Banking Policy without Commitment:
Suspension of Convertibility Taken Seriously

Huberto M. Ennis
Research Department
Federal Reserve Bank of Richmond
Huberto.Ennis@rich.frb.org

Todd Keister
Research and Statistics Group
Federal Reserve Bank of New York
Todd.Keister@ny.frb.org

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Abstract

We study banking policy credibility in a variant of the Diamond and Dybvig (JPE, 1983) model. By committing to temporarily close banks during a run, suspending the convertibility of deposits into currency, the banking authority can eliminate the possibility of a bank run as an equilibrium outcome. Without commitment, however, if a run were to actually occur it may not be optimal for the authority to keep its promise to suspend convertibility. In other words, the threat of suspension may not be credible. We derive conditions under which a credible suspension scheme can be used to rule out bank runs and conditions under which it cannot. In the latter case, bank runs can occur even when there is no uncertainty about aggregate liquidity demand. We relate the analysis to events in Argentina in 2001, when a system-wide suspension of convertibility was declared but only partially enforced.

1 Introduction

Bank runs were a common occurrence in the United States in the late 19th and early 20th centuries and remain an important phenomenon around the world today. The modern literature on bank runs, beginning with Bryant [6] and Diamond and Dybvig [11], tries to explain these events as equilibrium outcomes of a formal economic model. This has proved to be a challenging task. An equilibrium in which depositors run on the banking system can arise when banks offer short-term "demand" deposits while lending for longer time horizons. Each depositor runs in this equilibrium because she believes her bank will fail, and the run leads to this belief being fulfilled. However, Diamond and Dybvig [11] showed that if there is no uncertainty about the aggregate "fundamental" demand for withdrawals, a simple policy of suspending payments to depositors after this level of demand has been met is a costless way of eliminating the possibility of a bank run equilibrium. This result was interpreted as saying that bank runs could only occur in environments with substantial uncertainty about the normal level of withdrawal demand. Most of the subsequent literature has therefore focused on such environments, with mixed results.[1] We show how removing the (implicit) assumption of commitment and studying the credibility of threats to suspend payments provides another, more natural explanation of bank runs within the Diamond-Dybvig framework. When only credible suspension policies are allowed, a bank run equilibrium will exist under the optimal deposit contract if depositors are sufficiently risk averse, even when there is no uncertainty about fundamental withdrawal demand.

Our analysis is based on a standard version of the Diamond-Dybvig model. Depositors are uncertain about when they will need to consume and therefore pool their resources in the banking system for insurance purposes. By a law of large numbers, the fraction of depositors who will need to consume early is non-stochastic. We ask if the banking authority can implement the first-best allocation as the unique equilibrium, or if implementing the first best allocation necessarily introduces a bank run equilibrium as well. Diamond and Dybvig showed how a demand deposit contract with a suspension of convertibility clause could uniquely implement the first best allocation. They went on to study an environment where the total demand for early consumption is random, which makes suspending convertibility more problematic because the banking authority does not know the proper point at which to suspend. While this approach offers some advantages, it has several

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[1] See, for example, section IV of Diamond and Dybvig [11], Postlewaite and Vives [21], Wallace [24] - [25], Green and Lin [16], and Peck and Shell [20].

clear drawbacks. First, the optimal contract no longer resembles a standard banking contract in which each depositor has the right to withdraw her deposit at face value unless a suspension of convertibility has been declared. Instead, depositors receive payments that depend on their order of arrival at the bank in a complex way. Second, whether or not the resulting model has a run equilibrium depends on precisely what information depositors have about the order in which they would arrive at the bank during a run (see Green and Lin [16] and Peck and Shell [20]). Finally, it seems intuitively implausible to think that during a bank run, the banking authority is unsure whether a run is underway or it is simply observing an unusually high level of fundamental withdrawal demand. Bank runs are extreme events that, once fully underway, are easily recognized.[2]

We therefore confine our attention to the case where the proportion of depositors who need to withdraw early is known with certainty.[3] We take a new, more skeptical look at the suspension policy proposed by Diamond and Dybvig. We show that the effectiveness of this policy depends on the implicit assumption that the banking authority has full commitment power. If the banking authority cannot commit *ex ante* to suspend convertibility when faced with a run, the threat to suspend is often non-credible. In other words, if a run were to start and total withdrawals reached the point where the banking authority had claimed it would suspend payments, the optimal policy from that point onwards will often be to continue to serve depositors for a while longer. The critical question is then whether a *credible* suspension policy can be used to implement the first best allocation without introducing a run equilibrium. We study this question under two sets of assumptions. In the first, the banking authority must either continue to allow withdrawals at face value or suspend payments entirely. In the second case, the banking authority can declare a *partial* suspension in which depositors are allowed to continue withdrawing if they wish, but at a discount. The analysis is quite different for the two cases, but the end result is the same: if depositors are sufficiently risk averse, the banking authority cannot implement the first best allocation without also introducing a run equilibrium. Taking time consistency issues into account, therefore, shows that the possibility of a bank run *cannot* be costlessly ruled out in the standard Diamond-Dybvig framework.

These results are reminiscent of events that took place during the crisis in Argentina in 2001. Following a run on the banking system in late November, a suspension of convertibility was an-

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nounced. However, it was recognized that a complete suspension would place substantial hardships on many depositors and, therefore, each depositor was allowed to continue to withdraw a fixed amount per week from his/her account(s). In addition, depositors could under certain circumstances obtain court orders that allowed them to withdraw all of their funds. As a result of these policies, a substantial fraction of deposits was withdrawn from the banking system *after* the suspension was declared, and these withdrawals placed additional strain on the system. Our analysis shows how the inability to commit to a complete suspension of payments policy, which became so patently evident during the Argentinean crisis, can severely limit the ability of a banking authority to avoid bank runs.

The rest of the paper is organized as follows. In the next section we present the basic model and review the main results regarding demand deposit contracts without a suspension clause. In Section 3 we examine a class of simple suspension schemes in which the banking authority must choose to either continue paying a fixed amount to depositors or close the banking system to further withdrawals. We show that such a policy can always uniquely implement the first-best allocation if the banking authority can commit to it but is often not credible without commitment. We also describe how the potential for intervention by the court system during a run can make it more difficult for the banking authority to rule out the run equilibrium. In Section 4 we allow the banking authority to choose a partial suspension scheme in which it reschedules payments once it discovers a run is underway. We again derive conditions under which implementing the first-best allocation as an equilibrium implies that the run equilibrium will also exist. In Section 5 we provide a brief discussion of the banking crisis in Argentina, focusing on how the suspension of convertibility was implemented. Finally, in Section 6 we offer some concluding remarks.

2 The Basic Model

Our basic model follows the now-standard formulation of Cooper and Ross [10], which generalizes the Diamond and Dybvig [11] environment by introducing costly liquidation and a non-trivial portfolio choice.

2.1 The environment

There are three time periods, indexed by $t = 0, 1, 2$. There is a continuum of *ex ante* identical

depositors with measure one. Each depositor has preferences given by

$$u\left(c_1, c_2; \theta\right) = \frac{\left(c_1 + \theta c_2\right)^\gamma}{\gamma},$$

where c_t is consumption in period t, θ is a binomial random variable with support $\{0, 1\}$, and $\gamma < 1$ holds. If the realized value of θ is zero, the depositor is *impatient* and only cares about consumption in period 1. A depositor's type (patient or impatient) is private information and is revealed to her at the beginning of period 1. Let π denote the probability with which each individual depositor will be impatient. By a law of large numbers, π is also the fraction of depositors in the population who will be impatient. Note that π is non-stochastic; there is no aggregate uncertainty in this model.

