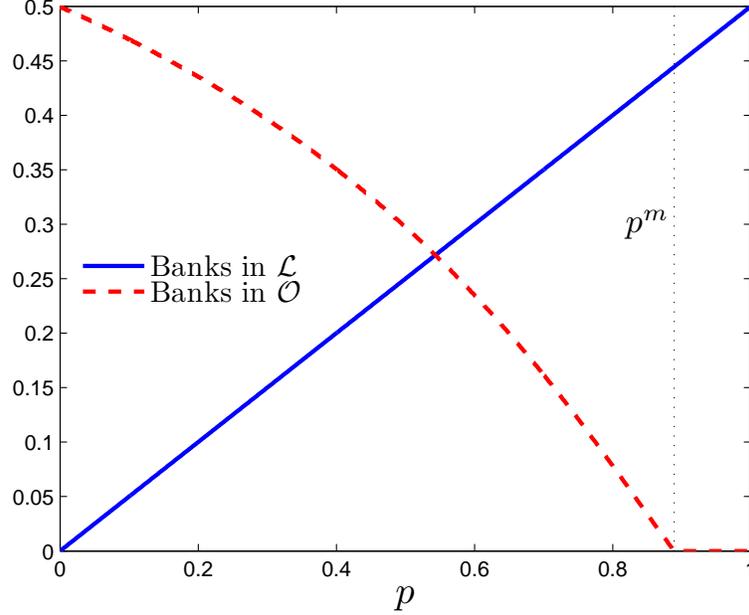
*Proof.* See Appendix D. □

This result follows immediately from the previous lemmas: increasing disclosure above  $p^m$  offers no benefits from unfreezing markets while still causing weak banks to suffer runs, so the planner will never choose a level

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<sup>17</sup>This is not a general property of information disclosure in an adverse selection setting. For example, if the asymmetric information pooling equilibrium is such that investment is efficient, disclosing the identity of strong banks weakly decreases welfare, since it reduces the likelihood that the pooling equilibrium will induce efficient investment. A previous version of our model considered this possibility. Our chosen form of disclosure technology is both more realistic and analytically tractable.

Figure 7: Expected mass at  $\mathcal{L}$  and  $\mathcal{O}$ ,  $\theta \sim \mathcal{U} [z^R, z^I]$



This figure plots the expected mass of banks in the set  $\mathcal{O}$  (banks that opt out of credit markets due to adverse selection) and the set  $\mathcal{L}$  (banks that suffer a run and liquidate assets) as a function of  $p$ , assuming a uniform distribution of the aggregate state,  $\pi(\theta) = \mathcal{U} [z^R, z^I]$ .

of disclosure beyond  $p^m$ . We now characterize the solution to the disclosure problem in terms of the properties of the distribution of the aggregate state. Proposition 9 describes the government's optimal disclosure policy for different characteristics of the distribution  $\pi(\theta)$ .

**Proposition 9.** *Let*

$$\chi(\theta) \equiv \theta \frac{\pi'(\theta)}{\pi(\theta)}$$

*If  $\chi(\theta) \geq \frac{3z^I-1}{1-z^I}, \forall \theta \in [z^R, z^I]$ , welfare is a strictly concave function in  $[0, p^m]$ , and the optimal level of disclosure solves the first-order condition*

$$\pi[\theta^I(p)] \theta^I(p) (qV - k) \left[ -\frac{d\theta^I(p)}{dp} \right] - \mathbb{E}_\theta [1 - \theta] [\delta A^b + qV - k] = 0$$

*If  $\chi(\theta) \leq \frac{3z^R-1}{1-z^R}, \forall \theta \in [z^R, z^I]$ , welfare is a strictly convex function in  $[0, p^m]$ . The optimal level of disclosure is  $p = 0$  if and only if*

$$\frac{p^m (\delta A^b + qV - k)}{qV - k + p^m (\delta A^b + qV - k)} \geq \mathbb{E}_\theta [\theta] \quad (11)$$

*and is  $p = p^m$  otherwise.*

*Proof.* See Appendix D. □

The results in the proposition are intuitive:  $\chi(\theta)$  is proportional to the slope of the density function for the aggregate state at  $\theta$ . A distribution with a more positive slope will tend to have more mass to the right and a higher expectation than one with a lower slope. With more mass to the right of the distribution, in expectation fewer runs will occur and if adverse selection occurs it will be costlier because the proportion of strong banks will be higher. The planner therefore has an incentive to choose some non-zero, interior level of disclosure. On the other hand, if  $\chi(\theta)$  is low, the opposite is true. The proposition shows that, for  $\chi(\theta)$  low enough, welfare is convex and the planner chooses either zero disclosure or the upper bound  $p^m$ . Which corner solution is optimal depends on  $\mathbb{E}_\theta[\theta]$ : below the threshold given in the proposition, zero disclosure is the optimum. Again, this corresponds with the intuition that if the state of the economy is expected to be bad, many banks will be run and disclosure will have proven costly.

To illustrate this result, Figure 8 plots the expected welfare function for different distributions of the aggregate state (normalized by first-best welfare for each distribution) in the right panel. We focus on distributions with support  $[z^R, z^I]$  and of the form  $\pi(\theta) = \beta\theta^\chi$  for  $\chi \in \mathbb{R}$ , where  $\beta$  is an appropriate normalizing constant, *bequiv*  $\frac{\chi+1}{(z^I)^{\chi+1} - (z^R)^{\chi+1}}$ . The pdf's for high and low *chi* are plotted in the left panel (for this class of distributions,  $\chi(\theta) = \chi$  is constant). Given our choice of parameters (see Appendix A),  $\chi = -1.5$  results in a convex welfare function, and  $\chi = 7$  a concave one.<sup>18</sup> For this functional form, we can use the following corollary to 9 to show that the welfare function is first convex and then concave in the  $[0, p^m]$  interval.

**Corollary 10.** *Assume that  $\pi(\theta) = \beta\theta^\chi$  (where  $\beta$  is an appropriate normalizing constant that depends on  $\chi$ ). Then: (i) Expected welfare is strictly concave for  $\chi \geq \frac{3z^I-1}{1-z^I}$ , (ii) Expected welfare is strictly convex for  $\chi \leq \frac{3z^R-1}{1-z^R}$ ; (iii) For  $\chi \in \left[\frac{3z^R-1}{1-z^R}, \frac{3z^I-1}{1-z^I}\right]$ , welfare is convex in  $p \in \left[0, \frac{1}{2} \left(3 - 1/z^I - \chi(1/z^I - 1)\right)\right]$  and concave in  $p \in \left[\frac{1}{2} \left(3 - 1/z^I - \chi(1/z^I - 1)\right), p^m\right]$ .*

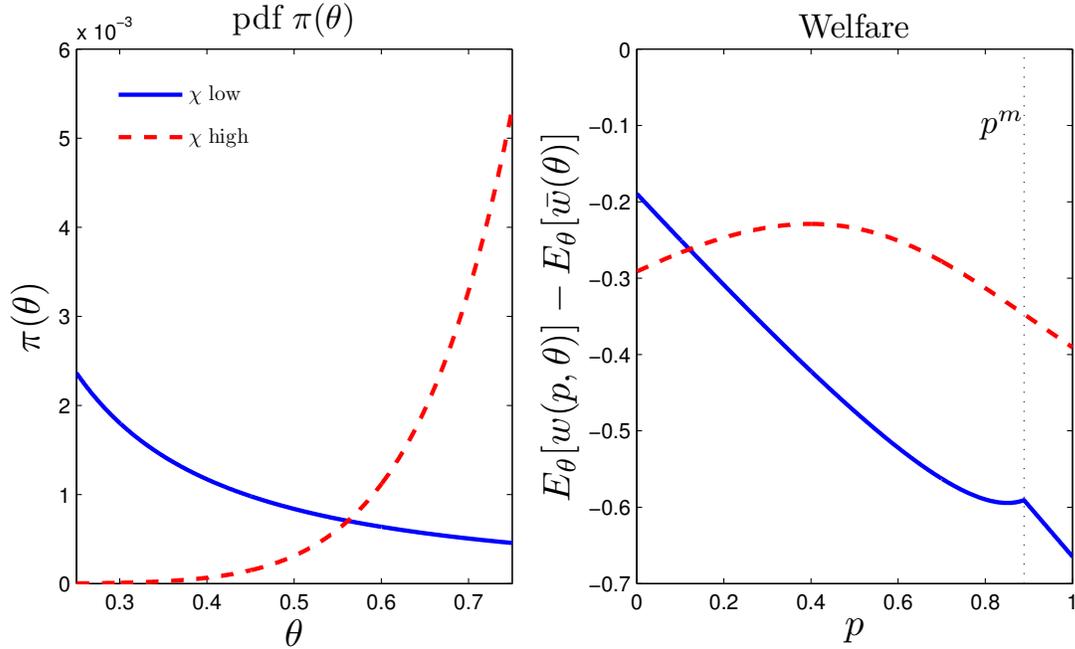
*Proof.* See Appendix D. □

For  $\chi = -1.5$ , welfare is convex for  $p \leq p^m$ ; moreover, it is non-monotonic, first decreasing and then increasing. For the chosen parameterization, no disclosure is the optimum. For  $\chi = 7$ , welfare is strictly concave and the optimal level of disclosure is interior.

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<sup>18</sup> $\chi = 0$  is the uniform distribution on  $[z^R, z^I]$ , and does not satisfy either of the sufficiency conditions. In our baseline parameterization,  $z^R = 0.25$  and  $z^I = 0.75$ . The thresholds are  $-1/3$  and  $5$  for convexity and concavity, respectively.

Figure 8: Densities  $\pi(\theta)$  and normalized welfare



The left panel of this figure plots the shape of the density function  $\pi(\theta) = \beta\theta^\chi$  for high and low values of  $\chi$  ( $-1.5$  and  $7$ , respectively). The right panel plots the corresponding shape of the expected welfare function,  $\mathbb{E}_\theta[w(p, \theta)] - \mathbb{E}_\theta[\bar{w}(\theta)]$ , as a function of  $p$ .

## 4 Disclosure and Fiscal Policy

In this section, we analyze the interaction between the government's disclosure policy and a type of fiscal policy that can be used to mitigate the costs of bank runs. We model the government's fiscal constraints as a convex (quadratic) cost of fiscal intervention, scaled by a parameter  $\gamma$ , which we refer to as the (inverse of) government's fiscal capacity. Unlike disclosure, fiscal interventions are undertaken after the aggregate state  $\theta$  has been realized. We start by characterizing the ex-post fiscal policy, and then proceed to analyze the joint problem of disclosure and fiscal interventions.

### 4.1 Deposit Insurance

We assume that the government may intervene to prevent liquidation by banks that receive the bad signal and are therefore susceptible to runs. Preventing runs on these banks is desirable both because liquidation is costly in itself, and because banks that are run are unable to invest at  $t = 1$ .

To prevent runs, the government announces deposit guarantees for a mass of banks  $\alpha$  that have received the bad signal. For these banks, the government guarantees to repay depositors the contractual deposit amount  $D$  at  $t = 2$ . By offering this guarantee, the government prevents asset liquidation by assuming the risk of the deposit contract: it commits to pay  $D$  to the depositors, and demands  $D$  from the bank at  $t = 2$ . As in the

decentralized equilibrium, some banks may be unable to repay their senior debt, in which case the guarantee is costly for the government.<sup>19</sup>

Guarantees are only extended to weak banks, since strong banks never receive the bad signal. The cost of guaranteeing the deposits for a weak bank is

$$D - [qD + (1 - q)A^b]$$

That is, the government always spends  $D$ , the amount it guarantees to depositors. Weak banks that survive a run invest with certainty: if the investment is successful, which happens with probability  $q$ , the bank is solvent and thus able to repay the full amount of the guarantee,  $D$ . With probability  $1 - q$ , the investment opportunity fails and the government receives the value of the bank's legacy assets  $A^b$ : in this case the government makes a loss, since it had guaranteed  $D > A^b$ . Deposit guarantees are therefore costly in expectation; the expected cost of supporting a weak bank is  $\psi_d \equiv (1 - q)(D - A^b)$ .

The net benefit of guaranteeing a weak bank is

$$\omega_d \equiv \delta A^b + (qV - k)$$

The benefit has two components: first, legacy assets are not liquidated which entails a net benefit of  $\delta A^b$  and, second, weak banks that avoid liquidation always invest in the project.

Denoting by  $\alpha$  the mass of banks that receives deposit guarantees, the total cost of the deposit guarantee policy is  $\Psi^d = \alpha\psi_d$  and ex-post welfare with policy is

$$w(\alpha; \theta, p) = w(\theta, p) + \alpha\omega_d - \gamma(\alpha\psi_d)^2 \tag{12}$$

The first term is decentralized welfare as defined in (8); the second term is the benefit of this policy, discussed above; the final term is the deadweight loss from government spending on deposit guarantees. The government solves the following program,

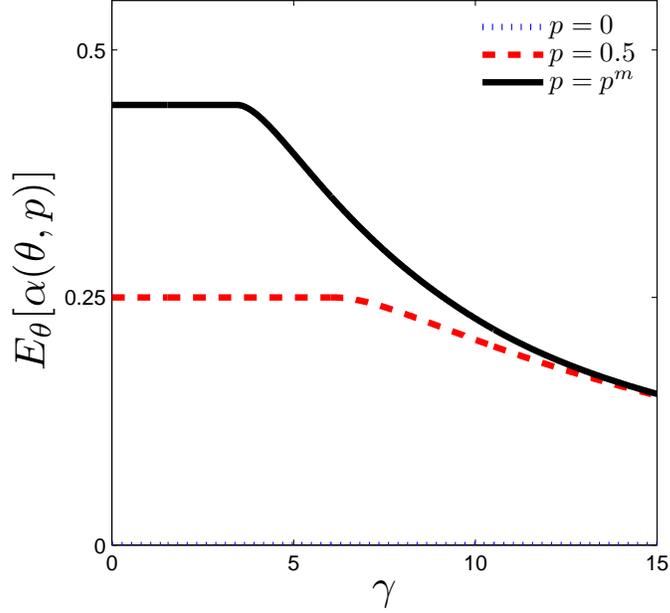
$$\alpha^*(\theta, p) = \arg \max_{\alpha \in [0, n_0(\theta, p)]} w(\alpha; \theta, p)$$

The optimal policy is summarized in Lemma 11.

