

Runs versus Lemons: Fiscal Capacity and Financial Stability

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Abstract

We study the link between fiscal capacity and financial stability in an economy that is subject to runs and adverse selection. The planner in our economy faces a rich set of policy options: it can disclose information about banks' assets, it can intervene to stop bank runs, recapitalize banks and intervene in credit markets. In any intervention, the planner faces a trade-off between mitigating adverse selection and causing inefficient bank runs. Reducing adverse selection increases welfare by increasing investment in positive NPV projects, but revealing information can trigger bank runs and inefficient liquidation. We find that the optimal policy depends on the fiscal capacity available to the planner. When capacity is ample, the planner chooses to reveal information and provide liquidity to banks that are run on; conversely, when capacity is low, the planner prefers to hide information and mitigate adverse selection by intervening in credit markets. Our model sheds light on optimal interventions and provides an explanation for the different choices that countries make in response to financial crises.

JEL: E5, E6, G1, G2.

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1 Introduction

Since the beginning of the financial crisis, the balance sheets of sovereigns and their financial institutions have become intertwined. This is in fact a generic feature of financial crises as argued in Reinhart and Rogoff (2009). Gorton (2012) shows that government interventions always play an important role in stopping financial panics. Governments use various tools to intervene during financial crises, but different governments use different tools and with varying degrees of success. Our goal is to understand these choices and their consequences.

In October 2008, the US government decided to inject cash into banks under the Troubled Asset Relief Program. In May 2009, the Federal Reserve publicly reported the results of the Supervisory Capital Assessment Program (SCAP). The SCAP, known as the banking stress test, was an assessment of the capital adequacy, under adverse scenarios, of a large subset of US financial firms. The exercise is broadly perceived as having been successful in reducing uncertainty about the state of the US financial system and helping to restore calm to financial markets.

The Committee of European Banking Supervisors (CEBS) also conducted an EU-wide stress test from May-October 2009, the results of which were not made public. A year later the exercise was repeated, but the results of the stress test, including bank-by-bank results, were published. In both cases, the stress tests are regarded as having been ineffective in restoring confidence to the financial sector.¹

What explains this marked difference in the success of stress tests as a means of restoring financial stability? We propose a model that highlights the tradeoffs faced by a regulator in deciding how much information about the financial system to make public.

We study optimal interventions by a planner in an economy that features adverse selection in the spirit of Akerlof (1970) and Stiglitz and Weiss (1981) as well as bank runs as in Diamond and Dybvig (1983). Our economy is populated by short-term funded intermediaries that differ in the quality of their existing assets.² The quality of these legacy assets is private information to each bank. In order to invest in new projects with positive net present value, banks must raise additional funds from the credit market. Asymmetric information about the quality of existing assets creates adverse selection in the credit market, leading to inefficiently high interest rates and low investment in the decentralized equilibrium. The planner might be able to improve welfare by disclosing information about banks' types. But runs make information disclosure potentially costly. If short term creditors (depositors) learn that a particular bank is bad, they might decide to run. Runs are inefficient for two reasons: there is a liquidation discount on the assets of banks that suffer a run, and liquidated banks cannot invest in new projects.

In this environment, a planner has a large set of potentially welfare improving policy tools at its disposal: asset quality reviews and stress tests, recapitalizations of "bad banks", liquidity support, among others. This paper provides a model through which the tradeoffs involved in the choice of these policies can be studied. We focus on combinations of two types of policies: information revelation (a 'stress test' or 'asset quality review') and fiscal

¹Ong and Pazarbasioglu (2013) provide a thorough overview of the details and perceived success of SCAP and the CEBS stress tests.

²We have in mind all short term runnable liabilities: MMF, Repo, ABCP, and of course large uninsured deposits. In the model, for simplicity, we refer to intermediaries as banks and liabilities as deposits.

interventions by the planner. The motivation for this focus is the ongoing interest in the academic literature and among practitioners in the (de)merits and perceived effectiveness of bank stress tests.

We are particularly interested in the effect that the fiscal capacity available to a planner for the implementation of a given policy has on the optimal choice of policy. The planner in our model must pay for its interventions with distortionary taxation. It may also have pre-existing obligations that it must pay for in the future. The extent to which taxation is distortionary and the magnitude of pre-existing spending commitments determine fiscal capacity.

Our main result is that a planner’s fiscal capacity shapes the optimal policy. When fiscal capacity is high, it is optimal for the planner to reveal information in a transparent manner and provide liquidity to at least a subset of banks that suffer a run, such that these banks survive and are able to invest in profitable projects. When capacity is low, the planner prefers to avoid runs by not revealing each bank’s type, and then mitigate the resulting adverse selection in the credit market by providing loans and credit guarantees.

We study two extensions of our basic model. In one extension, we show that aggregate uncertainty reinforces our results. We find that government with low fiscal capacity are effectively risk averse, and this makes them unwilling to risk runs by disclosing information.

2 Related literature

Our work builds on the rich literature that studies asymmetric information, following Akerlof (1970), Spence (1974), and Stiglitz and Weiss (1981). If no information is revealed by the planner, our economy very closely resembles the one studied by Philippon and Skreta (2012) and Tirole (2012). The optimal policy in the case in which information is not fully revealed is similar to theirs.

Since we add bank runs to an economy with asymmetric information, we also build on the large literature started by Diamond and Dybvig (1983). Several recent papers study specifically the tradeoffs involved in revealing information about banks. Goldstein and Leitner (2013) focus on the trade-off between a market breakdown due to asymmetric information and 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 play an important role in Allen and Gale (2000). Parlato Siritto (2013) studies a Diamond and Dybvig (1983) type economy with aggregate risk in which more precise information about realizations of the aggregate state can lead to more bank runs. A simple way to think about disclosure in models of bank runs is to view disclosure as a way to break pooling equilibria. Whether disclosure is good or bad then simply depends on whether the pooling equilibria is desirable. If agents pool on the “no run” equilibrium then there is no reason to disclose information. And of course this is more likely to happen in good times as long as we consider “refined” equilibria à la Carlsson and van Damme (1993) and Morris and Shin (2000), where fundamentals matter. On the other hand, in bad times, agents might run on all the banks, in which case it is better to disclose information to save at least the good banks.