The economy is endowed with one unit of the consumption good per capita in period 0. There are two constant-returns-to-scale technologies for transforming this endowment into consumption in the later periods. A unit of the good placed into *storage* in period 0 yields one unit of the good in either period 1 or period 2. A unit placed into *investment* in period 0 yields either $R > 1$ in period 2 or $1 - \tau$ in period 1, where $\tau \in (0, 1)$ represents a liquidation cost. In other words, investment offers a higher long-term return than storage but is relatively illiquid in the short term.

There is also a banking technology that allows depositors to pool resources and insure against individual liquidity risk. This technology is operated by a benevolent banking authority (BA), whose objective is to maximize the expected utility of depositors. This authority is a reduced-form representation of the entire banking system of the economy, together with any regulatory agencies and other government entities that have authority over the banking system. Our analysis would be exactly the same if there were a group of profit-maximizing banks competing for deposits in period 0 and if the authority to suspend payments were held by the (benevolent) government. To keep the presentation simple, and in line with the previous literature, we present the model with this system represented by a single, consolidated entity.

The timing of events is as follows. We begin our analysis with all endowments deposited in the banking technology.[4] In period 0, the BA divides these resources between storage and investment. In period 1, depositors are isolated from each other and no trade can occur (as described in Wallace [24]). However, each depositor has the ability to contact the BA, and hence the BA can make pay-

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[4] Because we focus only on the first-best allocation, this assumption is without any loss of generality. In other words, there is no need to examine what Peck and Shell [20] call the "pre-deposit game," because implementing the first-best allocation *requires* that all endowments be deposited. (In addition, depositing is a strictly dominant strategy if the first-best allocation is being uniquely implemented.) This is the same approach taken in Diamond and Dybvig [11].

ments to depositors from the pooled resources after types have been realized. Depositors choose between contacting the BA in period 1 and waiting until period 2. Those who choose to contact the BA in period 1 do so in a randomly-assigned order; they do not know this order when they decide whether or not to contact the BA.[5] The payment made by the BA to a particular depositor during period 1 can only be contingent on the number of previous withdrawals. This sequential-service constraint captures an essential feature of banking: the banking system pays depositors as they arrive and cannot condition current payments to depositors on future information.

2.2 The first-best allocation

Suppose the BA could observe each depositor's type and assign an allocation based on these types. The allocation it would assign is called the (full information) *first best*. This allocation would clearly give consumption to impatient depositors only in period 1 and to patient depositors only in period 2. Let c_E denote the amount given to impatient depositors (who consume "early"), and c_L the amount given to patient depositors (who consume "late"). Let i denote the fraction of the total endowment placed into investment; the remaining $1 - i$ would go into storage. Then the BA would choose c_E, c_L, and i to solve

$$\max \ \pi \frac{1}{\gamma} \left(c_E \right)^{\gamma} + (1 - \pi) \frac{1}{\gamma} \left(c_L \right)^{\gamma}$$

subject to

$$\pi c_E \ = \ 1 - i, \tag{1}$$
$$(1 - \pi) c_L \ = \ Ri,$$

$$c_E \geq 0, c_L \geq 0, \quad \text{and} \quad 0 \leq i \leq 0.$$

The solution to this problem is

$$c_E^* = \frac{1}{\pi + (1 - \pi) R^{\frac{\gamma}{1-\gamma}}}, \quad c_L^* = \frac{R^{\frac{1}{1-\gamma}}}{\pi + (1 - \pi) R^{\frac{\gamma}{1-\gamma}}}, \tag{2}$$

and

$$i^* = \frac{(1 - \pi) R^{\frac{\gamma}{1-\gamma}}}{\pi + (1 - \pi) R^{\frac{\gamma}{1-\gamma}}}.$$

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[5] This simplifying assumption implies that all depositors face the same decision problem, rather than facing different problems depending on their order of arrival at the BA. Most of the results below would also hold if this order were known. We discuss this issue in more detail in Section 4.

Notice that $c_L^* > c_E^*$ necessarily holds, meaning that patient depositors consume more than impatient ones.

In order for the possibility of bank runs to arise, the following condition on parameter values must hold.

Assumption 1. $(1 - \tau)R^{\gamma/(1-\gamma)} < 1.$

This assumption implies that $c_E^* > 1 - \tau i^*$ holds, or that the amount of consumption given to an impatient depositor in the first-best allocation is greater than the per-capita liquidation value of all assets in period 1. In other words, the banking system is illiquid in the short term. Notice that this assumption will hold if τ is large (liquidation costs are significant) and/or γ is small (depositors are sufficiently risk averse). We maintain Assumption 1 throughout.

For the remainder of this section and the next, we restrict attention to the case of $\gamma > 0$ so that $u(0, 0; \theta) = 0$ holds. This assumption is used primarily to simplify the exposition. Our results can be generalized to the case of $\gamma < 0$ in a straightforward way by changing the utility function to

$$u(c_1, c_2; \theta) = \frac{(c_1 + \theta c_2 + b)^{\gamma} - b^{\gamma}}{\gamma} \tag{3}$$

where b is an arbitrarily small scalar.

2.3 Demand deposit contracts

Diamond and Dybvig [11] showed how a payment schedule resembling a simple demand-deposit contract can implement the first-best allocation even though depositors' types are private information. In particular, consider the following arrangement: the BA allows each depositor to choose whether to withdraw her funds in period 1 or in period 2. A depositor withdrawing in period 1 will receive a specified payment c_E (as long as the BA has funds), while a depositor withdrawing in period 2 will receive a pro-rata share of the matured assets. This arrangement clearly respects the sequential service constraint. Depositors then play a game in which each chooses when to withdraw her funds after observing her type, and the payoffs of this game are determined by the promised payment c_E together with the investment decision i. If the BA chooses the policy (c_E^*, i^*), the (full information) first-best allocation is an equilibrium of this game. Impatient depositors will always choose to withdraw in period 1. A patient depositor who expects all other patient depositors to wait until period 2 to withdraw anticipates receiving c_E^* if she withdraws early and c_L^* if

she waits. Since $c_L^* > c_E^*$ holds, as shown above, her best response is to wait. Hence there is an equilibrium where all patient depositors wait until period 2 to withdraw and the first-best allocation obtains.

Proposition 1 *(Diamond and Dybvig* [11]*) The first-best allocation is an equilibrium under the policy* (c_E^*, i^*).

As Diamond and Dybvig also pointed out, however, this simple deposit contract does not uniquely (or, fully) implement the first-best allocation: there exists another equilibrium in which all depositors attempt to withdraw in period 1. In this case, depositors who contact the BA early enough receive c_E^*, while depositors who arrive late (or who deviate and wait until period 2) receive nothing. This equilibrium resembles a run on the banking system.

After pointing out this potential weakness of the demand deposit contract, Diamond and Dybvig showed how adding a suspension of convertibility clause to the contract could render the first-best allocation the *unique* equilibrium outcome. We study suspension policies in detail in the next two sections, beginning with the simple scheme proposed by Diamond and Dybvig.

3   Simple Suspension Schemes

Suppose the BA modifies the deposit contract studied above by announcing a maximum fraction of depositors that it will serve in period 1. Let π_s denote this fraction. In other words, after paying the specified amount c_E to a fraction π_s of depositors in period 1, the BA will close its doors and refuse to serve any more depositors until period 2. The policy of the BA is now summarized by the triple (c_E, i, π_s).

