

Bailouts and Financial Fragility

Todd Keister

Research and Statistics Group
Federal Reserve Bank of New York

and

Department of Economics
European University Institute

Todd.Keister@ny.frb.org

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Abstract

How does the belief that policy makers will bail out the financial system in the event of a crisis affect individual behavior and economic outcomes? I study this question in a model of financial intermediation with limited commitment. When a crisis occurs, the efficient policy response is to partially “bail out” those investors facing losses, using public resources to augment their private consumption. The anticipation of such a bailout creates a moral hazard problem, however, and leads financial intermediaries to choose ex ante arrangements with excessive illiquidity. A policy that prohibits bailouts would encourage intermediaries to adopt more liquid positions, but may leave the economy more susceptible to self-fulfilling runs. A policy of taxing illiquidity, in contrast, can correct the moral hazard problem without increasing the scope for financial fragility.

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1 Introduction

It is often claimed that government bailouts of the financial system during a crisis serve to plant the seed of future crises. By insulating financial institutions and investors from the full consequences of a negative outcome, bailouts are said to encourage risky behavior and thereby increase the likelihood and/or severity of a future crisis. This moral hazard effect has been discussed at length during the recent financial crisis and has been the basis for sharp criticism of the actions of the public sector in the U.S. and elsewhere. Some observers have argued that the economy would be better off if the government could credibly commit not to undertake such bailouts, since the private sector would then have greater incentive to prepare for adverse outcomes.

The anticipation of a government bailout can also have a stabilizing effect on the financial system, however. Financial crises are often believed to have an important self-fulfilling component, with individual investors each withdrawing funds in part because they fear the withdrawals of others will deepen the crisis and create further losses. The anticipation of a bailout provides these individuals with a form of insurance, since it lessens the potential loss they face if they do not withdraw their funds. As such, bailouts tend to decrease the incentive for individuals to withdraw, which, in turn, tends to make the financial system less susceptible to self-fulfilling crises. Government-sponsored deposit insurance programs, for example, are a type of bailout policy that is explicitly designed to play this stabilizing role.

Given these two competing effects, how does the belief that the government will bail out the financial system in the event of a crisis affect individual behavior and financial fragility? Would it be desirable for policy makers to commit to never bail out financial institutions and their creditors? This paper addresses these questions in a model of financial intermediation and fragility based on the classic paper of Diamond and Dybvig [5]. In particular, I study an environment with idiosyncratic liquidity risk and with limited commitment as in Ennis and Keister [6]. Individuals deposit resources with financial intermediaries, and these resources are invested in a nonstochastic production technology. Intermediaries perform maturity transformation and thereby insure investors against idiosyncratic liquidity risk. This maturity transformation makes an intermediary illiquid and may leave it susceptible to a self-fulfilling run by investors.

Fiscal policy is introduced into this framework by adding a public good that is financed by

taxing households' endowments.¹ In the event of a crisis, some of this tax revenue may be diverted from production of the public good and instead given to the remaining investors in the financial system. The policy maker chooses the size of this “bailout” payment in order to achieve an ex post efficient allocation of the remaining resources in the economy. Intermediaries and investors anticipate this reaction when making ex ante decisions.

I first characterize a benchmark allocation that represents the efficient distribution of resources in this environment *conditional* on investors running on the financial system in some states of the world. I show that this allocation always involves a transfer of public resources to the financial system in those states. In other words, a bailout is part of the *efficient* response to a crisis in this environment. I then compare the equilibrium outcomes of the model under three different policy regimes. In each case, intermediaries act in the best interest of their investors and a benevolent policy maker chooses the tax rate and the size of the bailout payment, if any. Neither intermediaries nor the policy maker can commit to future actions; both will react optimally to whatever situation they face.

The first policy regime corresponds to *laissez faire*; both intermediaries and the policy maker act in an unrestricted fashion. In the event of a crisis, the bailout payments will be chosen to implement the efficient *continuation* allocation, that is, the best allocation of the remaining resources given that a run has occurred. The fact that the policy maker will intervene in this fashion removes the private incentive for intermediaries and investors to prepare for such outcomes. As a result, intermediaries choose to perform more maturity transformation, and hence are more illiquid, than in the benchmark allocation. This excessive illiquidity, in turn, implies that the economy is more fragile in the sense that a self-fulfilling run equilibrium exists for a strictly larger set of parameter values. The moral hazard problem created by the anticipated bailout thus has two negative effects: it distorts the ex ante allocation of resources and increases the scope for financial fragility.

In the second regime, the policy maker is prohibited from providing a bailout payment in any state of the world. This regime can be thought of as a law or constitutional amendment that forbids the use of public funds to aid private investors or their intermediaries. The policy maker still chooses the tax rate optimally, but now all tax revenue will be used to provide the public good.

¹ Diamond and Dybvig [5] studied a form of deposit insurance that was financed by taxing investors after they have withdrawn from their intermediary. Wallace [13] pointed out that such a policy is inconsistent with the underlying assumptions of the model and emphasized that policy makers should be constrained by the same frictions as private agents. The model presented here is entirely consistent with this view, as endowments are taxed before investment takes place.

This policy removes the moral hazard problem described above. In fact, it leads intermediaries to perform *less* maturity transformation than in the benchmark efficient allocation. Despite this fact, the economy remains more fragile than in the benchmark allocation. While the decrease in illiquidity tends to make the financial system more stable, this effect can be more than offset by the loss of the insurance investors receive from the efficient bailout policy. For some economies that are not fragile under the laissez faire regime, a no-bailouts policy actually *introduces* the possibility of self-fulfilling runs. Contrary to the claims of many commentators, there is a well-defined sense in which a commitment to a no-bailouts policy can *increase* the fragility of the financial system.

In the final policy regime, the policy maker places a tax on maturity transformation, which can also be interpreted as a tax on illiquidity. Specifically, intermediaries are required to pay a fee that is proportional to the total value of their short-term liabilities. This fee is paid immediately after deposits are made and before any withdrawals take place. In the event of a crisis, the policy maker follows the ex post optimal bailout policy. I show that for the appropriate choice of tax rate, this policy implements the benchmark efficient allocation. The anticipation of a bailout generates a moral hazard problem, as before, but the tax on maturity transformation can be used to exactly correct this distortion. The policy maker will still provide a bailout in the event of a run, which helps stabilize the financial system by decreasing the incentive for investors to run. As a result, the scope for financial fragility is strictly smaller than in either the laissez faire or the no-bailouts regime.

One of the central messages of the paper is that a bailout in the event of a crisis is often part of the efficient allocation of resources. While the anticipation of a bailout creates a moral hazard problem, a policy of restricting or prohibiting bailouts cannot bring about the efficient allocation of resources and may actually increase financial fragility. In the environment studied here, the efficient policy response is to not restrict bailouts but to correct the moral hazard problem through ex ante taxation or regulation.

There is a large literature in which versions of the Diamond-Dybvig model are used to address issues related to banking policy and financial fragility. This paper follows Green and Lin [9], Peck and Shell [12], Ennis and Keister [7] and other recent work in specifying an explicit sequential service constraint and allowing intermediaries to offer any contract that is consistent with the information flow generated by that constraint. In particular, intermediaries and the policy maker are able to react as soon as they infer that a run is under way, rather than simply continuing to

allow withdrawals until all funds are depleted. The paper also focuses on the implications of a lack of commitment power on the part of policy makers, as in Mailath and Mester [11], Acharya and Yorulmazer [1], Ennis and Keister [6] and others. The focus on bailout policies in an environment without commitment is similar to Cooper and Kempf [3], who study the redistributive effects of deposit insurance when agents are ex ante heterogeneous. In the model here, however, investors are ex ante identical and I study policy interventions that are ex post efficient.