This is the basic result of Bouvard, Chaigneau, and de Motta (2012), who also consider ex-ante disclosure rules that allow pooling across macroeconomic states. Gorton and Metrick (2012) investigate how uncertainty about bank insolvency (and, implicitly, the quality of bank portfolios) leads to increases in repo haircuts that, along with declining asset values, cause several institutions to become insolvent. Shapiro and Skeie (2013) study reputation concerns by a regulator in an environment characterized by a trade-off between moral hazard and runs. None of these papers model new lending and borrowing by banks and therefore cannot address the trade-off between unfreezing credit markets and triggering bank runs. 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. In our model, it is optimal to disclose starting with bad types. This is consistent with what 19th century clearing houses did to contain financial panics, and also with current regulatory practice. (Gorton, 2012)

Our paper relates to the theoretical literature on bank bailouts. Gorton and Huang (2004) argue that the government can bail out banks in distress because it can provide liquidity more effectively than private investors. Diamond and Rajan (2005) show that bank bailouts can backfire by increasing the demand for liquidity and causing further insolvency. Diamond (2001) emphasizes that governments should only bail out the banks that have specialized knowledge about their borrowers. Aghion, Bolton, and Fries (1999) show that bailouts can be designed so as not to distort ex-ante lending incentives. Farhi and Tirole (2012) examine bailouts in a setting in which private leverage choices exhibit strategic complementarities due to the monetary policy reaction. Corbett and Mitchell (2000) discuss the importance of reputation in a setting where a bank's decision to participate in a government intervention is a signal about asset values, and Philippon and Skreta (2012) formally analyze optimal interventions when outside options are endogenous and information-sensitive. Mitchell (2001) analyzes interventions when there is both hidden actions and hidden information. Landier and Ueda (2009) provide an overview of policy options for bank restructuring. Philippon and Schnabl (2013) focus on debt overhang in the financial sector. Diamond and Rajan (2012) study the interaction of debt overhang with trading and liquidity. In their model, the reluctance to sell assets leads to a collapse in trading which increases the risks of a liquidity crisis.

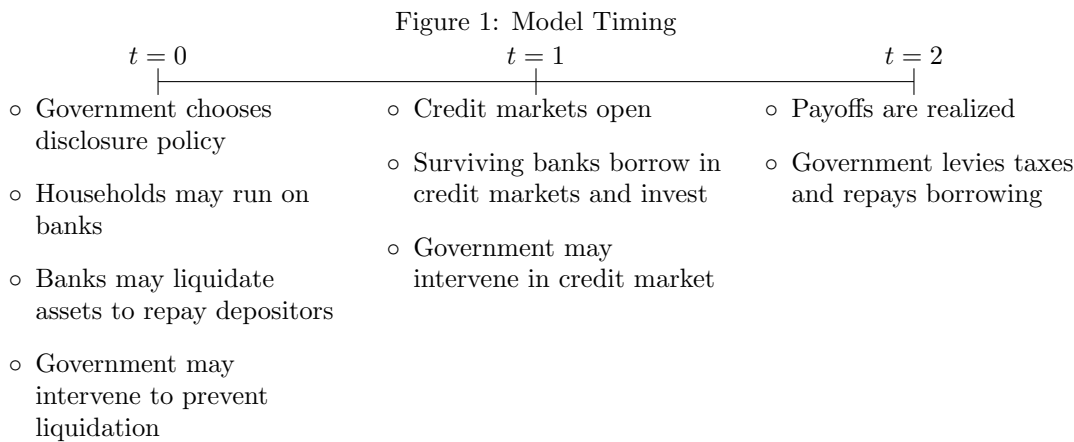
Goldstein and Sapra (2014) review the literature on the disclosure of stress tests results. They explain that stress tests differ from usual bank examinations in four ways: (i) traditional exams are backward looking, while stress tests project future losses; (ii) the projections under adverse scenarios provide information about tail risks; (iii) stress tests use common standards and assumptions, making the results more comparable across banks; (iv) unlike traditional exams that are kept confidential, stress tests results are publicly disclosed. They list two benefits of disclosure: (i) enhanced market discipline; (ii) enhanced supervisory discipline. Our model is based on another benefit, namely the unfreezing of the credit market. They list four costs of disclosure: (i) disclosure might prevent risk sharing through Hirshleifer (1971)'s effect, which is the focus of Goldstein and Leitner (2013); (ii) improving market discipline is not necessarily good for ex-ante incentives; (iii) disclosure might trigger runs; (iv) disclosure might reduce the ability of regulators to learn from market prices, as in Bond, Goldstein, and Prescott (2010). Our

model is based on cost (iii).

3 Model

3.1 Technology and Preferences

The economy is populated by a continuum of households, a continuum mass 1 of financial intermediaries (banks), and a government. There are three dates, $t = 0, 1, 2$. Figure 1 summarizes the timing of decisions in the model, which are explained in detail below.



Households Households are risk-neutral and their utility depends only on consumption at $t = 2$. At periods 0 and 1 they have access to a storage technology that pays one unit of consumption at time 2 per unit invested. There is no discounting. This allows us to treat total output at time 2 (which equals total consumption) as the measure of welfare that the government seeks to maximize.

Banks Banks are indexed by $j \in [0, 1]$ and may be of either good (g) or bad (b) type. A bank's type is private information, but agents in the economy have common beliefs about the probability s_j that a bank j is of good type, for $j \in [0, 1]$.³ The distribution of these beliefs in the population is summarized by the distribution function $F(s)$, with $\mathbb{E}[s] = \bar{s}$. We assume that \bar{s} is also the true (physical) fraction of good banks in the economy and is known to all agents.

Banks start with existing assets and liabilities, which can be thought of as any type of short-term demand liabilities (demand deposits, money market funds, repo, etc.), but which we refer to as deposits for simplicity. Legacy assets deliver a payoff $a = A^i$ for $i \in \{g, b\}$ at $t = 2$. The short-term demand liabilities entitle a depositor to $D > 1$ at $t = 2$ or their face value of 1 if withdrawn earlier. We impose the following ordering

³To economize on language we will refer to "the belief that agents have about bank j " as "bank j 's belief".

Assumption 1 *Good banks are fundamentally safe, bad banks are fundamentally risky.*

$$A^g > D > A^b > 0,$$

This assumption implies that legacy assets of good banks are large enough to cover liabilities, but those of bad banks are not. Demand deposits are senior to any other claims on the bank, and may be withdrawn at any time. This induces a maturity mismatch problem, and makes banks vulnerable to runs.