3.1   Simple suspension with commitment

When the BA has commitment power, the cutoff point π_s is chosen in period 0 and cannot be revised in period 1. For this case, Diamond and Dybvig [11] showed that a suspension of convertibility policy *can* implement the first-best allocation as the unique equilibrium of the game played by depositors.

Proposition 2 *(Diamond and Dybvig* [11]*) Under the policy* (c_E^*, i^*, π), *the first-best allocation is the unique equilibrium.*

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The intuition behind this result is simple. If a patient depositor knows the BA will only serve a fraction π of depositors in period 1, regardless of how many attempt to withdraw, then she is certain the BA will have enough resources to pay at least c_L^* in period 2. Since $c_L^* > c_E^*$ holds, waiting to withdraw is a strictly dominant strategy for her, and the only equilibrium has all patient depositors withdrawing in period 2.

In fact, this result does not require that the BA suspend payments right at π; it is sufficient for the BA to suspend payments at any point where it can still afford to give more than c_E^* to depositors who are paid in period 2. The following proposition shows that there is an interval of such values.

Proposition 3 *There exists a value $\pi^T > \pi$ such that the first-best allocation is the unique equilibrium under the policy (c_E^*, i^*, π_s) for all $\pi_s \in [\pi, \pi^T)$.*

Proof: Define the function $c_L(\pi_s)$ as the payoff to a patient depositor who waits until period 2 to withdraw when (i) all other patient depositors attempt to withdraw in period 1 and (ii) the BA suspends payment after a proportion π_s of depositors have withdrawn. Then we have

$$c_L(\pi_s) = \frac{R\left(1 - \tau i^* - \pi_s c_E^*\right)/\left(1 - \tau\right)}{(1 - \pi)(1 - \pi_s)}. \tag{4}$$

The numerator of this expression represents the total resources of the banking system in period 2, while the denominator represents the fraction of depositors who were not served in period 1 and are patient (and thus care about consumption in period 2).[6] Note that

$$c_L(\pi) = \frac{c_L^*}{(1 - \pi)} > c_L^* > c_E^*.$$

It is straightforward to show that $dc_L(\pi_s)/d\pi_s < 0$ holds. In addition, there exists a value $\pi_s^U < 1$ such that $c_L(\pi_s^U) = 0$; this value is given by $\pi_s^U \equiv 1 - \tau i^*/c_E^*$. Hence there is a unique value π^T such that $\pi_s < \pi^T$ implies $c_L(\pi_s) > c_E^*$ while $\pi_s > \pi^T$ implies $c_L(\pi_s) < c_E^*$. (See Figure 1.) Therefore, for any $\pi_s \in [\pi, \pi^T)$, waiting is a strictly dominant strategy for patient depositors. $\square$

Notice that the actual suspension point chosen does not matter as long as it is in this interval because a suspension never occurs in equilibrium. In this way, the BA is able to costlessly eliminate

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[6] We assume that impatient depositors who are not served in period 1 do not contact the BA in period 2 since they have no desire to consume. Our main results would also hold if these depositors did contact the BA and receive a share of the remaining funds.
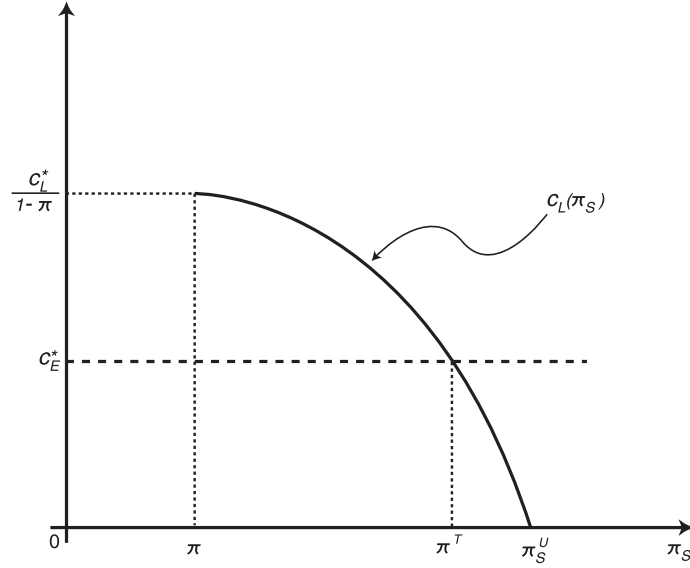
Figure 1: Payoff in period 2 after a suspension at π_s

the possibility of bank runs when it can commit to a simple suspension scheme.[7]

3.2 Simple suspension without commitment

The analysis in the previous subsection relies heavily on the assumption that the BA commits to the suspension scheme in period 0. If, instead, the BA can re-evaluate its decision after it discovers that a run is underway in period 1, would it want to actually follow through with the threat to suspend? Consider a situation where the BA, attempting to implement the first-best allocation, has already paid out c_E^* to a fraction π of depositors and then some additional depositors arrive to withdraw in period 1. The BA recognizes that the fraction of depositors attempting to withdraw in period 1 will be either π or 1. (In other words, the BA knows that patient depositors will play a symmetric, pure-strategy equilibrium of the game.) If more than π depositors attempt to withdraw, a run must be underway and the BA realizes that some of the money it has already paid out was given to depositors who are actually patient. Furthermore, it knows that some impatient depositors have not yet been served and will be attempting to withdraw. Suspending convertibility implies giving nothing to these depositors, which may be very costly from a social point of view, and hence the BA may not want to suspend payments right away.

We now consider *credible* suspension policies, in which the suspension point announced in

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[7] Gorton [15] offers another interpretation of the role of suspension clauses in demand deposit contracts. When the value of a bank's assets is random and a suspension triggers a costly state-verification process, the suspension can be *ex post* Pareto improving. Credibility issues are evidently not as relevant in such settings as they are here.

period 0 must equal what the BA would choose if it actually faced a run in period 1.[8] We ask if such a policy can be used to implement the first-best allocation as the unique equilibrium, or if the run equilibrium will also exist when the BA tries to implement the first best. The BA's objective in period 1 is the same as it was in period 0: to maximize the expected utility of depositors, which is equivalent to the weighted average of utilities after types have been realized. Once the BA discovers a run is underway, it will choose the suspension point π_s that maximizes

$$W(\pi_s) \equiv (\pi_s - \pi) \frac{1}{\gamma} (c_E^*)^\gamma + (1 - \pi_s)(1 - \pi) \frac{1}{\gamma} [c_L(\pi_s)]^\gamma. \tag{5}$$

This objective recognizes that, of the $1 - \pi_s$ depositors who are not served in period 1, a fraction $1 - \pi$ will be patient and return in period 2. The remaining fraction π will be impatient and will receive nothing, leaving them with a utility level of zero. Let π_s^M denote the value of π_s that maximizes (5). By Proposition 3, the effectiveness of the credible suspension policy in preventing a run depends crucially on whether π_s^M is smaller or larger than π^T, the threshold suspension point for eliminating the run equilibrium. (See Figure 1.) If it is smaller, the BA would choose to suspend payments relatively quickly when faced with a run, so that $c_L\left(\pi_s^M\right) > c_E^*$ holds and a patient depositor is better off waiting than participating in the run. In this case, the credible suspension scheme generates the first-best allocation as a unique equilibrium; bank runs will not occur. However, if π_s^M is greater than π^T, the BA would suspend payments relatively late when faced with a run and depositors who wait to withdraw will receive less than c_E^*. A patient depositor who expects others to run will, therefore, choose to run as well and the bank run equilibrium exists.

We first show that when the fraction of impatient depositors in the population is small enough, the BA would choose to immediately suspend convertibility when facing a run.