The remainder of the paper is organized as follows. The next section presents the model together with the first-best allocation of resources in this environment. Section 3 analyzes the efficient allocation of resources conditional on investors running in some states and shows that this allocation always involves a bailout in the event of a crisis. Section 4 studies competitive equilibrium in the model under the ex-post efficient bailout policy and the effects of the moral hazard problem. Section 5 presents the two other policy regimes: a no-bailout policy and a tax on maturity transformation.

2 The Model

I begin with a fairly standard version of the Diamond and Dybvig [5] model and augment this basic framework by introducing a public good. This section describes the physical environment and the first-best allocation in this environment. It also introduces the formal notion of illiquidity that will be used in the analysis.

2.1 The environment

There are three time periods, $t = 0, 1, 2$, and a continuum of investors, indexed by $i \in [0, 1]$. Each investor has preferences given by

$$U(c_E, c_L, d; \theta_i) = u(c_E + \theta_i c_L) + v(d),$$

where c_E is consumption of the private good in period 1 (i.e., “early” consumption), c_L is consumption of the private good in period 2 (i.e., “late” consumption), and d is the level of public good, which is provided in period 1. The parameter θ_i is a binomial random variable with support $\Theta = \{0, 1\}$. If the realized value of θ_i is zero, investor i is *impatient* and only cares about early consumption. An investor’s type θ_i is revealed to her in period 1 and remains private information. Let π denote the probability with which each individual investor will be impatient. By a law of

large numbers, π is also the fraction of investors in the population who will be impatient.

In some of what follows, it will be useful to assume that preferences are of the constant-relative-risk-aversion (CRRA) form, with

$$u(c) = \frac{(c)^{1-\gamma}}{1-\gamma} \quad \text{and} \quad v(d) = \delta \frac{(d)^{1-\gamma}}{1-\gamma}. \quad (1)$$

In this specification, the parameter δ measures the relative importance of the public good and is assumed to be common to all investors. As in Diamond and Dybvig [5], the coefficient of relative risk aversion γ is assumed to be greater than 1.

Each investor is endowed with one unit of the private good in period 0. As in Diamond and Dybvig [5], there is a constant-returns-to-scale technology for transforming this endowment into private consumption in the later periods. A unit of the good invested in period 0 yields $R > 1$ units in period 2, but only one unit in period 1. There is also a technology for transforming units of the private good one-for-one into units of the public good. This technology is operated in period 1, using goods that were placed into the productive technology described above in period 0.

In addition, there is an intermediation technology that allows investors to pool resources and insure against individual liquidity risk. This technology is operated in a central location. Investors are isolated from each other in periods 1 and 2 and no trade can occur among them. Upon learning her preference type, each investor chooses either to contact her intermediary in period 1 to withdraw funds or to wait and contact her intermediary in period 2. Those investors who contact their intermediary in period 1 do so in a randomly assigned order. Following Wallace [13], [14], I assume that investors must consume immediately after contacting their intermediary. This sequential-service constraint implies that the payment made to such a investor can only depend on the information received by the intermediary up to that point. In particular, this payment can be contingent on the number of early withdrawals that have taken place *so far*, but not on the *total* number of early withdrawals that will occur.

An *allocation* in this environment is an assignment of a private consumption level to each investor in each period, possibly depending on her preference type, along with a level of public good provision. An allocation is *feasible* if (i) it can be produced from the period-0 endowments using the technologies described above and (ii) the distribution of consumption across investors in period 1 satisfies the sequential service constraint. Each of these conditions are discussed in more detail below.

Since all investors are identical in period 0, it is natural to measure ex ante welfare in this economy as the period-0 expected utility of each investor. For ex post measures of welfare, after preference types (and potentially some consumption levels) have been realized, I use an equal-weighted sum of individual utilities to measure welfare. The expression

$$W = \int_0^1 E [u (c_{E,i}, c_{L,i}, d; \theta_i)] di$$

captures both of these notions and is, therefore, used to measure welfare throughout the analysis.

2.2 The first-best allocation

The first-best allocation of resources in this environment is the allocation that would be chosen by a fictitious planner who could observe each investor's type and allocate resources accordingly. The planner would give the same amount of consumption to all impatient investors in period 1; let c_E denote this amount. It would also give the same amount of consumption to all patient investors in period 2; denote this amount by c_L . The first-best allocation is then the solution to the following maximization problem

$$\max_{\{c_E, c_L, d\}} \pi u (c_E) + (1 - \pi) u (c_L) + v (d)$$

subject to

$$\pi c_E + (1 - \pi) \frac{c_L}{R} + d \leq 1.$$

Note that this problem combines two very standard elements: the division of resources between private consumption and a public good, plus the allocation of private consumption between patient and impatient agents as in Diamond and Dybvig [5] and many others.

The solution to this problem is characterized by the first-order conditions

$$u' (c_E) = R u' (c_L) = v' (d) = \lambda,$$

where λ is the Lagrange multiplier on the resource constraint. The first equality is the usual optimality condition for the Diamond-Dybvig model. The second inequality can be interpreted as the standard Samuelson condition for the efficient provision of a public good, which equates the sum of individuals' marginal rates of substitution to the marginal rate of transformation.² Let

² Note that because the first-best allocation is symmetric and there is a measure 1 of depositors, the sum of all investors' marginal rates of substitution is equal to each individual's marginal rate of substitution.

$(\tilde{c}_E, \tilde{c}_L, \tilde{d}, \tilde{\lambda})$ denote the solution to this problem. Welfare in the first-best allocation is then given by

$$\tilde{W} = \pi u(\tilde{c}_E) + (1 - \pi)u(\tilde{c}_L) + v(\tilde{d}).$$

For the constant relative risk aversion utility function in (1), the first-best allocation can be expressed in closed form as

$$\begin{aligned} \tilde{c}_E &= \left(\frac{1}{\tilde{\lambda}}\right)^{\frac{1}{\gamma}}, & \tilde{c}_L &= \left(\frac{R}{\tilde{\lambda}}\right)^{\frac{1}{\gamma}}, & \tilde{d} &= \left(\frac{\delta}{\tilde{\lambda}}\right)^{\frac{1}{\gamma}}, & \text{and} \\ \tilde{\lambda} &= \left(\delta^{\frac{1}{\gamma}} + \pi + (1 - \pi)R^{\frac{1-\gamma}{\gamma}}\right)^{\gamma} \equiv \alpha_0, \end{aligned}$$

where the constant α_0 is defined for notational convenience. The expression for welfare in this allocation reduces to

$$\tilde{W} = \tilde{\lambda} = \alpha_0.$$

2.3 The decentralized economy

Since there is a continuum of investors, no individual will voluntarily provide any of the public good from her own resources. In the decentralized economy, I assume that the public good is provided by a benevolent policy maker who has the ability to tax endowments in period 0. The revenue from this tax is placed into the investment technology and transformed into period 1 private goods. In period 1, the policy maker can use these private goods to produce units of the public good *or* can transfer some of these private goods to the financial intermediaries. I refer to this latter option as a “bailout” payment to the financial system.

Notice that the type of bailout policy I consider here is entirely consistent with the sequential service constraint in the model. The only opportunity to tax agents comes in the first period, before funds are deposited with intermediaries.³ To keep the notation simple, I assume that the policy maker does not transfer any funds to the financial system in the event that there is no run; this assumption is without any loss of generality.