At $t = 0$, before credit markets open, banks have access to a liquidation technology that yields $\delta \in [0, 1]$ units of the consumption good per unit of asset liquidated. The liquidation value of assets is δA^i for $i \in \{g, b\}$. In the event of a run, banks use this liquidation technology to meet depositors' demand for funds.

At $t = 1$, banks receive investment opportunities. All new investments cost the same fixed amount k and deliver random income v at $t = 2$, which does not depend on the type. Investment income is $v = V$ with probability q and 0 with probability $1 - q$.

3.1.1 Government

The government in our model has access to three policies: a *disclosure* technology (via an asset quality review, for instance)⁴ that can reveal information about a bank's type, and two types of *fiscal intervention*. The government can provide deposit insurance to prevent runs on banks, and it can provide loans directly to banks in the $t = 1$ credit market (equivalently, provide credit guarantees). To fund these fiscal interventions, the government borrows in international markets at the storage rate. At $t = 2$ borrowing is repaid in full and the government raises distortionary taxes to pay for the costs of programs.

We summarize the information set of the private sector after disclosure by a posterior distribution $H(s)$ of beliefs about banks' types. The advantage of disclosure is that changing beliefs about banks' types may mitigate adverse selection in credit markets; as we explain below, this may come at the cost of triggering costly runs on banks. We assume the disclosure technology is available at $t = 0$.

Fiscal interventions are described in greater detail in section 6. To pay for costs arising from fiscal interventions, the government levies distortionary taxes at $t = 2$. We assume that the deadweight costs of taxation are quadratic and scaled by a parameter γ . Denoting by Ψ the costs of fiscal interventions, the total welfare loss from taxation is $\gamma\Psi^2$.

3.1.2 Runs on Deposits at $t = 0$

Demand depositors can withdraw their deposits from banks $t = 0$. Before $t = 2$, when asset payoffs are realized, banks have to liquidate assets in order to pay depositors that withdraw using an inefficient liquidation technology

⁴Note that without aggregate uncertainty there is no meaningful distinction between a stress test and an asset quality review.

that yields δA^i per unit of asset liquidated. To simplify the analysis, we assume that banks that make use of this technology lose the investment opportunity at $t = 1$.

We denote by λ the fraction of assets that is liquidated and x the fraction of depositors in a given bank that run. If a fraction λ of a bank's assets are liquidated, the bank generates $\lambda \delta A^i$ at $t = 0$ and $(1 - \lambda)A^i$ at $t = 2$.

We assume that, under a full run, good banks are safe and bad banks are not

Assumption 2 *Good banks are safe even under a full run, bad banks are not*

$$\delta A^g > 1, \quad \delta A^b < 1$$

Consider the decision problem of a depositor in a bank that is known to be good. Withdrawing early yields 1 with certainty even if every other depositor runs. Waiting yields the minimum of the promised payment D and a pro-rata share of the residual value of the bank:

$$\min \left(D, \frac{(1 - \lambda)A^g}{1 - x} \right)$$

When a full run occurs $x = 1$ and $\lambda = \frac{1}{\delta A^g} < 1$, so the above expression is always equal to D . The implication is that even if every other depositor runs, a depositor prefers to wait because $D > 1$, so the unique equilibrium for a bank known to be good is no run, $x = 0$ and $\lambda = 0$.

For bad banks, because $\delta A^b < 1$, when $x = 1$, $\lambda = 1$ and the payoff to waiting is 0, so a full run is an equilibrium.

Since the type of a bank is private information, the run decision is a function of the belief about the quality of a bank. The above logic means that if $s_j = 1$, no run is the only equilibrium and for $s_j = 0$, a full run is an equilibrium. What if $s_j \in (0, 1)$? We first derive a threshold belief s^R above which no run is the unique equilibrium. This threshold must be such that depositors with this belief are indifferent between running and waiting even if every other depositor runs. This indifference condition is

$$s + (1 - s) \delta A^b = sD$$

Rearranging,

$$s^R = \frac{\delta A^b}{D + \delta A^b - 1}$$

For beliefs in the set $[0, s^R]$ multiple equilibria exist. We follow a common approach in the literature on equilibrium selection in models of bank runs (for example, Cooper and Ross (1998), Ennis and Keister (2007)) and use the realization of an exogenous sunspot variable as an equilibrium selection device. Let $\sigma \sim F$ with support $[0, 1]$ be a random variable that defines a class s^σ given by

$$s^\sigma = \sigma s^R \tag{1}$$

such that all banks with beliefs $s_j < s^\sigma$ suffer a full run and banks above this cutoff are spared from runs.

3.1.3 Borrowing Contracts at $t = 1$

At $t = 1$, banks do not have any cash and need to borrow l to take advantage of the investment opportunity. As is standard in the security design and corporate finance literature, we assume that only total income at time 2, $y = a + v$ is contractible

$$y(i) = a + i \cdot v$$

where $i = 1$ if the bank invests and $i = 0$ otherwise. The amount that banks need to borrow to invest is $l = k \cdot i$. This new borrowing is junior to deposits. Letting r denote the (gross) interest rate between periods 1 and 2, we have the following payoffs for long term debt holders (depositors), new lenders (at $t = 1$) and equity holders, respectively

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

Finally, we assume that new projects have positive NPV, and that households receive an endowment ω at time 1 that is enough to sustain full investment.

Assumption 4 *The investment project has positive NPV*

$$\mathbb{E}[v] > k$$

Assumption 5 *Full investment is feasible*

$$\omega > k$$

4 Equilibrium

In this section, we look at the credit market equilibrium at $t = 1$, which may feature adverse selection. We then proceed to describe first-best welfare, as well as welfare that results from the decentralized equilibrium without any sort of intervention.

4.1 Equilibrium at time 1

At $t = 1$, all banks with the belief s_j have the opportunity to borrow from a competitive and anonymous credit market.⁵ The equilibrium is characterized by a threshold belief s^I such that good banks with a lower belief do not participate in the credit market due to adverse selection, and all banks with higher beliefs borrow and invest.