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<sup>19</sup>Interpreting “banks” as broader classes of financial institutions, we can think of the choice of  $\alpha$  by the government as the choice of which types of financial institutions to support, e.g. providing insurance and guarantees to money market mutual funds as an extraordinary measure.

Figure 9: Optimal Deposit Insurance,  $\theta \sim \mathcal{U} [z^R, z^I]$



This figure plots the expected value of optimal deposit guarantees,  $\mathbb{E}_\theta [\alpha(\theta, p)]$  as a function of  $\gamma$ , for different levels of disclosure  $p$ .

**Lemma 11.** *The optimal mass of deposit guarantees for weak banks is*

$$\alpha^*(\theta, p) = \min \left\{ n_0(\theta, p), \frac{\omega_d}{2\gamma\psi_d^2} \right\}$$

*Proof.* See Appendix D. □

The optimal number of deposit guarantees is increasing in the marginal benefit of the policy, and decreasing in the marginal cost of the policy and the marginal cost of government spending ( $2\gamma$ ). The shape of the optimal policy is illustrated in Figure 9 for different levels of disclosure,  $p = \{0, 0.5, p^m\}$ . For  $p = 0$ , no banks are revealed to be weak so there are no runs for any realization of  $\theta$ , so deposit guarantees are not needed. For  $p > 0$ , a positive mass of banks is revealed to be weak,  $n_0(\theta, p) > 0, \forall \theta$ , so the government extends guarantees to depositors of (some or all) banks that suffer a run. Since the number of banks that are revealed as weak and run is increasing in  $p$ , the expected number of guarantees is weakly increasing in  $p$  - strictly for low  $\gamma$ . Fiscal support is, as one would expect, increasing in the level of fiscal capacity of the government (or decreasing in  $\gamma$ ).

## 4.2 Disclosure and Deposit Insurance

Having described the optimal ex-ante disclosure and ex-post fiscal policies separately, we now characterize the problem of a government that has access to both types of policies. Since fiscal policy is chosen after revelation

of the aggregate state, the results presented above for optimal deposit guarantees for arbitrary  $p$  and  $\theta$  are directly applicable.

Formally, the government's problem can be written as

$$p^* = \arg \max_p \mathbb{E}_\theta [w(\alpha_{\theta,p}^*; \theta, p)] \quad (13)$$

where the ex-post welfare function is as defined in (12).

We start by showing an intermediate result that is helpful in what follows.

**Lemma 12.** *If the welfare function  $\mathbb{E}_\theta [w(\theta; p, 0)]$  is concave in  $p$ , then  $\mathbb{E}_\theta [\max_\alpha w(\theta, p, \Psi)]$  is also concave in  $p$ .*

*Proof.* See Appendix D. □

This result states that deposit guarantees preserve concavity of the welfare function. High disclosure effectively increases the variance of the government's payoffs, by creating more uncertainty regarding the fiscal costs of deposit guarantees. Since these costs are quadratic,<sup>20</sup> the government is effectively risk-averse with respect to spending. This formalizes our notion that disclosure is a risky strategy: higher disclosure entails greater fiscal risk.

Proposition 13 is the main result of our paper: the availability of a fiscal backstop leads to greater information disclosure. Furthermore, under certain conditions, it is possible to establish a monotonic relationship between the degree of fiscal capacity  $\gamma$  and optimal disclosure  $p^*$ .

**Proposition 13.** *Optimal disclosure  $p^*$  is: (i) weakly greater when fiscal policy is available ( $0 \leq \gamma < \infty$ ) compared to when it is not ( $\gamma = \infty$ ); (ii) decreasing in  $\gamma$  when welfare is concave or convex.*

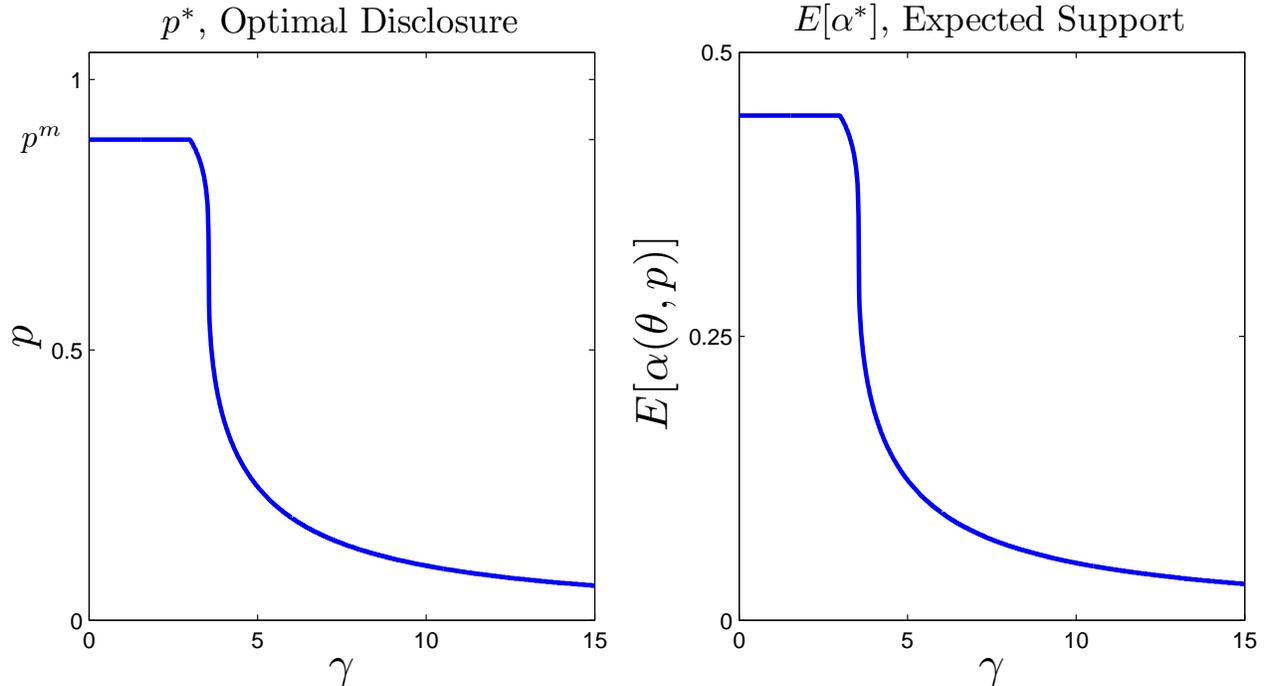
*Proof.* See Appendix D. □

This Proposition first states a general result: irrespective of the shape of the welfare function, the availability of fiscal interventions always (weakly) induces the government to disclose more. The second part states that whenever welfare is concave or convex, this result can be specialized to a monotonic relationship: more fiscal capacity always induces more disclosure. Figure 10 illustrates the result for the case where the aggregate state is uniformly distributed in  $[z^R, z^I]$ . The left panel plots optimal disclosure  $p^*$  as a function of  $\gamma$ , while the right panel plots the optimal amount of fiscal support,  $\mathbb{E}_\theta [\alpha(\theta, p^*)]$ . Disclosure and the expected number of guarantees are both weakly decreasing in  $\gamma$ .

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<sup>20</sup>Or, more generally, any convex function.

Figure 10: Optimal Disclosure with Deposit Insurance,  $\theta \sim \mathcal{U}[z^R, z^I]$



This figure plots the optimal level of disclosure  $p^*$  and the amount of expected fiscal support given optimal disclosure  $\mathbb{E}_\theta[\alpha(\theta, p^*)]$  as a function of  $\gamma$ .

The fiscal policy we study is such that the optimal spending and disclosure policies are positively related. Disclosure and fiscal capacity are strategic complements: with greater fiscal capacity, the planner is able to use disclosure to unfreeze markets while using fiscal interventions to prevent runs.

## 5 Extension: Bailouts

Our main result, Proposition 13, obtains when the government can use its fiscal capacity to prevent runs. In this section, we study fiscal policies aimed at unfreezing credit markets, and show that these introduce new trade-offs for the government (we call these policies “credit bailouts” or “credit guarantees” since, as shown below, the policy is optimally implemented as a guarantee on new borrowing). The main insight from this extension is that a more fiscally constrained planner may end up bailing out more banks through credit bailouts than a less constrained planner. This counter-intuitive result can be understood by recognizing that: (i) constrained governments are less likely to disclose because they are less able to cope with runs; and (ii) disclosure and credit bailouts are substitutes.

Deposit insurance, in the context of our model, is a guarantee on existing runnable liabilities. Credit guarantees, on the other hand, insure newly issued debt. Such guarantees were provided by the FDIC and by

most European governments in 2009 and 2010. These policies offer the same benefits as disclosure, but at the cost of fiscal resources instead of runs.

## 5.1 Optimal Intervention in the Credit Market

In this section, we characterize the optimal ex-post intervention to mitigate the costs of adverse selection. When  $z_1 \in [z^R, z^I]$  credit markets are affected by adverse selection, and the government may want to use fiscal policy to unfreeze credit markets and increase investment. Philippon and Skreta (2012) and Tirole (2012) study the design of such a policy with the objective of minimizing its cost to tax payers. In our setup, the following result applies:

**Proposition 14.** *The cost of intervention in markets with adverse selection equals the informational rents paid to informed parties. Under the assumptions of this model, direct lending by the government, or the provision of guarantees on privately issued debts, are constrained efficient.*

*Proof.* See Philippon and Skreta (2012). □

The proposition states that if the government chooses to intervene, it should either lend directly to banks or provide guarantees on new debts. Since banks with the bad signal are liquidated and lose the investment opportunity, this policy applies only to banks that receive the good signal. For a given posterior on banks with the good signal  $z$ , the optimal policy consists of choosing a number of banks  $\beta$  and guaranteeing loans made to those banks at the interest rate  $r = r^g = \frac{qV}{k}$ , the highest at which strong banks are willing to invest (as shown in Section 2). The policy always set the interest rate to  $r^g$  since setting  $r \in \left(r^g, \frac{1}{q}\right]$  is costly on average for the government and is completely ineffective. Setting  $r < \frac{qV}{k}$  is also costly and does not increase investment any further.

For a given bank with posterior  $z$ , the cost of implementing the program is

$$z(k - r^g k) + (1 - z)(k - qr^g k) = z(k - qV) + (1 - z)(k - q^2V)$$

the cost is strictly positive as long as  $z \leq z^I$ . The net benefit of implementing this program is given by

$$\omega_a = \mathbb{1}[z \leq z^I]z(qV - k)$$

Note that the benefit is increasing in  $z$  (up to  $z \leq z^I$ ), while the costs are decreasing in  $z$ . The total cost of the credit guarantee program is

$$\Psi^a = \beta \{k - qV [z(1 - q) + q]\} \equiv \beta\psi_a \quad (14)$$

Ex-post welfare with credit guarantees  $\beta$  is

$$w(\theta, p, \Psi) = w(\theta, p) + \beta\omega_a - \gamma(\beta\psi_a)^2 \quad (15)$$

where  $w(\theta, p)$  is welfare as given in (8). This policy increases investment by strong banks only, since weak banks that are not run invest without guarantees. The credit guarantee is therefore beneficial only if it is extended to a good bank, which in the pool of banks with good signals is the case with probability  $z(\theta, p)$ . This benefit is only materialized if the market is frozen, or  $z(\theta, p) \leq z^I$ . The final term corresponds to the deadweight loss generated by government expenditures.

Since the intervention is ex-post, the government takes the fraction of strong banks  $\theta$  and the precision of the signal  $p$  as given when choosing the size of the intervention, solving the following program

$$\max_{\beta \in [0, n_1(\theta, p)]} w(\theta, p, \Psi^a)$$

The below lemma summarizes the solution to this program:

**Lemma 15.** *The optimal number of credit guarantees is given by*

$$\beta = \min \left\{ n_1(\theta, p), \frac{\omega_a(\theta, p)}{2\gamma\psi_a(\theta, p)^2} \right\}$$

for  $z(\theta, p) < z^I$  and  $\beta = 0$  otherwise.

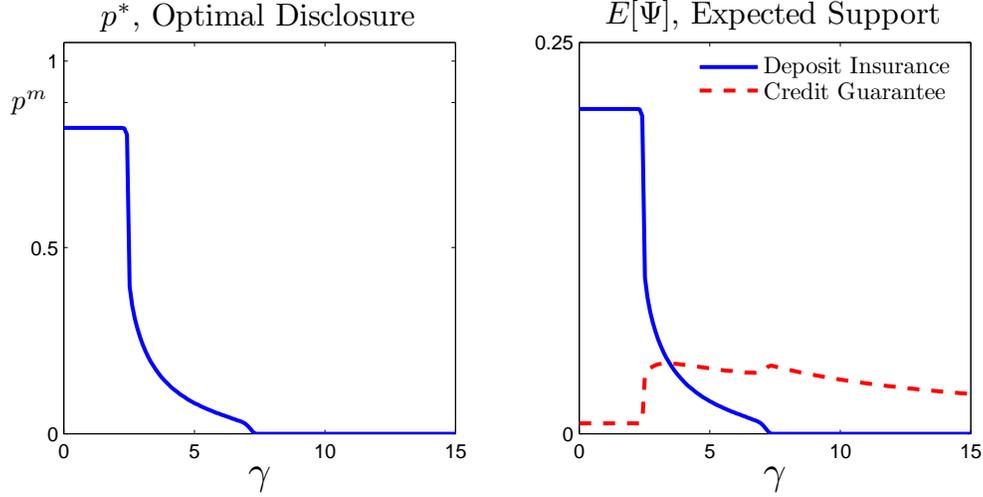
*Proof.* See Appendix D. □

When  $z < z^I$  and the credit market is frozen, the optimal number of credit guarantees is increasing in the marginal benefit of the policy, and decreasing both in the marginal cost of the policy and in the marginal cost of government spending ( $2\gamma$ ).