The intermediation technology is operated by a large number of competitive intermediaries,

³ If the environment allowed the government to tax depositors after it has observed the total level of withdrawal demand, then it would also be possible for the intermediaries to require advance notice of an investors’ intention to withdraw. The assumption here is that the sequential service constraint applies to the policy maker as well as to the intermediaries, which is consistent with the Wallace [13] critique of Diamond and Dybvig’s [5] analysis.

each of which aims to maximize the expected utility of its investors. Because investors' types are private information, the payment an investor receives from her intermediary cannot depend directly on her realized type. Instead, the intermediary allows each investor to choose the period in which she will withdraw. This arrangement, which resembles a demand-deposit contract, is well known to be a useful tool for implementing desirable allocations in economies with private information. However, such arrangements can also create the possibility of a “run” on the financial system in which all investors attempt to withdraw early, regardless of their realized preference type.

In order to allow a run on the financial system to occur with nontrivial probability, I introduce an extrinsic “sunspot” signal on which investors can potentially condition their actions. Let $S = \{s_1, s_2\}$ be the set of possible sunspot states, with $\text{prob}[s = s_2] = q \in (0, 1)$. Investor i chooses a strategy that assigns a decision to withdraw in either period 1 or period 2 to each possible realization of her preference type θ_i and of the sunspot variable

$$y_i : \Theta \times S \rightarrow \{1, 2\}.$$

In period 1, preference types are revealed and those investors who attempt to withdraw early contact the intermediary in a randomly-assigned order.

Neither the intermediaries nor the policy maker observe the realization of the sunspot variable. Instead, they must try to infer the state from the flow of withdrawals. This approach is standard⁴ and, combined with the sequential service constraint, implies that some payments must be made to withdrawing investors before the intermediaries or policy maker know whether or not a run is underway.

2.4 Illiquidity

The degree of illiquidity in the economy will play an important role in the analysis that follows. Define

$$\rho \equiv \frac{c_E}{1 - d},$$

so that ρ represents the private consumption of an impatient investor relative to the per-capita period-1 value of the resources designated for private consumption. In the decentralized economy, since each investor has the option of withdrawing her funds early, c_E will represent the per-capita

⁴ See, for example, Diamond and Dybvig [5, Section 4], Cooper and Ross [4], and Peck and Shell [12].

short term liabilities of the financial system. The short-run value of intermediaries' assets will equal the fraction of endowments that are invested to provide private consumption, $1 - d$. Hence ρ will represent the ratio of the short-term liabilities of the financial system to the short-run value of its assets. I will say that the financial system is *illiquid* whenever $\rho > 1$ holds.

For the utility function in (1), the degree of illiquidity in the first-best allocation is given by

$$\tilde{\rho} = \left(\pi + (1 - \pi) R^{\frac{1-\gamma}{\gamma}} \right)^{-1}.$$

It is easy to see from this expression that $\gamma > 1$ implies $\tilde{\rho} > 1$. This is the standard result in Diamond-Dybvig models: when the coefficient of relative risk aversion is larger than unity, the first-best allocation of resources involves illiquidity. This illiquidity is what potentially opens the door to self-fulfilling financial crises.

3 Efficient Allocations with Financial Crises

The first-best allocation of resources presented in the previous section requires that only impatient investors withdraw early. In this section, I study the efficient allocation if resources under the assumption that only impatient investors withdraw early in state s_1 , but all investors attempt to withdraw early in s_2 , so that a financial crisis occurs with probability $q > 0$. This allocation will be a useful benchmark for comparing the equilibrium outcomes under different policy regimes below.⁵

3.1 The q-efficient allocation

I assume the planner faces the same informational constraints that intermediaries and the policy maker face in the decentralized economy. In particular, the planner correctly anticipates investors' withdrawal strategies as a function of the sunspot state, but is unable to observe the realized state; the state must be inferred from the observed withdrawal behavior of investors. Under the profile of investor strategies assumed here, the fraction of investors who attempt to withdraw early will be π in state s_1 and 1 in state s_2 . As the first π withdrawals are taking place, therefore, no information about the state is revealed to the planner. If the fraction of investors withdrawing early goes past π , however, the planner is immediately able to infer that state s_2 has occurred.

⁵ The question of when this behavior by investors is consistent with equilibrium is addressed in the next two sections. The question here is simply how resources should be allocated conditional on this behavior.

An important element of this problem is determining how the planner responds once it discovers that a run is underway, and how investors who have not yet been able to withdraw react to this response. For this benchmark allocation, I assume that, once it has discovered a run is underway, the planner is able to implement the efficient *continuation* allocation of the remaining resources. In particular, only those remaining investors who are impatient withdraw early; the remaining patient investors wait until period 2 to withdraw. The planner allocates the remaining resources optimally between the private consumption of these remaining investors and the provision of the public good.

As the first π withdrawals are taking place, the planner gains no information about the state and, therefore, will choose to give the same consumption level to all of these investors. Let c_E denote this amount. If early withdrawals cease after a fraction π of investors has withdrawn, the remaining investors must all be patient and will each receive an amount c_L in period 2. Let d denote the amount of public good that is provided in this case.

If early withdrawals do not cease at π , the planner is able to infer that a run is taking place. Let c_{EP} denote the amount of consumption received by each remaining impatient investor, where the “P” subscript indicates that this amount is associated with the post-run allocation. Similarly, let c_{LP} denote the consumption received in period 2 by each remaining patient investor, and let d_P denote the amount of public good provided in this case. The appropriate notion of efficiency, given that all investors attempt to withdraw early with probability q , is as follows.

Definition: The q -efficient allocation is the list $\{c_E, c_L, d, c_{EP}, c_{LP}, d_p\}$ that solves

$$\begin{aligned} \max \quad & (1 - q) [\pi u(c_E) + (1 - \pi) u(c_L) + v(d)] + \\ & q [\pi u(c_E) + (1 - \pi) [\pi u(c_{EP}) + (1 - \pi) u(c_{LP})] + v(d_P)] \end{aligned}$$

subject to

$$\pi c_E + (1 - \pi) \frac{c_L}{R} + d \leq 1, \quad (2)$$

$$(1 - \pi) \left(\pi c_{EP} + (1 - \pi) \frac{c_{LP}}{R} \right) + d_P \leq 1 - \pi c_E, \quad (3)$$

and

$$c_L \geq c_E, \quad c_{LP} \geq c_{EP}.$$

Expression (2) is the resource constraint that applies in state s_1 , while (3) applies in s_2 . The final two constraints are incentive compatibility conditions that, in a decentralized economy, will ensure that withdrawing early is not a dominant strategy. It is straightforward to show that these constraints never bind at the solution.

Letting $(1 - q)\lambda$ and $q\lambda_P$ denote the multipliers on constraints (2) and (3), respectively, the solution to this problem is characterized by the conditions

$$\begin{aligned} u'(c_E) &= (1 - q)Ru'(c_L) + qRu'(c_{LP}) \\ Ru'(c_L) &= v'(d) = \lambda, \quad \text{and} \\ u'(c_{EP}) &= Ru'(c_{LP}) = v'(d_P) = \lambda_P. \end{aligned}$$

The first condition says that the marginal value assigned to resources paid out before the planner knows whether a run is underway should be equal to the expected marginal value of resources once the state is revealed. The other conditions require that the remaining resources be allocated efficiently in each state. Let $(c_E^*, c_L^*, d^*, c_{EP}^*, c_{LP}^*, d_P^*, \lambda^*, \lambda_P^*)$ denote the solution to this problem.