Proposition 4 *Given all other parameter values, there exists a value $\overline{\pi} \in (0, 1)$ such that $\pi_s^M = \pi$ holds if and only if $\pi \le \overline{\pi}$.*

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[8]   Our use of the word *credible* follows that in Mailath and Mester [18] and differs somewhat from that in Stokey [22], where the focus is on reputational equilibria in dynamic games. We view our approach as applying the time consistency notion of Kydland and Prescott [17] to policies that lie potentially off the equilibrium path; this can also be viewed as a form of subgame perfection. See the related work of Bassetto [4], which is also concerned with the specification of government policy along potentially off-equilibrium paths and shows how multiplicity of equilibria is more common than previously thought. His approach, however, assumes commitment and only requires that announced policies be *feasible* along all possible paths of play. In our setting, suspension is always feasible and commitment (or the lack thereof) is the critical issue.

Proof: Define

$$A\left(\pi_s\right) \equiv \frac{c_L\left(\pi_s\right)}{c_E^*}. \tag{6}$$

Using (1) and (4), this expression can be written as

$$A\left(\pi_s\right) = \frac{\left(1-\pi\right)R^{\frac{1}{1-\gamma}} - \left(\pi_s - \pi\right)\frac{R}{1-\tau}}{\left(1-\pi_s\right)\left(1-\pi\right)}. \tag{7}$$

Using (6), the BA's objective function (5) can be rewritten as

$$W(\pi_s) = \frac{(c_E^*)^\gamma}{\gamma}\left(\pi_s - \pi + (1-\pi_s)(1-\pi)A(\pi_s)^\gamma\right).$$

It is straightforward to show that W is strictly concave. Using (7), its derivative can be written as

$$W'\left(\pi_s\right) = \frac{(c_E^*)^\gamma}{\gamma}\left[1 - (1-\gamma)\left(1-\pi\right)A\left(\pi_s\right)^\gamma - \gamma\frac{R}{1-\tau}A\left(\pi_s\right)^{\gamma-1}\right]. \tag{8}$$

The optimal suspension point will equal π if and only if $W'\left(\pi\right) \leq 0$ holds. Evaluating (8) at $\pi_s = \pi$ and solving this inequality for π yields

$$\pi \leq 1 - \left(\frac{1}{(1-\gamma)R^{\frac{\gamma}{1-\gamma}} + \frac{\gamma}{1-\tau}}\right)^{\frac{1}{1-\gamma}} \equiv \overline{\pi}.$$

$\square$

This result demonstrates that for some parameter values, the BA *can* uniquely implement the first-best allocation using a credible suspension policy. When relatively few depositors have a real need to consume early, the cost of closing the banking system's doors and giving these depositors nothing is relatively small. In addition, a large proportion of any additional payments made in period 1 would go to depositors who are actually patient. The optimal response to a run in this case is to suspend convertibility right away and preserve a high payment to the relatively large number of patient depositors in period 2.

When π is greater than $\overline{\pi}$, however, the BA would not find it optimal to suspend convertibility at π in the event of a run. Rather, it would balance the costs and benefits of suspending, and the credible suspension point is implicitly defined by

$$W'\left(\pi_s^M\right) = 0.$$

As discussed above, the critical question is whether the resulting value of π_s^M is larger or smaller than π^T, the threshold beyond which the run equilibrium exists. The main result of this section shows that, for some parameter values, it is larger. In these cases, the BA would choose to wait "too long" before suspending convertibility when faced with a run and, as depositors anticipate this reaction when making their withdrawal decision, the run equilibrium exists. In other words, there exist cases where the BA *cannot* uniquely implement the first-best allocation using a credible suspension policy. The following proposition gives the precise conditions under which this does and does not occur.

Proposition 5 *A credible simple suspension policy can generate the first-best allocation as the unique equilibrium if and only if we have*

$$\pi < \frac{\gamma}{1-\gamma}\left(\frac{R}{1-\tau} - 1\right). \tag{9}$$

Proof: The credible suspension policy discussed above generates a unique equilibrium if and only if $\pi_s^M < \pi^T$ holds, or (by the concavity of W) if and only if we have

$$W'\left(\pi^T\right) < 0.$$

Using (8) and the fact that $A\left(\pi^T\right) = 1$ holds (see (6) and Figure 1), this condition becomes

$$1 - (1-\gamma)(1-\pi) - \gamma\frac{R}{1-\tau} < 0.$$

Straightforward manipulations then yield (9). □

Notice that (9) will necessarily hold if the right-hand side of the inequality is greater than one, or if we have

$$\gamma > \frac{1-\tau}{R}. \tag{10}$$

If this condition holds, depositors are relatively close to being risk neutral and it is not very costly to have some impatient depositors receive zero consumption. In this case, the credible suspension point is early enough to eliminate the run equilibrium for any value of π. Depositors must exhibit a minimal amount of risk aversion for bank runs to be an issue. On the other hand, notice that for any given value of π, condition (9) will be violated if gamma is small enough. In other words, regardless of the other parameter values, the bank run equilibrium will exist if depositors are sufficiently

risk averse. We state this result in the following corollary.

Corollary 1 *If depositors are sufficiently risk averse, the first-best allocation **cannot** be uniquely implemented by a credible simple suspension policy.*

3.3 Discussion

The results above give conditions under which a bank-run equilibrium exists when the BA attempts to implement the first-best allocation. Would a bank run actually occur in such cases? This question raises the difficult issue of equilibrium selection, which is beyond the scope of the present paper. However, the existing literature offers a fair amount of guidance on how the issue can be dealt with. The most common approach is to assume that depositors condition their actions on the realization of an extrinsic, commonly-observed "sunspot" variable; the run equilibrium is played if spots appear on the sun and the no-run equilibrium is played if they do not. The probability of a run is then equal to the (exogenous) probability of sunspots.[9]

From the standpoint of the present paper, the important point is that the existence of the run equilibrium will create costly distortions regardless of the probability assigned to it by the sunspots selection mechanism. If this probability is high enough, the BA will choose a "run-proof" contract, which offers less liquidity insurance than the first-best allocation but makes withdrawing in period 2 a dominant strategy for patient depositors. If the probability of a run is low, the BA will choose a contract that is not run proof, and a bank run will occur with positive probability in equilibrium. Even if a run does not occur, however, the allocation that is implemented will again not be the first best because the *ex ante* possibility of a run distorts the optimal deposit contract (see Cooper and Ross [10] and Ennis and Keister [14]). In other words, unless one arbitrarily assigns a probability of zero to the run equilibrium, its existence introduces distortions which imply that the first-best allocation cannot be achieved. We do not focus on the exact nature of these distortions here. Rather, our goal in this paper is to show how taking time-consistency issues into account reveals that the problem of bank runs is more pervasive than was previously thought. Even in the standard Diamond-Dybvig framework with no uncertainty about the level of fundamental withdrawal demand, in some cases the possibility of a bank run cannot be costlessly ruled out.[10]

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[9] This approach was suggested in Diamond and Dybvig [11, p. 410] and explicitly taken in Cooper and Ross [10], Peck and Shell [20], and others.