## 5.2 Disclosure and Joint Fiscal Policy

In this section we study the problem of a government that has access to ex-ante disclosure, and ex-post fiscal policies in the form of both deposit and credit guarantees. The analysis of credit guarantees is considerably more complex than that of deposit guarantees, since the benefits and costs of the credit policy are a function of

Figure 11: Optimal disclosure choice with fiscal policy



This figure plots optimal disclosure and expected fiscal spending as a function of  $\gamma$ , the measure of fiscal capacity. The left panel plots  $p^*$ , the optimal disclosure policy. The right panel plots expected spending, broken down by type.

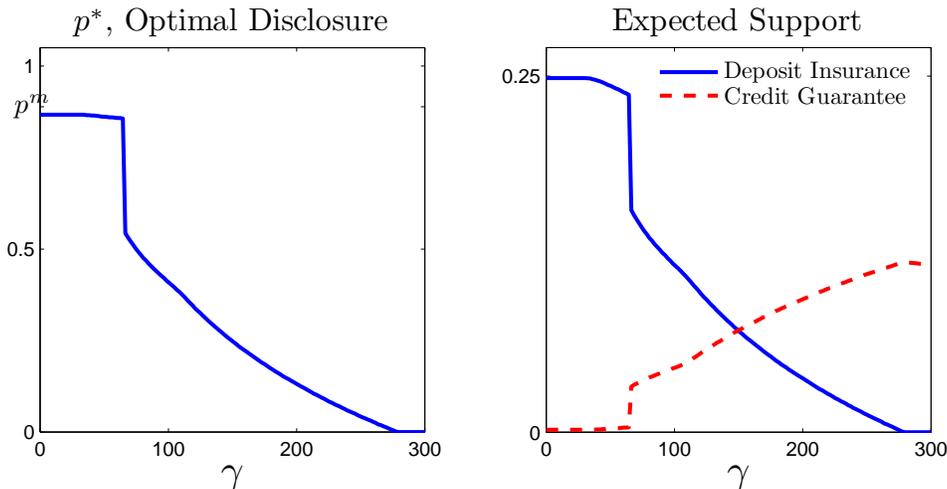
the aggregate state  $\theta$  and the government's choice  $p$ . A complete and detailed analysis of the credit guarantee policy, and its interaction with disclosure and deposit guarantees is presented in Appendix C. When the planner can use disclosure and credit guarantees (but not deposit guarantees), the optimal credit guarantee policy is decreasing in  $\gamma$ : a more fiscally constrained planner always provides less fiscal support.

Let us now consider the problem of a government who can intervene ex-post to minimize both runs and lemons, and ex-ante by using disclosure. In this setting, the government solves

$$\begin{aligned} & \max_{p \in [0,1]} \mathbb{E}_\theta \left[ \max_{\alpha, \beta} w(\theta; p, \Psi) \right] \\ \text{s.t. } & \beta \in [0, n_1(\theta, p)], \forall (\theta, p) \in [z^R, z^I] \times [0, 1] \\ & \alpha \in [0, n_0(\theta, p)], \forall (\theta, p) \in [z^R, z^I] \times [0, 1] \end{aligned}$$

where  $\Psi = \Psi^d + \Psi^a$  is the sum of spending on both policies. This is a complicated program, and few analytical results are attainable. For this reason, we study numerically how the optimal choice of disclosure changes with  $\gamma$ . The left panel of Figure 11 depicts this comparative static, for  $\theta \sim \mathcal{U}[z^R, z^I]$ . Optimal disclosure is (weakly) decreasing in  $\gamma$  as in our baseline result: high fiscal capacity translates into greater ability to provide credit and deposit guarantees - to “mop up” in case a bad state of the world materializes, leading the government to choose high levels of disclosure. As  $\gamma$  increases, and fiscal capacity becomes more limited, the government opts

Figure 12: Optimal disclosure choice with fiscal policy,  $\pi(\theta) = \beta\theta^{-1.5}$



This figure plots optimal disclosure and expected fiscal spending as a function of  $\gamma$ , the measure of fiscal capacity. For this plot, the exponent on spending is set to 5 instead of quadratic (the baseline case). The aggregate state  $\theta \sim \beta\theta^{-1.5}$ . The left panel plots  $p^*$ , optimal disclosure. The right panel plots expected spending for each policy.

for intermediate levels of disclosure, eventually choosing no disclosure,  $p = 0$ , for  $\gamma$  high enough. The right panel plots expected government spending  $\mathbb{E}_\theta[\Psi]$  given optimal disclosure  $p^*$ , disaggregated by type of spending. For low levels of  $\gamma$ , the planner chooses high disclosure, unfreezing markets and creating runs: it therefore makes use of deposit guarantees instead of credit guarantees. As the optimal level of disclosure decreases, the planner no longer needs to offer deposit guarantees, but increases spending on credit guarantees.

The result depicted in Figure 11 is not general due to the substitutability between the credit guarantee policy and disclosure. As the right panel of Figure 11 shows, when  $\gamma$  is high the deposit guarantee policy is no longer used, and the complementarity between disclosure and deposit guarantees is therefore not active. Whether the substitutability between fiscal spending and disclosure due to credit guarantees dominates the complementarities due to deposit guarantees is a quantitative question.

An interesting result that arises from our analysis is that a less fiscally constrained planner, by disclosing more, reduces the need to offer credit guarantees. Fiscally unconstrained governments are able to offer wider deposit guarantees schemes: this increases the incentive to disclose and reduces the number of ex-post bailouts in the form of credit guarantees. This implies that fiscal constraints as a device to achieve ex-ante commitment may actually backfire: restricting the amount of resources available to the government, or increasing the costs from spending to support the financial sector, may lead the government to disclose less, and offer support

in credit markets instead. Figure 12 presents an example that illustrates this effect: the distribution of the aggregate state is pessimistic, and the planner is more risk averse than in the baseline model.<sup>21</sup> The left panel plots the optimal level of disclosure as a function of  $\gamma$ , while the right panel plots expected spending on each of the policies. The expected spending on credit guarantees is increasing in  $\gamma$  - in this example, a more fiscally constrained planner implements more bailouts.

## 6 Conclusion

We provide a first analysis of the interaction between fiscal capacity and disclosure during financial crises. We identify a fundamental trade-off for optimal disclosure. To reduce adverse selection it is optimal to *increase* the variance of investors' posterior beliefs. To avoid runs, on the contrary, it is optimal *not* to increase posterior variance. Fiscal capacity improves this trade-off because it gives the government the flexibility to deal with runs if they occur. As a result, the government is likelier to disclose information when its fiscal position is strong. We argue that these predictions are consistent with government actions in Europe and in the United States during the recent financial crisis. It also implies that, somewhat paradoxically, governments with more fiscal flexibility can be less likely to rely on bailouts. This point has important implications for recent regulatory initiatives aimed at limiting bailouts by reducing policy discretion.

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<sup>21</sup> $\theta \sim \beta\theta^{-1.5}$  and the deadweight costs from taxation are  $\gamma\Psi^5$  instead of quadratic. We re-solve the optimal fiscal policy given this change.

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## A Parameters used in examples

To generate the figures, we use the parametrization in the table below.

Table 1: Parametrization for Numerical Examples

Parameter	Description	Value
$A^g$	Strong assets	10.3
$A^b$	Weak assets	0.9
$D$	Deposits	1.6
$V$	Project Payoff	10.9
$q$	Prob. Success	0.2
$k$	Investment Cost	1.8
$(1 - \delta)$	Recovery Rate	0.2

## B Incentives in case of full run

In this section, we briefly sketch an argument for why banks may have an incentive to act when a full run is imminent. Strong banks may have an incentive to act in order to prevent a full run. Weak banks will always mimic strong banks, so any equilibrium action must be pooling. We briefly describe two possible actions that can be taken by banks to immunize the system against a full run.

First, banks can raise debt that is junior to deposits and keep the liquid cash in their balance sheet during the run phase. For simplicity, we ignore investment in this analysis. For this, banks need to raise an amount of cash  $m$  that is sufficient to ensure that even weak banks are liquid in case of a run, or

$$m = 1 - (1 - \delta) A^b$$

To raise an amount  $m$ , given that lenders have access to unit storage, they need to promise a rate of return  $R$  such that

$$m = \theta Rm + (1 - \theta) \max(0, A^b + m - D) = \theta Rm + (1 - \theta) \max(0, \delta A^b + 1 - D)$$

The return rate on junior debt is

$$R = \frac{1}{\theta} \left[ 1 - \frac{(1 - \theta)}{m} \max(0, \delta A^b + 1 - D) \right]$$

Strong banks are willing to issue junior debt if and only if the payoff of doing so and not liquidating exceeds the payoff of liquidation,

$$A^g - D - (R - 1)m > (1 - \delta)A^g - 1$$

or

$$\theta \geq \frac{m - \max(0, \delta A^b + 1 - D)}{m + (\delta A^g + 1 - D) - \max(0, \delta A^b + 1 - D)} = \frac{\min[1 - (1 - \delta)A^b, D - A^b]}{\min[1 - (1 - \delta)A^b, D - A^b] + \delta A^g + 1 - D}$$

Secondly, banks can raise their deposit rates from  $D$  to  $D'$ . They would then set  $D'$  such that

$$\theta + (1 - \theta)(1 - \delta)A^b = \theta D'$$

This is equivalent to choosing  $D'$  such that  $z^R(D') = \theta$  so no full run takes place. This requires

$$D' = 1 + \frac{1 - \theta}{\theta}(1 - \delta)A^b$$

Strong banks choose to raise rates if and only if

$$A^g - D' > (1 - \delta)A^g - 1$$

or

$$\theta \geq \frac{(1 - \delta)A^b}{(1 - \delta)A^b + \delta A^g}$$

So, a full run only occurs if  $\theta \leq \min\left(\frac{\min[1 - (1 - \delta)A^b, D - A^b]}{\min[1 - (1 - \delta)A^b, D - A^b] + \delta A^g + 1 - D}, \frac{D - A^b}{1 - A^b + \delta A^g}\right)$ , as otherwise banks can undertake pooled actions that prevent a run.

## C Credit Guarantees and Joint Policy

In this appendix, we study the interaction between disclosure and credit guarantees when these are the only policy tools available to the government. We also characterize the optimal combination of ex-post policies, when both credit and deposit guarantees are available.

### C.1 Disclosure and Credit Guarantees

The analysis of this policy is considerably more complex since the welfare benefits and fiscal costs of this policy are now functions of the disclosure policy and the aggregate state. In the case of deposit guarantees,  $(\omega_d, \psi_d)$  were constants, but we now have that  $(\omega_a, \psi_a)$  are functions of  $(\theta, p)$ . The planner solves

$$\begin{aligned} & \max_{p \in [0, 1]} \mathbb{E}_\theta \left[ \max_{\beta} w(\theta; p, \Psi) \right] \\ \text{s.t. } & \beta \in [0, n_1(\theta, p)], \forall (\theta, p) \in [z^R, z^I] \times [0, 1] \end{aligned}$$

We show that some of our previous results are reversed for this policy. In the case of deposit guarantees, disclosure was complementary to fiscal backstops: more disclosure required a greater level of intervention. One of the reasons why this policy is interesting from a theoretical perspective is that it can be a substitute to disclosure: in some circumstances, disclosing more makes the fiscal intervention more effective. This happens because disclosure increases the average quality

of banks that receive the good signal. Therefore, it increases both the benefits of this policy (since, on average, there will be more strong banks in the pool with the good signal) and reduces the costs (since this policy's costs stem from supporting weak banks). With credit guarantees, disclosure may be increasing in  $\gamma$ .

If fiscal capacity is high, the planner can avoid runs by not disclosing and unfreezing credit markets via the fiscal backstop. As the capacity to intervene decreases, the planner loses its ability to fully unfreeze markets and may then be willing to disclose more: while this creates some runs on weak banks, it reduces the amount of intervention required to unfreeze markets through two different margins: first, it reduces the number of banks in the good pool, therefore decreasing the size of the pool that requires support. Second, since only weak types are disclosed, disclosure effectively “cleans” the pool of banks that receive the good signal, by increasing the average quality in this pool. This effect increases the welfare benefits of the credit guarantee policy, while reducing expected costs at the same time.

We summarize our findings in the following result:

**Proposition 16.** *If welfare is concave and  $\gamma \rightarrow 0$ , disclosure is increasing in fiscal capacity  $\frac{dp}{d\gamma} \leq 0$ . If welfare is convex, disclosure is decreasing in fiscal capacity,  $\frac{dp}{d\gamma} \geq 0$ .*

*Proof.* See Appendix D. □

The first part of this result states that if welfare is concave and fiscal capacity is high enough,  $\gamma \rightarrow 0$ , our previous result regarding the complementarity of disclosure and fiscal capacity still holds, and the planner decreases the amount of disclosure as fiscal capacity decreases. The reason is that the forces pushing towards substitutability are only particularly effective when the government is sufficiently fiscally constrained: when  $\gamma$  is low, the government is able to support all banks in the good pool regardless, and the two margins that we mentioned are irrelevant. The second part of the result establishes that when welfare is convex, it is possible to show that disclosure will always be (weakly) decreasing in fiscal capacity (increasing in  $\gamma$ ) due to the forces described above.