Good banks find it profitable to to borrow at rate r and invest if and only if⁶

$$A^g - D + qV - rk \geq A^g - D$$

This constraint implies a maximum interest rate r^g above which good banks do not participate in the credit market:

$$r \leq r^g \equiv \frac{qV}{k} \quad (2)$$

Similarly, bad banks earn $q(V - D + A^b - rk)$ if they invest, and 0 otherwise (since their assets are insufficient to repay senior depositors, in case of no investment or project failure), so they invest if and only

$$q(V - D + A^b - rk) \geq 0$$

This implies:

$$V - D + A^b \geq rk,$$

So if the equilibrium interest rate is such that bad banks find it profitable to invest, junior investors are repaid only if the project succeeds, which happens with probability q . Since the outside option for junior investors is zero net return storage, the rate of return on the junior debt of bad banks is q^{-1} .

Our interest is in studying situations where the information asymmetry in this economy induces adverse selection in the $t = 1$ credit market, creating a role for government interventions via information disclosure or credit market policies (as in Philippon and Skreta (2012)). This requires that the fair interest rate when only bad types invest, q^{-1} , exceeds the maximum interest rate at which good types are willing to invest, which is equivalent to imposing $q \leq \sqrt{\frac{k}{V}}$. Since the liabilities of bad banks are risky in our model it may be the case that, even in the absence of asymmetric information, underinvestment (by bad banks instead of good banks) occurs in equilibrium due a debt overhang problem as in Philippon and Schnabl (2013). For most of the paper we ensure that this is not the case by imposing $q \geq \frac{k}{V - (D - A^b)}$.

⁵The credit market is competitive and anonymous for each s_j ; lenders can differentiate between banks with different beliefs, which can be thought of as accessing different credit markets.

⁶We assume that A^g is large enough that the junior debt taken on by good banks to finance the investment opportunity is safe: $A^g - D > rk$.

Assumption 6 *The equilibrium (without government intervention) of the $t = 1$ credit market features adverse selection but no debt overhang.*

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

Note that $r = q^{-1}$ and $i(g) = 0$ is always a possible equilibrium of the credit market: equilibrium multiplicity is a feature of these models. We rule this out by assuming that, in case multiple equilibria exist, the best pooling equilibrium is selected.⁷

If both good and bad types invest for a certain belief s_j , the interest rate must satisfy the break-even condition for lenders

$$k = s_j r_j k + (1 - s_j) q r_j k$$

yielding

$$r_j = \frac{1}{s_j + (1 - s_j) q}$$

Note that for good types to invest, the interest rate must satisfy equation (2). Equating good banks' participation constraint with lenders' break-even constraint we can define a threshold posterior s^I such that above this threshold all banks invest and below it only bad banks do so:

$$s^I = \frac{\frac{k}{qV} - q}{1 - q} \quad (3)$$

To summarize, the credit market equilibrium can be characterized as

- For banks with $s_j < s^I$, only bad types invest and the interest rate is $r_j = \frac{1}{q}$
- If $s_j > s^I$, both good and bad types invest and the interest rate is $r_j = \frac{1}{s_j + (1 - s_j) q}$

4.2 Welfare at time 2

At period 2, payoffs from long-term assets, investment, deposits and storage are realized. The government repays its $t = 0, 1$ borrowing by levying distortionary taxes that entail a real resource cost.

Recall that all banks with $s \geq s^I$, as defined in equation (3) invest regardless of their type, and all banks with $s < s^\sigma$, as defined in equation (1) suffer a bank run. If $s^\sigma \geq s^I$, then all banks that are potentially subject to adverse selection suffer a run – bank runs effectively clean the market from adverse selection. To prevent this from occurring, and to make the problem interesting, we make the following assumption

Assumption 7 *The threshold for bank runs is strictly smaller than the threshold for full investment.*

⁷When we consider credit market interventions, this assumption is without loss of generality because the government would always be able to costlessly implement the best pooling by setting the interest rate appropriately.

$$s^\sigma \leq s^R < s^I$$

$$\frac{\delta A^b}{D + \delta A^b - 1} \leq \frac{\frac{k}{qV} - q}{1 - q}$$

Since we assume that households are risk-neutral, aggregate welfare coincides with aggregate output. Given a sunspot σ and government intervention Ψ , welfare is

$$\begin{aligned}
W(\sigma, \Psi) &= \omega + \int_{s^I}^1 [sA^g + (1-s)A^b + qV - k] dH(s) \\
&\quad + \int_{s^\sigma}^{s^I} [sA^g + (1-s)A^b + (1-s)(qV - k)] dH(s) \\
&\quad + \int_0^{s^\sigma} \delta [sA^g + (1-s)A^b] dH(s) \\
&\quad - \gamma \Psi^2
\end{aligned} \tag{4}$$

The first term is households' period 1 endowment. The second term corresponds to the total output generated by banks that do not suffer a run or adverse selection in the credit market. The third term corresponds to the output of banks that do not suffer a run but face suboptimally low investment due to adverse selection, and the fourth term is the value in liquidation of the assets of banks that suffer full runs. The final term is the deadweight loss of taxation.

4.2.1 First-Best Welfare

New projects have positive net present value, bank runs entail costly asset liquidation and taxation is distortionary. This means that in the first-best equilibrium, every bank invests and there is no distortionary taxation. First-best welfare is then

$$W^{FB} = \omega + \bar{s}A^g + (1 - \bar{s})A^b + qV - k \tag{5}$$

Proposition 1 summarizes the equilibrium of the model without government intervention.

Proposition 1. *With no government intervention, the private equilibrium is characterized by a distribution of beliefs $F(s)$ and threshold beliefs s^σ and s^I such that:*

1. *All banks j with beliefs $s_j < s^\sigma$ suffer full runs, liquidate their assets and do not invest at $t = 1$,*
2. *All banks with beliefs $s_j \in [s^\sigma, s^I)$ are spared from runs, but good banks with beliefs in this range do not invest in the new project due to adverse selection,*
3. *All banks with beliefs $s_j \in [s^I, 1]$ borrow and invest in the new project.*

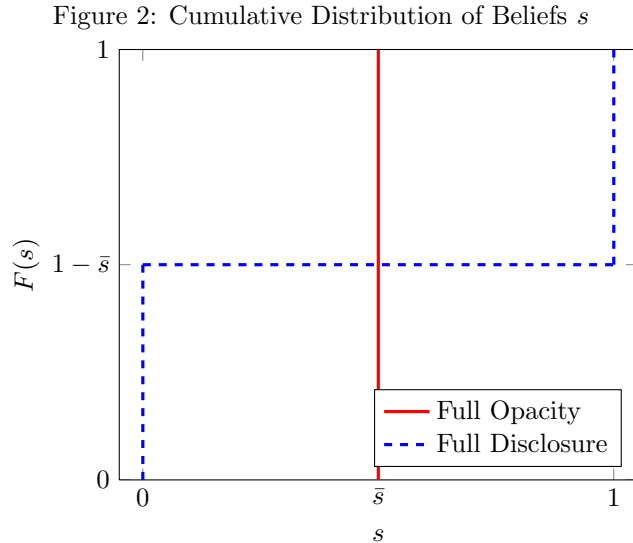
Welfare is described by equation (4).