For the CRRA case, the q -efficient allocation can be derived in closed form, yielding

$$c_E^* = \left(\frac{1}{(1 - q)\alpha_4 + q\alpha_5} \right)^{\frac{1}{\gamma}}, \quad c_L^* = \left(\frac{R}{\alpha_4} \right)^{\frac{1}{\gamma}}, \quad d^* = \left(\frac{\delta}{\alpha_4} \right)^{\frac{1}{\gamma}}$$

and

$$c_{EP}^* = \left(\frac{1}{\alpha_5} \right)^{\frac{1}{\gamma}}, \quad c_{LP}^* = \left(\frac{R}{\alpha_5} \right)^{\frac{1}{\gamma}}, \quad d_P^* = \left(\frac{\delta}{\alpha_5} \right)^{\frac{1}{\gamma}},$$

where the constants α_4 and α_5 are equal to the multipliers on the resource constraints (2) and (3) evaluated at the solution. The values of these constants are given by

$$\begin{aligned} \alpha_4 &\equiv \lambda^* = \frac{\alpha_3}{(1 - q)\alpha_3 + q\alpha_2} \left(\pi + [(1 - q)\alpha_3 + q\alpha_2]^{\frac{1}{\gamma}} \right)^\gamma \quad \text{and} \\ \alpha_5 &\equiv \lambda_P^* = \frac{\alpha_2}{(1 - q)\alpha_3 + q\alpha_2} \left(\pi + [(1 - q)\alpha_3 + q\alpha_2]^{\frac{1}{\gamma}} \right)^\gamma, \end{aligned}$$

where

$$\begin{aligned} \alpha_1 &\equiv \left(\pi + (1 - \pi)R^{\frac{1-\gamma}{\gamma}} \right)^\gamma, \quad \alpha_2 = \left(\delta^{\frac{1}{\gamma}} + (1 - \pi)\alpha_1^{\frac{1}{\gamma}} \right)^\gamma, \quad \text{and} \\ \alpha_3 &\equiv \left(\delta^{\frac{1}{\gamma}} + (1 - \pi)R^{\frac{1-\gamma}{\gamma}} \right)^\gamma. \end{aligned}$$

Note that if we evaluate the expressions for (c_E, c_L, d, λ) at $q = 0$, each reduces to the corresponding value in the first-best allocation.

The degree of illiquidity in the q -efficient allocation for the CRRA case can be written as

$$\rho^* = \frac{1}{\pi + (1 - \pi) R^{\frac{1-\gamma}{\gamma}} \left((1 - q) + q \frac{\alpha_2}{\alpha_3} \right)^{\frac{1}{\gamma}}}. \quad (4)$$

It is straightforward to show that $\gamma > 1$ implies $\alpha_2 > \alpha_3$. This relationship immediately implies that ρ is a decreasing function of q . In other words, the efficient response to an increase in the probability of a crisis is for the financial system to become more liquid.

3.2 Bailouts

One interesting feature of the q -efficient allocation is that whenever it involves illiquidity, the marginal social value of resources will be higher in the event of a crisis than in normal times.

Proposition 1 $c_E^* > 1 - d^*$ implies $\lambda_P^* > \lambda^*$.

Proof: The illiquidity condition implies

$$1 - \pi c_E^* - d^* < 1 - \pi (1 - d^*) - d^* = (1 - \pi) (1 - d^*),$$

so that we have

$$1 - d^* > \left(\frac{1 - \pi c_E^* - d^*}{1 - \pi} \right).$$

Combining this inequality with the period 0 resource constraint (2) yields

$$\pi c_E^* + (1 - \pi) \frac{c_L^*}{R} > \frac{1 - \pi c_E^* - d^*}{1 - \pi}. \quad (5)$$

In other words, setting $(c_{EP}, c_{LP}, d_P) = (c_E^*, c_L^*, d^*)$ would violate the post-run resource constraint (3). Suppose that, contrary to the claim of the proposition, we have $\lambda_P^* \leq \lambda^*$. Then from the first-order conditions of the problem we would have

$$c_{EP}^* \geq c_E^*, \quad c_{LP}^* \geq c_L^*, \quad \text{and} \quad d_P^* \geq d^*.$$

However, this would imply that (c_E^*, c_L^*, d^*) satisfies the post-run resource constraint, which contradicts (5). ■

The next result then follows immediately from the first-order conditions above.

Corollary 1 $c_E^* > 1 - d^*$ implies $d_P^* < d^*$.

This corollary provides one of the central messages of the paper. The property $d_P < d$ can be interpreted as a “bailout” of the financial system. Recall that d is the quantity of resources set aside to provide the public good in the event that there is no crisis. If a crisis occurs, however, some of these resources are instead used to provide private consumption to those investors who have not yet been able to withdraw. In other words, in the event of a run, all investors pay a utility cost in terms of a lower level of the public good in order to benefit that subset of agents who are facing losses on their financial investments. The corollary shows that this bailout is part of the *efficient* allocation of resources.

3.3 Financial fragility

In the decentralized economy studied in the next two sections, it will be natural to say that the financial system is *fragile* if there exists an equilibrium in which all investors withdraw early in some state. This notion of fragility can be extended to the benchmark allocation of this section in the following way. In the decentralized economy, a patient investor who runs when all other investors are running and is served before the planner discovers that a run is underway receives c_E , while she will receive c_{LP} if she decides instead to wait and withdraw in period 2. We can identify fragility, therefore, with a situation in which this investor has a strict incentive to participate in the run, that is, in which $c_E > c_{LP}$ holds. I will say that the financial system of a particular economy is fragile if this relationship holds for any strictly positive value of q .

Definition: The financial system of an economy defined by the parameters (R, π, u, v) is *fragile* under the q -efficient allocation if $c_E^* > c_{LP}^*$ holds for some $q > 0$.

Let Φ^* denote the set of parameter values (R, π, u, v) such that the financial system is fragile under the q -efficient allocation of resources. From the first-order conditions above, we have

$$\begin{aligned} u'(c_E^*) &= (1 - q)\lambda^* + q\lambda_P^* \\ u'(c_{LP}^*) &= \frac{1}{R}\lambda_P^* \end{aligned}$$

The condition $c_E^* > c_{LP}^*$ can, therefore, be written as

$$(1 - q) \lambda^* + q \lambda_P^* < \frac{1}{R} \lambda_P^*$$

or

$$\frac{\lambda_P^*}{\lambda^*} > \frac{1 - q}{R^{-1} - q}. \quad (6)$$

The financial system is fragile in the q -efficient allocation if this inequality holds for some $q > 0$.

For the CRRA case, it is straightforward to show that the ratio c_E^*/c_{LP}^* is strictly decreasing in q . If $c_E^* > c_{LP}^*$ holds for some value \hat{q} , therefore, it must also hold for all $q < \hat{q}$. This fact allows us to characterize the set Φ^* by looking at condition (6) in the limit as q goes to zero, which yields

$$\frac{\lambda_P^*}{\lambda^*} = \frac{\alpha_2}{\alpha_3} = \left(\frac{\delta^{\frac{1}{\gamma}} + (1 - \pi) (\alpha_1)^{\frac{1}{\gamma}}}{\delta^{\frac{1}{\gamma}} + (1 - \pi) R^{\frac{1-\gamma}{\gamma}}} \right)^\gamma > R.$$

This expression can be used to verify that the set Φ^* is nonempty.