[10] The issues discussed here are not unique to models of bank runs; they arise in any environment where multiple

3.4 Court intervention

In addition to suspending convertibility, there are a variety of other ways in which a banking authority or government might deal with the occurrence of a bank run. One notable feature of the banking crisis in Argentina in 2001 was the involvement of the court system. Depositors claiming to have urgent financial needs (due, for example, to illness or hospitalization) could file a legal recourse requesting withdrawal of some or all of their funds from the banking system while the suspension was in place. Nearly two hundred thousand such cases were filed between December 2001 and June 2003, and the courts awarded payments to depositors totaling over 14 billion pesos. (See Section 5 for a detailed discussion and breakdown of these figures.) This process was based on the presumption that the courts had at least some ability to differentiate between depositors who needed funds urgently and those who did not. In this section we show how such verification power can make it *more* difficult for the BA to uniquely implement the first-best allocation. By improving the ability to allocate resources once a run is underway, a court intervention can make suspending payments less attractive and thereby undermine the BA's ability to commit to policies that are desirable *ex ante*.

Suppose that once the BA discovers a run is underway, the court system intervenes and determines the true type of each remaining depositor. In principle, one would expect verifying types to involve some administrative costs. To keep the analysis as simple as possible, we abstract from such costs: we assume that type verification occurs costlessly, but only *after* π depositors have already withdrawn. The latter part of this assumption prevents the BA from using the courts to completely overcome the private information problem. With a positive verification cost, the BA would choose not to screen the types of the first π individuals to withdraw because it is trying to implement the first-best allocation. Our results below would then hold as long as the cost is low enough that using the verification technology is desirable *ex post*. We present the limiting case where the cost is zero only because it simplifies the expressions involved.

If the courts intervene after a suspension has been declared, they will award c_E^* to the remaining $\pi(1-\pi)$ impatient depositors in period 1. The $(1-\pi)^2$ remaining patient depositors will receive

$$c_{LC}^* \equiv \frac{R}{(1-\pi)^2}\left(i^* - \frac{(1-\pi)\pi}{(1-\tau)}c_E^*\right)$$

equilibria are possible and a policymaker makes some decisions before knowing which equilibrium will be played. See Bassetto and Phelan [5] and Ennis and Keister [13] for discussions of these issues in models of optimal taxation.

in period 2. What action would a patient depositor take at the beginning of period 1 if she expects other patient depositors to run and a suspension to be followed by a court intervention? If $c^*_{LC} > c^*_E$ holds, she would wait until period 2 to withdraw and the run equilibrium would not exist. In this case, the BA and courts together can uniquely implement the first-best allocation; note that the court system will not be used in equilibrium because a run will not occur. However, if the inequality is reversed she would choose to run and hence the run equilibrium will exist. The following proposition characterizes the set of parameter values for which each case occurs.

Proposition 6 *A deposit contract together with court intervention can generate the first-best allocation as the unique equilibrium if and only if we have*

$$\pi < \frac{(1-\tau)}{R - (1-\tau)} \left(R^{\frac{1}{1-\gamma}} - 1 \right). \tag{11}$$

Once again we see that uniquely implementing the first-best allocation is possible only if there are relatively few impatient depositors. It is interesting to compare (11) with condition (9) in Proposition 5. Recall that (9) is the necessary and sufficient condition for the run equilibrium to not exist when the BA uses a credible simple suspension scheme and the courts cannot intervene. Straightforward algebra shows that when liquidation costs are high, condition (11) is stronger than condition (9). In such cases, there exist intermediate values of π such that (i) without court intervention the credible simple suspension scheme uniquely implements the first-best allocation, but (ii) with court intervention the run equilibrium exists. We formalize this result in the following corollary.

Corollary 2 *Given all other parameter values, there exists $\hat{\tau} \in [0, 1)$ such that for all $\tau \geq \hat{\tau}$, condition (9) holds but condition (11) is violated for an interval of values for π.*

In other words, court intervention can undermine the ability of the BA to uniquely implement the most desirable allocation. We can go a step further and ask whether or not the (benevolent) BA would actually want the courts to intervene. Corollary 2 shows that, at least for some parameter values, in period 0 the BA would like to commit to *not* allowing the courts to intervene in the event of a run. However, it is not difficult to show that for some of these same parameter values, in period 1 the BA would choose to allow the courts to intervene once a run is underway because they lead to a better allocation of resources. In this sense, the possibility of using the courts to verify

depositors' types introduces a new kind of time-inconsistency problem. Even in cases where a credible simple suspension scheme would be able to eliminate the possibility of a bank run, the inability to credibly rule out a court intervention in the event of a run could render the banking system vulnerable to a run.

4 Partial suspension schemes

The policies studied above place a somewhat artificial restriction on the suspension scheme: the BA must pay c_E^* to all depositors it serves in period 1. We now relax this restriction and let the BA choose what the literature calls a *partial* suspension scheme. Because it is attempting to implement the first-best allocation, the BA will still pay c_E^* to the first π depositors who withdraw in period 1. However, if more than π depositors attempt to withdraw in period 1, the BA can choose any continuation of the payment schedule that it sees fit. This may involve offering payments smaller than c_E^*, partially suspending the convertibility of deposits, in addition to potentially suspending payments altogether.

If the BA declares a partial suspension and begins offering a payment of less than c_E^*, a patient depositor who had chosen to run but had not yet been served may prefer to come back in period 2 rather than accept this smaller payment. We allow depositors to do this. In other words, after π withdrawals have taken place and a partial suspension has been declared, depositors who have not yet withdrawn play a continuation game in which they each decide again whether to withdraw in period 1 or in period 2. It is possible that play in this continuation game will correspond to a continued run on the banking system, or the partial suspension may halt the run. The optimal payments for the BA to offer in a partial suspension depend on what it anticipates depositors will do after a suspension occurs. Suppose for the moment that the BA anticipates that *any* continuation payment schedule would halt the run. Then the BA would choose payments that solve the following problem[11]

$$\max_{c_E,c_L,i} (1 - \pi) \left[\pi \frac{1}{\gamma} (c_E)^\gamma + (1 - \pi) \frac{1}{\gamma} (c_L)^\gamma \right]$$

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[11] Note that the solution to this problem is the first-best allocation for the continuation economy after π agents have each received c_E^* from the banking system. It is also the allocation that a court system with the ability to distinguish depositors' types and to enforce a partial suspension of payments (paying impatient depositors less than c_E^*) would choose.

subject to

$$(1 - \pi) \, \pi c_E \ \leq \ (1 - \tau) \, i^*,$$
$$(1 - \pi)^2 c_L \ = \ R \left[i^* - \frac{(1 - \pi) \, \pi c_E}{(1 - \tau)} \right],$$

$$c_E \geq 0 \ \text{ and } \ c_L \geq 0.$$

The first constraint reflects the fact that all of the resources in storage have already been paid out to the first π depositors who withdrew. Additional payments in period 1 can only come from liquidating investment. Also note that since the BA expects the new payment schedule to deter patient depositors from running, only a proportion π of the $(1 - \pi)$ depositors who have not yet withdrawn are expected to withdraw in period 1. The second constraint is the standard pro-rata share of remaining resources that determines the payment in period 2. The solution to this problem is given by

$$c_{ER}^* = \frac{1}{(1 - \pi) \, \widehat{R} + \pi} \frac{(1 - \tau) \, i^*}{(1 - \pi)} \quad \text{and} \quad c_{LR}^* = \left(\frac{R}{1 - \tau} \right) \frac{\widehat{R}}{(1 - \pi) \, \widehat{R} + \pi} \frac{(1 - \tau) \, i^*}{(1 - \pi)} \qquad (12)$$

where

$$\widehat{R} = [R/(1 - \tau)]^{\gamma/(1 - \gamma)}.$$

Note that $c_{LR}^* > c_{ER}^*$ holds.