## C.2 Combining Deposit Insurance and Credit Guarantees

To complete our description of equilibrium with fiscal intervention, we characterize the ex-post welfare function when the government can use both policies.

$$w(\theta, p, \Psi) = w(\theta, p) + \alpha\omega_d + \beta\omega_a - \gamma\Psi^2 \tag{16}$$

where  $\Psi \equiv \Psi^a + \Psi^d$  is total spending. The first term is decentralized welfare, the second term are the benefits of deposit guarantees, the third term represents the benefits of credit guarantees, and the final term are the distortionary costs of

government spending. Optimal joint fiscal policy is the solution to

$$\begin{aligned} & \max_{\alpha, \beta} w(\theta, p, \Psi) \\ \text{s.t. } & \alpha \in [0, n_0(\theta, p)] \\ & \beta \in [0, n_1(\theta, p)] \end{aligned} \tag{17}$$

The government chooses  $\alpha, \beta$  to maximize (16) subject to the constraints that the supported masses cannot exceed the size of the respective target pools of banks. The optimal policy consists of comparing the marginal benefits of the two policies, and first exhausting the policy that yields the highest marginal benefit to cost ratio. Only if that policy is exhausted is the second ever used. The net benefits and costs of the deposit and credit guarantee policies are  $(\omega_i, \psi_i)_{i=\alpha, \beta}$  as defined previously. The costs and benefits of the deposit policy are parametric since this policy only applies to weak banks. In contrast, the costs and benefits of the credit policy depend on  $z(\theta, p)$ : the recipients of this policy can potentially be both weak and strong banks, and composition of the class of banks that received the good signal matters for the net social benefits of the policy. This policy is more attractive the greater the perceived quality of the banks that received the good signal, so will be prioritized for combinations of  $\theta$  and  $p$  that result in a greater  $z(\theta, p)$ : this happens because the marginal benefits of the credit guarantee are weakly increasing in  $z(\theta, p)$ , while its marginal costs are strictly decreasing.

The following proposition summarizes the design of the optimal fiscal interventions.

**Proposition 17.** (*Optimal Joint Fiscal Policy*) Define  $z^c$  as

$$z^c \equiv z^I \frac{1}{1 + \left(1 - \frac{k}{qV}\right) \frac{(D - A^b)}{\delta A^b + qV - k}} < z^I$$

Then, the optimal joint fiscal policy is as follows: for  $z_1(\theta, p) < z^c$ , the planner exhausts the deposit policy first

$$\begin{aligned} \alpha &= \min \left\{ n_0(\theta, p), \frac{\omega_d}{2\gamma\psi_d^2} \right\} \\ \beta &= \max \left\{ 0, \min \left\{ n_1(\theta, p), \frac{\omega_a(\theta, p)}{2\gamma\psi_a(\theta, p)^2} - \frac{\psi_d}{\psi_a(\theta, p)} n_0(\theta, p) \right\} \right\} \end{aligned}$$

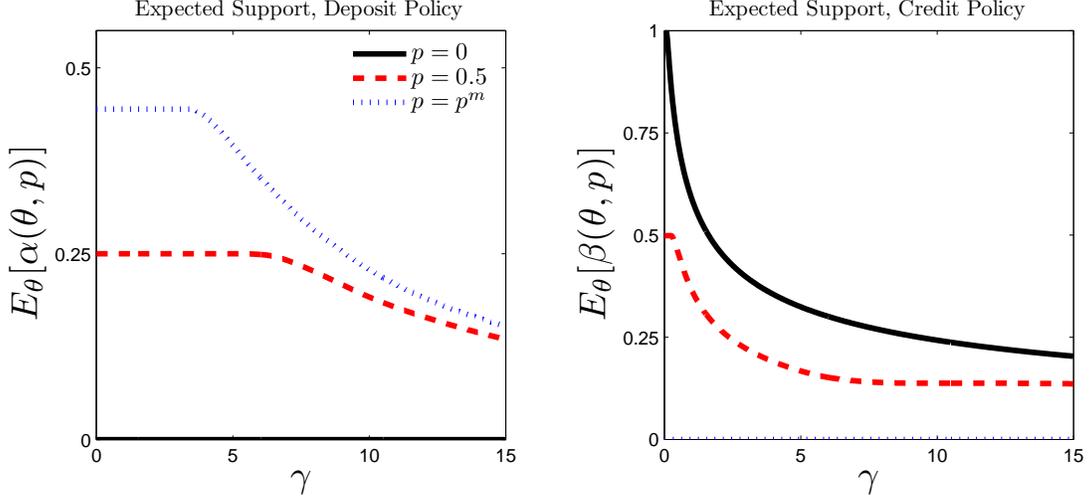
for  $z_1(\theta, p) \in [z^c, z^I]$ , the planner exhausts the credit policy first

$$\begin{aligned} \beta &= \min \left\{ n_1(\theta, p), \frac{\omega_a(\theta, p)}{2\gamma\psi_a(\theta, p)^2} \right\} \\ \alpha &= \max \left\{ 0, \min \left\{ n_0(\theta, p), \frac{\omega_d}{2\gamma\psi_d^2} - \frac{\psi_a(\theta, p)}{\psi_d} n_1(\theta, p) \right\} \right\} \end{aligned}$$

and for  $z_1(\theta, p) > z^I$ , only the deposit policy is used

$$\alpha = \min \left\{ n_0(\theta, p), \frac{\omega_d}{2\gamma\psi_d^2} \right\}$$

Figure 13: Optimal Joint Fiscal Policy,  $\theta \sim \mathcal{U}[z^R, z^I]$



This figure depicts the optimal joint fiscal policy as a function of the fiscal capacity parameter  $\gamma$ , for different values of  $p$ . The left panel plots the expected number of banks that receive credit support, while the right panel plots the expected number of banks that receive deposit support.

*Proof.* See Appendix D. □

The amount of fiscal support is always decreasing in the measure of fiscal capacity  $\gamma$ . Figure 13 illustrates the expected mass of banks supported by each policy as a function of this parameter. The left panel plots the expected credit policy support,  $\mathbb{E}_\theta[\beta(\theta, p)]$ , while the right panel plots the expected deposit policy support  $\mathbb{E}_\theta[\alpha(\theta, p)]$  for different levels of disclosure,  $p = \{0, 0.5, p^m\}$ . For  $p = 0$ , a market freeze is certain, and no runs occur. Thus the level of credit support is at a maximum, and the level of deposit support is zero. For  $p = p^m$ , the other polar case, most banks have their types revealed: there is no adverse selection so credit support is not needed, and the deposit policy is most active for all  $\gamma$ . For the intermediate case, both policies are activated, since both runs and market freezes occur with positive probability.

## D Proofs

### Proof of Lemma 6

*Proof.* Without runs, welfare can be written as

$$\mathbb{E}_\theta[w(\theta, p)] = \mathbb{E}_\theta[\theta]A^g + \mathbb{E}_\theta[1 - \theta](A^b + qV - k) + \int_{\theta^I(p)}^{\bar{\theta}} \theta(qV - k) d\Pi(\theta)$$

The derivative of welfare with respect to  $p$  is

$$\frac{d\mathbb{E}_\theta[w(\theta, p)]}{dp} = \mathbb{1}[\theta^I(p) \geq \underline{\theta}] \pi[\theta^I(p)] \theta^I(p) (qV - k) \left[ -\frac{d\theta^I(p)}{dp} \right] \geq 0$$

It is strictly positive for  $p : \theta^I(p) \geq \underline{\theta}$ , and zero otherwise. Welfare is strictly increasing in  $p$  for  $p \leq p^m$ , and constant afterwards. Full disclosure is then (weakly) optimal.  $\square$

### Proof of Lemma 7

*Proof.* Without adverse selection, expected welfare can be written as

$$\mathbb{E}_\theta [w(\theta, p)] = p\mathbb{E}_\theta [1 - \theta] (1 - \delta)A^b + \mathbb{E}_\theta [\theta] (A^g + qV - k) + (1 - p)\mathbb{E}_\theta [1 - \theta] (A^b + qV - k)$$

The derivative with respect to  $p$  is

$$\frac{d\mathbb{E}_\theta [w(\theta, p)]}{dp} = -\mathbb{E}_\theta [1 - \theta] [\delta A^b + qV - k] < 0$$

strictly negative for  $p \in [0, 1]$ . Therefore,  $p = 0$  is optimal.  $\square$

### Proof of Corollary 8

*Proof.* Welfare with runs and lemons is given by 9. The derivative of expected welfare with respect to  $p$  is

$$\frac{d\mathbb{E}_\theta [w(\theta, p)]}{dp} = \mathbb{1}[\theta^I(p) \geq \underline{\theta}] \pi[\theta^I(p)] \theta^I(p) (qV - k) \left[ -\frac{d\theta^I(p)}{dp} \right] - \mathbb{E}_\theta [1 - \theta] [\delta A^b + qV - k]$$

The first term is only positive for  $p \leq p^m$ , while the second term is always negative. Thus welfare is strictly decreasing for  $p > p^m$ , and the planner sets at most  $p = p^m$ .  $\square$

### Proof of Proposition 9

*Proof.* For any distribution  $\pi(\theta)$ , the derivative of expected welfare with respect to  $p$  is

$$\frac{d\mathbb{E}_\theta [w(\theta, p)]}{dp} = \mathbb{1}[\theta^I(p) \geq \underline{\theta}] \pi[\theta^I(p)] \theta^I(p) (qV - k) \left[ -\frac{d\theta^I(p)}{dp} \right] - \mathbb{E}_\theta [1 - \theta] [\delta A^b + qV - k]$$

We can write the second derivative of expected welfare with respect to  $p$  as

$$\frac{d^2\mathbb{E}_\theta [w(\theta, p)]}{dp^2} = -\mathbb{1}[\theta^I(p) \geq \underline{\theta}] (qV - k) \pi[\theta^I(p)] \left\{ \left[ \frac{d\theta^I(p)}{dp} \right]^2 \left[ 1 + \theta^I(p) \frac{\pi'[\theta^I(p)]}{\pi[\theta^I(p)]} \right] + \theta^I(p) \frac{d^2\theta^I(p)}{dp^2} \right\}$$

Replace for the derivatives of  $\theta^I(p)$  and simplify to obtain

$$\frac{d^2\mathbb{E}_\theta [w(\theta, p)]}{dp^2} = \mathbb{1}[\theta^I(p) \geq \underline{\theta}] (qV - k) \pi[\theta^I(p)] \frac{(1/z^I - 1)}{(1/z^I - p)^4} \{3 - 1/z^I - \chi[\theta^I(p)] (1/z^I - 1) - 2p\} \quad (18)$$

Note that all the terms except for the last one are strictly positive for  $p \leq p^m$ . The shape of the welfare function is therefore determined by the sign of this last term. For the welfare function to be strictly concave, we need this term to

be strictly negative for any  $p \in [0, p^m]$ . This is equivalent to

$$\begin{aligned} & 3 - 1/z^I - \chi [\theta^I (p)] (1/z^I - 1) - 2p < 0 \\ \Leftrightarrow & \chi [\theta^I (p)] > \frac{3 - 1/z^I - 2p}{1/z^I - 1} \end{aligned}$$

Note that the right-hand side is strictly decreasing on  $p$ . It is then enough to show that

$$\min_{p \in [0, p^m]} \chi [\theta^I (p)] > \max_{p \in [0, p^m]} \frac{3 - 1/z^I - 2p}{1/z^I - 1} = \frac{3z^I - 1}{1 - z^I}$$

So that a sufficient (but not necessary) condition for this to be satisfied is to ensure that

$$\chi (\theta) > \frac{3z^I - 1}{1 - z^I}, \forall \theta \in [\underline{\theta}, \bar{\theta}]$$

In this case, the expected welfare function is strictly concave on  $[0, p^m]$ , so the first-order condition is sufficient and necessary for the optimum

$$\frac{d\mathbb{E}_\theta [w (\theta, p)]}{dp} = \pi [\theta^I (p)] \theta^I (p) (qV - k) \left[ -\frac{d\theta^I (p)}{dp} \right] - \mathbb{E}_\theta [1 - \theta] [\delta A^b + qV - k] = 0$$

Equivalently, we can establish a sufficient condition for convexity by ensuring that the last term of 18 is strictly positive. This happens, whenever

$$\chi [\theta^I (p)] < \frac{3 - 1/z^I - 2p}{1/z^I - 1}$$

It is enough to show that

$$\max_{p \in [0, p^m]} \chi [\theta^I (p)] < \min_{p \in [0, p^m]} \frac{3 - 1/z^I - 2p}{1/z^I - 1} = \frac{3z^R - 1}{1 - z^R}$$

A sufficient condition for this is to ensure that

$$\chi (\theta) < \frac{3z^R - 1}{1 - z^R}, \forall \theta \in [z^R, z^I]$$

In this case, due to strict convexity of the welfare function, the optimum must be at one of the boundaries of the choice set. These are 0 and  $p^m$ . We can evaluate expected welfare at each of these points and compare the values

$$\begin{aligned} \mathbb{E}_\theta [w (\theta, p)]|_{p=0} &= \mathbb{E}_\theta [\theta] A^g + \mathbb{E}_\theta [1 - \theta] (A^b + qV - k) \\ \mathbb{E}_\theta [w (\theta, p)]|_{p=p^m} &= \mathbb{E}_\theta [\theta] (A^g + qV - k) + p^m \mathbb{E}_\theta [1 - \theta] (1 - \delta) A^b + (1 - p^m) \mathbb{E}_\theta [1 - \theta] (A^b + qV - k) \end{aligned}$$

The planner prefers not to disclose,  $p = 0$ , if and only if

$$\begin{aligned}\mathbb{E}_\theta [w(\theta, p)]|_{p=0} &\geq \mathbb{E}_\theta [w(\theta, p)]|_{p=p^m} \\ p^m &\geq \frac{\mathbb{E}[\theta]}{\mathbb{E}_\theta [1 - \theta]} \frac{1}{1 + \frac{\delta A^b}{qV - k}}\end{aligned}$$

□

### Proof of Corollary 10

*Proof.* (i) and (ii) follow directly from the proof to Proposition 9. To show (iii), note that the term whose sign determines the concavity or convexity of welfare is now given by

$$3 - 1/z^I - \chi(1/z^I - 1) - 2p$$

so it is strictly decreasing in  $p$ . For  $\chi \in \left[\frac{3z^R - 1}{1 - z^R}, \frac{3z^I - 1}{1 - z^I}\right]$ , this term is strictly positive for  $p = 0$  and strictly negative for  $p = p^m$ . It crosses zero at

$$p^c = \frac{1}{2} [3 - 1/z^I - \chi(1/z^I - 1)]$$

So welfare is convex for  $p \in [0, p^c]$  and concave for  $p \in [p^c, p^m]$ .