4 Equilibrium and Moral Hazard

I now study the allocation that emerges in a competitive equilibrium of the model and compare this outcome to the q -efficient allocation derived above. The information structure is the same as in the previous section. Each investor chooses when to withdraw from her intermediary after observing her own preference type. Intermediaries and the policy maker do not observe the realization of the sunspot state, but they will eventually be able to infer it from the withdrawal behavior of investors. I will look for equilibria in which all investors run on their intermediary in state s_2 . Once more than π withdrawals take place, therefore, intermediaries and the planner will immediately be able to infer that the state is s_2 .

Intermediaries act to maximize the expected utility of their investors at all times; there are no agency problems in the model. However, as in Ennis and Keister [6], [8], they cannot commit to future actions. This inability to commit implies that they are unable to use the type of suspension of convertibility plans discussed in Diamond and Dybvig [5] or the type of run-proof contracts studied in Cooper and Ross [4]. Instead, the payment given to each investor who withdraws in period 1 will be a best response given the intermediary's current belief about the state.

4.1 Rescheduling payments

As the first π withdrawals are taking place in period 1, an intermediary gains no information about the state and will, therefore, choose to give the same consumption level to each of these investors. If the fraction early withdrawals goes past π , the intermediary is able to infer that a run is taking place. The intermediary will respond to this information by changing the amount of consumption given to any additional investors who withdraw early. Investors anticipate this reaction, of course, and may wish to change their withdrawal plans, if possible. In general, the relationship between an intermediary's response to a run and the reactions of its remaining investors is a complex issue and many different patterns of behavior are possible (see Ennis and Keister [8]).

To simplify matters, I assume here that once it has discovered a run is underway, an intermediary is able to implement the efficient allocation of its remaining resources among its remaining investors. As part of this allocation, only those remaining investors who are impatient withdraw early; the remaining patient investors wait until period 2 to withdraw. There are several different ways in which this allocation could come about. It could, for example, be the result of an intervention by a court system that is able to screen investors' types in the event of a run, as in Ennis and Keister [6]. Alternatively, it could be the result of equilibrium behavior in a game played by the planner and those investors who anticipate they will be late to arrive at their intermediary in period 1, as in Ennis and Keister [8]. Whatever the mechanism, this approach ensures that none of the results below are driven by some assumed inefficiency in the distribution of resources following a run.⁶

The equilibrium of the model is constructed by working backward. First, suppose the realized state is s_2 and that a run occurs. A fraction π of investors will withdraw before the intermediaries and the policy maker are able to infer the state; investors withdrawing from intermediary j each receive payment c_E^j . Let ϕ_j denote intermediary j 's remaining resources, per remaining investor, after the first π withdrawals have taken place,

$$\phi_j = \frac{1 - \tau - \pi c_E^j}{1 - \pi}.$$

Suppose that the bailout policy has already been decided, with intermediary j receiving an

⁶ The results would not change if, for example, a fraction of the intermediary's remaining assets were lost in the event of a run. Such an inefficiency would only serve to increase the scope for financial fragility under all of the policy regimes studied here.

amount $b_j \geq 0$ per remaining investor. Let

$$\psi_j = \phi_j + b_j$$

be the amount of resources, per remaining investor, available to intermediary j in the event of a run. The efficient allocation of these resources requires that the payments to the remaining investors solve

$$\max \pi u(c_{EP}^j) + (1 - \pi) u(c_{LP}^j) \quad (7)$$

subject to

$$\begin{aligned} \pi c_{EP}^j + (1 - \pi) \frac{c_{LP}^j}{R} &\leq \psi_j \quad \text{and} \\ c_{LP}^j &\geq c_{EP}^j. \end{aligned} \quad (8)$$

The solution is characterized by the first-order conditions

$$u'(c_{EP}^j) = R u'(c_{LP}^j) = \lambda_P^j, \quad (9)$$

where λ_P^j is the multiplier on the resource constraint (8). Let $(\widehat{c}_{EP}^j, \widehat{c}_{LP}^j, \widehat{\lambda}_P^j)$ denote the solution to this problem. It is easy to see that both \widehat{c}_{EP}^j and \widehat{c}_{LP}^j are strictly increasing in the quantity of resources ψ_j , while $\widehat{\lambda}_P^j$ is strictly decreasing in ψ_j . Define the value function

$$V_P(\psi_j) = \pi u(\widehat{c}_{EP}^j) + (1 - \pi) u(\widehat{c}_{LP}^j). \quad (10)$$

Then the function V_P measures the average utility from private consumption of the remaining investors.

For the CRRA case, the solution can be written as

$$\widehat{c}_{EP}^j = \left(\frac{1}{\widehat{\lambda}_P^j} \right)^{\frac{1}{\gamma}} \quad \text{and} \quad \widehat{c}_{LP}^j = \left(\frac{R}{\widehat{\lambda}_P^j} \right)^{\frac{1}{\gamma}},$$

with

$$\widehat{\lambda}_P^j = \left(\pi + (1 - \pi) R^{\frac{1-\gamma}{\gamma}} \right)^{\gamma} \psi_j^{-\gamma}.$$

Note that we can use the constant α_1 defined above to write $\widehat{\lambda}_P^j = \alpha_1 \psi_j^{-\gamma}$. Straightforward algebra

then shows

$$V_P = \alpha_1 \frac{\psi_j^{1-\gamma}}{1-\gamma}.$$

4.2 The ex-post efficient bailout policy

In the event of a run, the resources τ available to the policy maker can be divided between provision of the public good and bailout payments to the financial system. These payments are allocated among the intermediaries in an ex post efficient manner. Let c_j denote total resources that will be used for the private consumption of the remaining investors in intermediary j , that is

$$c_j \equiv (1 - \pi) (\phi_j + b_j).$$

Let σ_j represent the fraction of investors in the economy that have deposited with intermediary j . Then the policy maker's budget constraint is

$$d_P + \sum_j \sigma_j (1 - \pi) b_j = \tau.$$

Using the definition of c_j above, we can write the problem of choosing the optimal bailout policy in terms of dividing the remaining resources between private and public consumption, that is,

$$\max_{\{c_j, d_P\}} \sum_j \sigma_j (1 - \pi) V_P \left(\frac{c_j}{1 - \pi} \right) + v(d_P)$$

subject to

$$\sum_j \sigma_j c_j + d_P = \sum_j \sigma_j (1 - \pi) \phi_j + \tau.$$

The solution to this problem is characterized by first-order conditions

$$V'_P \left(\frac{c_j}{1 - \pi} \right) = v'(d_P) = \lambda_B \quad \text{for all } j.$$

These conditions immediately imply

$$c_j = c_{j'} \quad \text{for all } j \text{ and } j'.$$

In other words, the resources available for private consumption should be the same in all intermediaries, which implies that an intermediary with fewer remaining resources (because it chose a

higher value of c_E) will receive a larger bailout. In equilibrium, of course, all intermediaries will choose the same value of c_E and receive the same bailout payment.

Let c denote the common level of c_j and let $(\hat{c}, \hat{d}_P, \hat{\lambda}_B)$ denote the solution to the problem above. The total size of the bailout payments is then given by

$$\hat{b} \equiv \sum_j \sigma_j \hat{b}_j = \frac{\tau - \hat{d}_P}{1 - \pi}.$$

Define the value function

$$V(\chi) \equiv (1 - \pi) V_P\left(\frac{\hat{c}}{1 - \pi}\right) + v(\hat{d}).$$

Then V represents the contribution to total welfare of the private consumption of the remaining $(1 - \pi)$ investors and the public consumption of all investors, given that the total remaining resources χ will be divided optimally among the competing uses.