If γ is positive, it is easy to see that the solution satisfies

$$(1 - \pi) \, c_{ER}^* \leq (1 - \tau) \, i^*.$$

In this case, the BA has enough resources to pay c_{ER}^* to all remaining depositors in period 1. A depositor who waits until period 2 would then receive more than c_{ER}^*, even if all other depositors withdraw in period 1, and therefore waiting until period 2 to withdraw is a dominant strategy for patient depositors following the rescheduling of payments. In other words, the continuation contract is run proof, and the BA's expectation that the run would be halted must clearly be fulfilled.

Given that depositors know the BA would respond to a run by changing the payments to (c_{ER}^*, c_{LR}^*), thereby halting the run, does an equilibrium exist where patient depositors run at the beginning of period 1? A patient depositor who believes that all other depositors are running will have an expected payoff of $\pi \frac{1}{\gamma} (c_E^*)^\gamma + (1 - \pi) \frac{1}{\gamma} (c_{LR}^*)^\gamma$ if she also runs, but will receive c_{LR}^* for

certain if she does not run. Using (2) and (12), it is straightforward to show that $\gamma \geq 0$ implies that $c_{LR}^* \geq c_L^* > c_E^*$ holds and, therefore, the depositor would prefer not to run. In other words, the run equilibrium does not exist when γ is positive. We summarize this discussion in the following proposition.

Proposition 7 *For $\gamma \in [0, 1)$, a credible partial suspension policy can generate the first-best allocation as the unique equilibrium.*

It is interesting to note that the continuation game after π depositors have withdrawn during a run resembles the original Diamond-Dybvig model, which had a single asset and no portfolio decision. The analysis above shows that, as in Diamond and Dybvig [11], the first-best allocation in the continuation game is run proof if the coefficient of relative risk aversion is smaller than one. Proposition 7 shows that this result has important implications for our full model: if γ is positive, then, regardless of the size of the liquidation cost τ, a credible suspension scheme will allow the banking authority to achieve the first-best allocation without having to worry about the possibility of a run.

The parallel between our continuation game and the original Diamond-Dybvig model suggests that the results may be very different when $\gamma < 0$ holds.[12] In this case, we have $(1 - \pi) c_{ER}^* > (1 - \tau) i^*$ and the continuation contract is not run-proof. The possibility of a run in the continuation game substantially complicates the analysis. The decision of a patient depositor to run or not at the beginning of period 1 will now be influenced not only by the payments offered under the suspension scheme, but also by her assessment of the probability that the suspension would halt the run. In other words, the issue of equilibrium selection in the continuation game necessarily comes into play.

Our interest is solely in whether or not there exists an equilibrium of the overall game in which all depositors attempt to withdraw at the beginning of period 1. To keep matters simple, we focus on equilibria in which the BA and depositors believe that a run will halt after the BA declares a partial suspension. In other words, we (arbitrarily) select the no-run equilibrium of the continuation game. More generally, one could introduce a sunspot variable and study situations in which there is a positive probability of both the run and the no-run equilibrium being played. Focusing on this

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[12] In the analysis that follows, there are no circumstances in which some depositors receive zero consumption. We can therefore study the case where the coefficient of relative risk aversion is greater than one without changing the form of the utility function to (3).

one (fairly extreme) case, however, is sufficient for establishing our point, and it allows us to give a relatively simple sufficient condition for the run equilibrium to exist in the overall game.

Suppose a patient depositor believes all other depositors will initially attempt to withdraw in period 1, but the partial suspension given by (12) will halt the run. Would she choose to participate in the run? If she does, she will receive c_E^* with probability π and c_{LR}^* with probability $(1 - \pi)$. She would choose to run, and hence the run equilibrium will exist in the overall game, if $c_{LR}^* \leq c_E^*$ holds. Using the definitions of c_E^*, i^*, and c_{LR}^*, this inequality can be shown to be equivalent to

$$f(\tau, \gamma) \equiv R^{\frac{1}{1-\gamma}} \frac{\left(\frac{R}{1-\tau}\right)^{\frac{\gamma}{1-\gamma}}}{(1 - \pi)\left(\frac{R}{1-\tau}\right)^{\frac{\gamma}{1-\gamma}} + \pi} \leq 1. \tag{13}$$

We state this result as the following proposition.

Proposition 8 *A credible partial suspension policy **cannot** generate the first-best allocation as the unique equilibrium if* (13) *holds.*

It is worth emphasizing precisely what this proposition says. When (13) holds, there is an equilibrium where all depositors attempt to withdraw their funds in period 1. The BA pays c_E^* to a fraction π of these depositors and then declares a partial suspension. Impatient depositors who contact the BA after the suspension has been declared receive c_{ER}^*, while patient depositors who have not yet been served decide not to contact the BA in period 1 and instead receive c_{LR}^* in period 2. There may be other equilibria in which, for example, the partial suspension does not halt the run and the BA must suspend payments a second time (and possibly a third time, and so on). We do not study such equilibria here because our interest is in whether or not the first-best allocation can be uniquely implemented. Once we have constructed an equilibrium in which depositors run at the beginning of the period, the answer is clearly negative.

It is worth emphasizing that the set of contracts we study in this section is completely general. The BA must pay c_E^* to the first π depositors who withdraw in order for there to be an equilibrium that implements the first-best allocation. After these payments are made, we allow for *any* possible continuation contract. We differ from the existing literature in requiring that the choice of contract be optimal for the continuation economy; in fact, the first-best continuation allocation is implemented in the run equilibrium we construct. The existence of the run equilibrium in our setting is, therefore, not the result of the "simple contracting" approach of Diamond and Dybvig

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(see Green and Lin [16]). It is also worth noting that our results would not change if depositors knew the order in which they would contact the BA in period 1 before deciding when to withdraw their funds. Patient depositors who will contact the BA after a suspension has been declared decide (in the run equilibrium) to delay withdrawing until period 2, but any patient depositor who knows she will arrive before the suspension is declared strictly prefers to withdraw early.[13]

Notice that (13) will not hold if π is close to zero, which is reminiscent of Propositions 4 and 5 in the earlier sections. When there are relatively few impatient depositors, a run is discovered quickly and sufficient assets remain for it to be optimal to offer a relatively large payment in period 2 under the partial suspension. If the partial suspension will halt the run, this large payment removes the incentive for patient depositors to run in the first place. Also notice that, consistent with Proposition 7, (13) cannot hold if γ is positive. However, if γ is negative then for high enough values of the liquidation cost τ, the inequality does hold. In other words, if the coefficient of relative risk aversion is greater than one, a run equilibrium will exist whenever liquidation costs are large.

Corollary 3 *When γ is negative, there exists $\overline{\tau}$ such that for all $\tau \in [\overline{\tau}, 1)$ the first-best allocation* ***cannot*** *be uniquely implemented by a credible partial suspension policy.*

Villamil [23] suggests that banks could commit to suspending convertibility by making investments that cannot under any circumstances be liquidated (and shows how the optimal lending contract can have this property in some settings). This idea can be captured in our notation by setting $\tau = 1$, in which case suspending payments after all liquid assets have been depleted is clearly credible. However, Corollary 3 points out the knife-edge nature of this argument. If liquidation is difficult but not impossible (*i.e.*, τ is close to but not equal to 1), the banking authority will choose to liquidate some investment when faced with a run even if doing so is extremely costly and, as a result, the run equilibrium is certain to exist.

Given a value of the liquidation cost (and all other parameter values), (13) will necessarily hold if γ is small enough. The result in Proposition 8 can therefore be stated another way: the banking authority cannot implement the first-best allocation without introducing a run equilibrium if depositors are sufficiently risk averse.