□

### Proof of Lemma 11

*Proof.* The first-order condition follows from taking the derivative of 12 with respect to  $\alpha$ ,

$$\omega_d - 2\gamma\alpha\psi_d \leq 0$$

The optimal policy is then

$$\alpha = \frac{\omega_d}{2\gamma\psi_d^2}$$

up to being contained in the  $[0, n_0(\theta, p)]$  interval.

□

### Proof of Lemma 12

*Proof.* First, note that we can write the welfare function as

$$\mathbb{E}_\theta [w(\theta; p, \Psi)] = \mathbb{E}_\theta [w(\theta; p, 0)] + \mathbb{E}_\theta \left[ \alpha(\theta, p) \omega_d - \gamma \{ \alpha(\theta, p) \psi_d \}^2 \right]$$

This allows us to write the disclosure problem with fiscal policy as the sum of the original welfare function, and a new term. It is useful to define the threshold beyond which the planner exhausts the deposit guarantee policy,  $\alpha(\theta, p) = n_0(\theta, p)$ .

This threshold is given by

$$\theta^\alpha(p) = 1 - \frac{\omega_d}{2\gamma\psi_d^2 p}$$

So we can rewrite the welfare function as

$$\begin{aligned}\mathbb{E}_\theta[w(\theta; p, \Psi)] &= \mathbb{E}_\theta[w(\theta; p, 0)] + \int_{z^R}^{\theta^\alpha(p)} \left[ \frac{\omega_d^2}{2\gamma\psi_d^2} - \gamma \frac{\omega_d^2}{4\gamma^2\psi_d^2} \right] d\Pi(\theta) + \int_{\theta^\alpha(p)}^{z^I} \left[ \omega_d p (1 - \theta) - \gamma\psi_d^2 p^2 (1 - \theta)^2 \right] d\Pi(\theta) \\ &= \mathbb{E}_\theta[w(\theta; p, 0)] + \int_{z^R}^{\theta^\alpha(p)} \frac{\omega_d^2}{4\gamma\psi_d^2} d\Pi(\theta) + \int_{\theta^\alpha(p)}^{z^I} \left[ \omega_d p (1 - \theta) - \gamma\psi_d^2 p^2 (1 - \theta)^2 \right] d\Pi(\theta)\end{aligned}$$

The first-order condition is

$$\begin{aligned}\frac{d\mathbb{E}_\theta[w(\theta; p, \Psi)]}{dp} &= \frac{d\mathbb{E}_\theta[w(\theta; p, 0)]}{dp} + \int_{\theta^\alpha(p)}^{z^I} \left[ \omega_d (1 - \theta) - 2p\gamma\psi_d^2 (1 - \theta)^2 \right] d\Pi(\theta) \\ &= \frac{d\mathbb{E}_\theta[w(\theta; p, 0)]}{dp} + 2\gamma\psi_d^2 \int_{\theta^\alpha(p)}^{z^I} (1 - \theta) \left[ \frac{\omega_d}{2\gamma\psi_d^2} - p(1 - \theta) \right] d\Pi(\theta)\end{aligned}$$

Note that, by definition, we have that

$$\frac{\omega_d}{2\gamma\psi_d^2} - p(1 - \theta) \geq 0, \forall \theta \geq \theta^\alpha(p)$$

so the integral term is positive. This leads us to an intermediate result, meaning then that

$$\frac{d\mathbb{E}_\theta[w(\theta; p, \Psi)]}{dp} \geq \frac{d\mathbb{E}_\theta[w(\theta; p, 0)]}{dp}$$

or, the planner always weakly chooses more disclosure when fiscal policy is available. To establish the claim, we now take the second derivative with respect to  $p$  to obtain

$$\begin{aligned}\frac{d^2\mathbb{E}_\theta[w(\theta; p, \Psi)]}{dp^2} &= \frac{d^2\mathbb{E}_\theta[w(\theta; p, 0)]}{dp^2} - 2\gamma\psi_d^2 \left[ \int_{\theta^\alpha(p)}^{z^I} (1 - \theta)^2 d\Pi(\theta) + \pi[\theta^\alpha(p)] \frac{d\theta^\alpha(p)}{dp} (1 - \theta^\alpha(p)) \left[ \frac{\omega_d}{2\gamma\psi_d^2} - p(1 - \theta^\alpha(p)) \right] \right] \\ &= \frac{d^2\mathbb{E}_\theta[w(\theta; p, 0)]}{dp^2} - 2\gamma\psi_d^2 \int_{\theta^\alpha(p)}^{z^I} (1 - \theta)^2 d\Pi(\theta)\end{aligned}$$

Note then that

$$\frac{d^2\mathbb{E}_\theta[w(\theta; p, \Psi)]}{dp^2} \leq \frac{d^2\mathbb{E}_\theta[w(\theta; p, 0)]}{dp^2} \leq 0$$

establishing our claim. □

### Proof of Proposition 13

*Proof.* The first part of the claim is proved in the proof of Lemma 12. For the second part, if welfare is concave in  $p$ , then optimal disclosure solves

$$\frac{d\mathbb{E}_\theta[w(\theta; p, \Psi)]}{dp} = \Phi(p, \gamma) = 0$$

This means that we can derive the comparative static by applying the implicit function theorem,

$$\frac{dp}{d\gamma} = - \left( \frac{\partial \Phi}{\partial p} \right)^{-1} \left( \frac{\partial \Phi}{\partial \gamma} \right)$$

Note that

$$\frac{\partial \Phi}{\partial p} = \frac{d^2 \mathbb{E}_\theta [w(\theta; p, \Psi)]}{dp^2} \leq 0$$

by assumption. This means that the derivative of interest will have the same sign as  $\frac{\partial \Phi}{\partial \gamma}$ . We can compute this term as

$$\begin{aligned} \frac{\partial \Phi}{\partial \gamma} &= -2\psi_d^2 \int_{\theta^\alpha(p)}^{z^I} (1-\theta)^2 d\Pi(\theta) - \pi[\theta^\alpha(p)] \frac{d\theta^\alpha(p)}{dp} 2\gamma\psi_d^2 \left[ \frac{\omega_d}{2\gamma\psi_d^2} - p(1-\theta^\alpha(p)) \right] \\ &= -2\psi_d^2 \int_{\theta^\alpha(p)}^{z^I} (1-\theta)^2 d\Pi(\theta) \leq 0 \end{aligned}$$

In particular, this inequality is strict if  $\theta^\alpha(p) < z^I$ . This then establishes that

$$\frac{dp}{d\gamma} \leq 0$$

We can also show this result if the welfare function is strictly convex. In this case, the planner either chooses no disclosure,  $p = 0$ , and there is no need to activate fiscal policy (since there are no runs), or it chooses full disclosure,  $p = p^m$ . Welfare in the case of no disclosure is

$$\mathbb{E}_\theta [w(\theta; 0, 0)] = \mathbb{E}_\theta [\bar{w}(\theta)] - \int_{z^R}^{\theta^I(p)} \theta (qV - k) d\Pi(\theta)$$

If the planner discloses fully, welfare is

$$\begin{aligned} \mathbb{E}_\theta [w(\theta; p^m, \Psi)] &= \mathbb{E}_\theta [\bar{w}(\theta)] - p^m \mathbb{E}_\theta [1-\theta] [\delta A^b + qV - k] + \int_{z^R}^{\theta^\alpha(p^m)} \frac{\omega_d^2}{4\gamma\psi_d^2} d\Pi(\theta) \\ &\quad + \int_{\theta^\alpha(p^m)}^{z^I} \left[ \omega_d p^m (1-\theta) - \gamma\psi_d^2 (p^m)^2 (1-\theta)^2 \right] d\Pi(\theta) \\ &= \mathbb{E}_\theta [\bar{w}(\theta)] + \omega_d \int_{z^R}^{\theta^\alpha(p^m)} \left[ \frac{\omega_d}{4\gamma\psi_d^2} - p^m (1-\theta) \right] d\Pi(\theta) - \gamma\psi_d^2 (p^m)^2 \int_{\theta^\alpha(p^m)}^{z^I} (1-\theta)^2 d\Pi(\theta) \end{aligned}$$

The planner chooses not to disclose if and only if

$$\mathbb{E}_\theta [w(\theta; 0, 0)] \geq \mathbb{E}_\theta [w(\theta; p^m, \Psi)]$$

This inequality can be rewritten as

$$\Lambda(\gamma) \equiv - \int_{z^R}^{\theta^\alpha(p^m)} \left[ \frac{\omega_d^2}{4\gamma\psi_d^2} - p^m (1-\theta) \omega_d \right] - \int_{z^R}^{\theta^I(p)} \theta (qV - k) d\Pi(\theta) + \gamma\psi_d^2 (p^m)^2 \int_{\theta^\alpha(p^m)}^{z^I} (1-\theta)^2 d\Pi(\theta) \geq 0$$

It is then enough to show that  $\Lambda'(\gamma) \geq 0$ . That is, as  $\gamma$  increases, the planner is never more likely to choose full as opposed to no disclosure. Taking this derivative yields

$$\begin{aligned}\Lambda'(\gamma) &= -\pi[\theta^\alpha(p)] \frac{d\theta^\alpha(p)}{d\gamma} \left[ \frac{\omega_d^2}{4\gamma\psi_d^2} - p^m (1 - \theta^\alpha(p^m)) \omega_d + \gamma\psi_d^2 (p^m)^2 (1 - \theta^\alpha(p^m))^2 \right] + \frac{\omega_d^2}{4\gamma^2\psi_d^2} \int_{z^R}^{\theta^\alpha(p^m)} d\Pi(\theta) \\ &\quad + \psi_d^2 (p^m)^2 \int_{\theta^\alpha(p^m)}^{z^I} (1 - \theta)^2 d\Pi(\theta) \\ &= \frac{\omega_d^2}{4\gamma^2\psi_d^2} \int_{z^R}^{\theta^\alpha(p^m)} d\Pi(\theta) + \psi_d^2 (p^m)^2 \int_{\theta^\alpha(p^m)}^{z^I} (1 - \theta)^2 d\Pi(\theta) \\ &\geq 0\end{aligned}$$

□

### Proof of Lemma 15

*Proof.* The first-order condition follows from taking the derivative of (15) with respect to  $\alpha$ ,

$$\mathbf{1}[z(\theta, p) < z^I] z(\theta, p) (qV - k) - 2\gamma\beta [k - qV(z(\theta, p)(1 - q) + q)]^2 \leq 0$$

The first term (marginal benefits) is zero for  $z(\theta, p) \geq z^I$  and positive otherwise. The second term (marginal costs) is always positive for  $\beta > 0$ . This means that the optimal policy is  $\beta = 0$  for  $z(\theta, p) \geq z^I$ , and interior otherwise

$$\beta = \frac{z(\theta, p) (qV - k)}{2\gamma [k - qV(z(\theta, p)(1 - q) + q)]^2} = \frac{\omega_a(\theta, p)}{2\gamma\psi_a(\theta, p)^2}$$

up to being contained in the  $[0, n_1(\theta, p)]$  interval.

□

### Proof of Proposition 16

*Proof.* As with deposit guarantees, we can write the welfare function as

$$\mathbb{E}_\theta [w(\theta; p, \Psi)] = \mathbb{E}_\theta [w(\theta; p, 0)] + \mathbb{E}_\theta \left[ \beta(\theta, p) \omega_a(\theta, p) - \gamma \{ \beta(\theta, p) \psi_a(\theta, p) \}^2 \right]$$

As before, we can find a threshold  $\theta^\beta(p)$  beyond which the planner exhausts the credit guarantee policy,  $\beta(\theta, p) = n_1(\theta, p)$ .