For the CRRA case, straightforward algebra shows

$$\hat{b} = \left(\frac{\alpha_1}{\alpha_2}\right)^{\frac{1}{\gamma}} ((1 - \pi)\phi + \tau) - \phi$$

and

$$V(\chi) = \alpha_2 \frac{\chi^{1-\gamma}}{1-\gamma}.$$

4.3 The equilibrium deposit contract

Each intermediary will choose the payment it initially offers for early withdrawals to maximize investors' expected utility. Since all intermediaries face the same decision problem, I will omit the j subscript and use c_E to denote the payment offered by a representative intermediary. In choosing this payment, the intermediary takes as given the level of public good provision in both states *and* the allocation of private consumption among the remaining $1 - \pi$ investors in the event of a run. The indiscriminate nature of the bailout implies that the consumption of the remaining investors will depend only on aggregate conditions, not on the condition of their individual intermediary. This external effect – an individual intermediary's choice of contract affects the consumption of other intermediaries' investors in the event of a run – is the source of the moral hazard problem.

The equilibrium value of c_E can, therefore, be found by solving the following maximization

problem

$$\max_{\{c_E, c_L\}} (1 - q) (\pi u(c_E) + (1 - \pi)u(c_L) + v(\tau)) + q (\pi u(c_E) + V)$$

subject to

$$\begin{aligned} \pi c_E + (1 - \pi) \frac{c_L}{R} &= 1 - \tau, \quad \text{and} \\ c_L &\geq c_E. \end{aligned}$$

The first-order condition that characterizes the solution to this problem when the incentive-compatibility constraint does not bind is

$$u'(c_E) = (1 - q) R u'(c_L) = \lambda. \quad (11)$$

The effect of the moral-hazard problem is clear from the first equality. The equilibrium payment c_E will balance the marginal value of resources in the early period with the marginal value of resources in the late period *in the no-run state*, ignoring the value of resources in the event of a run. The larger the probability of a run q is, the more this moral hazard problem will distort the allocation of resources. We can also see from this expression that the incentive compatibility constraint will be satisfied at the interior solution as long as

$$(1 - q) R \geq 1 \quad (12)$$

holds, but will otherwise be violated. Since $R > 1$, we know that the constraint will not bind as long as q is small enough. Let $(\hat{c}_E, \hat{c}_L, \hat{\lambda})$ denote the solution to this problem and define the value function

$$V_0(\tau) = \pi u(\hat{c}_E) + (1 - q) ((1 - \pi)u(\hat{c}_L) + v(\tau)) + qV(1 - \pi\hat{c}_E). \quad (13)$$

For CRRA preferences, the solution for the case of $(1 - q) R \leq 1$ can be written as

$$\hat{c}_E = \left(\frac{1}{\alpha_6} \right)^{\frac{1}{\gamma}} (1 - \tau), \quad \hat{c}_L = \left(\frac{(1 - q) R}{\alpha_6} \right)^{\frac{1}{\gamma}} (1 - \tau), \quad \hat{\lambda} = \alpha_6 (1 - \tau)^{-\gamma}$$

where

$$\alpha_6 = \left(\pi + (1 - \pi) (1 - q)^{\frac{1}{\gamma}} R^{\frac{1-\gamma}{\gamma}} \right)^{\gamma}. \quad (14)$$

For the case of $(1 - q)R > 1$, the solution is

$$\widehat{c}_E = \widehat{c}_L = \left(\frac{1}{\alpha_7} \right)^{\frac{1}{\gamma}} (1 - \tau),$$

where

$$\alpha_7 = (\pi + (1 - \pi)R^{-1})^\gamma.$$

4.4 The equilibrium tax rate

The final element of the equilibrium is the policy maker's choice of tax rate τ . The policy maker chooses τ at the beginning of period 0, taking into account how intermediaries and investors will react to this choice. Using the notation developed above, the policy maker will choose τ to maximize the function $V_0(\tau)$ in (13). The first-order condition for this problem can be written as

$$v'(\tau) = \frac{1}{1 - q} \widehat{\lambda} + \frac{q}{1 - q} \widehat{\lambda}_P \pi \frac{d\widehat{c}_E}{d\tau}.$$

If the probability of a crisis (q) were zero, the tax rate would be set to equate the marginal utility of the public good with the marginal value of goods used for private consumption ($\widehat{\lambda}$), exactly as in the first-best allocation. When q is positive, however, the policy maker must also take into account the fact that changes in τ will lead to changes in the equilibrium level of c_E , which in turn affects the total quantity of resources available in the event of a run. In this event, resources have a higher marginal value, $\widehat{\lambda}_P$. Letting $\widehat{\tau}$ denote the solution to this problem, welfare in the competitive equilibrium is given by

$$\widehat{W} = V_0(\widehat{\tau}).$$

4.5 Illiquidity and fragility

In the CRRA case, the degree of illiquidity in the financial system is independent of the tax rate τ . Using the government budget constraint in the no-run state, $d = \tau$, we have

$$\widehat{\rho} = \frac{\widehat{c}_E}{1 - \widehat{d}} = \left(\frac{1}{\alpha_6} \right)^{\frac{1}{\gamma}}.$$

Note that the constant α_6 (defined in (14)) is strictly decreasing in the probability of a crisis q . This expression thus delivers the following result.

Proposition 2 *Under (1), the degree of illiquidity in the equilibrium allocation is strictly increasing in q .*

In other words, as a financial crisis becomes more likely, the financial system adopts a *less* liquid position. The anticipation that they will be bailed out in the event of a crisis leads investors to prefer contracts with a higher short-run return, which implies a more illiquid financial system.

Comparing the degree of illiquidity in the CRRA case for the different allocations studied so far, it is easy to see that we have

$$\widehat{\rho}|_{q=0} = \rho^*|_{q=0} = \widetilde{\rho}.$$

In other words, when the probability of a crisis is zero, the degree of illiquidity (and, indeed, the entire allocation) in the competitive equilibrium is equal to that in the constrained efficient allocation, which is in turn equal to that in the first-best allocation. Combining this fact with expression (4) and Proposition 2 shows that whenever q is positive, the equilibrium level of illiquidity in the competitive equilibrium allocation is strictly greater than that in the constrained efficient allocation.

Corollary 2 *Under (1), for any $q > 0$, we have $\widehat{\rho} > \rho^*$.*

When a crisis is possible, the efficient reaction is to shift resources toward the bad state, which has the effect of making the financial system more liquid. In the competitive equilibrium, however, individual banks and investors have no incentive to prepare for the bad state, since they correctly anticipate the bailout payments that will be made in this state. As a result, an increase in the probability of a crisis leads them to adopt a *less* liquid position in equilibrium.

This higher degree of illiquidity increases the scope for financial fragility in the model. Let Φ_{LF} denote the set of parameter values (R, π, u, v) such that $\widehat{c}_E > \widehat{c}_L$ holds for some $q > 0$ in the laissez faire regime.