5 Disclosure

The government might find it optimal to disclose information about banks' quality, since reducing information asymmetries can mitigate adverse selection. Disclosure, however causes bank runs, and the net gains from this policy depend on the balance between the benefits of increasing investment and the costs of banks runs.

We model disclosure as the choice of a posterior distribution of beliefs $H(s)$. Specifically, since s is a proportion, it is convenient to work with Beta distributions. We characterize the prior $F(s)$ as a beta distribution with shape parameters α_0 and β_0 and the posterior as having shape parameters α_1 and β_1 .

It is useful to characterize the full transparency and opacity benchmarks in our model. Agents in our model have a belief s_j associated with each bank j . When information is perfect investors know exactly which banks are good ($s_j = 1$) and which ones are bad, so $s_j = \{0, 1\} \forall j$. In this case, the PDF $f(s)$ has mass only at 0 and 1. In particular, $F(0) = 1 - \bar{s}$, the mass of bad banks (and $F(1) - F(0) = \bar{s}$, the mass of good banks). In contrast, the maximum opacity benchmark is the situation where good and bad banks appear identical to outsiders. This situation is described by $s_j = \bar{s} \forall j$. The PDF of s is therefore a mass point at \bar{s} . Restricting attention only to beta distributions with a single shape parameter $d = \alpha = \beta$, the full information benchmark is achieved as $d \rightarrow 0$ and full opacity as $d \rightarrow \infty$ (note that the one parameter beta always has mean 0.5, and we set $\bar{s} = 0.5$ with no loss of generality). The two informational extremes of our model are plotted in Figure 2.



We impose an additional restriction on the government's choice of posterior distribution. In the model without aggregate uncertainty, the mass of good banks in the economy is \bar{s} (the mean of the prior belief distribution), which is known to all agents. Since the government's disclosure policy simply improves the information agents have about individual banks, it cannot affect agents' beliefs about the mass of good banks in the economy as a whole, so it must be the case that the posterior distribution has the same mean as the prior.⁸

⁸In other words, agents in our model are fully Bayesian: since the physical fraction of good banks is known, they would fully disregard

Following the above logic, disclosure in our model has a simple geometric interpretation: through its choice of disclosure the government can reallocate mass (area below the curve) from the region $[s_R, s_I]$ into $[0, s^R]$ and $[s^I, 1]$. Without the restriction that the average belief under the posterior must equal \bar{s} , the government would optimally put all the mass at or above s^I , since this would eliminate runs and undo adverse selection. However in our model the government must trade off improving some banks' beliefs and worsening others'.

The government's disclosure problem is

$$\begin{aligned} \max_{d_1 < d_0} W(\sigma, 0) &= \omega + \int_{s^I}^1 [sA^g + (1-s)A^b + qV - k] dH(s) \\ &+ \int_{s^\sigma}^{s^I} [sA^g + (1-s)A^b + (1-s)(qV - k)] dH(s) \\ &+ \int_0^{s^\sigma} \delta [sA^g + (1-s)A^b] dH(s) \end{aligned} \quad (6)$$

Where $H(s)$ is Beta(d_1, d_1) and $F(s)$ is Beta(d_0, d_0) (since the prior and posterior are one parameter beta distributions, $\bar{s} = 0.5$ in both cases).

Figure 3 provides an example of the effect on the magnitude of runs, adverse selection and welfare of the government's choice of d_1 , as well as the posterior distribution for different values of d_1 . As disclosure increases, the proportion of banks that suffer runs increases and the proportion of banks in the adverse selection region decreases. The proportion of banks that suffer runs as a function of disclosure depends on the level of σ , and consequently so does welfare. Recalling that $s^\sigma = \sigma s^R$, lower values of σ imply a smaller mass of banks are run on for any level of disclosure, and hence reduce the costs of disclosure. Since the benefits of disclosure do not depend on σ , lower σ implies that a lower d_1 (higher disclosure) is optimal, as shown in the top left panel of Figure 3. The bottom right panel plots the PDF of the Beta(d, d) distribution for three values of d , and the thresholds s^I and s^R for the chosen parametrization.

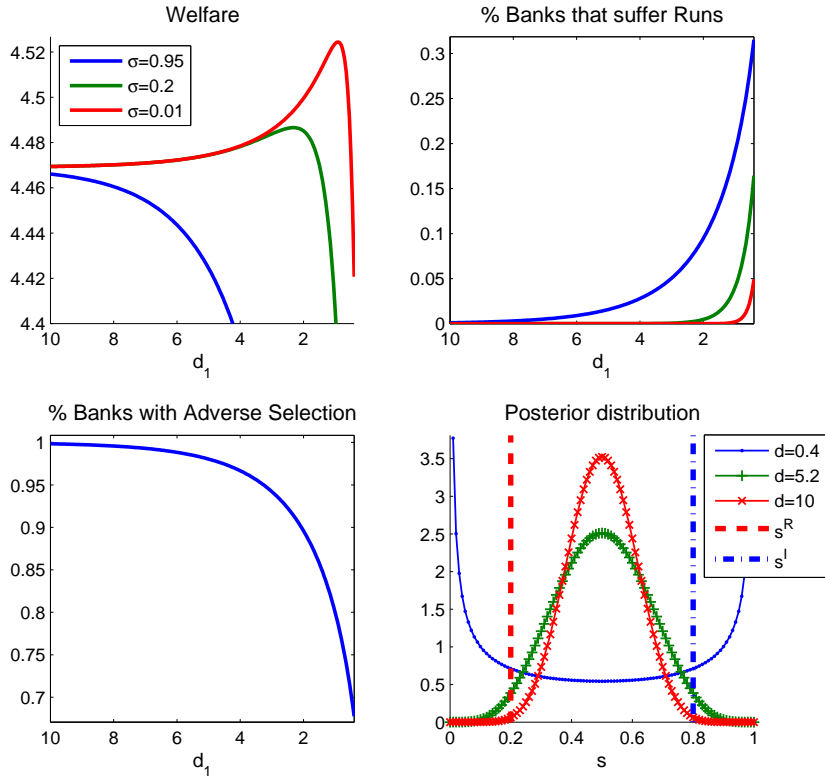
6 Fiscal Interventions

In this section, we describe in greater detail the fiscal interventions that the government can use to mitigate adverse selection and bank runs. We start by analyzing pure fiscal interventions in the absence of any sort of information disclosure. We then proceed by combining the two types of policies.