This number is given by

$$\theta^\beta(p) = \theta^I(p) + \frac{qV - k}{4\gamma [qV(1 - q)(1 - pz^I)]^2} - \sqrt{\left[ \theta^I(p) + \frac{qV - k}{4\gamma [qV(1 - q)(1 - pz^I)]^2} \right]^2 - [\theta^I(p)]^2}$$

It can be shown that  $\theta^\beta(p)$  is strictly decreasing in  $p$ , and strictly decreasing in  $\gamma$ . In particular, we have that

$$\begin{aligned}\lim_{\gamma \rightarrow 0} \theta^\beta(p) &= 0 \\ \lim_{\gamma \rightarrow \infty} \theta^\beta(p) &= \theta^I(p)\end{aligned}$$

This threshold allows us to rewrite the welfare function in a more convenient form

$$\mathbb{E}_\theta [w(\theta; p, \Psi)] = \mathbb{E}_\theta [w(\theta; p, 0)] + \int_{z^R}^{\theta^\beta(p)} \frac{\omega_a(\theta, p)^2}{4\gamma\psi_a(\theta, p)^2} d\Pi(\theta) + \int_{\theta^\beta(p)}^{\theta^I(p)} \left[ n_1(\theta, p)\omega_a(\theta, p) - \gamma n_1(\theta, p)^2 \psi_a(\theta, p)^2 \right] d\Pi(\theta)$$

The first-order condition with respect to  $p$  is

$$\begin{aligned}\frac{d\mathbb{E}_\theta [w(\theta; p, \Psi)]}{dp} &= \frac{d\mathbb{E}_\theta [w(\theta; p, 0)]}{dp} + \pi[\theta^\beta(p)] \frac{d\theta^\beta(p)}{dp} \left[ \frac{\omega_a(\theta^\beta, p)^2}{4\gamma\psi_a(\theta^\beta, p)^2} - n_1(\theta, p)\omega_a(\theta, p) + \gamma n_1(\theta, p)^2 \psi_a(\theta, p)^2 \right] \\ &+ \pi[\theta^I(p)] \frac{d\theta^I(p)}{dp} \left[ n_1(\theta, p)\omega_a(\theta, p) - \gamma n_1(\theta, p)^2 \psi_a(\theta, p)^2 \right] \\ &+ \frac{(qV - k)(k - q^2V)}{2\gamma} \int_{z^R}^{\theta^\beta(p)} \frac{dz(\theta, p)}{dp} \frac{\omega_a(\theta, p)}{\psi_a(\theta, p)^3} d\Pi(\theta) + 2\gamma(k - q^2V) \int_{\theta^\beta(p)}^{\theta^I(p)} (1 - \theta) n_1(\theta, p) \psi_a(\theta, p) d\Pi(\theta) \\ &= \frac{d\mathbb{E}_\theta [w(\theta; p, 0)]}{dp} + \pi[\theta^I(p)] \frac{d\theta^I(p)}{dp} n_1(\theta^I, p) \omega_a(\theta^I, p) \\ &+ \frac{(qV - k)(k - q^2V)}{2\gamma} \int_{z^R}^{\theta^\beta(p)} \frac{dz(\theta, p)}{dp} \frac{\omega_a(\theta, p)}{\psi_a(\theta, p)^3} d\Pi(\theta) + 2\gamma(k - q^2V) \int_{\theta^\beta(p)}^{\theta^I(p)} (1 - \theta) n_1(\theta, p) \psi_a(\theta, p) d\Pi(\theta)\end{aligned}$$

Recall that

$$\frac{d\mathbb{E}_\theta [w(\theta; p, 0)]}{dp} = -\pi[\theta^I(p)] \frac{d\theta^I(p)}{dp} n_1(\theta^I, p) \omega_a(\theta^I, p) - \mathbb{E}_\theta [1 - \theta] \omega_d$$

so,

$$\begin{aligned}\frac{d\mathbb{E}_\theta [w(\theta; p, \Psi)]}{dp} &= -\mathbb{E}_\theta [1 - \theta] \omega_d + \frac{(qV - k)(k - q^2V)}{2\gamma} \int_{z^R}^{\theta^\beta(p)} \frac{dz(\theta, p)}{dp} \frac{\omega_a(\theta, p)}{\psi_a(\theta, p)^3} d\Pi(\theta) \\ &+ 2\gamma(k - q^2V) \int_{\theta^\beta(p)}^{\theta^I(p)} (1 - \theta) n_1(\theta, p) \psi_a(\theta, p) d\Pi(\theta)\end{aligned}$$

Note that whether this derivative exceeds the derivative of welfare without fiscal policy or not is ambiguous, and depends

on the shape of the distribution  $\pi(\theta)$ . The second derivative of welfare with respect to  $p$  is

$$\begin{aligned}
\frac{d^2 \mathbb{E}_\theta [w(\theta; p, \Psi)]}{dp^2} &= \pi[\theta^\beta(p)] \frac{d\theta^\beta(p)}{dp} \left\{ \frac{(qV - k)(k - q^2V)}{2\gamma} \frac{dz(\theta^\beta, p)}{dp} \frac{\omega_a(\theta^\beta, p)}{\psi_a(\theta^\beta, p)^3} - 2\gamma(k - q^2V)(1 - \theta^\beta) n_1(\theta^\beta, p) \psi_a(\theta^\beta, p) \right\} \\
&+ \pi[\theta^I(p)] \frac{d\theta^I(p)}{dp} 2\gamma(1 - \theta^I) n_1(\theta^I, p) \psi_a(\theta^I, p) \\
&+ \frac{(qV - k)(k - q^2V)}{2\gamma} \int_{z^R}^{\theta^\beta(p)} \left[ \frac{d^2 z(\theta, p)}{dp^2} \frac{\omega_a(\theta, p)}{\psi_a(\theta, p)^3} + \left( \frac{dz(\theta, p)}{dp} \right)^2 \frac{(qV - k)}{\psi_a(\theta, p)^3} - 3 \frac{dz(\theta, p)}{dp} \frac{\omega_a(\theta, p)}{\psi_a(\theta, p)^4} \right] d\Pi(\theta) \\
&- 2\gamma(k - q^2V) \int_{\theta^\beta(p)}^{\theta^I(p)} (1 - \theta)^2 d\Pi(\theta) \\
&= 3 \frac{(qV - k)(k - q^2V)}{2\gamma} \int_{z^R}^{\theta^\beta(p)} \frac{dz(\theta, p)}{dp} \frac{\omega_a(\theta, p)}{\psi_a(\theta, p)^4} \left[ \frac{(1 - \theta)}{n_1(\theta, p)} \psi_a(\theta, p) - 1 \right] d\Pi(\theta) \\
&- 2\gamma(k - q^2V) \int_{\theta^\beta(p)}^{\theta^I(p)} (1 - \theta)^2 d\Pi(\theta)
\end{aligned}$$

A sufficient (but not necessary) condition to ensure concavity of the welfare function is to have

$$\frac{(1 - \theta)}{n_1(\theta, p)} \psi_a(\theta, p) - 1 \leq 0$$

as then the entire second derivative is negative.

Under concavity, can we derive any comparative statics? Let us use the same argument as before, and take

$$\begin{aligned}
\frac{d^2 \mathbb{E}_\theta [w(\theta; p, \Psi)]}{dp d\gamma} &= - \frac{(qV - k)(k - q^2V)}{2\gamma^2} \int_{z^R}^{\theta^\beta(p)} \frac{dz(\theta, p)}{dp} \frac{\omega_a(\theta, p)}{\psi_a(\theta, p)^3} d\Pi(\theta) \\
&+ \pi[\theta^\beta(p)] \frac{d\theta^\beta(p)}{d\gamma} \left[ \frac{(qV - k)(k - q^2V)}{2\gamma} \frac{dz(\theta^\beta, p)}{dp} \frac{\omega_a(\theta^\beta, p)}{\psi_a(\theta^\beta, p)^3} - 2\gamma(k - q^2V)(1 - \theta^\beta) n_1(\theta^\beta, p) \psi_a(\theta^\beta, p) \right] \\
&+ 2(k - q^2V) \int_{\theta^\beta(p)}^{\theta^I(p)} (1 - \theta) n_1(\theta, p) \psi_a(\theta, p) d\Pi(\theta) \\
&= - \frac{(qV - k)(k - q^2V)}{2\gamma^2} \int_{z^R}^{\theta^\beta(p)} \frac{dz(\theta, p)}{dp} \frac{\omega_a(\theta, p)}{\psi_a(\theta, p)^3} d\Pi(\theta) + 2(k - q^2V) \int_{\theta^\beta(p)}^{\theta^I(p)} (1 - \theta) n_1(\theta, p) \psi_a(\theta, p) d\Pi(\theta) \\
&= 4(k - q^2V) \int_{\theta^\beta(p)}^{\theta^I(p)} (1 - \theta) n_1(\theta, p) \psi_a(\theta, p) d\Pi(\theta) - \frac{1}{\gamma} \mathbb{E}_\theta [1 - \theta] \omega_d
\end{aligned}$$

where the last step follows from the fact that if the function is concave, the FOC must be zero at the optimal level of disclosure. Let  $\gamma^\beta(p)$  be such that  $\theta^\beta(p) = z^R$ . This threshold exists since  $\theta^\beta(p) \in [0, \theta^I(p)]$ , and  $\theta^I(p) \geq z^R$  for  $p \leq p^m$ .

Then, for  $\gamma \leq \gamma^\beta(p)$ , this term is equal to

$$\frac{d^2 \mathbb{E}_\theta [w(\theta; p, \Psi)]}{dp d\gamma} = 4(k - q^2V) \int_{z^R}^{\theta^I(p)} (1 - \theta) n_1(\theta, p) \psi_a(\theta, p) d\Pi(\theta) - \frac{1}{\gamma} \mathbb{E}_\theta [1 - \theta] \omega_d$$

The derivative is negative as long as

$$\gamma \leq \min[\bar{\gamma}(p), \gamma^\beta(p)]$$

where

$$\bar{\gamma}(p) \equiv \frac{\mathbb{E}_\theta [1 - \theta] \omega_d}{4(k - q^2 V) \int_{z^R}^{\theta^I(p)} (1 - \theta) n_1(\theta, p) \psi_a(\theta, p) d\Pi(\theta)} > 0$$

so we have that this result holds, in particular, for  $\gamma \rightarrow 0$ .

$$\lim_{\gamma \rightarrow 0} \frac{d^2 \mathbb{E}_\theta [w(\theta; p, \Psi)]}{dp d\gamma} \leq 0$$

For  $\gamma \in [\bar{\gamma}(p), \gamma^\beta(p)]$ , the derivative is positive. For  $\gamma \geq \gamma^\beta(p)$ , the sign may change. As we would expect, at the limit, the term is equal to zero.

$$\lim_{\gamma \rightarrow \infty} \frac{d^2 \mathbb{E}_\theta [w(\theta; p, \Psi)]}{dp d\gamma} = 0$$

Similarly, if the function is strictly convex, the planner either chooses full disclosure, exposing itself to a full run but not needing to use fiscal policy,

$$\mathbb{E}_\theta [w(\theta; p^m, 0)] = \mathbb{E}_\theta [\bar{w}(\theta)] - p^m \mathbb{E}_\theta [1 - \theta] \omega_d$$

or it uses fiscal policy,

$$\begin{aligned} \mathbb{E}_\theta [w(\theta; 0, \Psi)] &= \mathbb{E}_\theta [\bar{w}(\theta)] - \int_{z^R}^{\theta^I(p)} n_1(\theta, p) \omega_a(\theta, p) d\Pi(\theta) + \int_{z^R}^{\theta^\beta(p)} \frac{\omega_a(\theta, p)^2}{4\gamma \psi_a(\theta, p)^2} d\Pi(\theta) \\ &\quad + \int_{\theta^\beta(p)}^{\theta^I(p)} \left[ n_1(\theta, p) \omega_a(\theta, p) - \gamma n_1(\theta, p)^2 \psi_a(\theta, p)^2 \right] d\Pi(\theta) \\ &= \mathbb{E}_\theta [\bar{w}(\theta)] + \int_{z^R}^{\theta^\beta(p)} \left[ \frac{\omega_a(\theta, p)^2}{4\gamma \psi_a(\theta, p)^2} - n_1(\theta, p) \omega_a(\theta, p) \right] d\Pi(\theta) - \gamma \int_{\theta^\beta(p)}^{\theta^I(p)} n_1(\theta, p)^2 \psi_a(\theta, p)^2 d\Pi(\theta) \end{aligned}$$

The planner prefers no disclosure if and only if

$$\Lambda(\gamma) \equiv \int_{z^R}^{\theta^\beta(p)} \left[ \frac{\omega_a(\theta, p)^2}{4\gamma \psi_a(\theta, p)^2} - n_1(\theta, p) \omega_a(\theta, p) \right] d\Pi(\theta) - \gamma \int_{\theta^\beta(p)}^{\theta^I(p)} n_1(\theta, p)^2 \psi_a(\theta, p)^2 d\Pi(\theta) + p^m \mathbb{E}_\theta [1 - \theta] \omega_d \geq 0$$

Do we have that  $\Lambda'(\gamma) \geq 0$ ?

$$\begin{aligned} \Lambda'(\gamma) &= \pi[\theta^\beta(p)] \frac{d\theta^\beta(p)}{d\gamma} \left[ \frac{\omega_a(\theta, p)^2}{4\gamma \psi_a(\theta, p)^2} - n_1(\theta, p) \omega_a(\theta, p) + \gamma n_1(\theta, p)^2 \psi_a(\theta, p)^2 \right] \\ &\quad - \frac{1}{4\gamma^2} \int_{z^R}^{\theta^\beta(p)} \frac{\omega_a(\theta, p)^2}{\psi_a(\theta, p)^2} d\Pi(\theta) - \int_{\theta^\beta(p)}^{\theta^I(p)} n_1(\theta, p)^2 \psi_a(\theta, p)^2 d\Pi(\theta) \\ &= -\frac{1}{4\gamma^2} \int_{z^R}^{\theta^\beta(p)} \frac{\omega_a(\theta, p)^2}{\psi_a(\theta, p)^2} d\Pi(\theta) - \int_{\theta^\beta(p)}^{\theta^I(p)} n_1(\theta, p)^2 \psi_a(\theta, p)^2 d\Pi(\theta) \\ &\leq 0 \end{aligned}$$

So that, if welfare is convex, disclosure is weakly increasing in  $\gamma$ . □

## Proof of Proposition 17

*Proof.* Define the marginal benefits and marginal costs for each policy as before,

$$\begin{aligned}\omega_a(\theta, p) &\equiv z(\theta, p)(qV - k)_{z(\theta, p) < z^I} \\ \omega_d &\equiv \delta A^b + qV - k\end{aligned}$$

and

$$\begin{aligned}\psi_a(\theta, p) &\equiv k - qV [z(\theta, p)(1 - q) + q] \\ \psi_d &\equiv (1 - q)(D - A^b)\end{aligned}$$

The first-order conditions with respect to each of the policies are

$$\begin{aligned}\alpha &: \frac{\omega_d}{\psi_d} - 2\gamma\Psi \leq 0 \\ \beta &: \frac{\omega_a(\theta, p)}{\psi_a(\theta, p)} - 2\gamma\Psi \leq 0\end{aligned}$$

where  $\Psi = \alpha\psi_d + \beta\psi_a$  is total fiscal spending.