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[13]   In other words, it does not matter if we adopt the Green and Lin [16] assumption that depositors know their time of arrival at the BA or the Peck and Shell [20] assumption that they do not. The backward-induction based argument used by Green and Lin cannot be applied to the equilibrium we construct.

Corollary 4 *There exists $\overline{\gamma} < 0$ such that for all $\gamma \leq \overline{\gamma}$ the first-best allocation **cannot** be uniquely implemented by a credible partial suspension policy.*

To summarize, we have shown how time-consistency issues may undermine the ability of a banking authority to achieve desirable allocations. In a standard Diamond-Dybvig environment where only credible suspension schemes are allowed, in many cases the BA cannot engineer a policy that implements the first-best allocation as the unique equilibrium of the strategic interaction among depositors. In the next section, we discuss how these types of problems limited the effectiveness of the suspension scheme imposed by the government of Argentina during the banking crisis of 2001.

## 5   Suspension of Convertibility in Argentina in 2001

During the economic expansion in Argentina in the 1990s, total deposits in the banking system grew from less than 10% to almost 30% of GDP. As the banking system became more important, it also became highly dollarized.[14] By 1999 the proportion of deposits denominated in foreign currency (US dollars) was close to 60%. For a variety of reasons, including adverse external shocks and increased political instability, by the end of the year 2000 the risk of a peso devaluation had increased significantly. Since the banking system was dollarized, a devaluation was directly linked to insolvency. Dollarized loans implied that a devaluation would leave a large portion of debtors unable to pay back their commitments, since their earnings were not pegged to the dollar. As a result, the banking system, which had become an important part of the economy, was increasingly under strain.

Figure 2 shows the evolution of total deposits in the banking system between the beginning of 2001 and the middle of 2002. In July and August of 2001, deposits fell by 8.5 billion dollars (10%) and the system became further dollarized. In September, Argentina reached an agreement with the IMF and expectations improved. During that month, the system gained deposits. However, in October and November, the political situation worsened and deposits started to fall again. In the

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[14]   Effectively, the banking system in Argentina had a significant proportion of what could be considered *real* contracts, which makes the use of Diamond-Dybvig and related models especially appropriate. Recently, a number of papers have dealt with the issue of liquidity provision in systems with *nominal* contracts, where additional liquidity can be created by printing more currency. (See, for example, Champ *et al.* [8], Allen and Gale [2], Antinolfi et al. [3], and Martin [19].) The fact that a large proportion of contracts in Argentina were dollarized makes such models less applicable.

last two days of November deposits fell 2.5 billion dollars (3%) and the government decided to suspend convertibility. Initially, the rule established a type of partial suspension for 90 days and stated that during this period depositors could withdraw a maximum of $1,000 per month from each account. It should be noted, though, that depositors were allowed to move their balances from one bank to another and make certain payments as long as the funds stayed within the banking system. International outflows were heavily restricted.

Figure 2: Evolution of Deposits During the Crisis
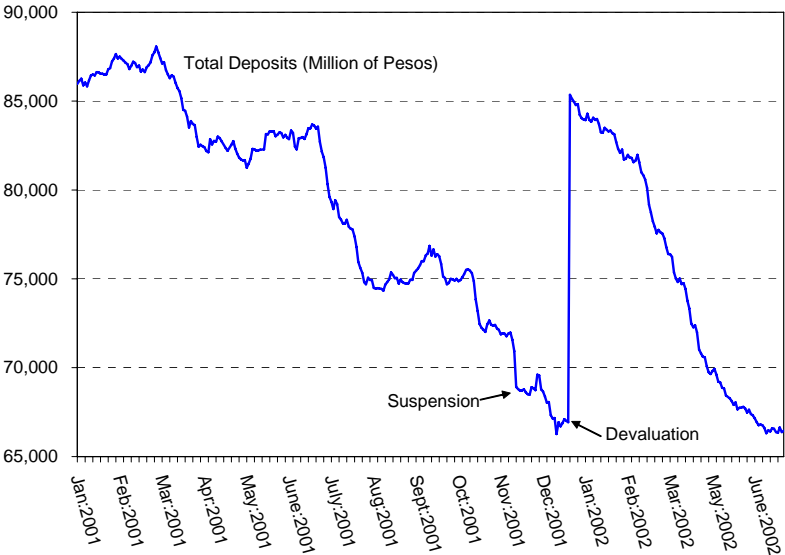
Source: Ministry of the Economy and Production of Argentina.

In spite of the suspension, deposits continued falling during the month of December (at the pace allowed by the partial restrictions on availability). At the same time, deposits flowed towards a select group of institutions that the public perceived as better positioned to confront the crisis. This flow of funds within the system created a liquidity crunch in those institutions outside the select group and in late December the government created a Bank Liquidity Fund to assist the most troubled institutions. All banks in the system contributed to the Liquidity Fund. The creation of this Fund is conceptually important because it demonstrates the importance of studying liquidity shortages at the level of the banking system as a whole and not at the level of an individual bank.

At the time of the devaluation (January 11, 2002), 70% of deposits were denominated in dollar terms. These deposits were converted into pesos using the official exchange rate of 1.4 pesos per dollar. The partial suspension remained in place. Depositors responded to the continued suspension

by filling legal recourses. By April 2002 more than 28 thousand cases were favorably resolved in court and the payments corresponding to those cases contributed to an extra 2.3 billion pesos of reduction in deposits. Legal recourses continued being filed and during the year 2002 more than 150 thousand cases were resolved (see Table 1). Of the value of total deposits in the system as of March 2002 (around 65 billion pesos) more than 18% were paid out to depositors via legal recourse.

Illness and other urgent personal financial needs were common justifications given for court rulings in favor of depositors. The average size of the payment in a typical legal case was fairly stable across time.[15] In the first five months of the suspension the average payment was $82 thousand pesos, falling later to $75 thousand pesos in the second half of 2002 and $60 thousand in the first half of 2003. These numbers are not much different from the average size of individual deposits in the system during the first half of 2001, which was around $23 thousand pesos (equivalent to $70 thousand pesos in 2002).

Table 1. Legal recourse against convertibility restrictions in Argentina 2001-2003

Period	Number of Court Cases	Total Payment (Mill. Pesos)	Total Drop in Banks' Liabilities (Mill. Pesos)	Average Size of Payment (Pesos)
Dec., 2001-April, 2002	28,430	2,346	1,312	82,518
May.-June, 2002	28,285	2,124	1,026	75,093
Dec., 2001-June, 2002	56,715	4,470	2,338	78,815
July-Dec., 2002	92,926	7,109	3,834	76,502
Jan.-June, 2003	42,249	2,437	1,643	57,682
Total (Dec. 2001 - June 2003)	191,890	14,016	7,815	73,042

Note: Court Cases ("Amparos") stands for court-ordered repayments of individuals' frozen deposits. Banks' deposit liabilities were accounted in pesos after converting dollar deposits into pesos at the 1.4 official exchange rate (the liability also includes the indexation called CER). However, some payments to depositors (second column) were made for the dollar amount of the deposits (according to court rule). Hence, total payments (in pesos) tends to be larger than the accounting value (third column).

The banking crisis in Argentina in 2001 highlights the practical limitations of a suspension of convertibility scheme. While the suspension did reduce the outflow of funds from the banking system in December 2001, two features limited its effectiveness. First, it was politically infeasible for the government to order a complete suspension. Many depositors needed access to at least

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[15]   Somewhat surprisingly, this data does not suggest that large depositors were the first to be successful in court.

some of their funds for daily living expenses, and granting this partial access led to a slow but steady "leaking" of funds out of the system. Second, the government could not stop the courts from allowing an additional leakage of funds after the suspension was declared. These issues correspond to precisely the type of commitment problems studied in the previous sections. In particular, it seems plausible that the anticipation of the lack of full commitment to the suspension scheme could have been an important factor in motivating the initial run in late November 2001.