6.1 Credit Bailout: Optimal Intervention to Unfreeze Credit Market without Disclosure

In the region where banks do not suffer runs, but in which there is underinvestment due to adverse selection, $s_j \in [s^\sigma, s^I]$, the government can promote full investment by offering a credit subsidy to banks. This consists in any new information that would set this fraction to a number different than \bar{s} .

Figure 3: Disclosure Policy



The first three panels plot several endogenous variables as a function of the level of disclosure, d_1 , for three possible values of $s^\sigma = \sigma s^R$. The first panel plots the government's objective function as in eq. (6); the second panel plots the measure of banks that suffer a run, or $H(s^\sigma)$; the third panel plots the measure of banks that suffer adverse selection, or $H(s^I) - H(s^\sigma)$; the fourth panel plots the posterior PDF $h(s)$ for different levels of d_1 , as well as the relative positions of s^R, s^I .

setting the interest rate $r_j = r^g = \frac{qV}{k}$, so that good banks which would otherwise not do so are willing to invest. For any bank with belief s_j , the policy consists of either setting $r_j = r^g$ or doing nothing, since (as explained below) setting $r \in \left(r^g, \frac{1}{q}\right]$ is costly on average for the government and does not contribute to mitigating adverse selection. Setting $r_j < \frac{qV}{k}$ is also costly and cannot increase investment further.

For a particular class of banks with belief $s_j = s$, the cost of implementing the program is

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

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

$$s(qV - k)$$

Note that the benefit is increasing in s , while the costs are decreasing in s . Alternatively, the benefits are decreasing in $1 - s$ and the costs increasing in $1 - s$. This implies that the government will adopt a threshold rule s^k , implementing the program for all banks with beliefs in the set $[s^k, s^I]$. The total cost of such a program is

$$\Psi^k = \int_{\max(s^k, s^\sigma)}^{s^I} [k - qV(q(1 - s) + s)] dF(s)$$

And the welfare of implementing a given threshold s^k is

$$\begin{aligned} W(\sigma, \Psi^k) &= \omega + \int_{\max(s^k, s^\sigma)}^1 [sA^g + (1 - s)A^b + qV - k] dF(s) \\ &+ \int_{\min(s^k, s^\sigma)}^{s^k} [sA^g + (1 - s)A^b + (1 - s)(qV - k)] dF(s) \\ &+ \int_0^{s^\sigma} \delta [sA^g + (1 - s)A^b] dF(s) - \gamma(\Psi^k)^2 \end{aligned} \quad (7)$$

The government solves the problem

$$\max_{s^k} W(\sigma, \Psi^k)$$

And the following first order condition yields the threshold s^k

$$s^k (qV - k) = 2\gamma\Psi^k [k - qV(s^k + q * (1 - s^k))]$$

If $s^k < s^\sigma$, the government offers credit guarantees to banks in $[s^\sigma, s^I]$ – interventions below s^σ are ineffective since banks with belief $s_j < s^\sigma$ suffer full runs and lose the investment opportunity.

6.2 Deposit Guarantees

The government may also intervene to prevent liquidation by banks that are susceptible to runs (those with beliefs in $[0, s^\sigma]$). Preventing runs on these banks is desirable both because liquidation is costly in itself, and also because banks that are run on are unable to invest at $t = 1$.

To prevent runs, the government announces deposit guarantees for banks in a belief class s . These guarantees work as follows: the government guarantees to repay depositors of all banks in class s the contractual deposit amount D at $t = 2$. With probability ρ , the guarantee is ineffective, as the bank liquidates its assets, but the government still has to pay D at $t = 2$. With probability $1 - \rho$, the guarantee succeeds and the government prevents bank asset liquidation. In either case, the government effectively purchases the deposit contract: it commits to pay D to the depositors, and demands D from the bank. As before, some banks may be unable to repay their senior debt, in which case the program is costly for the government.

The cost of guaranteeing deposits for class s is then

$$\begin{aligned} \text{effective :} & \quad (1 - \rho)[D - sD - (1 - s)[qD + (1 - q)A^b]] \\ \text{ineffective :} & \quad +\rho[D - s \min(D, \delta A^g) - (1 - s)\delta A^b] \end{aligned}$$

If the guarantee is effective, the government pays D to depositors and, with probability s the bank is good in which case the program breaks even (since good banks can always repay D if they are not liquidated), while with probability $1 - s$ the bank is bad and is only able to repay with probability q (recall that bad banks always invest). If the guarantee is ineffective, the government still has to repay D ; if the bank is good, the government is able to recover $\min(D, \delta A^g)$, while if the bank is bad, the government only recovers $\delta A^b < A^b < D$. This establishes that, for any s , the costs for this program are always non-negative. Furthermore, the costs are decreasing in s , or increasing in $1 - s$, meaning that classes with lower s are more expensive to save.

The net benefit of guaranteeing class s , on the other hand, is

$$(1 - \rho)[(1 - \delta)(sA^g + (1 - s)A^b + (1 - s)(qV - k)]$$

where we use the fact that $s^R \leq s^I$, so any class that suffers a run is potentially subject to adverse selection. We make the following technical assumption that ensures that benefits are increasing in s , or decreasing in $1 - s$,

Assumption 8 *Marginal benefits of saving class s are increasing in the belief over the class s*

$$(1 - \delta)(A^g - A^b) \geq qV - k$$

Since costs are increasing, and benefits are decreasing in $1 - s$, it is optimal for the government to adopt a

threshold policy s^d such that all banks with $[s^d, s^\sigma]$ are supported by the deposit guarantee program and potentially saved from a run.