Proposition 3 *Under (1), the relationship $\Phi_{LF} \supset \Phi^*$ holds.*

This result follows from two observations. First, for any economy in Φ^* , we know that $c_E^* > c_{LP}^*$ holds in the limit as q goes to zero. We also know that when q is close to zero, \widehat{c}_E is close to c_E^* and \widehat{c}_{LP} is close to c_{LP}^* , which implies that $\widehat{c}_E > \widehat{c}_{LP}$ necessarily holds when q is small enough. Any economy in Φ^* must, therefore, also be in Φ_{LF} . Second, there exist some economies for which

$\widehat{c}_E < \widehat{c}_{LP}$ holds when q is close to zero but not for larger values of q . As q increases, the moral hazard problem tends to drive up c_E , which, in turn, tends to lower both c_{EP} and c_{LP} . If c_{LP} falls below c_E for some $q > 0$, the economy is in the set Φ_{LF} but not in Φ^* . Proposition 3 thus shows that there is a precise sense in which the moral hazard problem caused by bailouts can make the economy more susceptible to self-fulfilling financial crises.

5 Policy Measures

In this section I analyze two policy measures designed to mitigate the moral hazard problem and potentially improve welfare compared to the laissez faire regime described above. The first policy is one that has received considerable attention in the popular press and elsewhere: a commitment to not providing any bailout payments. This policy aims to eliminate the *source* of the moral hazard problem. The second policy instead addresses the *symptoms* of the moral hazard problems by placing a tax on illiquidity.

5.1 Committing to no bailouts

Suppose now that it is possible for the policy maker to commit in period 0 to setting $b = 0$ in all states of nature. This idea is perhaps best interpreted as the ability to write an enforceable law prohibiting bailout payments to the financial system. The question is how such a law affects behavior and whether it improves welfare relative to the equilibrium studied in the previous section.

5.1.1 Equilibrium

In the event of a run, each intermediary reschedules payments to implement the efficient continuation allocation among its own investors, given the amount of resources it has available, as in the problem (7) above. The equilibrium deposit contract will then solve

$$\max_{\{c_E, c_L\}} \pi u(c_E) + (1 - q)(1 - \pi)u(c_L) + qV_P \left(\frac{1 - \tau - \pi c_E}{1 - \pi} \right) + v(\tau)$$

subject to

$$\begin{aligned} \pi c_E + (1 - \pi) \frac{c_L}{R} &\leq 1 - \tau, \quad \text{and} \\ c_L &\geq c_E. \end{aligned}$$

As indicated in the objective function above, the level of the public good will be equal to tax

revenue τ in both states. Intermediaries and investors take the level of τ as given when making their individual decisions. Note that the value function V_P is evaluated at the level of resources (per investor) that the intermediary will have after π withdrawals, a quantity that depends on the intermediary's choice of c_E . Because of the no-bailout policy, intermediaries and investors now recognize that, in the event of a run, the only resources that will be available for the private consumption of the remaining investors will be those funds still deposited with their intermediary.

Letting $(1 - q)\lambda$ be the multiplier on the intermediary's budget constraint, the solution to this problem is characterized by the first-order conditions

$$u'(c_E) = (1 - q)\lambda + qV'_P \left(\frac{1 - \tau - \pi c_E}{1 - \pi} \right)$$

and

$$Ru'(c_L) = \lambda.$$

Using the envelope condition $V'_P = \lambda_P$, where λ_P is the multiplier on the intermediary's post-run budget constraint (8), we can write

$$u'(c_E) = (1 - q)Ru'(c_L) + q\lambda_P.$$

Comparing this condition with (11) shows the effect of the no-bailout policy and how it mitigates the moral hazard problem. Under this policy, an intermediary must balance the value of the promised payment c_E not only against the value of late consumption in the no-run state c_L , but also against the marginal value of resources in the run state λ_P .

For the CRRA case, the solution to this problem is

$$\hat{c}_E = \left(\frac{1}{\alpha_7} \right)^{\frac{1}{\gamma}} (1 - \tau) \quad \text{and} \quad \hat{c}_L = R \left(\frac{(1 - q)R^{1-\gamma} + q\alpha_1}{\alpha_7} \right)^{\frac{1}{\gamma}} (1 - \tau),$$

where

$$\alpha_7 = \left(\pi + (1 - \pi) \left((1 - q)R^{1-\gamma} + q\alpha_1 \right)^{\frac{1}{\gamma}} \right)^{\gamma}.$$

5.1.2 Illiquidity

For the CRRA case, the degree of illiquidity chosen by intermediaries is independent of the tax

rate τ ,

$$\widehat{\rho} = \left(\frac{1}{\alpha_7} \right)^{\frac{1}{\gamma}} = \frac{1}{\pi + (1 - \pi) ((1 - q) R^{1-\gamma} + q\alpha_1)^{\frac{1}{\gamma}}}. \quad (15)$$

Note that when $q = 0$ holds, this expression reduces to the first-best degree of illiquidity $\widetilde{\rho}$. Moreover, it is straightforward to show that $\alpha_1 > R^{1-\gamma}$ and, hence, that $\widehat{\rho}$ is strictly decreasing in q . Recall that this result is the opposite of that obtained in the previous section. When intermediaries and investors anticipate a bailout in the event of a run, an increase in the probability of a run leads them to adopt a more illiquid position. Here, in contrast, an increase in the probability of a run leads intermediaries to adopt a more *liquid* position. In this sense, the no-bailout policy is successful in offsetting the moral hazard problem.

Comparing $\widehat{\rho}$ to the degree of illiquidity in the q -efficient allocation, however, shows that the no-bailout policy actually leads intermediaries to be *too liquid* (see equation (4)).

Proposition 4 *Under (1) and a no-bailout policy, $q > 0$ implies $\widehat{\rho} < \rho^*$.*

Proof: Using expressions (4) and (15), we have that $q > 0$ implies $\widehat{\rho} < \rho^*$ if and only if

$$\frac{\alpha_1}{R^{1-\gamma}} > \frac{\alpha_2}{\alpha_3}$$

or

$$\frac{(\alpha_1)^{\frac{1}{\gamma}}}{R^{\frac{1-\gamma}{\gamma}}} > \frac{\delta^{\frac{1}{\gamma}} + (1 - \pi) (\alpha_1)^{\frac{1}{\gamma}}}{\delta^{\frac{1}{\gamma}} + (1 - \pi) R^{\frac{1-\gamma}{\gamma}}}.$$

The assumption $\gamma > 1$ implies that $(\alpha_1)^{\frac{1}{\gamma}} > R^{\frac{1-\gamma}{\gamma}}$ holds, which in turn implies that the above inequality necessarily holds. ■

Proposition 4 shows that the moral hazard problem is actually over-corrected by the no-bailout policy. Instead of performing too much maturity transformation, and taking on too much illiquidity, intermediaries perform too little under this policy. The reason for this is that the intermediaries must now completely self-insure against the possibility of a run. In the q -efficient allocation, in contrast, the bailout policy provides intermediaries with some insurance against this event, as established in Corollary 1.

Equilibrium welfare under the no bailout policy is lower than that in the constrained efficient allocation for two reasons. The first reason is the *ex ante* inefficiency described above: interme-

diaries perform too little maturity transformation. The second reason is the ex-post inefficiency in the event of a run. With no bailout payment, the marginal social value of goods used for private consumption is higher than the marginal social value of the public good; efficiency requires these marginal values to be equal. Hence, while the bailout policy effectively eliminates the moral hazard problem created by the anticipation of a bailout, it introduces new inefficiencies. The net effect of this policy may be to either raise or lower welfare, depending on parameter values.