6 Conclusion

Credibility and time-inconsistency issues are pervasive in economics and have been studied extensively. In banking theory, however, the importance of policy credibility has received relatively little attention, apart from often informal treatments of bank bailouts.[16] In this paper, we analyze for the first time the credibility limitations associated with policies designed to respond to a run on the banking system. We find that such limitations can be important and may render some of the most commonly-proposed policies ineffective in preventing a run. If commitment to a suspension of payments is hard to guarantee, the problems associated with bank runs may be more pervasive than previously thought. In particular, bank runs are a relevant issue even in the simple framework of Diamond and Dybvig [11].

We use this simple framework for our analysis because it is widely known and it allows us to present our ideas in a clear and transparent way. Many of the simplifying assumptions in this model, however, are not essential for our purposes. For example, assuming that there is no aggregate uncertainty about fundamental withdrawal demand, and hence that the banking authority knows the exact point at which suspending payments is appropriate, may be considered extreme. Changing the model so that the fraction of depositors who are impatient is random will complicate matters, but our insights will remain valid as long as the support of the distribution is not too large. What is important for our analysis is that there is a upper bound on the level of normal withdrawal demand, and that suspending payments to depositors once this bound is reached would rule out the possibility of a self-fulfilling bank run. In any such setting, the credibility of the threat to suspend comes into question and the issues highlighted in this paper are relevant.

The ability of a banking authority to commit to suspending payments in reality is likely to de-

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[16] Two notable exceptions are Mailath and Mester [18] and Acharya and Yorulmazer [1], both of which deal with policies regarding bank closure.

pend on how long the banking system needs to remain closed in order for the "panic" to subside. If the actual time lapse between periods 1 and 2 in the model corresponds to only a day or two, the fraction of depositors who need access to their funds during that period is probably rather small. This case corresponds, therefore, to a low value of π in the model. Our results (see especially Propositions 4 and 5) show that if π is low enough, a credible suspension policy often *can* uniquely implement the first-best allocation. In other words, if only a short suspension of payments is required, commitment is less likely to be problematic. The longer the time period involved, however, the more difficult it becomes for the banking authority to commit to a suspension. It was clear to observers that the banking crisis in Argentina was not likely to be sorted out quickly, which undoubtedly made commitment to a complete suspension of payments more difficult and may have contributed *ex ante* to individuals' decisions to run. This reasoning suggests that a banking system with fundamental weaknesses, where a longer suspension of payments would likely be required, should be more susceptible to a run than a system that is fundamentally sound. Formalizing this argument would require a more fully dynamic model and seems a promising avenue for future research.

Studying suspension policies in a longer-horizon setting would introduce other interesting issues. It is well known, for example, that reputational concerns can substitute for commitment in some settings. (See Stokey [22] and Chari and Kehoe [9].) The extent to which the desire to build a reputation for being "tough" in the face of a run would enable the banking authority to credibly suspend payments (and thereby rule out runs) is an interesting question. The answer will likely depend on how, if ever, the reputation is tested given that bank runs potentially lie off the equilibrium path. While these difficult issues are beyond the scope of the present paper, we believe that our analysis provides a critical first step by highlighting their relevance. Once it is recognized that suspension of convertibility policies may not be time consistent even in simple settings, issues of both static and dynamic credibility become important and the classic model of Diamond and Dybvig becomes a natural benchmark for their study.

References

[1] Acharya, Viral V. and Tanju Yorulmazer, "Too many to fail: an analysis of time-inconsistency in bank closure policies," mimeo., May 2005.

[2] Allen, Franklin and Douglas Gale, "Optimal financial crises," *Journal of Finance* 53 (1998), 1245–1284.

[3] Antinolfi, Gaetano, Elisabeth Huybens, and Todd Keister "Monetary stability and liquidity crises: the role of the lender of last resort," *Journal of Economic Theory* 99 (2001), 187-219.

[4] Bassetto, Marco, "Equilibrium and government commitment," *Journal of Economic Theory* 124 (2005), 79-105.

[5] Bassetto, Marco and Christopher Phelan, "Tax riots," mimeo., Federal Reserve Bank of Minneapolis, January 2006.

[6] Bryant, John, "A model of reserves, bank runs, and deposit insurance," *Journal of Banking and Finance* 43 (1980), 749–761.

[7] Campbell, Doug, "Why economists still worry about bank runs," Federal Reserve Bank of Richmond *Region Focus* 9 (Fall 2005), 36-38.

[8] Champ, Bruce, Bruce D. Smith, and Stephen D. Williamson "Currency elasticity and banking panics: theory and evidence," *Canadian Journal of Economics* 29 (1996), 828-864.

[9] Chari, V. V. and Patrick J. Kehoe, "Sustainable Plans," *Journal of Political Economy* 98 (1990), 783-802.

[10] Cooper, Russell and Thomas W. Ross, "Bank runs: liquidity costs and investment distortions," *Journal of Monetary Economics* 41 (1998), 27-38.

[11] Diamond, Douglas W. and Phillip H. Dybvig, "Bank runs, deposit insurance, and liquidity," *Journal of Political Economy* 91 (1983), 401-419.

[12] Engineer, Merwan, "Bank runs and the suspension of deposit convertibility," *Journal of Monetary Economics* 24 (1989), 443-454.

[13] Ennis, Huberto M. and Todd Keister, "Optimal fiscal policy under multiple equilibria," *Journal of Monetary Economics* 52 (2005), 1359-1377.

[14] Ennis, Huberto M. and Todd Keister, "Bank runs and investment decisions revisited," *Journal of Monetary Economics*, forthcoming.

[15] Gorton, Gary, "Bank suspension of convertibility," *Journal of Monetary Economics* 15 (1985), 177-193.

[16] Green, Edward J. and Ping Lin, "Implementing efficient allocations in a model of financial intermediation," *Journal of Economic Theory* 109 (2003), 1-23.

[17] Kydland, Finn E. and Edward C. Prescott, Rules rather than discretion: the inconsistency of optimal plans," *Journal of Political Economy* 85 (1977), 473-492.

[18] Mailath, George J. and Loretta J. Mester, "A positive analysis of bank closure," *Journal of Financial Intermediation* 3 (1994), 272-299.

[19] Martin, Antoine, "Liquidity provision vs. deposit insurance: preventing bank panics without moral hazard." *Economic Theory* 28 (2006), 197-211.

[20] Peck, James and Karl Shell, "Equilibrium bank runs," *Journal of Political Economy* 111 (2003), 103-123.

[21] Postlewaite, Andrew and Xavier Vives, "Bank runs as an equilibrium phenomenon," *Journal of Political Economy* 95 (1987), 485-491.

[22] Stokey, Nancy L., "Credible public policies," *Journal of Economic Dynamics and Control* 15 (1991), 627-656.

[23] Villamil, Anne, "Demand deposit contracts, suspension of convertibility, and optimal financial intermediation," *Economic Theory* 1 (1991), 277-288.

[24] Wallace, Neil. "Another attempt to explain an illiquid banking system: the Diamond and Dybvig model with sequential service taken seriously," *Federal Reserve Bank of Minneapolis Quarterly Review* 12 (Fall 1988), 3-16.

[25] Wallace, Neil. "A banking model in which partial suspension is best," *Federal Reserve Bank of Minneapolis Quarterly Review* 14 (Fall 1990), 11-23.