Consider first the situation where  $z \geq z^I$ . Then,  $\omega_a = 0$ , and the FOC for  $\alpha$  reads

$$-2\gamma\Psi \leq 0$$

with a strict inequality if  $\beta > 0$ . This implies that  $\beta = 0$  is optimal. We then have that  $\Psi = \alpha\psi_d$ , and the FOC for  $\alpha$  becomes

$$\alpha = \frac{\omega_d}{2\gamma\psi_d^2} \in [0, n_0(\theta, p)]$$

Consider now the case in which  $z < z^I$ . In this case, both policies yield positive marginal benefits. First, note that the marginal benefits of each policy are constant and positive, while marginal costs are increasing from 0. Thus setting  $\alpha = 0$  and  $\beta = 0$  cannot be optimal, as the planner could benefit from raising at least one of the policies. Furthermore, the first-order conditions form a linear system of inequalities, and depend on the controls  $\alpha, \beta$  only through the total spending term. The policies solve the following system of inequalities

$$\begin{aligned}\alpha\psi_d &= \frac{1}{2\gamma} \frac{\omega_d}{\psi_d} - \psi_a(\theta, p)\beta, \quad \alpha \in [0, n_0(\theta, p)] \\ \beta\psi_a(\theta, p) &= \frac{1}{2\gamma} \frac{\omega_a(\theta, p)}{\psi_a(\theta, p)} - \psi_d\alpha, \quad \beta \in [0, n_1(\theta, p)]\end{aligned}$$

This is equivalent to solving a demand system for substitute goods with upper bounds on consumption: the planner will choose the policy that yields the best marginal benefit to marginal cost ratio up to capacity, and only then choose the

following policy. Consider first the case in which

$$\frac{\omega_a(\theta, p)}{\psi_a(\theta, p)} \geq \frac{\omega_d}{\psi_d}$$

This condition is equivalent to

$$z_1(\theta, p) \geq z^I \frac{1}{1 + \left(1 - \frac{k}{qV}\right) \frac{(D - Ab)}{\delta A^b + qV - k}} \equiv z^c$$

In this case, the planner sets  $\beta$  first, since it yields a greater benefit-to-cost ratio. The optimal  $\beta$  satisfies

$$\beta = \min \left\{ n_1(\theta, p), \frac{\omega_a(\theta, p)}{2\gamma\psi_a(\theta, p)^2} \right\}$$

and the optimal  $\alpha$  becomes active only if  $\beta$  is at capacity. We can write the optimal choice as

$$\alpha = \max \left\{ 0, \min \left\{ n_0(\theta, p), \frac{\omega_d}{2\gamma\psi_d^2} - \frac{\psi_a(\theta, p)}{\psi_d} n_1(\theta, p) \right\} \right\}$$

The opposite case, in which  $\alpha$  yields the greater marginal benefit to cost ratio occurs when  $z(\theta, p) \leq z^c < z^I$ . In this case, the policies are analogous

$$\alpha = \min \left\{ n_0(\theta, p), \frac{\omega_d}{2\gamma\psi_d^2} \right\}$$

and

$$\beta = \max \left\{ 0, \min \left\{ n_1(\theta, p), \frac{\omega_a(\theta, p)}{2\gamma\psi_a(\theta, p)^2} - \frac{\psi_d}{\psi_a(\theta, p)} n_0(\theta, p) \right\} \right\}$$

□

## E Online Appendix - General Model for $[\underline{\theta}, \bar{\theta}] \supset [z^R, z^I]$

In this section, we present the general set-up where the support of the distribution  $\pi(\theta)$  is larger than  $[z^R, z^I]$ . Note that, in this case, full system-wide runs are possible if  $\theta < z^R$ . Similarly, a good state where neither runs nor adverse selection arise in equilibrium is possible for  $\theta \geq z^I$ . The analysis of the cases in which the support of  $\theta$  is a strict subset of  $[z^R, z^I]$  follow from specializations of the analysis in the main text.

Define thresholds  $\theta^R(p)$  and  $\theta^I(p)$  given by

$$\begin{aligned} \theta^R(p) &= \frac{1-p}{1/z^R - p} \\ \theta^I(p) &= \frac{1-p}{1/z^I - p} \end{aligned}$$

The main analysis disregards  $\theta^R(p)$ , since  $\theta \geq z^R$ , but this threshold is relevant for the general case. It is the threshold

below which banks that receive the good signal are run on. Expected welfare for the private equilibrium can be written as

$$\begin{aligned}
\mathbb{E}_\theta [w(\theta, p, \Psi)] &= \bar{y}_1 - \gamma(\Psi)^2 + p\mathbb{E}[1 - \theta](1 - \delta)A^b \\
&+ (1 - \delta) \int_{\underline{\theta}}^{\theta^R(p)} [\theta A^g + (1 - \theta)(1 - p)A^b] d\Pi(\theta) \\
&+ \int_{\theta^R(p)}^{\bar{\theta}} [\theta A^g + (1 - \theta)(1 - p)(A^b + qV - k)] d\Pi(\theta) \\
&+ \int_{\theta^I(p)}^{\bar{\theta}} \theta(qV - k) d\Pi(\theta)
\end{aligned}$$

The first line is as before, and contains the endowment, the fiscal costs and the costs from disclosing banks that are weak with certainty. The second line is the new component: by letting  $\theta \leq z^R$ , we are allowing for the possibility of system-wide runs, in which even banks with the good signal suffer a run. This happens if the aggregate state, the average quality of the banks, is low enough, and the level of disclosure is also low enough. Thus the general case contains an additional benefit of disclosure that was not present in the main analysis: by disclosing more, the planner is reducing the likelihood that the good pool suffers a run (or even eliminating it altogether).

First-best welfare is as before, and corresponds to the situation in which there are no runs and all banks invest

$$\mathbb{E}_\theta [\bar{w}(\theta)] = A^b \mathbb{E}_\theta [1 - \theta] + A^g \mathbb{E}_\theta [\theta] + qV - k$$

## E.1 Economy without Runs

As before, it is useful to understand the impact of disclosure on each source of inefficiency separately, before moving to the analysis of the full problem. In this case, we can write welfare as

$$\begin{aligned}
\mathbb{E}_\theta [w(\theta, p)] &= \bar{y}_1 + \int_{\underline{\theta}}^{\theta^I(p)} [\theta A^g + (1 - \theta)(A^b + qV - k)] d\Pi(\theta) \\
&+ \int_{\theta^I(p)}^{\bar{\theta}} [\theta(A^g + qV - k) + (1 - \theta)(A^b + qV - k)] d\Pi(\theta) \\
&= \bar{y}_1 + \mathbb{E}_\theta [1 - \theta](A^b + qV - k) + A^g \mathbb{E}_\theta [\theta] + (qV - k) \int_{\theta^I(p)}^{\bar{\theta}} \theta d\Pi(\theta)
\end{aligned}$$

Welfare is weakly increasing in disclosure in the absence of runs, since  $\frac{d\theta^I(p)}{dp} < 0$ : by disclosing more, the planner unfreezes markets at no cost. This is true up to  $p$  such that  $\theta^I(p) = \underline{\theta}$ , beyond which disclosure has no effect on welfare. We can then define

$$p^I : \theta^I(p^I) = \underline{\theta} \Leftrightarrow p^I = \frac{z^I - \underline{\theta}}{z^I(1 - \underline{\theta})}$$

as the maximum  $p$  for which welfare is increasing in disclosure. Note that this is the same as the threshold  $p^m$  defined in the main text.

## E.2 Economy without Lemons

Assume now that there is no adverse selection problem in credit markets. This allows us to write expected welfare as

$$\begin{aligned}
\mathbb{E}_\theta [w(\theta, p)] &= \bar{y}_1 + p\mathbb{E}_\theta [1 - \theta] (1 - \delta)A^b + (1 - \delta) \int_{\underline{\theta}}^{\theta^R(p)} [\theta A^g + (1 - \theta)(1 - p)A^b] d\Pi(\theta) \\
&+ \int_{\theta^R(p)}^{\bar{\theta}} [\theta(A^g + qV - k) + (1 - \theta)(1 - p)(A^b + qV - k)] d\Pi(\theta) \\
&= (1 - \delta) \int_{\underline{\theta}}^{\theta^R(p)} [\theta A^g + (1 - \theta)A^b] d\Pi(\theta) \\
&+ \int_{\theta^R(p)}^{\bar{\theta}} [\theta(A^g + qV - k) + (1 - \theta)(1 - p)(A^b + qV - k) + (1 - \theta)p(1 - \delta)A^b] d\Pi(\theta)
\end{aligned}$$

Contrary to the baseline analysis, in which no trade-off exists and welfare is strictly decreasing in disclosure, disclosure now has a benefit when it comes to runs: by disclosing, the planner will be reducing the likelihood that the economy finds itself in the midst of a system-wide run, when  $\theta < z^R$ . This means that optimal disclosure, without adverse selection, can potentially be different from  $p = 0$ . The derivative of expected welfare with respect to  $p$  is

$$\begin{aligned}
\frac{d\mathbb{E}_\theta [w(\theta, p)]}{dp} &= \mathbf{1}[\theta^R(p) \geq \underline{\theta}] \pi[\theta^R(p)] \left( -\frac{d\theta^R(p)}{dp} \right) \{ \theta^R(p) [\delta A^g + qV - k] + (1 - p) [1 - \theta^R(p)] [\delta A^b + qV - k] \} \\
&- \int_{\theta^R(p)}^{\bar{\theta}} (1 - \theta) [\delta A^b + qV - k] d\Pi(\theta)
\end{aligned}$$

Note that the first component of the derivative only depends on  $p$  for  $\theta^R(p) \geq \underline{\theta}$ : as with adverse selection, beyond a certain point, disclosure is so high that a system-wide run becomes impossible. We can let that point be denoted as

$$p^R : \theta^R(p^R) = \underline{\theta} \Leftrightarrow p^R = \frac{z^R - \underline{\theta}}{z^R(1 - \underline{\theta})}$$

For  $p \geq p^R$ , the derivative of welfare is equal to the term on the second line only, and thus strictly negative. Expected welfare is strictly decreasing on disclosure for  $p \geq p^R$ , since disclosing anything beyond this point has no impact on the probability of a system-wide run (which is averted with certainty) and only causes inefficient runs on weak banks. This logic is similar to the one in the baseline model.

Focusing on  $p \leq p^R$ , there are benefits and costs to disclosure. The second derivative of the welfare function is

$$\begin{aligned}
\frac{d^2\mathbb{E}_\theta [w(\theta, p)]}{dp^2} &= - \left\{ \pi'[\theta^R(p)] \left( \frac{d\theta^R(p)}{dp} \right)^2 + \pi[\theta^R(p)] \frac{d^2\theta^R(p)}{dp^2} \right\} \\
&\times \{ \theta^R(p) [\delta A^g + qV - k] + (1 - p) [1 - \theta^R(p)] [\delta A^b + qV - k] \} \\
&- \pi[\theta^R(p)] \left( \frac{d\theta^R(p)}{dp} \right)^2 \\
&\times \{ \delta [A^g - (1 - p)A^b] + p(qV - k) \} + 2\pi[\theta^R(p)] \frac{d\theta^R(p)}{dp} (1 - \theta^R(p)) [\delta A^b + qV - k]
\end{aligned}$$

Note that both terms in the second line are negative. For the first line, it is enough to show that the first factor is positive to establish the entire term as negative. We can sign it as

$$\begin{aligned}
& \pi [\theta^R(p)] \left\{ -2 \frac{1/z^R - 1}{(1/z^R - p)^3} + \frac{\pi' [\theta^R(p)] (1/z^R - 1)^2}{\pi [\theta^R(p)] (1/z^R - p)^4} \right\} \\
= & \pi [\theta^R(p)] \frac{1/z^R - 1}{(1/z^R - p)^3} \frac{1}{1-p} \left\{ -2 + 2p + (1/z^R - 1) \theta^R(p) \frac{\pi' [\theta^R(p)]}{\pi [\theta^R(p)]} \right\} \\
= & \pi [\theta^R(p)] \frac{1/z^R - 1}{(1/z^R - p)^3} \frac{1}{1-p} \{ \chi [\theta^R(p)] (1/z^R - 1) - 2 + 2p \}
\end{aligned}$$

It is then enough that the term in brackets be positive. This happens when

$$\min_p \chi [\theta^R(p)] \geq \max_p \frac{2(1-p)}{1/z^R - 1} = \frac{2z^R}{1 - z^R}$$

This then becomes a sufficient condition for concavity of the welfare function. This means that the optimum is interior and solves the first-order condition.