5.1.3 Fragility

Despite making financial intermediaries more liquid, the no-bailout policy actually increases the scope for financial fragility relative to the q -efficient allocation. This fact can be seen by examining the limiting case as q goes to zero. The components of the allocation that apply to the no-run state (c_E , c_L , and τ) converge to the corresponding components of the q -efficient allocation. However, the post-run components of the allocation (c_{EP} , c_{LP} , and d_P) do not. As c_E approaches the efficient level, the total amount of resources that will be available in the event of a run approaches its efficient level as well. However, using Corollary 1, we know that the no-bailout policy will leave the level of the public good too high in the bailout state (relative to the q -efficient allocation), which implies that the private consumption levels c_{EP} and c_{LP} will be lower than in the q -efficient allocation. It then follows that the condition $c_E > c_{LP}$ will hold for a strictly larger set of parameter values. Letting Φ_{NB} denote the set of economies for which $\hat{c}_E > \hat{c}_{LP}$ holds under the no-bailout policy for some $q > 0$, we have the following result.

Proposition 5 *Under (1), the relationship $\Phi_{NB} \supset \Phi^*$ holds.*

This same logic can be used to show that some economies that are not fragile under the laissez faire regime *become* fragile when a no-bailout policy is implemented.

Proposition 6 *Some economies in the set Φ_{NB} are not in the set Φ_{LF} .*

This result is somewhat surprising in light of the arguments made by critics of bailouts during the recent financial crisis. While committing to a no-bailout policy increases the liquidity of the financial system, it can simultaneously leave the system more vulnerable to a run. The intuition behind this result is clear: by increasing c_{LP} , bailouts reduce the cost to an investor of leaving

her funds deposited in the event of a run. In other words, in addition to the moral hazard effect described above, the anticipation of a bailout also has a *positive* effect on ex ante incentives in that it encourages investors to keep their funds deposited in the financial system. The no-bailout policy removes the positive effect and, as a result, can create financial fragility. This phenomenon tends to occur when investors place a high value on the public good, which implies that the resources available to the policy maker are relatively large.

5.2 Taxing maturity transformation

Another policy option is to place no restrictions on the bailout policy, but to try to offset the moral hazard effect using a Pigouvian tax on maturity transformation (or, a tax on illiquidity). Suppose that each intermediary must pay a fee that is proportional to its own contribution to illiquidity, defined as

$$\text{fee}_j = \eta\pi\rho_j\sigma_j(1 - \tau),$$

where, as above, σ_j is the fraction of investors who deposit with intermediary j . The tax rate in this policy is $\eta\pi$, where η is chosen by the policy maker. The variable ρ_j is the degree of illiquidity in intermediary j 's portfolio, which is defined as above

$$\rho_j = \frac{c_{E,j}}{1 - \tau}.$$

Recall that the intermediary is said to be illiquid if $\rho_j > 1$ holds. Combining the two equations above yields

$$\text{fee}_j = \eta\pi c_E \sigma_j.$$

For simplicity, I will make the policy revenue neutral by giving each intermediary a lump-sum transfer $N\sigma_j(1 - \tau)$, where N is equal to the average fee collected per unit of deposits. This assumption is only to facilitate comparison with the earlier cases.

5.2.1 Equilibrium

Under this policy, the equilibrium payment c_E will solve

$$\max_{\{c_E, c_L\}} \pi u(c_E) + (1 - q) ((1 - \pi) u(c_L) + v(\tau)) + qV$$

subject to

$$\pi c_E + (1 - \pi) \frac{c_L}{R} \leq 1 - \tau - \eta \pi c_E + N(1 - \tau),$$

where the j subscripts have been omitted since all intermediaries face the same decision problem. Notice that I have already used the fact that total deposits will equal $(1 - \tau)$; this is only to avoid introducing additional notation. As in the previous section, investors and intermediaries take as given the level of provision of the public good in all states, as well as the allocation of private consumption to the remaining investors in the event of a crisis.

The first-order conditions of this problem are

$$u'(c_E) = (1 + \eta)(1 - q)Ru'(c_L) = (1 + \eta)\lambda.$$

We know that the post-run allocation of resources will be efficient, and hence will solve

$$\max_{\{c_{EP}, c_{LP}, d_P\}} (1 - \pi)(\pi u(c_{EP}) + (1 - \pi)u(c_{LP})) + v(d_P)$$

subject to

$$(1 - \pi) \left(\pi c_{EP} + (1 - \pi) \frac{c_{LP}}{R} \right) + d_P \leq 1 - \pi c_E.$$

The first-order conditions of this problem are the usual ones

$$u'(c_{EP}) = Ru'(c_{LP}) = v'(d_P) = \lambda_P.$$

Revenue neutrality implies

$$N = \eta \pi c_E.$$

Substituting this condition into the budget set of the representative intermediary yields the standard resource constraint for the no-run state.

5.2.2 The optimal tax rate

The question of interest is whether the tax rate η can be set so that the equilibrium allocation matches the constrained efficient allocation. In the constrained efficient allocation, we have

$$u'(c_E^*) = (1 - q)Ru'(c_L^*) + qRu'(c_{LP}^*)$$

In order for the equilibrium allocation to be efficient, therefore we need

$$\eta(1 - q) Ru'(c_L^*) = qRu'(c_{LP}^*)$$

or

$$\eta = \frac{q}{1 - q} \frac{u'(c_L^*)}{u'(c_{LP}^*)} \equiv \eta^*. \quad (16)$$

When η is set equal to η^* , the constrained efficient allocation will satisfy all of the conditions characterizing the competitive equilibrium allocation. Since these conditions uniquely determine the equilibrium, we have the following result.

Proposition 7 *When the tax rate η is set according to (16), the equilibrium allocation with a tax on maturity transformation is equal to the constrained efficient allocation.*

This result shows that, in the context of the model studied here, a tax on maturity transformation is a powerful policy tool. It allows the policy maker to continue following the ex-post efficient bailout policy, while offsetting the moral hazard problem this policy creates. In doing so, the policy maker can implement the constrained efficient allocation of resources. The set of economies for which the financial system is fragile will then be identical to that in the q -efficient allocation. Φ^* .

6 Concluding Remarks

The central message of the paper is that the efficient policy response to a financial crisis typically involves a redistribution of resources that resembles a “bailout” of those investors facing losses. The anticipation of such a bailout, however, distorts investors’ incentives and leads them to take actions that are inefficient from a social point of view. If policy makers could commit to never provide bailouts, this moral hazard problem would be removed but the resulting allocation would still be inefficient and may yield lower welfare than a laissez faire regime. In addition, a no-bailout policy could leave the economy more susceptible to self-fulfilling financial crises. In the setting studied here, the efficient allocation of resources is achieved by instead following the ex post efficient bailout policy and correcting the moral hazard problem through taxation or regulation of intermediaries’ ex ante choices.

It should be emphasized that the bailout policies studied here are efficient; they do not lead to rent-seeking behavior, nor are they motivated by outside political considerations. In reality, these

types of distortions are important concerns. The message of the paper is *not* that any type of bailout policy is acceptable ex post as long as the ex ante effects are offset through taxation. Limits on the ability of policy makers to undertake inefficient redistribution during a crisis may well be desirable. Rather, the message here is that restrictions on bailouts are not *sufficient* to ensure that investors face the correct ex ante incentives. The efficient allocation of resources requires that investors receive some insurance in the form of a bailout payment. Providing this insurance generates moral hazard, however, and this distortion must be corrected. Limits on bailouts must, therefore, be used in conjunction with ex ante taxation or regulation.

The relatively simple model studied here highlights the logic behind the results described above in a clear and transparent fashion. In doing so, it abstracts from several other important features of reality. The bailouts studied here generate only a limited type of redistribution, for example, as individuals are ex ante identical. In reality, bailouts often shift resources across different segments of society and hence lead to distributional concerns. Adding additional features to the analysis seems a promising avenue for future research.

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