The total cost of the deposit guarantee policy is

$$\Psi^d = \int_{s^d}^{s^\sigma} (1 - \rho) (1 - q) (1 - s) (D - A^b) + \rho (s \max(D - \delta A^g, 0) + (1 - s) (D - \delta A^b)) \, dF(s)$$

The first term under the integral is the cost of a successful guarantee - in this case, only guarantees of bad banks are costly. If the guarantee fails, however, guaranteeing a good bank may also be costly if $\delta A^g < D$ (if the opposite is true, we assume the bank's owners are entitled to the residual value in liquidation).

Welfare with the deposit guarantee is

$$W(\sigma, \Psi^d) = \omega + \int_{s^l}^1 [sA^g + (1 - s)A^b + qV - k] \, dF(s) \quad (8)$$

$$+ \int_{s^\sigma}^{s^l} [sA^g + (1 - s)A^b + (1 - s)(qV - k)] \, dF(s) \quad (9)$$

$$+ \int_{s^d}^{s^\sigma} (1 - \rho) [sA^g + (1 - s)A^b + (1 - s)(qV - k)] + \rho \delta [sA^g + (1 - s)A^b] \, dF(s) \quad (10)$$

$$+ \int_0^{s^d} \delta [sA^g + (1 - s)A^b] \, dF(s) - \gamma(\Psi^d)^2 \quad (11)$$

where the first term is the endowment; the second term is the surplus generated by banks that do not suffer adverse selection and are not subject to runs; the second line is surplus generated by banks that do not suffer runs, but are subject to adverse selection; the third line is the surplus generated by banks that are supported by the deposit guarantee program; while the final line is the surplus from non-supported banks and costs of intervention.

The government solves,

$$\max_{s^d} W(\sigma, \Psi^d)$$

The solution to this problem characterizes the optimal deposit insurance as a threshold s^d . The first-order condition is

$$\begin{aligned} & (1 - \rho)[(1 - \delta)(s^d A^g + (1 - s^d)A^b) + (1 - s^d)(qV - k)] \\ & = 2\gamma\Psi^d[(1 - \rho)(1 - q)(1 - s^d)(D - A^b) + \rho(s^d \max(D - \delta A^g, 0) + (1 - s^d)(D - \delta A^b))] \end{aligned}$$

Due to increasing marginal costs and decreasing marginal benefits, a solution exists $s^d \in [0, s^\sigma]$.

6.3 Combining deposit insurance and credit guarantees

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

$$W(\sigma, \Psi^{d+k}) = \omega + \mathcal{A}(s^\sigma, s^d) + \mathcal{I}(s^\sigma, s^k, s^d) - \gamma(\Psi^{d+k})^2 \quad (12)$$

where $\mathcal{A}(s^\sigma, s^d)$ is the welfare component that pertains to surplus generated by assets and liquidation

$$\begin{aligned} \mathcal{A}(s^\sigma, s^d) &= \int_{s^\sigma}^1 [sA^g + (1-s)A^b] dF(s) \\ &+ \int_{s^d}^{s^\sigma} [1 - \rho(1 - \delta)][sA^g + (1-s)A^b] dF(s) \\ &+ \int_0^{\min(s^d, s^\sigma)} \delta[sA^g + (1-s)A^b] dF(s) \end{aligned}$$

the first line corresponds to asset surplus generated by banks that suffer no run; the second line is asset surplus for banks supported by the deposit guarantee program; and the third line is the surplus generated by unsupported banks that suffer a run. $\mathcal{I}(s^\sigma, s^k, s^d)$ is the welfare component related to surplus generated by investment

$$\begin{aligned} \mathcal{I}(s^\sigma, s^k, s^d) &= \int_{\max(s^k, s^\sigma)}^1 (qV - k) dF(s) \\ &+ \int_{\min(s^k, s^\sigma)}^{s^k} (1-s)(qV - k) dF(s) \\ &+ \int_{\max(s^k, s^d)}^{s^\sigma} (1-\rho)(qV - k) dF(s) \\ &+ \int_{s^d}^{\min(s^k, s^\sigma)} (1-s)(1-\rho)(qV - k) dF(s) \end{aligned}$$

the first line is investment by classes that suffer no adverse selection and no run; the second line is investment by classes that suffer adverse selection and no run; the third line is investment by classes that are supported by the deposit guarantee and face no adverse selection; the fourth line is investment by classes that are supported by the deposit guarantee and face adverse selection. Finally, total costs of intervention are given by

$$\begin{aligned} \Psi^{d+k} &= \int_{s^d}^{s^\sigma} (1-\rho)(1-q)(1-s)(D - A^b) + \rho(s \max(D - \delta A^g, 0) + (1-s)(D - \delta A^b)) dF(s) \quad (13) \\ &+ \int_{\max(s^k, s^\sigma)}^{s^I} [k - qV(q(1-s) + s)] dF(s) \\ &+ \int_{s^k}^{s^\sigma} (1-\rho)[k - qV(q(1-s) + s)] dF(s) \end{aligned}$$

where the first term is the cost of the deposit guarantee; the second line is the cost of the credit program for banks that are not supported by the deposit guarantee; and the third line is the cost of the credit program for banks that are also supported by the deposit guarantee.

The optimal fiscal policy is the solution to

$$\max_{s^d, s^k} W(\sigma, \Psi^{d+k})$$

The first-order conditions for the government are, for s^d

$$\begin{aligned} & \mathbf{1}[s^d \leq s^\sigma] 2\gamma \Psi^{d+k} [(1-\rho)(1-q)(1-s^d)(D-A^b) + \rho(s^d \max(D-\delta A^g, 0) + (1-s^d)(D-\delta A^b))] \\ & = \mathbf{1}[s^d \leq s^\sigma] (1-\rho) \{ (1-\delta)(s^d A^g + (1-s^d)A^b) + (1-s^d \mathbf{1}[s^d \leq s^k]) (qV-k) \} \end{aligned}$$

and for s^k

$$\begin{aligned} & [\mathbf{1}[s^k \geq s^\sigma] + (1-\rho)\mathbf{1}[s^d \leq s^k \leq s^\sigma]] 2\gamma \Psi^{d+k} [k - qV(q(1-s^k) + s^k)] \\ & = [\mathbf{1}[s^k \geq s^\sigma] + (1-\rho)\mathbf{1}[s^d \leq s^k \leq s^\sigma]] (qV-k) s^k \end{aligned}$$

The government never finds it optimal to set $s^d > s^k$, and setting $s^d > s^\sigma$ is weakly dominated. We can then write the first-order conditions in a simpler form, as

$$\begin{aligned} 2\gamma \Psi^{d+k} (1-q)(1-s^d)(D-A^b) & = (1-\rho) [(1-\delta)(s^d A^g + (1-s^d)A^b) + (1-s^d)(qV-k)] \\ 2\gamma \Psi^{d+k} [k - qV(q(1-s^k) + s^k)] & = (qV-k) s^k \end{aligned}$$

where Ψ^{d+k} is given in equation (13). The above system can then be solved for the two unknowns (s^d, s^k) .