### E.3 Full Economy

We now proceed to the disclosure problem in the full economy. As before, the general problem without fiscal policy is

$$\max_{p \in [0,1]} \mathbb{E}_\theta [w(\theta, p)]$$

where the objective function can be written as

$$\begin{aligned}
\mathbb{E}_\theta [w(\theta, p)] &= \bar{y}_1 + (1 - \delta)A^b \\
&+ \mathbf{1}[p \leq p^R] \left\{ (1 - \delta) \int_{\underline{\theta}}^{\theta^R(p)} \theta (A^g - A^b) d\Pi(\theta) + \int_{\theta^I(p)}^{\bar{\theta}} \theta (qV - k) d\Pi(\theta) \right\} \\
&+ \mathbf{1}[p \leq p^R] \int_{\theta^R(p)}^{\bar{\theta}} [\theta (A^g - (1 - \delta)A^b - (1 - p) [\delta A^b + qV - k]) + (1 - p) (\delta A^b + qV - k)] d\Pi(\theta) \\
&+ \mathbf{1}[p^R \leq p \leq p^I] \left\{ \int_{\underline{\theta}}^{\bar{\theta}} [\theta (A^g - (1 - \delta)A^b - (1 - p) [\delta A^b + qV - k]) + (1 - p) (\delta A^b + qV - k)] d\Pi(\theta) \right\} \\
&+ \mathbf{1}[p^R \leq p \leq p^I] \int_{\theta^I(p)}^{\bar{\theta}} \theta (qV - k) d\Pi(\theta) \\
&+ \mathbf{1}[p \geq p^I] \left\{ \int_{\underline{\theta}}^{\bar{\theta}} [\theta (A^g - (1 - \delta)A^b + qV - k - (1 - p) [\delta A^b + qV - k]) + (1 - p) (\delta A^b + qV - k)] d\Pi(\theta) \right\}
\end{aligned}$$

We can recover the previous result that the planner will never set  $p \geq p^I$ : given that  $z^I > z^R$  implies that  $p^R < p^I$ , we know that the benefits of disclosure are zero beyond this point: not only has the planner averted a system-wide run with certainty, but it has also unfrozen the market. Disclosing beyond this point only causes costly runs, and is therefore not

optimal. The generic first-order condition is

$$\begin{aligned} & \mathbb{1} [p \leq p^I] \pi [\theta^I(p)] \left( -\frac{d\theta^I(p)}{dp} \right) \theta^I(p) (qV - k) \\ & + \mathbb{1} [p \leq p^R] \pi [\theta^R(p)] \left( -\frac{d\theta^R(p)}{dp} \right) \{ \theta^R(p) \delta A^g + (1 - \theta^R(p)) (1 - p) [\delta A^b + qV - k] \} \\ & - \int_{\theta^R(p)}^{\bar{\theta}} (1 - \theta) [\delta A^b + qV - k] d\Pi(\theta) \end{aligned}$$

where the first line is the marginal benefit of reducing adverse selection, and positive for  $p \leq p^I$ , the second line is the marginal benefit of reducing system-wide runs, and positive for  $p \leq p^R$ . The final term is the marginal cost of disclosure: the cost of creating runs on weak banks. Note that for  $p \in [p^R, p^I]$ , both the welfare function and the first-order condition collapse to the case analyzed in the main text, and the same results apply locally.

## E.4 Fiscal Policy

The analysis of fiscal policy is undertaken taking  $(p, \theta)$  as given. We first look at fiscal policy separately, and then jointly.

### E.4.1 Credit Guarantees

Credit guarantees are now offered only to the good pool, since the bad pool consists only of weak banks. This means that depositors/lenders know that if a bank in the bad pool survives, then it invests with certainty (it can only survive with deposit guarantees - more coming next). As before, the government chooses to support a mass equal to  $\beta$  banks in the good pool. As before, the cost per bank supported in the good pool is given by

$$\psi_a = k - qV [z + q(1 - z)]$$

We look at fiscal policy in three different situations

1.  $\theta \leq \theta^R(p)$ , in which case the good pool suffers a run, and no credit guarantees are ever offered. Thus  $\beta = 0$ .
2.  $\theta \in [\theta^R(p), \theta^I(p)]$ . In this case, the good pool suffers from adverse selection. Welfare is given by

$$n_0(1 - \delta)A^b + (n_1 - \beta) [zA^g + (1 - z)(A^b + qV - k)] + \beta [zA^g + (1 - z)A^b + qV - k] - \gamma\Psi^2$$

where

$$\Psi = \beta\psi_a$$

Define as before

$$\omega_a \equiv z(qV - k)$$

and the first-order condition simply implies

$$\beta = \min \left\{ n_1, \frac{\omega_a}{2\gamma\psi_a^2} \right\}$$

note that both marginal benefit and marginal cost are functions of  $(p, \theta)$  through  $z$ .

3.  $\theta \geq \theta^I(p)$ , in which case the bad pool suffers a run and the good pool is free from adverse selection, so  $\beta = 0$ .

#### E.4.2 Deposit Insurance

Deposit guarantees can be offered to either pool, since the bad pool always suffers a run, and the good pool may or may not suffer a run now. Let  $\alpha_i$  denote the mass of banks supported in each pool for  $i \in \{0, 1\}$ . We define the costs of saving each of the pools as

$$\begin{aligned} \psi_0 &\equiv (1 - q)(D - A^b) \\ \psi_1 &\equiv (1 - q)(D - A^b)(1 - z) \end{aligned}$$

So that it is cheaper to provide deposit guarantees to the good pool (since there are less weak banks in that pool): note that  $\psi_0$  is equal to the variable that we have previously called  $\psi_d$ , while  $\psi_1$  is now the expected cost of supporting the good pool in case of a run.  $\psi_1$  will depend on  $z$ , the fraction of good banks in this pool.

1. If  $\theta \leq \theta^R(p)$ , both pools suffer a run, and the government may activate deposit guarantees for both of them. Welfare is then

$$(n_0 - \alpha_0)(1 - \delta)A^b + \alpha_0(A^b + qV - k) + (n_1 - \alpha_1)(1 - \delta)[zA^g + (1 - z)A^b] + \alpha_1[zA^g + (1 - z)(A^b + qV - k)] - \gamma\Psi^2$$

where

$$\Psi = \sum_{i=0,1} \alpha_i \psi_i$$

Let, as before,

$$\begin{aligned} \omega_0 &\equiv \delta A^b + qV - k \\ \omega_1 &\equiv (1 - z)[\delta A^b + qV - k] + z\delta A^g \end{aligned}$$

then, the FOC are

$$\begin{aligned} \alpha_0 : \omega_0 - 2\gamma\Psi\psi_0 &\leq 0 \\ \alpha_1 : \omega_1 - 2\gamma\Psi\psi_1 &\leq 0 \end{aligned}$$

Note that we have that

$$\frac{\omega_0}{\psi_0} \leq \frac{\omega_1}{\psi_1} \Leftrightarrow 0 \leq z\delta A^g$$

meaning that the government always chooses to exhaust support to the good pool before supporting the bad pool.

The optimal policy is then as follows: set

$$\alpha_1 = \min \left\{ n_1, \frac{\omega_1}{2\gamma\psi_1^2} \right\}$$

and

$$\alpha_0 = \max \left\{ 0, \min \left\{ n_0, \frac{\omega_0}{2\gamma\psi_0^2} - \frac{\psi_1}{\psi_0} n_1 \right\} \right\}$$

2. If  $\theta \geq \theta^R(p)$ , support is extended to the bad pool only. In this case, welfare is

$$(n_0 - \alpha_0)(1 - \delta)A^b + \alpha_0(A^b + qV - k) + n_1[zA^g + (1 - z)(A^b + qV - k)] + 1\{\theta \geq \theta^I(p)\}z(qV - k) - \gamma\Psi^2$$

where

$$\Psi = \alpha_0\psi_0$$

Implying that the optimal policy follows

$$\alpha_0 = \min \left\{ n_0, \frac{\omega_0}{2\gamma\psi_0^2} \right\}$$

### E.4.3 Both Policies

We now combine the two policies, and allow the government to offer credit and deposit guarantees at the same time. We consider the three different cases

1. If  $\theta \geq \theta^I(p)$ , the government sets  $\beta = \alpha_1 = 0$ , and  $\alpha_0$  is set as before.
2. If  $\theta \in (\theta^R(p), \theta^I(p))$ , the government sets  $\alpha_1 = 0$ . The government now has to jointly set  $\alpha_0, \beta$ . Welfare is given by

$$(n_0 - \alpha_0)(1 - \delta)A^b + \alpha_0(A^b + qV - k) + (n_1 - \beta)[zA^g + (1 - z)(A^b + qV - k)] + \beta[zA^g + (1 - z)A^b + qV - k] - \gamma\Psi^2$$

where

$$\Psi = \alpha_0\psi_0 + \beta\psi_a$$

The FOC, as before, is of the form

$$\begin{aligned} \alpha_0 : \omega_0 - 2\gamma\Psi\psi_0 &\leq 0 \\ \beta : \omega_a - 2\gamma\Psi\psi_a &\leq 0 \end{aligned}$$

So that the government fully exhausts the policy with the greatest marginal benefit-to-cost ratio before setting the

other. The planner chooses to set the credit guarantee first if and only if

$$z \geq \frac{[\delta A^b + qV - k] (k - q^2V)}{(1 - q) [(qV - k)(D - A^b) + qV [\delta A^b + qV - k]]} = \frac{z^I}{1 + \frac{\psi_0}{\omega_0} \frac{qV - k}{q(1 - q)V}}$$

Or, if  $z$  is high enough; note that  $\omega_0, \psi_0$  are independent of  $z$ , and hence of  $(p, \theta)$ , thus this restriction is purely parametric. In this case, we have that the optimal policy follows

$$\beta = \min \left\{ n_1, \frac{\omega_a}{2\gamma\psi_a^2} \right\}$$

and

$$\alpha_0 = \max \left\{ 0, \min \left\{ n_0, \frac{\omega_0}{2\gamma\psi_0^2} - \frac{\psi_a}{\psi_0} n_1 \right\} \right\}$$

If the condition is not satisfied,  $\alpha_0$  is set first.

3. If  $\theta \leq \theta^R(p)$ , the analysis is more complex as then the government has to compare the cost-benefit ratios of setting  $\alpha_0, \alpha_1, \beta$  as all three policies are potentially active. Welfare is then

$$\begin{aligned} & (n_0 - \alpha_0)(1 - \delta)A^b + \alpha_0(A^b + qV - k) + (n_1 - \alpha_1)(1 - \delta)[zA^g + (1 - z)A^b] \\ & + (\alpha_1 - \beta)[zA^g + (1 - z)(A^b + qV - k)] + \beta[zA^g + (1 - z)A^b + qV - k] - \gamma\Psi^2 \end{aligned}$$

where

$$\Psi = \alpha_0\psi_0 + \alpha_1\psi_1 + \beta\psi_a$$

Note that the problem is slightly more complex: while the planner still chooses the policy such that  $\frac{\omega_i}{\psi_i} \geq \max_{j \in \mathcal{P}} \left\{ \frac{\omega_j}{\psi_j} \right\}$ , it faces the constraint that  $\beta \leq \alpha_1$ . That is, credit guarantees can only be offered to the good pool if deposit guarantees are offered to prevent a run in the first place. We must therefore consider all possible cases separately. As we have shown above,  $\alpha_1$  always dominates  $\alpha_0$ .

- (a) Consider first the case in which  $\alpha_1$  is the preferred policy. Then

$$\alpha_1 = \min \left\{ n_1, \frac{\omega_1}{2\gamma\psi_1^2} \right\}$$

and the other policies are only set if  $\alpha_1 = n_1$ . In that case, the planner proceeds to compare  $\alpha_0, \beta$ , following the previous decision rule. The sufficient condition for  $\alpha_1$  to be preferred over  $\beta$  is a quadratic on  $z$ . In case  $\alpha_0$  is preferred, we have

$$\begin{aligned} \alpha_0 &= \max \left\{ 0, \min \left\{ n_0, \frac{\omega_0}{2\gamma\psi_0^2} - \frac{\psi_1 n_1}{\psi_0} \right\} \right\} \\ \beta &= \max \left\{ 0, \min \left\{ n_1, \frac{\omega_a}{2\gamma\psi_a^2} - \frac{\psi_1 n_1 + \psi_0 n_0}{\psi_a} \right\} \right\} \end{aligned}$$

otherwise,

$$\beta = \max \left\{ 0, \min \left\{ n_1, \frac{\omega_a}{2\gamma\psi_a^2} - \frac{\psi_1 n_1}{\psi_a} \right\} \right\}$$

$$\alpha_0 = \max \left\{ 0, \min \left\{ n_0, \frac{\omega_0}{2\gamma\psi_0^2} - \frac{(\psi_a + \psi_1)}{\psi_0} n_1 \right\} \right\}$$

- (b) Consider now the case in which  $\beta$  is the preferred policy. Then, the planner will set  $\alpha_1 = \beta$ , since we must have that  $\beta \leq \alpha_1$ . In this case, the optimal policy satisfies

$$\beta = \min \left\{ n_1, \frac{\omega_a}{2\gamma\psi_a(\psi_a + \psi_1)} \right\}$$

and  $\alpha_1 = \beta$ . If  $\beta < n_1$ , then  $\alpha_0 = 0$ . Otherwise,

$$\alpha_0 = \max \left\{ 0, \min \left\{ n_0, \frac{\omega_0}{2\gamma\psi_0^2} - \frac{(\psi_a + \psi_1)}{\psi_0} n_1 \right\} \right\}$$