6.4 Disclosure Choice with Fiscal Capacity

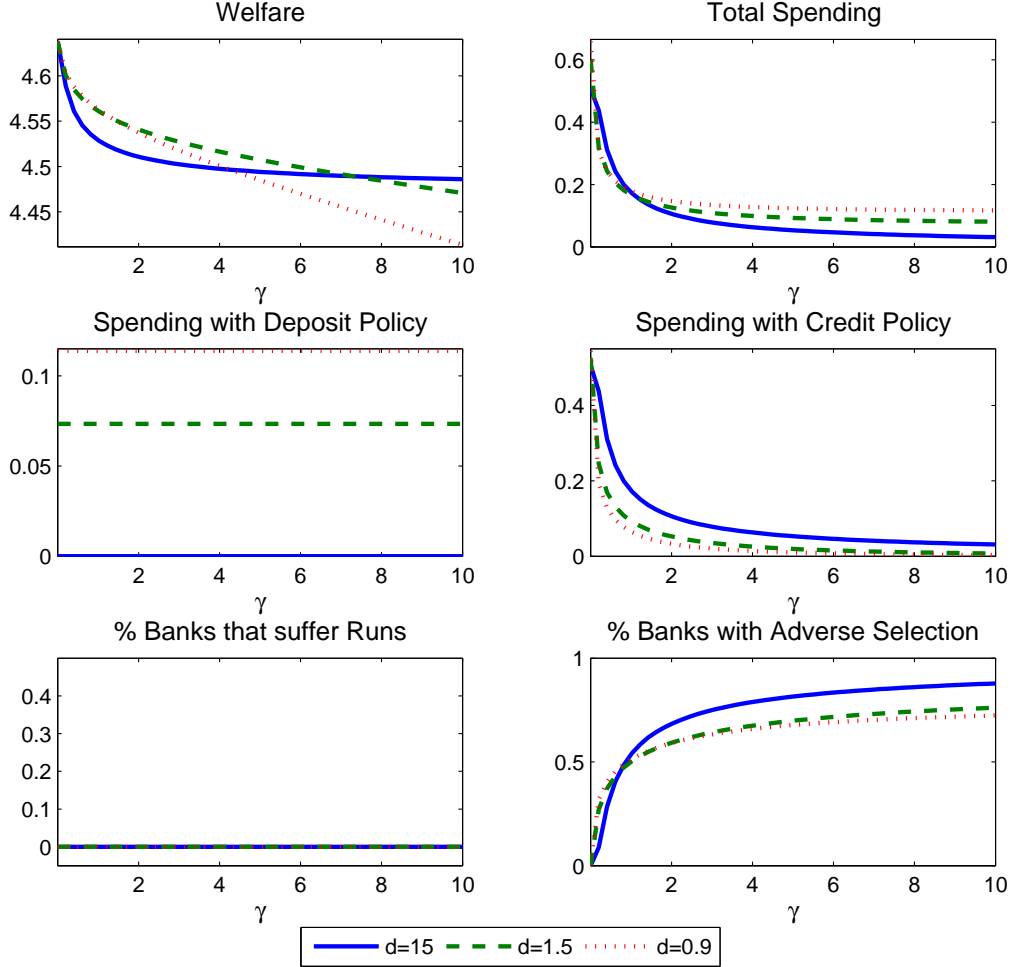
Finally, we consider the equilibrium with intervention when the government has access to disclosure and both fiscal policies. In addition to the thresholds s^d and s^k the government also chooses posterior beliefs. As described above, we model disclosure as a choice of a single parameter of a beta distribution. Formally, the government solves

$$\max_{s^d, s^k, d_1: d_1 < d_0} W(\sigma, \Psi^{d+k})$$

Where the welfare function is the one in equation 12 and the posterior $H(s) = \text{Beta}(d_1, d_1)$. Figure 4 illustrates the combinations of fiscal policies and disclosure that the government selects when both types of policies are available as a function of fiscal capacity γ . The lines represents different levels of disclosure: low ($d = 10$), intermediate ($d = 1.5$) and high ($d = 0.9$). For the chosen parameterization and the range of γ plotted, the government optimally prevents all runs using the deposit guarantee policy, as shown in the bottom left panel (as $\gamma \rightarrow \infty$ spending on the deposit policy $\rightarrow 0$). The top left panel plots welfare as a function of γ and disclosure. For all levels of disclosure, at $\gamma = 0$

the first-best welfare is achieved, since the government can freely use policy to prevent runs and adverse selection. As γ increases, the optimal disclosure level decreases: for low γ , the green (dashed) line is above the blue (solid), and the opposite is true for high γ .

Figure 4: Disclosure and Fiscal Policy



This figure plots several variables as a function of fiscal capacity γ , for different levels of disclosure d_1 . For a fixed level of fiscal capacity γ , and disclosure d_1 , the government solves for optimal fiscal interventions (deposit guarantees and credit market interventions). The first panel plots welfare $W(\sigma, \Psi^{d+k})$; the second panel plots total spending Ψ^{d+k} ; the third panel plots spending with the deposit policy Ψ^d ; the fourth panel plots spending with the credit policy Ψ^k ; the fifth panel plots the percentage of banks that suffer runs $H(s^d)$; and the sixth panel plots the measure of banks that suffer adverse selection $H(s^k) - H(s^d)$.

A Parameters used in examples

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

Table 1: Parameterization for Numerical Examples

Parameter	Description	Value
A^g	Good Assets	5
A^b	Bad Asset	3.6
D	Deposits	4.5
V	Project Payoff	7.4
q	Prob. Success	0.35
k	Investment Cost	2.26
δ	Recovery Rate	0.24

A.1 Welfare with Full Disclosure

A.2 Uncertainty about σ

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